2006

New Crop Opportunities

Research Report

ABOUT OUR COVER

The New Crop Opportunities Center conducts research on a wide variety of horticultural and specialty grains crops. These crops include blackberries, vegetables, greenhouse crops, nursery crops, sweet sorghum, wheat, and soybeans. The goal of this research is to help Kentucky farmers gain knowledge of diversification options that will enable them to be successful.

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Specialty Grains

New Crop Opportunities Center Overview—2006

The New Crop Opportunities Center was established in July of 2000 to provide farmers with production and marketing information on new crops and value-added versions of current crops. The center is funded by a special grant from the USDA. It supports research on specialty crops, offers electronic and printed educational materials, and provides on-farm demonstrations of selected crops.

Eighty projects involving horticultural and specialty grains crops have been initiated through seven phases of New Crop Opportunities Center funding. Thirteen of those projects will begin this year. A Web site (www.uky.edu/ag/newcrops) was established in October of 2000 to make information about the Center's research as well as information on a variety of additional crops available to Cooperative Extension agents and farmers. The Web site includes links to decision aids to help farmers decide if a particular crop is right for them and crop profiles to give farmers a quick look at production factors and economic considerations associated with a variety of crops. These profiles are a starting point to help farmers determine which crops might work for their enterprises and warrant further investigation. Profiles are currently available on 88 crops or enterprises such as agritourism or starting a nursery business. Additional crops are being added, and older profiles are being updated.

The New Crop Opportunities Center builds on successful multi-disciplinary programs and provides resources to intensify the research and extension efforts for a more rapid response to critical state needs and opportunities. The integrated research and extension components of this proposal include faculty, staff, and graduate student activities at the Horticulture Research Farm and Spindletop Farm in Lexington, the Robinson Experiment Station in Quicksand, and the Research and Education Center in Princeton. Since it began in 2000, New Crops research has involved 82 faculty and staff from six departments in the College of Agriculture (Plant and Soil Sciences, Horticulture, Agricultural Economics, Entomology, Plant Pathology, Biosystems and Agricultural Engineering) and from Family and Consumer Sciences in the Cooperative Extension Service as well as county extension agents and graduate students.

Justification

It is well-documented that many of Kentucky's family farms have been highly dependent upon tobacco as a primary source of income. In 2005, Kentucky tobacco cash receipts fell to $275 million, down from $450 million in 2004. Interest in alternative crops rose dramatically in anticipation of the national tobacco buyout, which was legislated in 2004. Other farmers are seeing the potential success of horticultural crops, but most lack the technical knowledge and management skills for immediate success with these production/marketing systems.

Market prices for corn, soybeans, and wheat, which together account for nearly all of Kentucky's grain crop production area, have been relatively low in recent growing seasons. While some growers have been able to devise new combinations of inputs to reduce their production costs without incurring yield penalties, most growers are convinced that the best way to improve the profitability of their operations is to secure higher market prices for their products. The concept of "high-value" commodities has been invoked in other Kentucky industries as a means by which more of the additional product value generated through post-production processing can be captured by the state. In the case of specialty grains, the additional value is due to genetic modifications made in the crop variety prior to its planting. Such modifications have resulted in an impressive array of specialty types of corn, soybeans, and wheat.

With so many specialty grain types being developed, it is somewhat perplexing to producers to determine bona fide opportunities for their operations. Some specialty grains may produce lower yields, and growers need to have a reliable estimate of just how much that yield penalty might be. In addition, some specialty characteristics may be sensitive to environmental conditions during the growing season. A goal of this project is to provide accurate information on both the yields and selected quality characteristics of each specialty grain tested, thus giving producers a solid information base from which to decide which specialty grains to investigate under their own unique conditions.

About this report

The 2006 New Crop Opportunities Progress Report includes 43 reports on research projects that have been conducted on horticultural and specialty grains crops. The report includes the following sections:

- blackberries
- greenhouse crops
- nursery crops
- organic production of horticultural crops
- vegetables
- marketing and economic information on horticultural crops
- corn
- drying and storage of specialty grains
- organic production of specialty grains
- soybeans
- sweet sorghum
- wheat
- economic assessment of specialty grains.

Some of these projects have been completed; others are ongoing. Results of the ongoing projects can be accessed as they become available at www.uky.edu/ag/newcrops/current.html.

Evaluation of Thornless Semi-Erect and Erect Blackberry Varieties and Training Systems

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Introduction

Blackberries continue to be popular with Kentucky consumers, and most growers find that high quality blackberries are readily marketable. This study was initiated as part of the New Crop Opportunities Fruit Project at the Horticulture Research Farm in Lexington, Kentucky. One portion of the study has been designed to evaluate two cane training systems using a double-T four-wire trellis for three thornless, semi-erect blackberry varieties. The second portion of the study is to evaluate a plastic bailing twine trellis for cane stabilization versus no trellis for two thornless, erect blackberry varieties.

Materials and Methods

Semi-erect thornless blackberry plants were set in spring 2000 into black plastic-mulched beds with trickle irrigation. Each plot consisted of three plants of either the Hull Thornless, Triple Crown, or Chester varieties, spaced 8 ft apart in the row with 12 ft between rows. Each plot was replicated three times in a randomized block design. All plants were trained on a double-T four-wire trellis with the lower two wires 2 ft apart and the top two wires 4 ft apart. Two training systems were used: a conventional system and the minimal pruning system (referred to as the Oregon system in previous UK Research Reports). One plant of the three in each plot was harvested for yield.

In the conventional system, primocanes were tipped when they had extended one foot above the top of the trellis. Dead fruiting canes that had cropped were removed in the fall. During early spring dormant pruning, spindly canes and/or those that had red-necked cane borer swellings were removed. Lateral branches were pruned to 18 inches in length and those that were within 18 inches of the ground were removed completely.

In the minimal pruning system, primocanes were not summer tipped. In the spring, floricanes were not thinned, although those with red-necked cane borer swellings were removed. Low laterals, within 18 inches of the ground, were removed. Laterals above this were not cut back and were wound around, and sometimes loosely tied to the closest trellis wire, extending away from the plant.

Arapaho and Apache erect blackberry plants were set 3 ft apart in the guard rows on the north and south sides of the semi-erect blackberry plot. These were also set in black plastic with trickle irrigation. Trellising treatments (supported and unsupported) and varieties were each replicated three times in a completely randomized design. Plots consisted of three plants of the same variety, of which two plants were harvested for yield. Metal fence posts were set every 9 ft, and plastic bailer twine was run on both sides of the supported treatment at a height of 3.5 ft.

During the first (2000) growing season, canes were allowed to trail and grow as much as possible. In the spring of 2001, the erect blackberry floricanes were pruned severely to encourage development of more vigorous shoots for the following season. During the summers (2001-2003), primocanes were tipped at a height of about 3 ft. Spindly canes and those with red-necked cane borer swellings were removed in the spring. Laterals were cut back to 16 to 18 inches in length.

All plants were fertilized in February 2005 with calcium nitrate at the rate of 8 lb/100 ft row (44 lb N/A). Irrigation was necessary in 2005. Weeds were controlled with a preemergent application of Surflan, postemergence treatment with Poast, and hand weeding. Liquid lime sulfur at the half-inch growth stage and Cabrio and Nova during the season were used for disease control. Japanese and green June beetles were controlled with malathion. Raspberry crown borers were noted in a number of plants in 2004, and guthion was applied as a soil drench in October 2004. Bird pressure was severe early in 2002 and 2003 and moderate in 2004 and 2005. An avian alarm was used to reduce bird losses.

Plants were harvested each year from 2001 through 2005. Data were collected for yield, fruit size, and fruit soluble solids. The 2002 and 2005 seasons were hot and dry, while the 2003 and 2004 seasons were cool and wet. Data are shown for the 2005 season.

Results and Discussion

In 2005 the Chester semi-erect variety significantly out-yielded the Triple Crown variety (Table 1), while in 2004 Chester out-yielded both Hull Thornless and Triple Crown. In 2003 both Chester and Hull Thornless significantly out-yielded Triple Crown. Yields in 2005 were roughly 4,000 pounds less for all varieties as compared to 2004. This could be attributed to the extremely dry 2005 season and possible overproduction in 2004. Prior to 2005, yields had substantially increased annually for all three varieties. Triple Crown has consistently produced the largest berries for the last four years, and these had a higher soluble solids content than those of Chester, which had a higher soluble solids content than Hull Thornless berries.

As in all years except 2004, there was no difference in yield between the minimal pruning and the conventional training system (Table 2). In 2004 the minimal pruning system yielded more than the conventional system. Thus, the minimal pruning system may yield slightly more than the conventional system. However, average berry weight was again smaller for the minimal pruning system, as in all previous

Table 1. Thornless semi-erect blackberry variety yield, average berry weight, and soluble solids, 2005 harvest.

Variety	Yield[1] (lb/A)	Avg. Berry Wt.[1](oz)	Soluble Solids[1](%)
Chester	27,585 a	0.21 b	9.4 b
Hull Thornless	22,380 ab	0.21 b	8.5 c
Triple Crown	15,839 b	0.30 a	11.7 a

[1] Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 2. Thornless semi-erect blackberry yield, average berry weight, and soluble solids based on training system, 2005 harvest.			
Training System	**Yield[1] (lb/A)**	**Avg. Berry Wt.[1] (oz)**	**Soluble Solids[1] (%)**
Conventional	21,949 a	0.24 a	9.8 a
Minimal pruning	21,921 a	0.21 b	9.9 a

[1] Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 3. Thornless erect blackberry variety yield, average berry weight, and soluble solids, 2005 harvest.			
Variety	**Yield[1] (lb/A)**	**Avg. Berry Wt.[1] (oz)**	**Soluble Solids[1] (%)**
Apache	6,330 a	0.25 a	11.5 a
Arapaho	607 b	0.12 b	11.0 a

[1] Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

years but 2002. When average berry weight is examined with respect to training system and variety, both Triple Crown and Hull Thornless produced their largest berries in the conventional training system in 2005, while there was no difference in berry size between the two systems for Chester (data not shown). The only other year in which a variety produced larger berries using a particular training system was in 2003 when Hull Thornless produced larger berries using the conventional system. There was no difference in berry soluble solids contents between training systems in 2005, while the minimal pruning system had slightly higher berry soluble solids levels in 2004.

For the thornless erect varieties, Apache far out-yielded Arapaho in 2005, as it had in 2003 and 2004 (Table 3). As with the thornless semi-erect varieties, yields were lower than in 2004. Apache has consistently produced larger berries than Arapaho, but there was no difference in soluble solids contents between the two varieties as there was in 2003 and 2004. Berry weight for Apache thornless erect berries averaged 0.26 oz, while that of Triple Crown, the largest of the semi-erect berries, averaged 0.30 oz.

There were no significant differences in yield, average berry weight, or soluble solids between the no-trellis and string trellis treatments for the erect thornless varieties (Table 4). This has been consistent throughout this study. The 2005 growing season was not a windy one, and there was very little cane breakage in the no-trellis plot. Apache had the more attractive fruit of the two varieties. The first, middle, and last harvest dates in 2005 for all the varieties can be found in Table 5.

Table 4. Thornless erect blackberry yield, average berry weight, and soluble solids based on training system, 2005 harvest.			
Training System	**Yield[1] (lb/A)**	**Avg. Berry Wt.[1] (oz)**	**Soluble Solids[1] (%)**
No trellis	3,481 a	0.24 a	11.2 a
String trellis	3,457 a	0.24 a	11.5 a

1 Means within a column followed by the same letter are not significantly different (Duncan Waller LSD P = 0.05).

Table 5. Harvest date data, 2005 harvest.			
Variety	**First Harvest**	**Mid-Point[1]**	**Last Harvest**
Arapaho	June 24	July 9	July 29
Apache	July 8	July 24	Aug. 16
Triple Crown	July 8	July 23	Aug. 26
Hull Thornless	June 30	July 31	Sept. 2
Chester	July 12	Aug. 8	Sept. 6

[1] Date on which half of the berries were harvested, based on total yield weight.

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HORTICULTURAL CROPS—BLACKBERRIES

Blackberry Cultivar Trial

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Introduction

Blackberry (*Rubus* spp.), a native plant, grows well in Kentucky. Improved blackberry cultivars offer a high income-per-acre crop for Kentucky agricultural producers looking to diversify production. Blackberries have lower establishment and labor costs than many horticultural enterprises. This experiment was begun to evaluate the performance of newer blackberry cultivars in western Kentucky's climate.

Materials and Methods

In the spring of 2000, a blackberry cultivar trial was established at the University of Kentucky Research and Education Center (UKREC), Princeton, Kentucky. The experimental design consisted of five cultivars (Apache, Arapaho, Chickasaw, Kiowa, and Navaho) and five replications arranged in a randomized complete block design. Five rows or replications, each consisting of five cultivars per row, were spaced 14 ft apart. Rows were 70 ft long with 10 ft for each cultivar and 5 ft grass buffer areas between cultivars. Six plants were spaced 2 ft apart within each plot. Plants looked fine throughout the 2000 season. In the spring of 2001, all Navaho plants started to develop symptoms of tobacco ring spot virus. These plants were removed that fall after laboratory confirmation of the virus infection. Chickasaw plants developed systems of impatiens necrotic spot virus in 2002 and were removed that fall, after harvest.

Plots were harvested from 18 June through 1 August in 2002, from 26 June through 4 August in 2003, and from17 June to 30 July in 2004. Harvesting was every two to six days, depending on berry ripeness. Yields and berry weights (weight of 25 berries) were measured at each harvest, and the total yields and average berry weights calculated (Table 1).

Table 1. Yield parameters of the blackberry cultivar trial established in 2000 at UKREC, Princeton, Kentucky.

	Yield (lb/acre)			Berry Weight (g)			Harvest Period		
Cultivar[1]	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**	**2002**	**2003**	**2004**
Apache	9801	3525	8179	7.6	7	7.2	6/27-8/1	7/9-8/4	6/25-7/30
Kiowa	7499	3194	7309	8.7	6.7	8	6/18-8/1	6/26-8/4	6/17-7/30
Chickasaw[2]	6192	-	-	7	-	-	6/18-7/26	-	-
Arapaho	3454	807	641	3.5	2.6	3.3	6/18-7/12	6/26-8/4	6/17-7/30
LSD (5%)	2987	1130	1668	0.9	1.6	0.9	-	-	-

[1] Cultivars listed in descending order of yield.
[2] Chickasaw variety was eliminated in 2003.

Results and Discussion

All cultivars ripened a couple of weeks earlier in 2004 than in 2003. In addition, yields in 2004 were more than double those observed in 2003 for Apache and Kiowa (Table 1). In general, the plants were healthy and grew well. The drop in yields in 2003 compared to 2002 could be attributed to excessive fall pruning of canes infested with the rednecked cane borer.

Arapaho ripened early but yielded significantly less fruit with significantly small berry size (as measured by average weight per berry) than Apache and Kiowa for all three years that fruit has been harvested from this trial. Conversely, Apache tended to be the last to ripen but yielded the most fruit. Kiowa and Chickasaw were intermediate between Apache and Arapaho in yield and ripening date in 2002, and Kiowa was intermediate in yield in 2003 and 2004.

HORTICULTURAL CROPS—BLACKBERRIES

Extending Blackberry Fruit Shelf Life: Effects of Container Type and Modified Atmosphere Storage

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Blackberries have become increasingly popular as an alternative crop in Kentucky. They have grown in popularity with consumers who recognize that the fruit can provide health-beneficial phytochemicals in addition to their more generally known use in desserts. As a result, blackberry growers in Kentucky are looking at expanding market opportunities. Blackberry fruit has a short shelf life, and some quality loss can occur under recommended refrigerated storage conditions. Blackberry growers in the state have indicated some preference for fiber baskets over plastic clamshell containers for marketing the berries, although the latter type of container is most common in the major retail chains. Shelf life of blackberries in the fiber baskets has not been directly compared to that in the clamshell containers. Modified atmosphere (MA) storage, raising CO_2 and/or lowering O_2 from ambient levels, has become a common postharvest practice for extending shelf life of many perishable crops, such as blackberries. Simple, cost-effective techniques for MA use are commercially available, regardless of the scale of production. Although blackberries grown on the West Coast are commonly stored and shipped under MA conditions, the response of eastern thornless blackberries to MA storage has not been reported. Also, it is not known if the health-beneficial components of blackberries (total antioxidant capacity, total phenolics, and total anthocyanins) change during cold storage.

The objective of this work was to study 1) the influence of storage container type on blackberry fresh weight during postharvest storage, 2) the response of thornless blackberry cultivars to MA conditions in refrigerated storage, and 3) the total antioxidant capacity, total phenolics, and total anthocyanin content of blackberries during cold storage. Berry firmness, fresh weight, juice pH, soluble sugars, titratable acidity, total antioxidant capacity, total phenolics, and total anthocyanins were measured at harvest, after one week of MA storage at 4° C, and after three additional days at room temperature. The MA treatments were initial levels of CO_2 at 10%, O_2 at 5-9%, and the two gases combined at those levels.

The influence of storage container type. When stored at 4° C for seven days, blackberry fruit in fiber baskets lost significantly more fresh weight than those in clamshell containers—8.5% versus 6.3 %, respectively. During a post-cold storage three-day period at room temperature, berries in the fiber baskets lost significantly more fresh weight as well—15.1% versus 10.6%, respectively. Thus, fiber baskets may work well for immediate marketing of blackberries, but they are inferior to clamshells if a period of cold storage precedes marketing.

The response of thornless blackberry cultivars to MA conditions. Though there were some differences between Chester and Hull thornless blackberry fruit quality traits at harvest within each harvest season (2003 and 2004), the differences were not consistent across years. None of the MA treatments affected postharvest quality of these cultivars after seven days of cold storage or after another three days at room temperature storage. Fruit quality declined some in cold storage; it declined very rapidly after removal from cold storage in all treatments. MA storage had no consistent beneficial impact on blackberry fruit quality and can't be recommended for commercial use.

The total antioxidant capacity, total phenolics, and total anthocyanin content of blackberries during cold storage. Blackberry fruit were found to be a rich source of health-beneficial antioxidant compounds. Levels of total antioxidant capacity, total phenolics, and total anthocyanins varied some between cultivars and harvest seasons, though levels did not change appreciably during cold storage. MA storage reduced total anthocyanins by an average of 11% but had no effect on total antioxidant capacity or total phenolic content. Thus, blackberry fruit generally retain health-beneficial components as long as overall fruit quality remains good.

Cut Roses for Christmas and Valentine's Day from Cuttings

Robert G. Anderson, Department of Horticulture

Today, commercial greenhouses, in Kentucky and the rest of the United States, primarily grow bedding plants. Although cut flowers were as much as 50% of greenhouse production in the early 1970s, cut flowers are no longer produced in Kentucky and surrounding states. The cut flower market in Kentucky and the United States remains strong, however. Over 1.3 billion rose stems were sold in the United States in 2002, and per capita consumption has doubled in the last 20 years (Roses, Inc., Bulletin, 2003).

The primary market periods for cut flowers are three major U.S. holidays—Valentine's Day, Mother's Day, and the Christmas season. Mother's Day is a major sales time for bedding plants, while Valentine's Day is the largest market for cut flowers. Traditional greenhouse cut flower production was year-round, but U.S. and Kentucky growers can no longer compete with the year-round production from the mountains of South America. The objective of this project was to determine whether cut roses could be economically produced for only six months of the year, harvesting flowers for the Christmas season and Valentine's Day.

The proposed production schedule would allow roses to be grown as part of a currently successful bedding plant business. Roses could be grown from cuttings started in August, just as poinsettias are potted. Roses would compete with garden mums and poinsettias for greenhouse space in the summer and fall, but both those crops have saturated their markets, and prices have not increased in a number of years. After cut stems are harvested for the Christmas season and Valentine's Day, the plants would be discarded. This six-month alternative is well-supported by an economic evaluation of single stem roses (Anderson and Woods, 1999). An unusually high internal rate of return (175%) was estimated for Valentine's Day rose production integrated into a typical greenhouse system that produced bedding plants, garden mums, and poinsettias.

Methods and Results July 2002 – February 2003

Prepare economic simulations of the model that focus on production costs for alternative plant densities, containers, and pruning systems.

It is relatively simple to compare the yield of cut rose stems with example production costs. Commercial greenhouses have an operating cost of approximately $0.25 per square foot per week (Will Southerland, 2002, personal communication). Rose plants transplanted in mid-October will use greenhouse space for 16 weeks if roses are harvested for Valentine's Day. Cut rose production in this system costs $4.00 per square foot of space used. The plants are planted into 6-inch pots, so there are four plants per square foot of space. Thus, the returns need to be at least $1.00 per plant. At prices of $1.00 or more per cut stem, this system needs to produce at least one high quality stem per plant.

Evaluate cultivars of red roses for their performance in a short-term production system.

Modern red greenhouse rose varieties ('Black Magic' and 'Fahrenheit'), traditional red greenhouse rose varieties ('Samantha' and 'Taboo'), modern garden roses ('Cesar Chavez,' 'Burning Desire,' 'Opening Night,' 'Veteran's Honor,' 'Crimson Bouquet,' and 'Cardinal's Song'), and traditional red garden roses ('Olympiad' and 'Ingrid Bergman') were evaluated in 2002-2003. 'Black Magic,' 'Olympiad,' 'Cesar Chavez,' 'Kardinal,' and 'Lady Diana' were used in 2003-2004 studies.

Develop a production model to produce roses from cuttings for Christmas and Valentine's Day.

Roses were relatively easy to grow from cuttings. Flowering stems were harvested for cuttings on Aug. 16 and 29 and Sept. 9 and 12, 2002, and Aug. 14, 21, and 28, 2003. Approximately 750 rooted cuttings from 14 red rose cultivars were transplanted into 6-inch pots on Sept. 28, Oct. 22, and Oct. 27, 2002, and approximately 1,000 cuttings of five rose cultivars were transplanted into 1-L pots on Oct. 5, 2003. Plants were placed pot-to-pot in 2002 and placed into rows 12 inches apart in 2003 in a greenhouse that received ambient light levels. Greenhouse temperatures were maintained at an average daily temperature of 60° F during the fall and winter. Plants were irrigated by hand each day with a fertilizer solution of Peter's 20-10-20, which had an EC of 1.0-1.2 dS and pH of 5.5-6.5.

Pruning practices were compared during the winter of 2002-2003. Plants were pruned to 5 inches or 12 inches on Dec. 2 and compared with un-pruned plants that were tied together in groups of four plants. The tying technique allowed light to reach the lower parts of the plant, where new shoots could emerge. In 2003-2004, plants were pruned to 12 inches and arched into the space between rows on Nov. 25, or un-pruned plants were tied together in groups of four plants.

Validate the optimal economic model by growing the roses in the greenhouse in replicated studies.

Rose growth is directly related to the amount of light the plants receive. The winter of 2002-2003 had unusually low light levels, so overall rose performance was poor.

All cultivars of roses pruned to a 5-inch height in early December had a yield of less than one stem per plant. 'Olympiad' and 'Cesar Chavez' roses produced 1.5 and 1.2 stems per plant in the 12-inch and tied treatments.

In 2003-2004, the greenhouse heating system failed during late December and was not working properly until late January. The average daily temperature was 51° F for nearly six weeks in December and January, so plant growth was not normal. Cut flower yield was less than 1.5 stems per square foot, so the trials were not successful.

This project was to continue in the winter of 2004-2005, but the greenhouses at the Horticulture Research Farm were demolished in the summer of 2004 for planned new construction.

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Evaluation of Pesticide-Free Insect Control for Flower, Fruit, and Vegetable Transplants with Nitrogen Gas Fumigation

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Over 2 trillion young flower plants (plugs, cuttings, liners) were grown and shipped to other growers in the United States in 2003. This number does not include the billions of vegetable, fruit, and nursery liners that are produced and shipped each year. Kentucky growers receive plants from many U.S. and foreign locations, and some Kentucky growers ship plants to various locations each year. Unfortunately and inevitably, arthropod pests are shipped incidentally with these plants, even though growers make every effort to prevent this problem. Most pest problems that aggravate Kentucky growers, especially new and small growers, come with the plants they receive. Kentucky growers could reduce their production costs dramatically—pesticides, labor for pesticide application, worker safety, consumer and environmental safety—if arthropod pests were not transported with the plants.

Arthropod pests can be controlled by modified atmosphere treatment (simple fumigation) of infested plants with nitrogen or carbon dioxide gases. Previous work demonstrated that exposure to >99% N_2 or CO_2 for 12 to 18 hours caused complete mortality of common greenhouse insect pests—green peach aphid, sweet potato whitefly, western flower thrips, and the twospotted spider mite. These treatments created hypoxic (nearly zero % oxygen) conditions that asphyxiated the arthropod pests and did not harm the treated plants.

The objective of this project is to determine the impact of the use of nitrogen gas fumigation (a modified atmosphere treatment) on the plants grown in greenhouses and shipped to Kentucky growers.

Progress

The nitrogen gas fumigation test system was completed in 2004 and updated three times in 2005. The system consists of six 10-liter chambers that can be flushed with selected gases for the hypoxia and control treatments. Each gas line to the individual chambers has an O_2 and CO_2 sensor. The sensors are attached to a Campbell Scientific CR-10 Datalogger to collect gas concentration levels each minute during an individual experiment. The treatment chambers are inside a controlled environment room maintained at 20ºC and 50% RH.

During the fall of 2004 and spring of 2005, preliminary trials evaluated approximately 75 genotypes of ornamental (petunia, verbena, poinsettia, vinca, begonia, etc.) and vegetable (tomato, pepper, lettuce, onions, etc.) transplants for their performance during and after treatment with the fumigation system. The nitrogen fumigation treatment consisted of flushing the 10-liter test vessels with 99.999% nitrogen for a 24-hour period. The interior oxygen level decreased to less than 0.1% within 60 to 80 minutes of the start of the treatment. The plant responses to the treatment varied widely. Some plants showed little signs of damage; others were visibly damaged; others were killed by the treatment.

The preliminary trials demonstrated a clear need to objectively quantify the amount of damage to the test plants. A high-quality scanner and specific software were purchased to measure damaged and undamaged leaf segments for an objective analysis of the treatment effects. Additionally, the CO_2 sensors will be used to determine changes in photosynthetic rate between the treated and control plants. The CO_2 sensor upgrades have been completed, and pilot testing is being conducted. Current and future experiments will focus on two species—vinca, *Catharanthus roseus,* tolerant to the preliminary treatment, and wax begonia, *Begonia semperflorens-cultorum,* intolerant to the preliminary treatments.

Perennial Garden Flower Trials—1999-2004 University of Kentucky Horticulture Research Farm

Robert Anderson, Kirk Ranta, and Joe Ulrich, Department of Horticulture

Annual and perennial garden flowers have been evaluated for many years at the University of Kentucky. Trials have occurred at the University of Kentucky Arboretum since 1993. These trials were expanded at the Horticulture Research Farm in 1999 and 2000 with grants from the Kentucky Department of Agriculture and the Kentuckiana Greenhouse Association. Grants from the USDA New Crop Opportunities Center allowed expansion of the trials to more than 20,000 square feet of trial gardens in Lexington that have been used from 1999 to 2004.

The collection of perennials in our ongoing trials continues to expand. We have nearly 1,200 individual plants in the perennial trials with more than 225 species and cultivars in the plots at the Horticulture Research Farm in Lexington. Our trials include the Perennial Plants of the Year from the Perennial Plant Association and Kentucky native plants. We now have five years experience with some so our ratings have many observations. However, our ratings should be used only as a guide to determine which perennials you might sell or use in Kentucky landscapes. In general, those that have grown well for two or more seasons are marked as highly recommended (++), recommended (+), or did not perform well on our site or were not hardy (-). Those unmarked need more time to determine a rating.

Photos and details about plant performance are continually added to the Kentucky Garden Flowers Web site at <http://www.uky.edu/Ag/Horticulture/gardenflowers>. You can also go to the UK home page at <http://www.uky.edu> and search for a plant name; you will be directed to the Kentucky Garden Flowers location.

Mexican Hyssop

Agastache 'Tutti Frutti' ('01-'02) (**-**)

Russian Hollyhock

Alcea rugosa ('03-'04)

Amsonia

Amsonia hubrectii ('01-'04) (**++**)
Amsonia tabernaemontana 'Blue Star' ('03-'04) (**++**)
[Ky Native]

Artemisia

Artemisia absinthium 'Huntington Gardens' ('01) (**-**)
Artemisia vulgaris 'Oriental Limelight' ('03-'04)

Aster

Aster apellus 'Triumph' ('00-'03) (-), *Aster azureus* ('03-'04) - Sky Blue Aster [Ky Native], *Aster laevis* 'Bluebird' ('00-'04) (**++**), *Aster latiflorus* 'Prince' ('00-'03) (-), *Aster novi-belgii* 'Celeste' ('01-'03)(-), *Aster novi-belgii* 'Purple Monarch' ('01-'03) (-), *Aster novi-belgii* 'Snow Cushion' ('00-'02) (-), *Aster novi-belgii* 'White Swan' ('00-'03) (**+**), *Aster novi-belgii* 'Winston Churchill' ('01-'03) (-), *Aster novi-belgii* 'Woods Purple' ('00-'03) (+), *Aster x frikarti* 'Monch' ('00-'03) (+), *Aster oblongifolius* ('03-'04) [Ky Native], *Aster oblongifolius* 'Raydon's Favorite' ('02 -'04) (++), *Aster simplex* ('03-'04) – Panicled Aster [Ky Native], *Aster tongolensis* 'Wartburg Star' ('03 -'04)
Boltonia asteroides ('00-'04) (+), - Star Flower
Kalimeris mongolica ('01-'04) (**++**) - Star Aster, *Kalimeris mongolica* 'Variegata' ('00-'04) (++) - Star Aster

Astilbe

Astilbe 'Sprite' ('00-'04) (++)

Columbine

Aquilegia x hybrida 'Rose w/White Edge' ('02 -'04), 'Songbird Cardinal' ('02-'04), 'Winky Red & White' ('02-'04)

Indigo

Baptisia leucophaea ('03-'04) [Ky Native], *Baptisia pendula* ('01-'04) [Ky Native], *Baptisia sphaerocarpa* ('03-'04)
[Ky Native]

Willowleaf Oxeye

Buphthalum salicifolium 'Sun Wheels' ('00-'03) (**-**)

English Daisy

Bellis perennis 'Galaxy Rose' ('02-'03), 'Rose Border'
('02-'03), 'Tasso Strawberry & Cream' ('02-'03)

Feather Reed Grass

Calamagrostis acutifolia 'Karl Foerster' ('00-'04) (**++**), *Calamagrostis acutifolia* 'Overdam', ('02 -'04) (++) - Variegated Feather Reed Grass, *Calamagrostis brachytricha*, ('02-'04) (++) - Korean Feather Reed Grass

River Oats, Northern Sea Oats

Chasmanthium latifolium ('00-'04) (**++**)[Ky Native]

Garden Mums

Ajania pacificum 'Pink Ice' ('00-'04) (**++**), *Chrysanthemum* 'Hillside Pink' ('01-'04) (+), *Chrysanthemum yezoense*
('00-'04) (+)

Dendranthema grandiflora

Prophet Series – 'Beth' ('04), 'Brandi'('04), 'Dark Triumph'('04), 'Dazzling Stacy'('04), 'Debonair'('04), 'Ginger'('04), 'Golden Helga'('04), 'Golden Spotlight'('04), 'Gretchen'('04), 'Harmony'('04), 'Heidi'('04), 'Helen'('04), 'Helga'('04), 'Janice'('04), 'Jennifer'('04), 'Jessica'('04), 'Linda'('04), 'Legend'('04), 'Marilyn' ('04), 'Natalie'('04), 'Natasha'('04), 'Nichole'('04), 'Okra'('04), 'Patricia'('04), 'Rhapsody'('04), 'Soft Lynn'('04), 'Spotlight'('04), 'Sunny Gretchen'('04), 'Sunny Robin'('04), 'Sunny Ursala'('04), 'Symphony'('04), 'Tabitha'('04), 'Yellow Ginger'('04), 'Yellow Triumph'('04), 'Zesty Barbara'('04),
Showmaker Series – 'Amata Purple'('04), 'Amour Pink'('04), 'Amour White'('04), 'Amour Spider White'('04), 'Argos Orange'('04), 'Caster Yellow'('04), 'Firecracker Yellow'('04), 'Goldfinch Yellow'('04), 'Gothic Purple'('04), 'Iduna Bronze'('04), 'Jason White'('04), 'Minerva White'('04), 'Pluto Red'('04), 'Rio Dark Purple'('04), *Dendranthema rubellum* 'Clara Curtis' ('00-'04) (+), *Dendranthema rubellum* 'Mary Stoker' ('00-'04) (+)

Shasta Daisy

Chrysanthemum (Leucanthemum) x superbum 'Becky'
('02 -'04)(++), 'Thomas Killen' ('03-'04) (++)

Cumberland Rosemary

Conradina verticillata ('02 -'03) [Ky Native]

Coreopsis

Coreopsis 'Tequila Sunrise' ('01-'04), *Coreopsis grandiflora* 'Domino' ('02 -'04) (+), *Coreopsis grandiflora* ' Early Sunrise' ('02 -'04) (+), *Coreopsis lanceolata* 'Baby Sun' ('02 -'04) (+) - Lanceleaf Coreopsis *Coreopsis rosea* 'American Dream' ('01-'04) (+), 'Sweet Dreams' ('03-'04), 'Limerock Ruby' ('03)(-), *Coreopsis tripteris* ('03-'04) – Tall Coreopsis [Ky Native], *Coreopsis verticillata* 'Moonbeam' ('00-'04) (**++**), 'Zagreb ('03-'04) (++) – Threadleaf Coreopsis

Montbretia
Crocosmia crocosmiifolia 'Venus' ('00-'02) (-)

Pinks
Dianthus 'Brilliant Star' ('03-'04), 'Sarah' ('03), *Dianthus allwoodii* 'Doris' ('02 -'04), 'Frosty Fire' ('02), 'Helen' ('03) - Allwood Pink, Dianthus caryophyllus 'Rosie Cheeks' ('03), 'Ruby's Tuesday' ('03), *Dianthus deltoides* 'Brilliant' ('01-'04) (++), 'Zing Rose ('03) - Maiden Pink, *Dianthus gratianopolitanus* 'Bath's Pink' ('02-'04) (**++**), 'Spotty' ('03) - Cheddar Pink

Cone Flower
Echinacea pallida ('00-'04) (+)[KY NATIVE], *Echinacea paradoxa* ('00-'04) (+)[KY NATIVE], *Echinacea purpurea* ('00-'04) (**++**)[KY NATIVE], *Echinacea purpurea* 'Magnus' ('00-'04) (**++**), 'Primadonna Deep Rose ('02-'04) (++), *Echinacea simulata* ('00-'04) (+)[KY NATIVE], *Echinacea tennessensis* ('00-'04) (**++**)

Silver Prairie Grass
Erianthus alopecuroides ('00-'03) [KY NATIVE]

Oregon Fleabane
Erigeron 'Azure Fairy' ('00-'03) (**-**)

Hardy Ageratum
Eupatorium coelestinum ('01-'04) (**++**)[KY NATIVE]

Joe Pye Weed
Eupatorium maculatum ('00-'04) (**++**) [KY NATIVE], *Eupatorium maculatum* 'Carin' ('02-'04) (++), *Eupatorium maculatum* 'Gateway' ('02-'04) (++)

Spurge
Euphorbia dulchis 'Chameleon' ('03-'04)

Hardy Fuchsia
Fuchsia magellanica 'Ricartonii' ('02) (**-**)

Blanket Flower
Gaillardia grandiflora 'Summer's Kiss' ('03)

Wand Flower
Gaura lindheimeri 'Siskiyou Pink' ('01-'02) (-)

Gazania
Gazania linearis 'Colorado Gold' ('03) (-)

Cranesbill, Hardy Geranium
Geranium 'Dusky Rose' ('00-'02), *Geranium cantabrigiense* 'Blokova' ('00-'02), *Geranium cantabrigiense* 'Karmina' ('00-'04) (++), *Geranium cinereum* 'Ballerina' ('00-'02), *Geranium clarkei* 'Kasmir Purple' ('00-'02), *Geranium maculata* 'Claridge Druce' ('00-'02) (++), *Geranium phaeum* 'Samobor' ('00-'04) (++)

Sneezeweed
Helenium 'Blutentisch' ('03), 'Coppella' ('00-'04) (+), *Helenium autumnale* ('03-'04) [KY NATIVE]

Sun Rose
Helianthemum 'Annabel' ('01-'04) (**++**), *Helianthemum nummularium* 'Dazzler' ('03-'04) (++), 'Double Red' ('01-'04)

Sunflower
Helianthus angustifolius ('03-'04) [KY NATIVE], 'Gold Lace' ('02-'04) (++) - Swamp Sunflower, Helianthus helianthoides ('03-'04) – Oxeyed Sunflower [KY NATIVE], *Helianthus mollis* ('00-'04) (+) - Downy Sunflower [KY NATIVE], Helianthus occidentalis ('03-'04) – Western Sunflower [KY NATIVE], *Heliopsis* 'Loraine Sunshine' ('00-'04) (**++**) - False Sunflower

Daylily
Hemerocallis 'Stella d'Oro' ('01-'04) (**++**)

Alum Root, Coral Bells
Heuchera 'Amber Waves' ('03) (-), 'Amethyst Mist' ('03-'04) (++), 'Purple Petticoats' ('03-'04), *Heuchera x brizoides* 'Bressingham Hybrid' ('01-'04) (+), *Heuchera micrantha* 'Palace Purple' (**++**) ('00-'04), *Heuchera sanguinea* 'Canyon Pink' ('03-'04), Splendens' ('03-'04) (++)

Garden Hibiscus
Hibiscus moscheutos 'Disco Bell Pink' ('00-'04) (**++**), 'Disco White' ('00-'04) (**++**), 'Kilimanjaro Red' ('01-'04) (**++**), 'Lord Baltimore ('03), 'Ranier Red' ('01-'04) (**++**), 'Mauna Kea' ('01-'04) (**++**), 'Etna Pink' ('01-'04) (**++**), 'Matterhorn' ('01-'04) (**++**),'Luna Blush' ('04), 'Luna Red' ('04),

Hosta
Hosta 'Francee' ('04), 'Golden Tiara' ('04), 'Patriot' ('04), Pizaz' ('04)

Siberian Iris
Iris sibirica 'White Swirl' ('00-'04) (+)

Crepe Myrtle
Lagerstroemia indica 'Supersonic Mix' ('02-'04) (++)

Tree Mallow
Lavatera thuringiaca 'Barnsley' ('03-'04)

Liatris
Liatris aspera ('03-'04) [KY NATIVE]

Acidsoil Lithodora
Lithodora diffusa 'Grace Ward' ('03)

Statice
Limonium latifolia ('00-'04) (+)

Lobelia
Lobelia speciosa 'Fan Burgundy' ('01-'03) (+)

Maltese Cross
Lychnis coronaria 'Angel Blush' ('01-'04) (+), *Lychnis flos-jovis nana* 'Peggy' ('01-'03) (**-**)

Marshallia
Marshallia grandiflora ('02-'04) (+) - Barbara's buttons [KY NATIVE], *Marshallia mohrrii* ('02-'04) (+)[KY NATIVE]

Maiden Grass
Miscanthus sinensis 'Morning Light' ('01-'04) (**++**)

Bee Balm
Monarda didyma 'Fireball' ('02-'04) - Petite Bee Balm, 'Jacob Cline' ('01-'04), 'Marshall's Delight' ('01-'04), 'Pink Supreme' ('02-'04) - Petite Bee Balm, 'Prairie Night' ('03-'04) (All cultivars severely infected with powdery mildew)

Catmint
Calamintha nepeta 'White Cloud' ('02-'04) (+) - Savory Calamint, *Nepeta* 'Dawn to Dusk' ('00-'04) (**++**), *Nepeta* 'Subsessilis' ('00-'04) (**++**), *Nepeta faassenii* 'Six Hills Giant' ('00-'04) (**++**), 'Walker's Low' ('02-'04) (++)

Evening Primrose
Oenothera macrocarpa ('03-'04)

Ornamental Oregano
Origanum laevigatum 'Herrenhausen' ('01-'04) (**++**)

Wild Quinine
Parthenium integrifolium ('00-'04) (++)[KY NATIVE]

Fountain Grass
Pennisetum alopecuroides 'Hameln' ('01-'04) (**++**)

Beard Tongue
Penstemon barbatus 'Prairie Dusk' ('01-'04), *Penstemon digitalis* 'Husker Red' ('00-'04) (**++**), *Penstemon fruticosa* 'Purple Haze' ('01-'04)

Russian Sage
Perovskia atriplicifolia ('00-'04) (**++**), 'Filagran' ('03-'04), 'Little Spire' ('02-'04) (++), 'Longin' ('03-'04)

Fleeceflower
Persicaria amplexicaule 'Firetail' ('01-'04) (+), *Persicaria bistorta* 'Superbum' ('01-'04) (-)

Garden Phlox
Phlox maculata 'Miss Lingard' ('00-'04) (**++**), 'Natasha' ('00-'04) (**++**), *Phlox paniculata* 'Becky Towe' ('03-'04), 'David' ('02-'04) (++), 'Jill' ('02-'04) (++), 'Margie' ('02-'04) (++), 'Nicky' ('02-'04) (++), 'Robert Poore' ('02-'04) (++), *Phlox pilosa* 'Eco Happy Traveller' ('02-'03) (-) - Downy Phlox

Painted Daisy
Pyrethrum coccineum 'Giant Red' ('02-'04)

Coneflower
Ratidiba columnifera 'Mexican Hat' ('00-'03) (**++**), *Ratidiba pinnata* ('03-'04) (++) [KY NATIVE]

Black Eye Susan, Cone Flower
Rudbeckia fulgida var. *fulgida* ('02-'04) (++), *Rudbeckia fulgida* var. *sullivanti* 'Goldsturm' ('00-'04) (**++**),*Rudbeckia hirta* ('03) - Black Eye Susan [KY NATIVE], 'Autumn Colors' ('03), 'Cordoba' ('03), 'Goldilocks' ('03), 'Indian Summer' ('03), 'Prairie Sun' ('03), 'Sonora' ('03), 'Toto Gold' ('03), 'Toto Lemon' ('03), 'Toto Rustic' ('03), (all cultivars of *Rudbeckia hirta* are best considered annuals) *Rudbeckia laciniata* 'Herbstonne' ('02-'04) (++) - Cutleaf Cone Flower, *Rudbeckia occidentalis* 'Black Beauty' ('02-'04) (+), *Rudbeckia subtomentosa* ('00-'04) (**++**) - Sweet Black Eye Susan [KY NATIVE], *Rudbeckia triloba* ('00-'04) (**++**) - Brown Eye Susan [KY NATIVE]

Meadow Sage
Salvia 'Blue Hill' ('00-'04) (**+**), 'Blue Queen' ('00-'04) (**+**), 'May Night' ('00-'04) (**++**), 'Blue Hill' ('00-'04) (**+**), 'Snow Hill' ('00-'04) (**+**), *Salvia lyrata* 'Burgundy Bliss' ('00-'03) (**-**)

Pincushion Flower
Scabiosa caucasica 'Perfecta Alba' ('00-'04) (+), *Scabiosa columbaria* 'Butterfly Blue' ('00-'02), 'Pink Mist' ('00-'03) (+)

Kaffir Lily
Schizostylis coccinea ('00-'03) (-)

Sedum
Sedum spectabile 'Autumn Joy' ('00-'04) (**++**), 'Brilliant' ('00-'04) (++), 'Stardust' ('02-'04) (++), *Sedum spurium* 'Vera Jameson' ('00-'04) (**++**)

Rosinweed
Silphium integrifolium ('03-'04) (++) [Ky Native]

Cup Plant
Silphium perfoliatum ('03-'04) (++) [Ky Native]

Goldenrod
Solidago rugosa 'Fireworks' ('02-'04) (+)

Meadowsweet
Spirea latifolia ('00-'04) (**++**)[Ky Native]

Prairie Dropseed
Sporobolis heterolepis ('02-'04) (++)[Ky Native]

Stokes Aster
Stokesia laevis 'Blue Danube' ('00-'02) (-), 'Klaus Jellito' ('00-'04), 'Mary Gregory' ('00-'04) (-), 'Omega Skyrocket' ('03), 'Purple Parasols' ('00-'03), 'Silver Moon' (-) ('00-'03)

Mulleins
Verbascum 'Helen Johnson' ('00-'02) (-), *Verbascum* 'Jackie' ('00-'03) (-)

Speedwells
Veronica 'Fascination' ('00-'04) (++), *Veronica* 'Giles van Hess' ('00-'04), *Veronica* 'Goodness Grows' ('00-'04) (+), *Veronica* 'Royal Candles' ('03-'04), *Veronica* 'Spring Dew' ('02-'04), *Veronica* 'Waterperry' ('01-'04) (+), *Veronica* 'White Jolanda' ('00-'04) (**++**), *Veronica alpinia* 'Alba' ('01-'04) (**++**), *Veronica austriaca* 'Crater Lake Blue' ('00-'04), 'Trehane' ('03-'04) *Veronica longifolia* 'Sunny Border Blue' ('00-'04) (**++**), *Veronica peduncularis* 'Georgia Blue' ('01-'04) (**+**), *Veronica spicata* 'Blue Carpet' ('02-'04) (+), 'Icicle' ('00-'04) (**+**), 'Noah Williams' ('00-'04), 'Red Fox' ('00-'04) (+), 'Rose' ('02-'04) (+), 'Sightseeing' ('02-'04) (+)

2004 Garden Flower Trials Results of Annual Flower Evaluations by Kentucky Master Gardeners

Robert Anderson, Department of Horticulture, and Master Gardeners from McCracken, Marshall, Warren, Allen, Hardin, Pulaski, Jefferson, Fayette, Boone, and Campbell Counties

Annual and perennial garden flowers have been evaluated for many years at the University of Kentucky. Trials have occurred at the University of Kentucky Arboretum since 1993. These trials were expanded at the Horticulture Research Farm in 1999 and 2000 with grants from the Kentucky Department of Agriculture, the Kentuckiana Greenhouse Association, and the USDA New Crop Opportunities Center.

Demonstration gardens have been established at eight locations across the state. We wish to thank the Extension agents and Master Gardeners at these garden locations for planting, maintaining, and evaluating the annual flowers in these trials.

- Purchase Area Master Gardener Garden, Paducah
- Marshall Co. Master Gardener Garden, Benton
- Warren Co. Master Gardener Garden, Bowling Green
- Allen Co. Master Gardener Garden, Scottsville
- Hardin Co. Master Gardener Garden, Elizabethtown
- Louisville Zoo, Louisville
- UK Arboretum, Lexington
- Boone Co. Master Gardener Garden, Burlington
- Campbell Co. Master Gardener Garden, Highland Heights
- Pulaski Co. Master Gardener Garden, Somerset
- Wayne Co. Master Gardener Garden, Monticello
- Russell Co. Master Gardener Garden, Russell Springs

Selected annual flowers were grown in Lexington and distributed to the demonstration gardens in May. The Master Gardeners and Extension agents planted the flowers in their trial gardens and evaluated them four times during the summer (mid-July, early August, late August, mid-September). All gardens were mulched with wood chip mulch; drip irrigation was used throughout the summer, and plants were fertilized during the summer. Plant performance was evaluated on a 1-to-5 scale with 1 = poor and 5 = excellent. The evaluation was based only on the individual gardener's determination of the quality of the plants. Although personal tastes are reflected in individual evaluations, the overall evaluation was accurate for the plant performance in each garden. The demonstration gardens seem to be a good educational activity for the Master Garden educational program. It is the goal of this program to allow Master Gardeners to see new flowers and compare them to the reliable annual flowers seen in Kentucky gardens.

A few plants performed poorly in the 2004 trials. Some plants of trailing petunia and spreading petunia were infected with stem and root disease at transplanting.

Photos and details about plant performance are continually added to the Kentucky Garden Flowers Web site at <http://www.uky.edu/Ag/Horticulture/gardenflowers>. You can also go to the UK home page at <http://www.uky.edu> and search for a plant name; you will be directed to the Kentucky Garden Flowers location.

Common Name	Scientific Name	Rating
Perilla - ‘Magilla’	*Perilla hybrida*	5.0
Petunia - ‘Easy Wave Blue’	*Petunia hybrida*	4.8
Vinca - ‘Titan Polka Dot’	*Catharanthus roseus*	4.7
Vinca - ‘Titan Blush’	*Catharanthus roseus*	4.7
Vinca - ‘Pacifica Magenta Halo’	*Catharanthus roseus*	4.6
Vinca - ‘Pacifica Punch Halo’	*Catharanthus roseus*	4.6
Vinca - ‘Titan Burgundy’	*Catharanthus roseus*	4.6
Lantana - ‘Patriot Dove Wings’	*Lantana camara*	4.6
Bedding Begonia - ‘Harmony Scarlet’	*Begonia semperflorens-cultorum*	4.6
Bedding Begonia - ‘Harmony White’	*Begonia semperflorens-cultorum*	4.6
Vinca - ‘Pacifica Halo Orchid’	*Catharanthus roseus*	4.5
Vinca - ‘Titan Lilac’	*Catharanthus roseus*	4.5
Bedding Begonia - ‘Prelude Pink’	*Begonia semperflorens-cultorum*	4.5
Bedding Begonia - ‘Prelude Scarlet’	*Begonia semperflorens-cultorum*	4.5
Petunia - ‘Easy Wave Red’	*Petunia hybrida*	4.4
Coleus - ‘Lifelime’	*Solenostemon scutellarioides*	4.4
Coleus - ‘Sedona’	*Solenostemon scutellarioides*	4.4
Petunia - ‘Double Cascade Blue’	*Petunia hybrida*	4.0

Common Name	Scientific Name	Rating
Bedding Begonia - ‘Hot Tip Pink’	*Begonia semperflorens-cultorum*	4.0
Nicoletta - ‘Nicoletta’	*Plectranthus coleoides*	4.0
Petunia - ‘Dreams Burgundy Picotee’	*Petunia hybrida*	3.8
Petunia - ‘Dreams Rose Picotee’	*Petunia hybrida*	3.8
Petunia - ‘Dreams Sky Blue’	*Petunia hybrida*	3.6
Heliotrope - ‘Atlantis’	*Heliotropium arborescens*	3.6
Trailing Petunia - ‘Superbells Coral Pink’	*Calibrachoa hybrida*	3.5
Trailing Petunia - ‘Superbells Pink’	*Calibrachoa hybrida*	3.5
Moss Rose - ‘Rose Samba’	*Portulaca grandflora*	3.5
Daisy - ‘Comet White’	*Argyranthemum frutescens*	3.5
Trailing Petunia - ‘Million Bells Yellow’	*Calibrachoa hybrida*	3.4
Daisy - ‘Comet Pink’	*Argyranthemum frutescens*	3.4
Trailing Petunia - ‘Superbells Blue’	*Calibrachoa hybrida*	3.3
Trailing Petunia - ‘Superbells Red’	*Calibrachoa hybrida*	3.3
Trailing Petunia - ‘Million Bells Terra Cotta’	*Calibrachoa hybrida*	3.1

HORTICULTURAL CROPS—NURSERY CROPS

Somatic Embryo Development in Willow Oak

Sara Wells, Sharon Kester, and Robert Geneve, Department of Horticulture

Nature of Work

Willow oak (*Quercus phellos*) is an important landscape plant and forestry tree generally propagated by seed for commercial production. Willow oak can be propagated from cuttings taken from juvenile stock plants; however, this does not allow for selection of mature characteristics such as autumn color, tree shape, winter hardiness, or ease of production.

Somatic embryogenesis is the creation of an embryo from vegetative rather than sexual reproduction. It would allow for the mature mother plant to be rejuvenated into a juvenile form for cutting propagation while still having the clonal characteristics desired (3). Somatic embryogenesis has been reported in a number of oak species with the majority of the work being performed in English (*Q. robur*) and cork oak (*Q. suber*). In these species, the frequency of somatic embryo induction is between 80 and 100% from immature zygotic embryo explants but less than 15% using seedling leaf tissue (8). However, regardless of the initial source, somatic embryo maturation, conversion, and germination have been difficult. Often the somatic embryo forms shoots or roots only, and complete recovery of plants is at a low frequency (8).

Typical treatments used to enhance normal somatic embryo formation and encourage conversion include abscisic acid (ABA) and altering the osmotic potential of the medium using sucrose, mannitol, and sorbitol. Treatments used to stimulate germination in oaks are cytokinins and gibberellic acid (8). The objective of this research was to investigate the effects of ABA, cytokinin, gibberellic acid, and sucrose concentration on development of somatic embryos derived from immature cotyledons of willow oak.

Acorns were collected in August and surface sterilized in 10% bleach for 15 minutes, followed by a dip in 70% ethanol and rinsed three times with sterile water. Cotyledon halves from the zygotic embryo were placed on MS (6) basal media in Petri plates containing 1 µM benzyladenine (BA) and 0, 1, 5, or 10 µM naphthaleneacetic acid (NAA). These plates were then placed under cool white fluorescent lights (16 hr lighted photoperiod, PAR 60 $\mu mol \cdot sec^{-1} \cdot m^{-2}$) at 21°C. Explants were transferred to MS media containing no growth regulators every three weeks until somatic embryos formed.

Somatic embryos that reached the cotyledon stage were moved to media containing ABA (0, 1, or 5 µM), GA_3 (0, 10, or 50 µM), or BA (0, 1, or 10 µM) in combination with 30 or 60 grams per liter of sucrose. Shoot and root development was evaluated after two months.

Results and Discussion

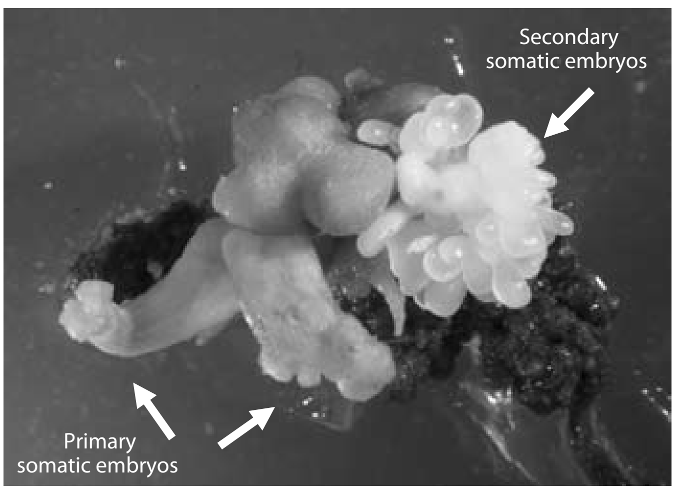
Somatic embryos formed at all concentrations of BA and NAA evaluated, with the greatest percentage being produced at 5 µM NAA (45%). Those at 10 µM NAA produced somatic embryos at 11%, and there was no difference between 1 µM NAA and the control (4%).

The use of ABA or GA3 only slightly increased the number of somatic embryos producing a root or a shoot (Table 1). On average, there was no difference between the two concentrations of sucrose. However, the highest frequency was seen using 50 µM GA3 and 6% sucrose. Including BA in the media had no effect on shoot or root production (data not shown).

Somatic embryos producing either a root or shoot were more frequent than the development of a seedling producing both. Seedlings having both a radicle and a shoot were transferred into a perlite and peat potting mix under high humidity, but none of the seedlings developed into plantlets.

NAA was effective at inducing somatic embryos in willow oak. NAA is often more effective than 2, 4-D at inducing somatic embryogenesis in various oak species (8). An auxin source was important in inducing primary somatic embryogenesis in willow oak, but secondary somatic embryos formed readily and repeatedly on basal medium without growth regulators (Figure 1).

Figure 1. Secondary somatic embryo formation in oak after three months.



ABA is often used during somatic embryogenesis to promote more normal embryo development, but ABA usually inhibits embryo germination. Therefore, it was unexpected that ABA would promote shoot and root growth (Table 1). In cork oak, ABA reduced the development of new secondary embryos (1). It is possible that by suppressing secondary somatic embryo formation, ABA allowed the continued development of the primary embryo that allowed it to germinate.

GA_3 can be used to promote germination in slowly developing somatic embryos. Previous work with other oak species showed that GA_3 had a minimal effect at promoting somatic embryo germination (4, 5, 7). More often, BA has been shown to stimulate shoot and root growth in oak (8). However, in willow oak BA was ineffective at promoting germination, while GA_3 was as effective as ABA (Table 1).

Doubling the sucrose concentration did not consistently impact somatic embryo development or germination, but there was a trend toward a higher frequency of embryos with roots or shoots when grown at 6% sucrose (Table 1). Sucrose plays the dual role of providing a carbohydrate source for growth and acting as an osmoticum. It is possible that the sucrose concentration used in this work was not high enough to impact embryo development. Using cork oak, Garcia-Martin et al. (2) found that 150 g/L of sucrose allowed 75% of the somatic embryos to convert to seedlings. This conversion rate is comparable to the improvement in conversion of English oak to 83% found by slowly drying somatic embryos for three weeks prior to germination (8).

Table 1. Percentage of somatic embryos forming a root or shoot after two months on MS media containing combinations of sucrose with abscisic acid or gibberellic acid.

Growth Regulator (µM)		Sucrose Concentration (%) 3	6
ABA	0	15%	6%
	1	4%	18%
	5	7%	0%
GA3	10	6%	16%
	50	20%	24%

To date, no plantlets have been recovered from willow oak via somatic embryos. Future research will focus on adjusting the water potential of the somatic embryo by drying or exposure to high osmotic concentrations to promote more normal seedling development.

Significance to the Industry

Oaks are important nursery and forestry species. Most oaks are propagated by seeds because they are difficult to root from cuttings, and many oaks experience delayed graft incompatibility. This severely limits availability of superior cultivars for the nursery trade. The ability to propagate superior mature clones of oak would result in increased selection and therefore profitability for oak liner and shade tree production. Recently, growers have begun to propagate some oak species (including willow oak) using cuttings from juvenile stock plants. The ability to regenerate mature oaks via somatic embryogenesis would produce juvenile stock plants from superior trees, which in turn could be used as a source for cutting propagation. The current research addresses some of the limiting steps toward achieving the goal of obtaining plants through somatic embryogenesis in North American oaks.

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New Management Approaches for Insect Pests of Nursery-Grown Maples

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Nature of Work

This project is evaluating tree cultivar resistance and other reduced-risk tactics for managing insect pests of nursery-grown maples. Resistance to certain diseases (e.g., sudden oak death) also is being rated. Maples are among the top nursery crops in Kentucky and likely will remain so given emerging problems afflicting other tree species (e.g., sudden oak death/decline, emerald ash borer). Maples, however, have their own pest problems. Flatheaded apple tree borer (FHATB) and potato leafhopper (PLH) are especially damaging to red maples (2, 3), and growers presently apply multiple cover sprays for each species. FHATB control is complicated by recent cancellation of traditional borer insecticides (e.g., lindane, chlorpyrifos). Growers also report increased problems with calico scale, maple spider mites, Japanese beetles, and shoot borers that destroy terminal buds, affecting tree symmetry. Little is known about biology or management of the latter four pests in production nurseries. Several large growers asked that we investigate these problems.

Host plant resistance ideally is the first line of defense against insects and pathogens both in nurseries and landscapes. Choosing species and cultivars that are less pest-prone reduces production costs and need for chemical inputs. This project is evaluating relative resistance of newer maple cultivars and popular standards to multiple insect pests. Species and cultivars being evaluated include:

- *Acer rubrum*: Autumn Flame, Burgundy Belle, October Glory, Red Sunset, Somerset, Sun Valley, Brandywine, Northwood
- *Acer sacharum*: Crescendo, Green Mountain, Commemoration, Legacy
- *Acer freemanii*: Autumn Fantasy, Autumn Blaze, Sienna Glen
- *Acer × truncatum*: Pacific Sunset
- *Acer compestre*: Hedge Maple

Trees were planted in replicated field plots at Snow Hill Nursery (Shelbyville), the University of Kentucky South Farm (Lexington), and at the UK research facility at Princeton. They were evaluated three times during the 2005 growing season for density of pests and/or severity of pest symptoms. South Farm trees were inoculated with calico scale to ensure adequate infestations. Severity of calico scale will be determined when females swell and become obvious in May 2006.

Susceptibility to sudden oak death disease (*Phytophthora ramorum*) was evaluated by shipping detached leaves to cooperators in Oregon who challenged them with two different strains of the pathogen.

In 2004, we identified a shoot borer that is damaging maples in Kentucky production nurseries as the caterpillar of *Proteoterus aesculana*, a tortricid moth. This pest causes flagging of new shoots and often a forked double leader. Training a new central leader is time-consuming, and despite those corrective measures, the trunk often incurs a noticeable crook that diminishes tree value. Little is known about the biology and management of this pest. To clarify its seasonal development, 20 infested shoots from various cultivars were collected weekly beginning May 10 over the subsequent five weeks. Each shoot was dissected, and the number of larvae per 20 shoots was recorded and the larvae preserved in 75% ETOH. Head capsule measurements were then taken on the larvae to learn more about the number of instars for this species.

We also did studies to identify the shoot borer sex pheromone because having such a lure would allow growers and Extension agents to hang sticky traps to detect infestations and monitor emergence for purposes of spray timing. We reared virgin female moths from infested shoots, extracted their pheromone glands, and analyzed the extract by gas chromatography/mass spectroscopy. We also measured physiological response of male antennae to components of the female extract to pinpoint the stimulatory compounds.

We also are studying two systemic soil insecticides, Discus (Imidacloprid) and Flagship (thiamethoxam), for season-long preventative control of major maple pests (especially FHATB and PLH) from a single early-spring soil treatment. Effectiveness against borers will be evaluated by quantifying incidence of cankers and emergence holes in spring 2006.

Results and Discussion

Our 2005 field evaluations revealed significant differences between maple species and cultivars within species with regard to each pest (Tables 1, 2). Red, sugar, and Freeman maples are all susceptible to shoot borers. Red and sugar maples are susceptible to maple spider mites and potato leafhopper, whereas Freeman maples were relatively resistant to those pests. Sugar maples, especially 'Crescendo,' are the only maples to sustain significant damage from Japanese beetles. *Acer × truncatum* and *A. compestre* showed resistance to all four pests.

Preliminary results indicate a very broad range of susceptibility to *P. ramorum*, varying from three varieties showing lesions covering almost 100% of the leaf area, to six varieties showing < 5% affected leaf area. The remaining varieties had lesions covering from between 40 to 60% of the leaf area. That evaluation will be repeated in 2006.

Shoot borer larvae were found in shoots as early as May 10, when the damage (flagged terminals) first became obvious (Table 3). They doubtless were present earlier, before the damage appeared. The borer reached full size by late May (note head capsule widths) and by mid-June, most of the damaged shoots were vacated as the larvae pupated. When infested shoots were "stuck" into moist sand for rearing out the moths in the laboratory, cocoons with pupae were found mainly in sand, often attached to the rearing container or stem below the substrate. Moths emerged mainly in June. We now can better predict when shoot borer larvae become active in the spring and begin determining its overwintering site and stage. Our findings of moth emergence in June, apparent lack of moth flight in early spring, and presence of medium-sized larvae in early May support the hypothesis that maple liners are already infested when they arrive from suppliers. If correct, that means that management by suppliers during the summer *before* shipment could eliminate the shoot borer problem faced by Kentucky nursery producers in newly planted maples.

In the pheromone work, two major components of maple shoot borer sex pheromone were identified, and various blends of these were made and field tested. Because it took about a month to do the analytical work, we were unable to field-test the candidate pheromone lures until late June near the end of what we presume was the seasonal flight period. Nevertheless, moths were captured with pure Z8-12:OH and the blend in which it was the primary component (Table 4). Using these data, we can begin monitoring seasonal maple shoot borer activity next spring, providing additional insight into the biology of this important pest.

Significance to the Industry

This project is evaluating relative resistance to insects and diseases of numerous maple cultivars being grown by Kentucky nursery producers. This information will help growers and consumers to choose the best-adapted varieties, helping to reduce production costs and need for chemical inputs. Our research on maple shoot borers will support more focused control, provide growers with a monitoring tool, and likely

Table 1. Comparative data on susceptibility of maple cultivars to important insect pests, 2005.

Species Cultivar	Shoot Borer (no. per tree)[a]	Maple Mite Rating[b]	Potato Leafhopper Rating[c]	Japanese Beetle (% defoliation)[d]
A. rubrum				
Brandywine	3.4 a	0.8 b	0.9 ab	4.5 a
Burgundy Belle	2.4 ab	0.3 c	1.3 ab	3.6 abc
October Glory	2.3 ab	0.8 b	0.8 bc	2.5 bc
Northwood	1.9 ab	1.5 a	0.3 c	4.4 ab
Autumn Flame	1.0 b	0.7 bc	1.6 ab	1.1 cd
Sun Valley	1.0 b	0.3 c	1.7 a	2.5 bc
Somerset	1.0 b	0.6 bc	0.9 abc	0.5 d
Red Sunset	0.8 b	0.6 bc	1.4 ab	2.0 cd
A. saccharum				
Legacy	3.6 a	0.2 a	0.0 a	11 c
Crescendo	1.3 a	0.3 a	0.1 a	39 a
Green Mountain	1.3 a	0.3 a	0.1 a	24 b
Commemoration	1.0 a	0.3 a	0.0 a	20 bc
A. freemanii				
Sienna Glen	2.5 a	0.5 a	1.1 a	5.0 a
Autumn Fantasy	1.7 a	0.4 a	0.0 a	1.0 b
Autumn Blaze	1.2 a	0.6 a	0.1 a	0.5 b
A. × truncatum				
Pacific Sunset	0.2	0.0	0.0	3.3
A. compestre				
Hedge Maple	0.2	0.0	0.0	1.0

* Within maple species, means followed by the same letter do not statistically differ (two-way ANOVA, LSD, P > 0.05).
[a] Mean number infested shoots per tree, Princeton site, 1 June 2005.
[b] Mite damage rating scale: 0 = no mites, 1 = 1-10 mites, 2 = 10-20 mites, 3 = 20-50 mites, 4 = 50-100 mites, 5 = 100+ mites, Shelbyville site, 15 July 2005.
[c] Potato leafhopper damage rating scale: 0 = no damage, 1 = slight damage, 2 = moderate damage, 3 = heavy damage, 4 = severe damage, Princeton site, 7 July 2005.
[d] Mean percentage defoliation based on visual estimate, Princeton site.

Table 2. Comparative susceptibility of nursery-grown maples to selected insect pests, averaged across cultivars within species.

Species[a]	Maple Shoot Borer (no. per tree)	Maple Mites Rating	Potato Leafhopper Rating	Japanese Beetle (% defoliation)
Red maples	1.7 a	0.5 b	0.4 b	2.6 b
Sugar maples	1.8 a	0.7 a	1.1 a	23.6 a
Freeman maples	1.8 a	0.0 d	0.0 c	2.2 b
A. × truncatum	0.2 b	0.2 c	0.1 c	3.3 b
A. compestre	0.2 b	0.0 d	0.0 c	1.0 b

[a] Ratings and data presentation as in Table 1.

Table 3. Seasonal development of maple shoot borer population in Shelbyville, Ky., 2005.

Date	No. Larvae per 20 Infested Shoots	Average Head Capsule Width (mm)
10 May	20	0.78
17 May	16	0.95
24 May	13	1.01
31 May	7	1.09
7 June	1	1.1

Table 4. Pheromone blends evaluated and shoot borer captures in field trial conducted in late 2005 shoot borer flight period (28 June to 19 July 2005).

Pheromone Blend	Shoot Borers Trapped
Z8-12:OH 50 µg	5
Z8-12:OH 50 µg Z8-12:AC 2 µg	2
Z8-12:OH 50 µg Z8-12:AC 50 µg	0
Z8-12:OH 50 µg Z8-12:AC 10 µg	0

will prove that nursery liners are already infested when they are shipped to Kentucky. Managing the pest during the summer before shipment may eliminate the flagging and loss of terminal leaders experienced by our growers. Our work on systemic insecticides may help nursery growers to multiple-target several key pests with a single application.

Evaluation of *Hydrangea macrophylla* for Cut Stem Potential

Robert E. McNiel and Sharon Bale, Department of Horticulture

Nature of Work

Hydrangea macrophylla cultivars were evaluated for feasibility of Kentucky farms growing the crop for floral cut stems. Hydrangea cut flowers are currently being shipped from the West Coast, Canada, or Europe into Kentucky. *Hydrangea macrophylla* growing in Kentucky's landscapes are not dependable to always flower in all locations. Nurseries have been able to market the species as container-grown flowering plants. Nursery-grown container plants receive winter protection that protects flower buds. Nursery production techniques were used to produce plants that could yield cut stems for the floral industry.

Four cultivars (Table 1) were placed in five-gallon containers during summer 2003. These plants were overwintered in an unheated house covered with white opaque poly. Inside the house, the plants were covered directly with another sheet of poly during the coldest months. Every bud produced a stem and flower during the summer of 2004. The evaluations of these stems included a stem count, stem length, flower diameter, and flower quality.

During the summer of 2004, an additional seven cultivars were containerized. All 11 cultivars were again evaluated for the same four characteristics during 2005.

If flower buds are protected using the overwintering practices of the container industry, can plants grown in the ground be protected in a similar manner? During the summer of 2004, 10 cultivars (Table 2) were planted in the ground, and the site was covered by an overwintering house. These plants were also covered by an additional direct covering during the coldest months. During 2005, the plants were evaluated for stem count, stem length, flower diameter, and flower quality.

Results and Discussion

Two growth types were represented in the four cultivars grown in containers and evaluated in 2004. The stiff upright growth of Masja produced fewer stems during its first full year of growth compared to the other growth type (layered and bending) represented by Nikko Blue, Dooley, and All Summer Beauty (Table 1). During 2005, Masja was comparable to the three other cultivars in stem count. Nikko Blue had the highest stem count in both years. Decatur Blue was injured and thus had a reduced number of stems. Stem length was acceptable for each of the original four cultivars during both years. The additional seven cultivars were not as long as expected (14+ inches) except for Mme. Emily Mouillére during this first year.

Flower diameter during both years averaged between 4.8 and 6.1 inches. This is an acceptable size for the floral market. Floral rating is based on a scale of 0 to 5. Irregular flowers were common during 2004's evaluation as three of the cultivars were no better than 2.5. Masja was definitely the best of these cultivars for floral use. During 2005, all cultivars had a floral rating above 4 except for All Summer Beauty, Nikko Blue, and Decatur Blue. Acceptable product was produced on container-grown plants. However, the plants cannot remain in production over an extended time and will have to be replaced.

The plants grown in the ground and covered by an overwintering house were also evaluated during 2005. Stem count in the ground did not match the production of plants in containers. Stem production by Mme. Emily Mouillére, Westfalen, and Harlequin did not make double figures (Table 2). The average stem length tended to be short for industry standards across most cultivars. This

Table 1. Cut stem characteristics from container-grown Hydrangea macrophylla cultivars.

	Stem Count		Stem Length		Floral Diameter		Floral Rating	
Name	**2004 (no.)**	**2005 (no.)**	**2004 (in.)**	**2005 (in.)**	**2004 (in.)**	**2005 (in.)**	**2004**	**2005**
All Summer Beauty	19.2 b	19.0	15.9	15.6	5.3	5.9	2.4 b	3.8
Masja	7.8 c	19.6	14.3	16.3	6.2	6.5	4.3 a	4.5
Dooley	21.8 ab	19.8	13.9	13.7	4.9	5.5	1.9 c	4.2
Nikko Blue	25.1 a	25.8	12.8	14.4	4.8	5.6	1.9 c	3.7
Fasan		15.3		12.2		6.2		4.0
Gen. Vic. DeVibrayé		15.9		13.0		6.1		4.3
Matilda Güteges		17.0		11.1		6.0		4.3
Mme. Emily Mouillére		18.3		14.3		5.9		4.1
Harlequin		24.0		11.6		5.6		4.0
Parzifal		29.2		13.5		5.6		4.2
Decatur Blue		8.2		9.0		5.4		3.6

may be a result of being in their first year of full growth. Average floral diameter was acceptable for all cultivars as they averaged between 5.4 and 7.8 inches. All cultivars had an average floral rating above 4. Flowers with a 4 or 5 rating are assumed acceptable for wholesale sales to wholesale or retail florists.

Significance to the Industry

Hydrangea macrophylla can be protected during production in order to keep all potential flower buds viable. Either container production or field tunnel production in Kentucky will create a product that is salable to the floral industry. Cultivar differences do occur, and specific cultivars may move better in certain markets. Additional information will result from this experiment as plants age in the production system.

Table 2. Cut stem characteristics from tunnel-grown Hydrangea macrophylla cultivars, 2005.

Name	Stem Count (no.)	Stem Length (in.)	Floral Diameter (in.)	Floral Rating
Nikko Blue	16.3	13.3	7.4	4.6
All Summer Beauty	16.0	13.0	6.7	4.6
Matilda Güteges	14.8	10.7	5.5	4.4
Oak Hill	14.0	13.0	6.4	4.6
Mme. Emily Mouilléré	3.1	14.8	7.3	4.7
Penny Mac	12.9	13.0	7.5	4.7
Endless Summer	10.7	11.5	7.8	4.5
Decatur Blue	10.6	12.4	7.5	4.6
Westfalen	9.1	10.5	5.7	4.5
Harlequin	3.9	9.9	5.4	4.1

Preservative and Temperature Postharvest Treatments on *Hydrangea paniculata* 'Kyushu'

Todd Leeson, Robert McNiel, and Sharon Bale, Department of Horticulture

Nature of Work

Hydrangea paniculata is available wholesale as a cut stem from the Holland market. Some *H. paniculata* are available in this country as a cut stem through farmers' markets. A national commercial wholesale source of this stem is not readily available. *H. macrophylla* cultivars are the flowers that are usually grown for the cut flower market. The other hydrangea species—*H. arborescens*, smooth hydrangea; *H. paniculata*, panicled hydrangea; and *H. quercifolia*, oakleaf hydrangea—have been grown for landscape plants (1). Therefore, the ability to produce quality field-grown cut stems of the *H. paniculata* flower may offer an alternative income source to Kentucky farmers.

In 1999, a hydrangea cut-flower cultivar trial was established at the University of Kentucky Research and Education Center at Quicksand, Kentucky (2). In 2001, preliminary studies were conducted at the University of Kentucky to determine the effects of irrigation and pruning influence on hydrangea for fresh cut flower production (2). Cutting the existing *H. paniculata* shrubs back in the fall produced strong straight stems the next season that definitely had potential for the cut stem market. In the summer and fall of 2002, a preliminary study was conducted to see if *H. paniculata* cultivars had the potential to become a specialty cut flower. The results were reported at the 2003 SNA Conference and showed an average vase life of five to six days in 2002. The overall objectives of this experiment were to observe *H. paniculata 'Kyushu'* to see if it has a reasonable vase life, to observe interactions with the floral preservatives and extender, and to see if the stems responded differently to cold treatments.

No information could be found on the best floral preservative to be used on these plants, nor was there any information on the effects cold, wet storage would have on these stems. Cold storage could mimic the effects of shipping time as well as the ability of a wholesale florist to "hold" the plant material.

The study was initiated when 150 stems were harvested on Sept. 16, 2003, at 9:00 EST. Stems were harvested when the first and second row of sterile florets were fully developed. Dry stems were transported to the lab and cut to a 36-inch length. Stems were then placed into a hydrating solution (Pokon Professional #2) for one and one-half hours. The 'Kyushu' blooms were then divided into two 75-stem lots to be placed into their no cold storage treatment and cold storage treatment. The 75 stems for the cold storage treatment were placed into Prokona containers for wet storage at 35°F and 90 percent relative humidity(RH) for seven days. The other 75 stems were then placed directly into their randomized treatments in a storage facility with a temperature of 73°F and 90 percent RH. The eight treatments (per package directions) were:

1. Control using tap water with a pH of 7.5
2. Floralife Original Flower Food
3. Pokon & Chrysal Professional #3
4. Aquaplus
5. Floralife + Flora Novus XL
6. Pokon & Chrysal Professional #3 + Flora Novus XL
7. Aquaplus + Flora Novus XL
8. Flora Novus XL

A floral extender (Flora Novus XL), which claims to add days of life to flowers, was added to the floral preservatives in treatments 5 through 8.

Stems remained in the treatments until the stem tips wilted or the sterile florets showed the first brown color and the flowers were no longer of commercial value. For example, if the stem in vase 3 failed to rehydrate and remained wilted after initial treatment, the vase life was considered 0 days. If the sterile florets started browning on the third day, vase life was over and considered to be three days. The stems that remained in cold storage for seven days were then taken out of the cooler and were placed into their designated treatments as described with no cold treatments.

Results and Discussion

The experiment was set up as a factorial experiment with eight replications using an ANOVA to determine the main effects and interactions that occurred with a P value <.05. The independent variable was the vase life. The three factors involved were the cold storage, preservative treatments, and extender. Wet, cold storage for seven days did seem to have a negative effect on the vase life of 'Kyushu,' as vase life was decreased by two days. Stems with no cold storage treatments had a mean vase life of 7.9 days, and stems in cold storage treatments had a vase life of 5.8 days (Figure 1).

The results with floral preservative treatments back up the idea that the cultivar would react differently with the different floral preservative treatments. Floralife treatment with no cold storage treatment was significantly better than either of the other two preservatives or the control (Figure 2). There was no difference between preservatives when stems were stored in cold prior to treatment; although all three preservatives were better than the control (Figure 3). The extender actually decreased the vase life by one to two days (Figure 4), but the extender + preservative interaction was not significant.

Figure 1. Treatments with the same letter are not significantly different. The P value for this graph was <0.05.

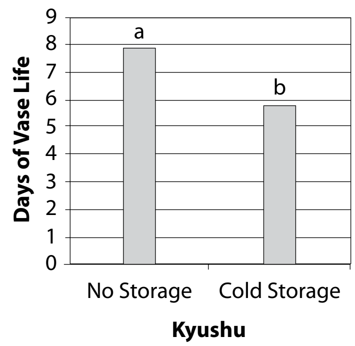


Figure 2. Treatments with the same letter are not significantly different. This graph showed a P value <0.05.

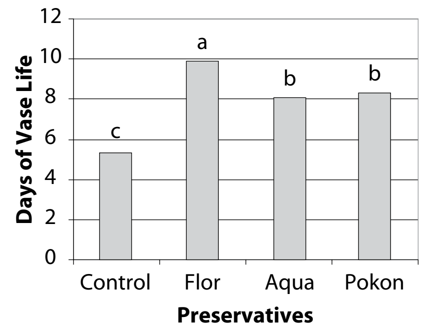


Figure 3. Treatments with the same letter are not significantly different. This graph showed a P value <0.05.

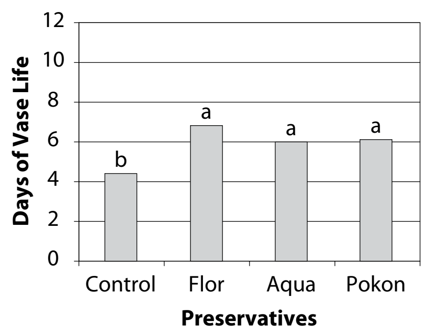
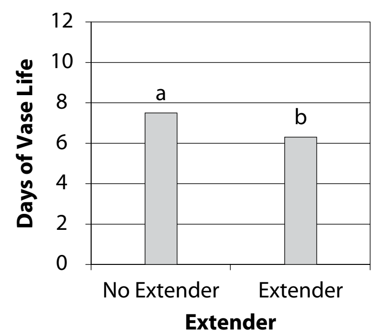


Figure 4. Treatments with the same letter are not significantly different. This graph showed a P value <0.05.



Questions to be addressed by future research to determine the maximum vase life of *H. paniculata* include: How long can these flowers remain in wet, cold storage before their quality/longevity is adversely affected? Does shipping and storage in a solution versus dry cold storage make a significant difference in vase life?

Significance to Industry

Results of this study indicate that *H. paniculata 'Kyushu'* has the potential to be a fresh cut flower. Implementation could potentially develop a supply of *H. paniculata* for the wholesale fresh cut flower market. Controlling production practices, storage methods, and preservation solutions can result in a hydrangea fresh cut flower market crop for growers interested in alternative farm incomes.

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Effect of Planting Date and Protective Structures on Finishing Date for Container-Produced Passiflora 'Lady Margaret'

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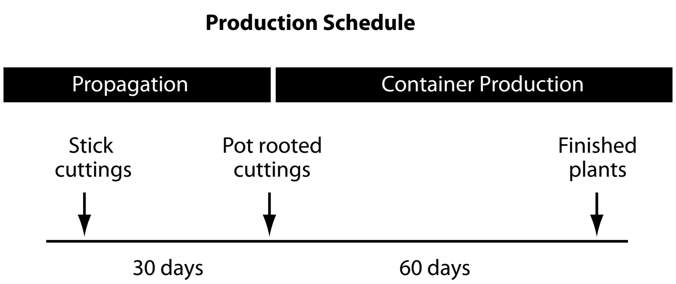
Nature of Work

Passiflora 'Lady Margaret' is a desirable passion flower cultivar for container production in Kentucky because it is easy to propagate from cuttings, is relatively cold tolerant, and begins to flower early in the season (5). Although it is not hardy in Zone 6, it can be grown as a single-season crop using a two-month production schedule (Figure 1) (1). Currently, passion flowers sold in Kentucky are shipped from the southern United States. This demonstrates potential for local producers, but there is little information available about planting dates and time to finish.

Figure 1. Production schedule for single-season, container-grown passion flowers in Kentucky.



The objective of this research was to investigate the use of heated and unheated protective structures and planting dates on growth and flowering of *P*. 'Lady Margaret.' The goal was to develop a range of finishing dates to provide growers with flexible production schedules to meet potential markets.

Materials and Methods

A randomized block design experiment with 24 replications for each treatment was carried out between Feb. 1, 2003, and June 11, 2003, and included six treatments which were combinations of three planting dates and three different growing environments (Figure 2). Plants were propagated from two node nonterminal cuttings taken from ontogenetically mature stock plants and treated with indole-3-butyric acid (IBA) (1,000 ppm in talc) and stuck in Oasis rooting cubes. Cuttings were placed in an intermittent mist bed (six seconds every 12 minutes) with 21°C (70°F) bottom heat. After 30 days, rooted cuttings were selected for uniformity and potted three plants per 4.7-liter (5-quart) containers (Classic 500, Nursery Supplies Inc., Columbus, Ohio) in southern pine bark substrate (Barky Beaver, Professional Grow Mix, Moss, Tennessee). One emitter was placed in each container, and they were fertilized at each watering with a 150 ppm N fertilizer solution (Peter's 20-10-20 Peat-lite Special, Scotts Company,

Figure 2. Planting dates, number of days to finish, and time to finish for six production scenarios for container grown Passiflora 'Lady Margaret' produced as a single-season crop in Kentucky.

February	March	April	May	June	Number of Days to Finish	Finish Date
Propagation (30 days)	Greenhouse (31 days)	Greenhouse (19 days)			50	19-Apr
Propagation (30 days)	Greenhouse (31 days)	Polyhut (29 days)			60	29-Apr
	Propagation (30 days)	Greenhouse (30 days)	Polyhut (11 days)		41	11-May
	Propagation (30 days)	Greenhouse (15 days) / Polyhut (30 days)	Nursery (2 days)		47	17-May
	Propagation (30 days)	Polyhut (30 days)	Nursery (32 days)		62	1-Jun
		Propagation (30 days)	Polyhut (31 days)	Nursery (8 days)	39	8-Jun

Marysville, Ohio) delivered one time per day by the automatic micro irrigation system. Thirty-six-inch tall bamboo hoop trellises were inserted into the containers, and the plants were tied as needed for support. Flowering data were collected daily, and plants were considered finished when they had produced 10 flowers per container.

The plants were grown in either a temperature-controlled greenhouse, polyhut, outdoor container nursery, or a combination of these environments. The planting dates were March 1, April 1, or May 1. Day/night temperatures in the greenhouse were set at 25°C/20°C (77°F/68°F), and supplemental lighting (61 $\mu mol \cdot m^{-2} \cdot sec^{-1}$ average photosynthetic photon flux density at bench top) was provided with 430-watt high-pressure sodium greenhouse lights set to turn on if light levels dropped below 300 $\mu mol \cdot m^{-2} \cdot sec^{-1}$ between 7:00 and 24:00. The polyhut was a 12-ft-by-50-ft freestanding polyethylene covered quonset hoop house with roll up side wall vents and doors at each end for ventilation. It was covered with a single layer of 6 mil translucent polyethylene greenhouse film. Doors and vents were opened and closed manually as needed to maintain suitable conditions. Two temperature data loggers (WatchDog 100, Spectrum Technologies Inc., Plainfield, Illinois) were placed with each treatment to monitor temperatures, and a mean of the two sensors was used to calculate degree hours.

Results and Discussion

Using three planting dates and combinations of heated and unheated protected cultivation, passion flower plants were finished at approximately 10-day intervals from April 19 to June 8 (Fig. 2). The plants to reach finished size in the least number of days were potted on May 1 and grown in the polyhut for 30 days before being moved to the outdoor container nursery. They reached finished size in 39 days versus those potted on April 1, which took a total of 41 days, the second shortest finish time. Of the three treatments planted on April 1, those that started in the greenhouse finished sooner, and for all treatments, the more time the plants were in the greenhouse, the earlier they finished. The plants potted on April 1 and moved directly to the polyhut, took 51 percent longer to finish than those that spent 30 days in the greenhouse and 32 percent longer than those that spent 15 days in the greenhouse. The plants potted on April 1 and moved directly to the polyhut took longer to finish than any other treatment. For the treatments that were moved directly to the polyhut without any time in the greenhouse, the plants potted on May 1 reached finished size 23 days sooner (39 days versus 62 days) than those potted on April 1.

When plants reach 10 flowers per container, they are considered ready for sale. At this time, the plants have reached a point of consistent flowering and will have between one and three flowers open each day. We were successful in producing passion flower plants for commercial sale between mid-April and mid-June. The differences in the number of days from potting to finished plants appear to be a function of light levels and temperature. For plants potted in March, low light levels delay consistent flowering and plants required between 50 and 60 days to reach a salable size. Low solar radiation can suppress the formation of new flower buds until carbohydrate status is favorable (2), and we have observed that flower abortion is common during winter growing conditions.

Plants took the least time to reach salable size when they were potted in April and grown at relatively consistent temperatures. For most passion flower species, there is a strong relationship between rate of vegetative growth and the production of flowers because flowers are produced on the new vegetative growth at the leaf axil. If the plants are stressed by environmental factors, the shoots may fail to elongate or may elongate without producing flowers (2). When grown in air temperatures between 20°C and 30°C, there is an increase in the number of flower buds on passion fruit (*P. edulis*) (3, 4). There is a significant reduction in number of flowers below 20°C and above 30°C. Additionally, when grown within this temperature range, the plants flower two weeks earlier. Temperature is the one environmental factor most likely to impact growth and flowering in passion flower (3, 4).

Significance to Industry

Passion flowers are a high-value crop and have good potential as an alternative nursery crop in Kentucky. Recommended cultural practices include:

1. Early flowering, cold-tolerant cultivars should be selected for early season production in a two-month period. 'Lady Margaret' and 'Amethyst' have proven to work well in this system. Later-flowering cultivars can have larger flowers but will finish in July or later. These would be suitable for production to meet southern markets, while early flowering cultivars are most suited for Kentucky and other Midwest states.
2. Plant three cuttings per container. Passion flowers have strong apical dominance and do not produce secondary branches until late in the growing season. Since passion flower produces one flower per node and these open for only one day, three plants per container increase the potential for consistent early flowering in the garden center.
3. Passion flower plants are relatively heavy feeders. They require more fertilizer than typical greenhouse and nursery plants. Therefore, a constant feed system that provides 150 ppm N per irrigation is recommended.
4. Planting dates and protective cover should be planned according to desired finish date.

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Pinching of Passiflora 'Lady Margaret' and 'Amethyst' Reduces Shoot Number and Delays Flowering

Stephen Berberich, Robert Geneve, and Mark A. Williams, Department of Horticulture

Nature of Work

Passion flowers (*Passiflora* sp.) have good market potential as high-value container-produced plants for patio or garden use, and selected cultivars can be successfully grown in Kentucky as a single-season crop using a two-month production scheme in an outdoor nursery (Figure 1) (1). However, cultural practices that reduce the time to flowering and increase overall flower production must be developed for this condensed production schedule.

Passion flower vines can produce a flower, shoot, and tendril at each node. In the majority of these plants, each flower opens for only one day. Once the vines start blooming, developing shoots can produce a flower at each node resulting in numerous flowers per plant each day (2). It becomes apparent that the flowering potential of each plant increases by increasing the number of nodes per plant. The objective of the current research was to investigate pinching treatments on time to first flower, number of nodes, and number of flowers per plant.

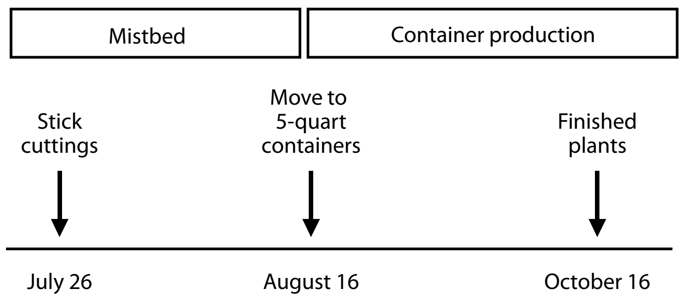
Between July 26, 2002, and October 16, 2002, two passion flower cultivars (*Passiflora* 'Lady Margaret' and 'Amethyst') were evaluated for flowering response following six pinching treatments. *Passiflora* 'Lady Margaret' and 'Amethyst' were propagated from two node cuttings treated with indole-3-butyric acid (IBA) (1,000 ppm in talc) and stuck in Oasis rooting cubes. Cuttings were placed in an intermittent mist bed (5 sec. every 10 min.) with bottom heat (75°F). After 21 days, cuttings were transferred to the greenhouse in 5-quart containers (Nursery Supplies, Inc. Classic 500) in Barky Beaver (Professional Grow Mix, Moss, Tennessee 38574) southern pine bark substrate and irrigated each day with 100 ppm N (Peters 20-10-20). Day/night temperatures in the greenhouse were set at 77°F/68°F (25°C/20°C), and supplemental lighting (61 µmol • m^{-2} • sec^{-1} average photosynthetic photon flux density at bench top) was used to maintain 17-hour day length.

Initial pinching treatments were all performed 21 days after rooted cuttings were potted and secondary pinching treatments 42 days after cuttings were potted. The pinching treatments consisted of the following: 1) pinch the main shoot at the third node, 2) sixth node, 3) ninth node, 4) third node with all resulting shoots pinched at third node, 5) sixth node with all resulting shoots pinched at the sixth node, and 6) no pinching. Flowers were counted each day, and number of shoots, shoot length, and number of nodes were recorded 45 days after applying the first pinching treatment.

Results and Discussion

Both cultivars exhibited strong apical dominance and, when pinched, one of the resulting shoots assumed dominance. None of the pinching treatments increased the number of shoots, and both cultivars showed delayed flowering of approximately three weeks when pinched once and approximately four weeks when pinched twice (Figure 2).

Figure 1. Production schedule for single-season container-grown passion flowers in Kentucky.



Amethyst passion flower pinched once produced 67% fewer flowers compared to non-pinched plants, and those pinched twice produced 88% fewer flowers. Lady Margaret passion flower pinched once produced 65% fewer flowers compared to non-pinched plants, and those pinched twice produced 89% fewer flowers (Table 1).

For both cultivars tested, pinching resulted in fewer shoots, fewer flowers, and delayed flowering. Cytokinin treatments are currently being tested to determine if they can be used effectively to induce branching. Additionally, the use of multiple plants per container has proven to be an excellent method for increasing the number of shoots and flowers, and this method eliminates the need to overcome the strong apical dominance exhibited by these plants.

Significance to the Industry

This is the third report on studies carried out to evaluate the production of container-grown passion flowers. This study has shown that selected varieties can be successfully grown in Kentucky as a single-season crop using standard nursery practices with the two-month production schedule presented in this paper. These plants have good potential as a high-value container-produced plant for patio or garden use in a market where customers are looking for exotic, tropical vines.

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Figure 2. Cumulative number of flowers per day for *Passiflora* 'Amethyst' and 'Lady Margaret' beginning on the day pinching treatments were performed. For both cultivars, flowering was delayed approximately three weeks when pinched one time and four weeks when pinched two times.

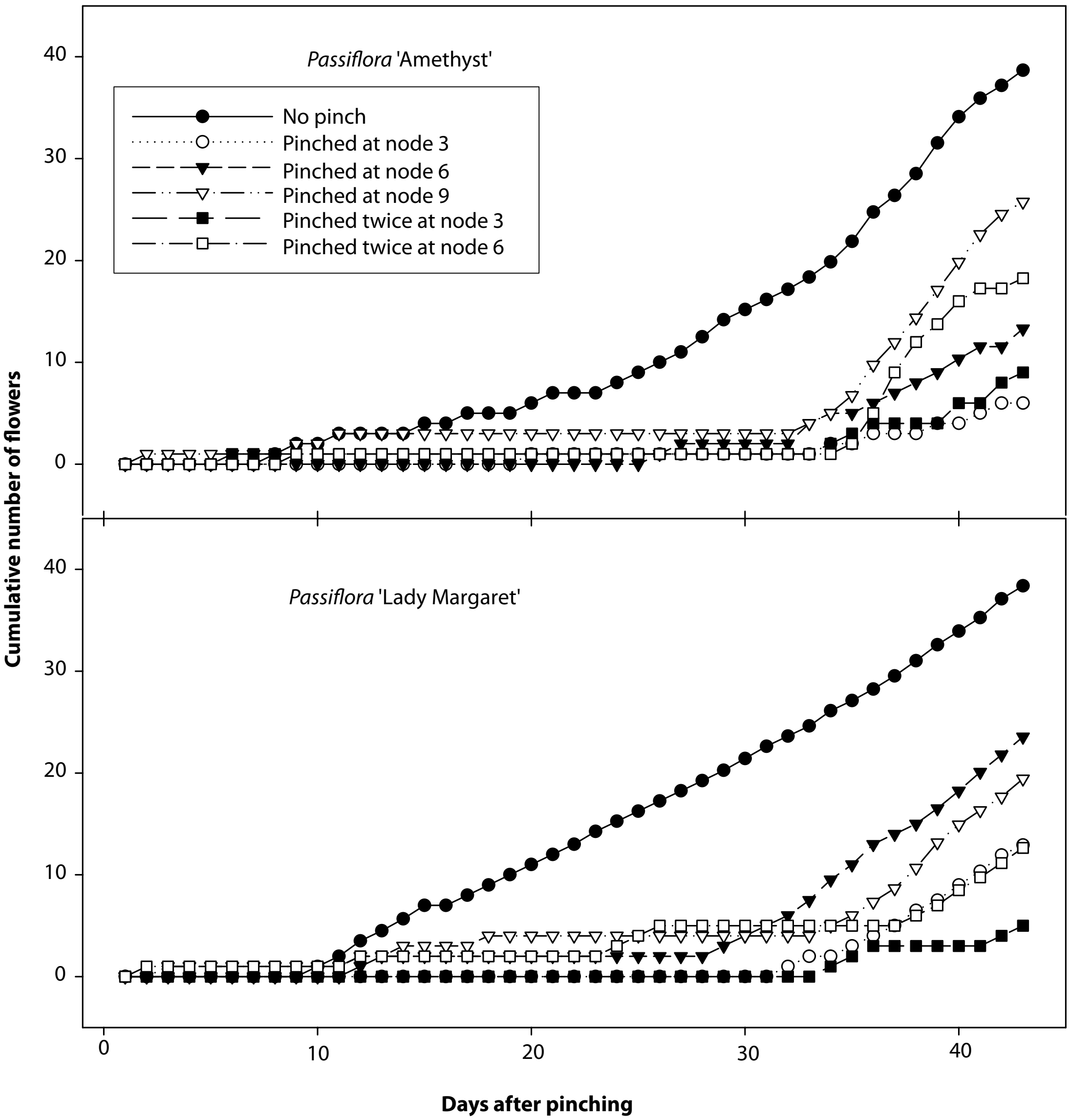

Table 1. Mean number of shoots, shoot length, number of nodes, and number of flowers for *Passiflora* 'Amethyst' and 'Lady Margaret' 45 days after applying initial pinching treatments.																
	P. 'Amethyst'									**P. 'Lady Margaret'**						
Pinch Treatment	**Mean number of shoots**		**Mean shoot length (cm)**		**Mean number of nodes**		**Mean number of flowers**			**Mean number of shoots**		**Mean shoot length (cm)**		**Mean number of nodes**		**Mean number of flowers**
No pinch	10.1	a[z]	969.0	ab	177.7	a	16.5	a		7.4	a	560.9	a	113.6	a	17.9 a
Pinched at node 3	7.3	b	890.5	ab	154.8	ab	0.6	b		5.0	b	412.1	ab	70.1	b	3.3 bc
Pinched at node 6	8.3	ab	1070.0	a	193.2	a	2.9	b		5.8	ab	517.6	a	101.8	ac	8.8 b
Pinched at node 9	7.1	b	863.9	ab	163.8	ab	12.7	a		5.8	ab	559.2	a	113.0	a	6.8 bc
Pinched at node 3 & 3	6.8	b	700.4	b	120.6	b	0.9	b		4.8	b	300.1	b	54.9	b	0.6 c
Pinched at node 6 & 6	7.8	b	1048.2	a	188.8	a	3.4	b		4.9	b	410.2	ab	87.3	bc	2.8 bc

[z] Means within a column for each cultivar followed by the same letter are not significantly different as determined by Tukey's test at $P < 0.05$.

Rudy Haag Burning Bush as a Non-Invasive Alternative to Current Burning Bush Cultivars for Kentucky Nursery Production

Robert Geneve, Winston Dunwell, Amy Poston and Cindy Finneseth, Department of Horticulture

Burning bush (*Euonymus alatus*) is a popular ornamental shrub and an important crop for the Kentucky nursery industry. However, Kentucky lists it as an exotic invasive plant. Many other states have designated burning bush and its cultivars as invasive plants, and at least two states on the East Coast have legislation in place to restrict importation and sale of any burning bush cultivar. Burning bush is an easy to grow, profitable nursery shrub in Kentucky, and a quarantine on plant production and sales could adversely effect many nursery businesses.

Rudy Haag burning bush (*Euonymus alatus* 'Rudy Haag') is a nearly seedless cultivar that has the potential to become an acceptable replacement for currently marketed burning bush cultivars. It was discovered in Kentucky, and the most cited planting is at Bernheim Arboretum and Research Forest in Clermont, KY. It has not been extensively grown in Kentucky nurseries because it is slower growing than other burning bush cultivars such as compact burning bush (*Euonymus alatus* 'Compactus'). Rudy Haag burning bush may have a significant marketing advantage for Kentucky nursery producers if data to support a non-invasive character can be substantiated and a production scheme can be developed to accelerate its growth under nursery conditions.

Seed production. Compact and Rudy Haag burning bush field plots were established in 2004 at the University of Kentucky Horticulture Research Farm in Lexington and at the University of Kentucky Research and Education Center in Princeton. Plants in Lexington are not irrigated, and half are receiving 75% shade. Those in Princeton are irrigated and in full sun. Preliminary data confirms the near seedless character of Rudy Haag burning bush. After two years of growth, plants are now established, and in 2006, seed production will be compared between the two cultivars at each location.

Seed development. Burning bush blooms in Kentucky in late April through May, and seeds are mature by late fall. Burning bush seeds normally follow a pattern of development where a single ovule develops within an enclosed aril inside a dry capsule. Anatomical data will be collected during seed development in 2006 to establish the time and stage of development where Rudy Haag ovules abort (Figure 1).

Seed germination. Burning bush seeds display deep physiological dormancy. In growth chamber studies, germination did not begin until seeds received at least 13 weeks of chilling stratification. In order to establish the relationship between seed production and seedling establishment, field plots were established in 2005 at the University of Kentucky Horticulture Research Farm in Lexington. Seedling emergence will be evaluated over the next two years.

Nursery production. Rudy Haag plants will need to be clonally produced using cutting propagation. Cuttings rooted at higher percentages and with greater root numbers for cuttings taken in May compared to June (Table 1). Auxin at 3,000 and 6,000 ppm was effective at improving overall rooting. Rudy Haag cuttings rooted at high percentages, indicating that cutting propagation will not be limiting for nursery production of this crop.

Studies will be conducted to evaluate Rudy Haag production under Kentucky nursery conditions using treatments to accelerate growth. A container type and fertilizer interaction study was established in the spring of 2006 at the University of Kentucky Horticulture Research Farm in Lexington. Growth for compact and Rudy Haag burning bush plants will be compared in 1- or 2-gallon container sizes in a traditional or root trainer design. Plants within each container treatment will be fertilized with a standard three- to five-month Osmocote slow release fertilizer and supplemented with single or multiple liquid feed fertilizations.

Figure 1. Normal and aborted ovule development in burning bush.

Table 1. The impact of IBA concentration and collection time on rooting in cuttings from burning bush.

		Burning bush		Rudy Haag burning bush	
Collection time	IBA [mM]	Rooting (%)	Roots/ cutting	Rooting (%)	Roots/ cutting
May	0	84.7	5.65	94.4	12.7
	1,000	87.5	9.06	100.0	19.3
	3,000	94.4	17.2	100.0	23.7
	6,000	88.9	13.2	95.8	24.6
June	0	9.7	0.2	69.4	3.9
	1,000	16.7	0.4	70.8	7.3
	3,000	43.1	1.5	50.0	2.8
	6,000	69.4	4.2	69.4	9.4

Solarization and Cultivated Fallow for Weed Control on a Transitioning Organic Farm

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Introduction

Surveys of organic farmers and those wishing to transition to certified organic crop production consistently report that weed control is one of their most important concerns (Bond and Grundy, 2001; Walz, 2004). Numerous tools and techniques to destroy germinating weeds and reduce weed populations over time are available to organic farmers, but the efficacy of some newer weed control strategies have yet to be tested against more time-honored techniques, particularly when confronted with a troublesome perennial weed species like johnsongrass (*Sorghum halepense*).

Johnsongrass is considered an invasive and noxious weed in many states, and while it is controlled with repeated herbicide applications on conventionally managed farms, herbicides are not available for use by organic or transitioning-to-organic farmers (USDA, 2005). Prior to the use of herbicides, johnsongrass control was accomplished primarily by a combination of mowing and tillage (Cates, 1907). A technique recommended early in the 20th century was to plant pasture grasses in the infested area; these grasses were repeatedly mowed or grazed for hay throughout the first season. Repeated mowing or grazing alters johnsongrass root growth forcing it to become more shallowly rooted, a fact that was exploited by farmers and Extension workers (McWhorter, 1989). The pasture system was maintained for at least a year or until shallow cultivation (either in association with a cash crop or bare fallow) could be used to kill the weakened perennial weeds. Multiple passes of a cultivator equipped with sweeps was suggested to bring rhizomes to the surface during the summer months to allow them to desiccate and die (Hunt, 1915; Talbot, 1928). Although it took up to two years to pass through the cycle of mowing and cultivation, this method was considered effective.

Solarization is a hydrothermal soil disinfestation technique that has proven useful in combating many soil pathogens and weed species (Stapleton, 2000; Standifer, 1984). The technique uses clear plastic sheets stretched over bare soil during the summer so that solar radiation heats the soil beneath while leaving soil structure undisturbed (Katan, 1981). Johnsongrass has been documented as being susceptible to solarization together with other perennial weeds such as purple nutsedge (*Cyperus rotundus)* and bermudagrass (*Cynodon dactylon* L.) (Elmore, 1993; Egley, 1990; Ricci et al. 1999). Though most often used in arid climates, this technique offers promise as an alternative to herbicides and is allowed for use by organic farmers.

The objective of this study was to compare soil solarization with the traditional methods of johnsongrass control using a cultivated bare fallow.

Materials and Methods

2003-2004. A 300 ft. by 125 ft. field at the UK Horticulture Research Farm in Lexington, Kentucky, was selected for this trial based on its uniform and heavy infestation of johnsongrass which covered 40 to 50% of the field. This field lies within a 12-acre portion of the farm which was in its second year of transition from conventional to organic management in 2003. Prior to the start of the experiment, the field had been planted to a winter wheat cover crop (80 lb/acre, Southern States, Lexington, Ky.) in the fall of 2002. The field was plowed in mid-May 2003, and the soil (Maury silt loam) was disked twice before the start of the experiment on 15 July. The field was divided into twelve 25 ft. by 125 ft. plots. The following three treatments were assigned to these plots in a completely random design with four replications.

The solarization treatment consisted of stretching a 25 ft. by 125 ft. piece of four mil. plastic over an entire plot and burying the edges. Researchers in California found that solarization worked best as a weed control technique when applied to well-moistened soil during the hottest period of the summer (Elmore et al., 1991). Drip lines were laid underneath the plastic at approximately 4 ft. intervals, and the soil was irrigated until thoroughly moistened. The plastic and drip tape were applied on 15 July and removed 16 Sept.

The second treatment was cultivated bare fallow. This treatment was cultivated weekly using a field cultivator equipped with sweeps. Cultivation began on15 July and ended on 16 Sept. The third treatment was an untreated check (control). These plots were left undisturbed during the season except for two passes with a rotary mower on 26 July and 20 Sept. which prevented johnsongrass from going to seed. Following the second mowing in September, check plots were disked and planted with a winter wheat cover crop (80 lb/acre, Southern States, Lexington, Ky.).

During the fall and winter of 2003, all solarization and cultivated bare fallow plots were left untouched. On 14 May 2004, all solarization and cultivated bare fallow plots were divided in half; half of each of these subplots was then disked to a depth of 3-4 inches. Check plots with winter wheat were left undisturbed until 1 June 2004 when they were plowed and disked twice.

Weed data from the solarization and cultivated bare fallow plots were collected on 15 July from both the tilled and untilled portions of each plot. Data collected included a visual estimation of the percentage of the soil surface covered with johnsongrass and a count of all johnsongrass plants found on a 30 ft. transect line. These plants were separated into those derived from seed and those from rhizomes. Finally johnsongrass plants were counted within a randomly chosen 1-meter square within each plot area.

2004-2005. The check plots from 2003 were used for the experimental plots in 2004. Each of these four 25 ft. by 125 ft. areas was divided into three 25 ft. by 40 ft. plots, and the same three treatments from 2003 were randomly assigned to these plots. This was necessary as no other sections of the UK Horticulture Research farm had a similar infestation of johnsongrass.

All treatments were applied on 16 July 2004 using the same methods as in 2003. Solarization plastic was removed on 18 Sept., and bare fallow cultivation ended on 17 Sept. The check plots were mowed twice (29 July and 25 Sept.); all plots were then left undisturbed until the following spring. On 28 May 2005, half of the plots were randomly chosen for disking to a 3-4 inch depth as in 2004. On 14 July, weed data were collected from all treated plots within the original 300 ft. by 125 ft. area using the same procedures as in 2004.

Analysis of variance of all data was conducted using the PROC GLM procedure of the Statistical Analysis System, and means were separated by Waller-Duncan K-Ratio t-tests (SAS Institute, 1999). Since data for density, transect, rhizome, and seed were small whole numbers, they were transformed by square root plus 0.5 (Steel and Torrie, 1960).

Results

2003-2004. Significant differences were found among the treatments for all five measurements of the johnsongrass population (Table 1). The portion of the plot covered by johnsongrass was significantly lower in the tilled and untilled portions of the solarization plots and in the untilled cultivated plots compared to the check and tilled cultivated plots (Table 1). The solarized and untilled cultivated treatments also had significantly lower johnsongrass plant densities than the tilled cultivated treatments or check plots (Table 1).

The 30 ft. transect reflected the same trend with a significantly lower johnsongrass population in the solarized and the untilled cultivated treatments compared to the check and tilled cultivated treatments (Table 1). When plants on the transect line in the solarized and the untilled cultivated plots were excavated, significantly fewer had grown from rhizomes than from seeds. Only the solarized treatments had significantly fewer numbers of seedling johnsongrass plants along the transect lines compared to the other treatments.

There were no significant differences between the tilled and untilled sections of the solarized plots in 2003-2004 (Table 1). However, johnsongrass density and the number of plants per 30 ft. transect were substantially higher in the tilled portions of the cultivated plots (Table 1).

Check plots from 2003-2004 retained the same average level of johnsongrass infestation that was present at the beginning of this study (Table 1). None of the johnsongrass population data from the check plots were significantly different from the tilled cultivated plots.

2004-2005. As in 2003-2004, there were significant differences among treatments for all five measurements of johnsongrass populations in 2004-2005 (Table 2). The percentage of ground covered by johnsongrass was highest in the tilled cultivated plots and lower in check plots, tilled solarized plots, and untilled cultivated plots. The percentage of ground covered by johnsongrass was lowest in the untilled solarized plots (Table 2). No johnsongrass plants grew in any of the untilled solarized plots; however, this was not significantly different from the low johnsongrass populations in the untilled cultivated plots. Solarized or cultivated plots that were left untilled had the lowest johnsongrass populations as in 2003-2004.

Johnsongrass density was lowest in the untilled solarized plots which was significantly less than densities in tilled solarized, tilled cultivated, or check plots (Table 2). As with percent of ground covered by johnsongrass, the zero johnsongrass population found in the untilled solarized plots was not significantly different from the low johnsongrass population found in the untilled cultivated plots.

Table 1. 2004 johnsongrass population data from plots treated in 2003 with solarization or cultivation.

Treatment[z]		Control[a] %		Density[b] No./m2		Transect[c] No. Plants/30 ft.		Rhizomes[d] No./30 ft.		Seed[e] No./30 ft.	
Cultivated	Tilled	27.5	ab	35.0	a	15.5	a	6.3	a	9.3	a
	Untilled	11.8	b	7.8	b	4.3	b	1.3	b	3.0	ab
Solarization	Tilled	11.3	b	4.8	b	3.3	b	1.5	b	1.8	b
	Untilled	13.0	b	6.3	b	4.8	b	2.5	b	2.3	b
Check	Untilled	42.5	a	18.0	ab	14.8	a	9.5	a	5.3	ab

[a] Mean percent ground covered by johnsongrass.
[b] Mean number of johnsongrass plants found in 1 sq. m.
[c] Mean number of johnsongrass plants found on one 30 ft transect.
[d] Mean number of johnsongrass plants found on 30 ft transect that derived from rhizome.
[e] Mean number of johnsongrass plants found on 30 ft transect that derived from seed.
[z] Mean separation based on transformed data. Means followed by the same letter are not significantly different (P<0.05).

Table 2. 2005 johnsongrass population data from plots treated in 2004 with solarization or cultivation.

Treatment[z]		Control[a] %		Density[b] No./m2		Transect[c] No. Plants/30 ft.		Rhizomes[d] No./30 ft.		Seed[e] No./30 ft.	
Cultivated	Tilled	10.0	a	5.0	a	4.5	ab	3.0	a	1.5	a
	Untilled	3.8	cd	1.5	ab	1.5	cd	1.0	bc	0.5	b
Solarization	Tilled	5.8	bc	4.3	a	2.3	bc	1.8	ab	0.5	b
	Untilled	0.0	d	0.0	b	0.0	d	0.0	c	0.0	b
Check	Untilled	8.8	ab	4.3	a	6.0	a	3.8	a	2.3	a

[a] Mean percent ground covered by johnsongrass.
[b] Mean number of johnsongrass plants found in 1 sq.m.
[c] Mean number of johnsongrass plants found on one 30 ft transect.
[d] Mean number of johnsongrass plants found on 30 ft transect that derived from rhizome.
[e] Mean number of johnsongrass plants found on 30 ft transect that derived from seed.
[z] Mean separation based on transformed data. Means followed by the same letter are not significantly different (P<0.05).

The number of plants found on the 30 ft. transect in untilled solarized plots (no johnsongrass) was significantly less than in check plots, which were highest (Table 2). Although more johnsongrass plants found on the 2004 transect were from rhizomes, this was not significantly different from the number of plants derived from seed.

The inclusion of a spring tillage event influenced johnsongrass populations significantly with lower overall control and higher numbers of plants on the 30 ft transect in both cultivated and solarized plots. In addition, tilled solarized and tilled cultivated plots had significantly higher numbers of plants from rhizomes on the 30 ft. transect (Table 2).

Only 9% of the ground was covered by johnsongrass in the check plots in 2004-2005 which was dramatically lower than the 40-50% coverage in 2003. All treated plots had significantly lower johnsongrass populations at the end of the experiment than at the beginning (Table 2).

Discussion

Our major objective was to compare two practical methods of johnsongrass control: solarization and bare fallow with cultivation. Bare fallow with cultivation did not appear as effective as solarization for long-term johnsongrass control in this experiment. Initial populations were reduced in both years to essentially the same levels as found in solarized plots; however, when these plots were tilled, johnsongrass populations rose. Johnsongrass eradication was of great interest in the early part of the 20th century, and cultivation during midsummer was found to be an effective control. This experiment confirmed that bare cultivated fallow is an effective technique; however, one year of bare fallow cultivation may not be enough to eradicate heavy johnsongrass infestations like those present at the beginning of this study. The additional plowing, disking, and cover cropping of the check plots from 2003-2004 (which became treatment plots in 2004-2005) probably played a large role in the overall reduction of johnsongrass by the end of the experiment.

From our results, it appears that solarization effectively controlled johnsongrass as populations were greatly reduced in both years in solarized plots. Even when solarized plots were tilled, johnsongrass populations remained much lower than the 40-50% infestation present at the start of the experiment. These results corroborate findings of Elmore (1993), Standifer et al. (1984), and Ricci et al. (1999), who found solarization effectively controlled perennial weed species with extensive rhizomatous growth.

The majority of solarization research has been conducted in warm temperate and tropical areas with the major focus being on soil-borne pathogen control. Weather is a critical factor influencing the effectiveness of either of these techniques in Kentucky. Precipitation and ambient air temperature play a role in the success of both bare fallow cultivation and solarization. Weather data from Lexington's Bluegrass Regional Airport for the months of July through September of 2003 showed that the mean ambient temperature was 72°F, tying it for the 16th coolest summer period since 1896. Mean ambient temperature from July to September for 2004 was 70°F, which ranked it as the fifth coolest summer period recorded since 1896 (MRCC, 2005). Precipitation for the months of July to September in 2003 was 14.68 inches, which ranked it as the 14th wettest year, and was 15.96 inches in 2004, which ranked it as the 12th wettest year since 1896 (MRCC, 2005). As solarization was the more effective of the two treatments for the control of johnsongrass, it is interesting to note that the two years of this study were both cooler and wetter than average years in Kentucky. In years closer to average, it can be expected that solarization would perform even better than it did in this study.

Organic farmers often depend on cultural and mechanical means to control weeds and farmers transitioning to organic production techniques must learn and master these strategies to achieve profitability. Yet, when confronted with land infested with a troublesome perennial weed such as johnsongrass, growers are understandably interested in faster alternatives for eliminating such weeds. Solarization has been used by limited resource and organic growers in California as an alternative to methyl bromide and for weed control, and from this research it may well be of use to small farmers in Kentucky (Stapleton et al., 2005). Future research might focus on including solarization in a greenhouse rotation so that more value from the purchase of greenhouse plastic could be realized, or utilizing solarization on soils before they are planted to perennial plants such as strawberries or other small fruits.

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Weed Management Systems for Organically Grown Bell Peppers

Derek Law, Mark Williams, and Brent Rowell, Department of Horticulture

Introduction

Organic agriculture continues to grow rapidly nationwide. According to the Organic Trade Association's 2004 Manufacturer Survey, total sales of organically labeled products expanded to nearly $11 billion, and the annual growth rate was a robust 20% making organically produced foods the fastest-growing segment of American agriculture. Opportunities exist in Kentucky for farmers to adopt this method of production, especially in the area of vegetable production.

Bell peppers are one of the most profitable and widely grown vegetable crops in Kentucky and are an ideal crop for farmers seeking to diversify from tobacco production, particularly for wholesale fresh vegetable sales. To encourage Kentucky farmers to consider converting to organic production, research on organic methods for bell pepper production has continued into a second year at the University of Kentucky Horticulture Farm in Lexington. While we compared the general effectiveness of various mulch materials for weed control in the first year, year two was used to study the best way of using mulches in an organic production *system* to achieve high yields.

Methods and Materials

Five different mulch treatments were applied to bell peppers grown on plastic-covered raised beds and flat ground plots in 2003. The mulches were applied at planting, and records were kept to show how long the mulches provided good weed suppression. The three best weed control treatments (straw, wood chips, and compost) were used again in 2004. None of the mulch materials were effective for the entire growing season in 2003, so we decided to include shallow cultivation in the plots for the first month and a half after planting in 2004.

Bell peppers (cv. Red Knight) were sown on 29 March and transferred to cells filled with Sunshine Organic Gro-mix on 16 April. This variety was chosen because of its high yields and resistance to bacterial leaf spot and because untreated seed was readily available. Difficulties were experienced with nutrient availability and water retention in small-celled planting trays (Styrofoam, 253 cells per tray) when fish emulsion (Maxicrop Liquid Fish Fertilizer 5-1-1) was used as the primary nitrogen source. This combination seemed to induce an impermeable layer or film on the media surface in the cells, limiting water penetration and therefore nutrient availability to the roots. Threatened with the loss of all the transplants, we applied conventional 20-10-20 soluble fertilizer twice as a rescue treatment for the seedlings. Although this is unacceptable for certified organic production, we did it to ensure that the entire experiment would not be lost. Organic pepper transplants were grown successfully in 2003 using larger cell sizes (72 cells/tray) and Omega 6-6-6 organic liquid fertilizer. Future transplant production will focus on using larger cell sizes and an organic potting media pre-amended with either compost or a balanced organic fertilizer.

In 2003, peppers were planted into a field that previously contained a winter wheat cover crop. Peppers in 2004 were planted into ground that had been cover cropped for over a year. During the preceding summer the plot had been planted with a sudex/cowpea cover that was plowed down in the fall and followed with rye and hairy vetch winter cover. This was plowed down on 23 May 2004 and was estimated to provide approximately 50 lb of N/A to the incoming pepper crop. An additional 45 lb N/A in the form of dry pelleted Nature Safe fine 10-2-8 fertilizer was applied to the plot and disked in on 7 June. An additional 30 lb N/A was fertigated in two doses at mid-season through the drip irrigation system using the liquid organic fertilizer Phytamin 7-0-0. *Trichograma ostriniae* wasps were released as a precautionary measure on 16 July and 14 August at a rate of 150,000/A as a biological control for European corn borer; no excessive insect or disease problems were observed during the growth of the crop.

Field plots were 75 ft long flat or raised beds with pepper plants spaced every 12 inches in the rows. Each combination of either raised or flat ground beds was then separated into 5 five subplots that were 12 ft long by 12 ft wide. The mulch treatments were randomly assigned to the subplots. Thus, within each main plot, each mulch treatment was applied to one raised bed section and one flat ground section. The plots were replicated four times in a split plot design with raised or flat beds as the main plots and mulch treatments as the subplots. Black plastic mulch and drip irrigation was used solely on the raised bed treatments, and the mulch treatments were placed in-between the beds. Drip irrigation was used on the flat ground treatments, and the mulch treatments were spread evenly over the entire 144 sq ft area. Prior to mulch application, three shallow cultivations were performed on the plots at approximately two-week intervals following planting.

The compost, wood chips, and straw treatments were applied on 20 July. The compost was obtained from Creech Compost Company, a local producer of bulk compost derived from used horse muck. The straw mulch was baled wheat straw obtained from a local farm supply store, while the wood chips were from materials brought to the University of Kentucky Horticulture Farm by regional tree trimming businesses. Cultivated plots were treated as all other plots prior to the application of mulch; however, following 20 July, they were cultivated five more times until final harvest on Oct 11. Control plots were cultivated as the other plots, but after 20 July, weeds were allowed to grow and compete with the crop. Wood chips and compost were applied to a depth of 3 inches, while the wheat straw was spread to a depth of 6 inches. A tensiometer was placed in one black plastic subplot and one flat ground subplot, and water was applied when necessary.

Weed density was recorded on 30 August and 8 October, using objective visual analysis and a 1 to 10 scale. A weed species list was compiled through regular observation during the growing season. These data will be presented in subsequent reports. Peppers were harvested on 5, 16, and 30 August, 16 September, and 11 October. Fruits were graded as marketable or culls and then counted and weighed. Marketable fruits were sorted into USDA X-Large, Large, and Medium grades.

Results and Discussion

The primary purpose of this research is to develop a practical commercial organic production system for bell peppers. There are several critical components of this system. These are the use of mixed leguminous and grass cover crops as nitrogen and carbon sources, planting disease-resistant varieties, releasing biocontrol agents as part of an insect and disease management program, and using shallow rather than deep cultivation. Both flat ground and plastic-mulched raised beds are allowed and used regularly in certified organic systems; however, the effects of inclusion of different organic mulch materials into these production systems is less well known.

While the 2003 objective was to ascertain which mulches controlled weeds best, the primary objective in 2004 was to maximize yields. By combining cultivation with the most promising mulches from 2003, the major yield-limiting problem of weed competition was solved. Each of the three mulch types tested provided very good to excellent weed control from the time they were applied until final harvest two months later. Total marketable yield of the organic peppers grown on raised beds with plastic mulch and drip irrigation was comparable to the highest yielding conventionally grown varieties in a nearby variety trial conducted this year on the same farm.

Table 1. Yields of organically grown peppers from 10 weed management treatments at the Horticulture Research Farm, Lexington, Kentucky, 2004. All data are means from four replications.

	Pepper Yields				Total Marketable Yield Lb/A
	X-Large & Large		Medium		
Treatments	No./Plot	Wt./Plot	No./Plot	Wt./Plot	
Bare ground					
Compost	809	333	379	97	34062
Wood chips	735	318	363	96	31375
Straw	732	304	298	78	28249
Cultivated	739	308	273	74	29278
Control	666	279	294	78	25562
Average	736	308	321	85	29705
Black plastic					
Compost	1097	449	377	102	46345
Wood chips	1079	444	303	77	42516
Straw	976	398	323	82	38511
Cultivated	1149	478	352	91	46258
Control	1021	419	313	79	40949
Average	1064	438	334	86	42916

Yields from plastic-covered raised beds were substantially higher than from any of the flat ground treatments. The addition of mulches between the plastic-mulched beds did not affect overall yields in these plots. Although the addition of three cultivations between the beds in the plastic-covered raised bed system reduced weed competition, it is likely that less cultivation could be used prior to applying a mulch and high yields could still be expected.

Bare ground treatments exhibited more variability among mulches with compost outperforming the others; however, none of the differences were statistically significant. Both the use of mulch and continued cultivation throughout the season produced higher total yields than the control. The treatments on bare ground may have required additional nitrogen, which could have explained the slightly higher yields from bare ground plots treated with compost mulch. The compost may have provided a small amount of additional nitrogen.

Any of the organic mulches, (compost, straw, or wood chips) could be incorporated in a large field production operation; however, given the data from last year, it is clear that post-transplanting cultivation is required to ensure good yields. While the three cultivations in this experiment resulted in good weed control for bare ground treatments, it seems likely that at least one less cultivation could have been used in between the black plastic raised beds since mulch application did not affect total yields. This combination of shallow cultivation following planting coupled with mid-season mulch application was capable of producing high yields in an organically managed system.

Evaluating Crop and Soil Fertility Changes during Transition to an Organic Vegetable Production System

Mark Williams and Brent Rowell, Department of Horticulture

This project is focused on providing information for growers who are transitioning into organic vegetable production from tobacco or conventional vegetable production. We are analyzing and documenting changes in produce yield and quality; changes in soil biological, chemical, and physical properties; weed dynamics; and economic outcomes during the three-year transition from conventional to organic vegetable production. Although evaluating changes during the three-year transition to organic is a main focus, a five-year rotation is being used to allow a comparison between three production systems: organic, conventional, and low-input.

Two years of the five-year rotation plan for this project have been completed. Data collected includes yield and quality of each crop, weed density, rates of insect and disease damage, and soil physical and biological parameters. Soil has been sampled from each plot in the fall and spring of each year at two depths. A sample of undisturbed sod adjacent to the field has been taken for baseline comparison. Physical properties such as organic matter, water holding capacity, macronutrients, cation exchange capacity, and salinity have been measured. The biological parameters being evaluated have been focused on determining the overall activity and diversity of the microbial community in the soil. Activity of four key enzymes involved in the nutrient cycling of nitrogen, phosphorous, sulfur, and carbon have been measured. Following is a brief summary of the results at this time:

In the first year of the rotation, edamame soybeans were grown. The three production systems being compared (organic, conventional, low-input) differed by type of fertilizer, rate of fertilizer, herbicide use, and rate of herbicide. The edamame was harvested from a 100 ft^2 area in each of the plots, sorted for quality (2, 3 beans/pod, unmarketable), and weighed. There were no economic levels of insect or disease damage in any treatment. Weed density was significantly decreased in treatments receiving the full rate of herbicide and increased with the half rate and no herbicide treatments. There were no significant differences in yield between treatments. In the second year, sweet corn was grown. Again, the treatments differed with type and rate of fertilizer, use of herbicide and rate, and pest control method. Yield and quality between treatments were similar; however, raccoons caused significant damage in some of the plots, causing some of the replications to have significantly reduced yields. This coming year (2006) is the fallow period of the rotation. All treatments will have a grass/clover cover crop for the summer. The organic plots will include pastured poultry as a soil improvement technique.

Two years of soil sampling data have been taken. Physical property analysis has shown that some considerable variability exists across the field, but within each replication, the parameters have not changed significantly with treatment. Enzymatic assays have shown variability across the field as well, but some differences are being observed between treatments, notably with the carbon and nitrogen cycling enzymes. More data is needed in order to confirm treatment effects in soil enzyme activity.

Developing Organic Apple Thinning Agents for Kentucky Fruit Growers

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Of all the cultural practices involved in apple production, fruit thinning is one of the most critical. Without fruit thinning, a large proportion of the fruit crop would be undersized and of poor quality. Without fruit thinning, trees would be thrown into a biennial bearing pattern with heavy crop years followed by very light crop years. Thinning is conventionally done with synthetic chemicals because hand thinning is very labor-intensive and cost-prohibitive. Unfortunately, there are no thinning agents that are recommended for use in organic apple production. Recent work in New York and elsewhere has indicated that lime sulfur has significant potential as an organic thinning agent. The recent work has combined lime sulfur with fish oil; the oil acts as a surfactant to increase uptake of the lime sulfur. The recent work also suggested that applications of lime sulfur as late as petal fall plus seven (PF + 7) days thinned the fruit and increased fruit size at harvest. Fruit thinning after petal fall is commonly delayed in Kentucky until after the chance of frost has passed, since frost also can thin fruit.

The fruit thinning efficacy of lime sulfur plus fish oil (LS/FO), a possible organic alternative to conventional synthetic thinners, is being examined. In 2004, one or two sprays of LS/FO were applied as branch treatments to five cultivars: Gala, Fuji, Senshu, Golden Delicious, and Red Delicious. The LS/FO was applied at 30% LS and 3% FO on three dates: PF, PF + 5 days, PF + 10 days, or their combinations. The objectives were to determine if the LS/FO sprays would cause significant foliar or fruit phytotoxicity.

Leaf phytotoxicity was evident from most treatments, with more damage from two applications than a single one. No fruit damage was observed. Most leaf injury occurred on leaves that were immature at the time of application. Leaves with more severe symptoms eventually dropped from the trees, but most leaves survived. As the season progressed, injury symptoms were barely noticeable. In 2005, LS/FO (30%/3%) was applied once at PF + 7 days to whole trees of Redfree, Gala, and Golden Delicious apple. The results were promising, as LS/FO application reduced fruit load almost 70% across the three cultivars. Golden Delicious showed the greatest thinning effect, with an 85% reduction in fruit per flower cluster, while Redfree showed the least, with a 50% reduction in fruit per flower cluster.

HORTICULTURAL CROPS—VEGETABLES

Bell Pepper Evaluations for Yield and Quality in Eastern Kentucky

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Introduction

As a result of several multi-year studies evaluating bell pepper cultivars for resistance to bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria* or Xcv) and fruit quality, nearly 100% of Kentucky's pepper acreage is planted with resistant bell pepper cultivars with high fruit quality, like Aristotle. As new pepper cultivars are released, we try to test them for leaf spot resistance, as well as for fruit yield and quality under Kentucky conditions. Because Kentucky farmers are planting more vegetable crop acreage, new disease problems like Phytophthora blight (*Phytophthora capsici*) and tomato spotted wilt virus (TSWV) are becoming more prevalent. Past studies have shown that pepper cultivars with leaf spot resistance to at least three races of Xcv (races 1, 2, and 3) perform better under high disease pressure. Several of the cultivars in this study also contain resistance or tolerance to TSWV or Phytophthora blight in addition to bacterial spot resistance.

The bell pepper cultivars were tested in replicated trials at two Kentucky locations in 2005 (central and eastern). See the report for central Kentucky elsewhere in this publication.

Materials and Methods

Eleven new bell pepper cultivars with the Bs2 gene for bacterial spot resistance were compared with a main season and early season control varieties, Aristotle and King Arthur, respectively (Table 3). Mature green fruit were harvested two times from late June to mid-August. Fruit were graded and weighed according to class size (U.S. No. 1 extra large, large, medium, chopper and cull). Yields in each class size were multiplied by their respective wholesale market prices to determine gross returns (income) for each cultivar. Wholesale prices for 2005 were used to calculate incomes for the different varieties. The income variable has been a good indicator of a cultivar's overall performance, taking into account time of harvest as well as yields of the different size classes and their price differentials.

The 13 bell peppers were seeded in 72-cell trays in the greenhouse at the Robinson Station on 18 March and were transplanted to the field on 12 May.

Based on the soil test results shown in Table 2, 50 pounds of actual nitrogen along with 60 pounds of P_2O_5 and 60 pounds of K_2O/A were applied the day before planting. Ninety additional

Table 1. Seed company descriptions of bell cultivars tested at Quicksand and Lexington, 2005.

Cultivar	Source	Days to Maturity	Comments
Aristotle (X3R)	SW	72	Very large green to red, BLS 1,2,3 and PVY, TMV
Socrates	SW	64	Very early, blocky, green to red, sturdy-medium size plants BLS 1, 2, 3
PS 9915776	SI		5 race BLS resistance, Phytophthora tolerant
Revolution (HMX 1660)	HM	72	Large to ex lg blocky fruit, tall plants. BLS 1,2,3,5, CMV & Phytophthora tolerant. Cool tolerant
Heritage	HM	75	Green to red fruit, tall plant, TSWV resistant, BLS 1, 2, 3, 5
Alliance (HMX2643)	HM	73	Blocky, green to red fruit; BLS 1, 2, 3, 5, "intermediate resistance" to Phytophthora, PVY, PepMoV, CMV.
Patriot	HM	70	Early red, blocky concentrated fruit, BLS 1, 2, 3, 5, and PVY
Double-up	SW	69-80	Early to mid-season. Resistant to BLS 1, 2, 3 and Tobamo virus
Excursion II	RU	75	Large blocky fruit; BLS 1, 2, 3, TSWV, PVY, and TMV
Mahi	EN		large, high-yielding green to red blocky pepper
E41.8338	EN		
Telestar	HZ	Early	Resistant to PVY, TMV, BLS
King Arthur	SI	65-70	BLS susceptible

pounds of nitrogen/A were applied to the peppers during the growing season for a total of 140 lb actual N/A.

Each plot contained 14 plants in a double row with 7 plants/row. The in-row spacing was 14 in. with 20 in. between rows. One empty space/row was left between plots. Plots were replicated four times in a randomized complete block design. Dual II Magnum 1.3 pt/A was applied to the bare ground between plastic strips to control weeds.

Fruit appearance ratings. All pepper cultivars harvested on (7/18) were laid out on the ground and evaluated for fruit appearance. Overall appearance ratings were the result of several factors listed in order of decreasing importance: overall attractiveness, shape, smoothness, degree of flattening, color, and uniformity of shape.

Table 2. Soil test results for pepper trial plot at Quicksand, Ky., 2005.

pH	Buf-pH	P	K	Ca	Mg	Zn
6.8	6.95	65	339	3236	392	6.6

Results and Discussion

Total marketable yields, gross incomes, and fruit quality characteristics are shown in Table 3. Total marketable yields based on two harvests ranged from 12.8 to 21.2 tons/acre. The growing season was very dry and temperatures were warm-hot with clear skies. Incomes were lower than in previous years and ranged from around $3175 to $5178 per acre. Heritage had the highest marketable yield and the highest number of pounds of extra large fruit. The total marketable yield of nine other pepper cultivars was not significantly different from Heritage (Table 3.).

Table 3. Yields, gross returns, and appearance ratings of bell pepper cultivars in Quicksand, Ky.

Cultivar	Seed Source[1]	Tot. Mkt. Yield[2] (tons/A)	Pounds XL Fruit/A[3]	% XL + Large[4]	Income ($/acre)[5]	Overall Appearance[6]	No. Lobes	Fruit Color	Comments
Aristotle	SW	18.8 AB	14,040 BC	64 BCD	$4,564 ab	6	4-3	Dk green	Good yield.
Socrates	SW	15.9 ABC	11,982 C	52 E	$4,131 abc	4.5	4-3	Pale med. green	Some misshapen fruit distorted lobes.
PS9915776	S	19.2 AB	16,725 ABC	71 AB	$4,571 ab	6	4-3	Dk green	Good shape, little distortion.
Revolution	HM	14.2 BC	13,525 BC	68 ABC	$3,486 bc	5	4-3	Med. green	A lot of pumpkin-shaped fruit.
Heritage	HM	21.2 A	21,250 A	73 A	$5,178 a	6	3-4	Variable green	Slightly irregular shape.
Alliance	HM	12.8 C	11,468 C	65 ABCD	$3,176 c	6	3-4	Variable pale-med green	About 1/3 flattened misshapen fruit.
Patriot	HM	17.5 ABC	13,239 BC	56 DE	$4,130 abc	7	4-3	Mostly dk green	About 1/4-1/3 flattened fruit.
Double-up	HM	17.5 ABC	18,288 AB	67 ABC	$4,318 abc	4.5	3-4-5	Dk green	About 1/4-1/3 flattened fruit. Ugly blossom end.
Excursion II	RU	16.2 ABC	13,297 BC	64 ABCD	$3,738 bc	7	4-3	Dk green	A lot of pumpkin-shaped fruit.
Mahi	EZ	14.0 BC	12,203 C	63 ABCD	$3,281 bc	5	4-3	Med. green	About 1/4 fruit pumpkin-shaped.
E41.8338	EZ	16.8 ABC	14,763 BC	62 BCD	$3,955 abc	5	4-3		A lot of fruit pumpkin-shaped.
Telestar	HZ	17.8 ABC	15,802 ABC	60 CDE	$4,192 abc	5	4-3		
King Arthur	S	17.1 ABC	14,059 BC	62 BCD	$4,206 abc	4	4-3		
Waller-Duncan MSD (P<0.05)		5.64	5,513	9.1	1,311				

1 Seed source identification and address information are listed in Appendix A of this publication.
2 Total marketable yield includes the yields of U.S. Fancy and No. 1 fruits of medium (>2.5 in. diameter) size and larger plus misshapen but sound fruit that could be sold as choppers to foodservice buyers.
3 Pounds of extra large peppers (>3.5 in. diameter).
4 Percentage of total yield that was extra large (>3.5 in. diameter) and large (>3 in. diameter but ≤3.5 in. diameter).
5 Income + gross returns per acre: average 2005 season local wholesale prices were multiplied by yields from the different size/grade categories: $0.17-0.19/lb for extra large; $0.09-0.14/lb for large and mediums, and $0.05-0.11/lb for "choppers," i.e., misshapen fruits.
6 Visual rating: 1-9 scale where 1 = worst, 9 = best, taking into account overall attractiveness, shape, smoothness, degree of flattening, color, and shape uniformity; all fruit from two separate replications were observed on 7/18. A rating of 5 was considered commercially acceptable.

Table 4. Appearance ratings of fresh market bell peppers, Quicksand and Lexington, 2005.									
	Overall Appearance[1]			**Number of Lobes**		**Fruit Color**		**Comments**	
Cultivar	**(QSD)**	**(LEX)**	**(Avg)**	**(QSD)**	**(LEX)**	**(QSD)**	**(LEX)**	**(QSD)**	**(LEX)**
Aristotle	6	6.5	6.25	4/3	Mostly 4	Dark green on shaded side, light green	Med-dk	High yielder	
Socrates	4.5	4.5	4.5	4/3	Mostly 4	Light green	Lt.-med.	Deep distorted lobes	50% flattened; pumpkin-shaped
PS 9915776	6	6	6.0	4/3	3-4	Dark green, light green on side	Med.	Good shape	Very few flattened; some misshapen
Revolution	5	4.5	4.75	4/3	Mostly 4	Light/dark green	Med-dk.	Pumpkin shape, large ones	50% flattened; otherwise ok
Heritage	6	5.75	5.88	3/4	Mostly 4	Variable green	Med.	Changes color just a little bit	No flattening; shapes somewhat irreg.
Alliance	6	5.5	5.75	3/4	Mostly 4	Variable green	Med-dk.	Shaded side a lighter green	1/3 flattened, otherwise nice
Patriot	7	5	6	4/3	Mostly 4	Mostly dark green	Med-dk.		1/4 to 1/3 flattened.
Double-up	4.5	5	4.75	3/4/5	3-4	Dark green	Med.	Ugly blossom end	1/4 to 1/3 flattened, many 3-lobed
Excursion II	7	5	6.0	4/3	3-4	Dark green, some light	Med.-dk.	A lot of pumpkin-shaped fruits	1/3 flattened; some 3-lobed, nice color
Mahi	6.0	5.5	5.75	4/3	Mostly 4	Dark green, some light	Med.-dk.		1/4 flattened, otherwise nice
E41.8338	5	5.5	5.25	4/3	Mostly 4	Uniform green	Lt-med. Med-dk.	A lot of pumpkin-shaped fruits	<25% flattened
Telestar	5	6	5.5	4/3	3-4	Good green	Med.	A lot of misshapen lobes, deep lobes	Many 3-lobed; some flat and long
King Arthur	4	na	4.0	4/3	na	Medium green	na	A lot of culls, choppers, pumpkin-shaped fruits	Not grown in LEX

[1] Visual rating: 1-9 scale where 1 = worst, 9 = best, taking into account overall attractiveness, shape, smoothness, degree of flattening, color, and shape uniformity; a rating of 5 or above is considered commercially acceptable. QSD = Quicksand, Kentucky; LEX = Lexington, Kentucky.

Heritage produced significantly more pounds of extra large peppers than nine of the other cultivars (Aristotle, Socrates, Revolution, Alliance, Patriot, Excursion II, Mahi, E41.8338, and King Arthur). Only three other pepper cultivars had similar yields of extra large fruit (PS9915776, Double-up, and Telestar (Table 3.).

Fruit quality ratings showed that Aristotle, PS9915776, Patriot and Heritage and Excursion II fruit had the best overall appearance ratings at Quicksand. Socrates and King Arthur had the lowest overall fruit quality ratings. Nine cultivars (Aristotle, PS9915776, Heritage, Alliance, Patriot, Excursion II, Mahi, E41.8338, and Telestar) had commercially acceptable fruit at both Lexington and Quicksand (Table 4).

Growers should also see results from a similar trial in 2005 from central Kentucky found elsewhere in this publication. Results of additional Kentucky research on pepper cultivars can be viewed in annual Fruit and Vegetable Crops Research Reports on the Web at: www.uky.edu/Ag/Horticulture/comveggie.html.

Table 5. Dates and prices (in dollars) of the grades of bell peppers, 2005.			
Date	**Jumbo and Extra Large**	**Large and Medium**	**Chopper**
June 26	$0.21	$0.15	$0.12
July 3	0.21	0.15	0.12
July 10	0.17	0.12	0.05
July 17	0.19	0.11	0.10
July 24	0.19	0.10	0.07
July 31	0.09	0.09	0.06
August 7	0.17	0.09	0.10
August 14	0.17	0.14	0.11
August 21	0.17	0.08	0.05
August 28	0.09	0.08	0.05
September 4	0.09	0.08	0.05
September 11	0.09	0.08	0.05

Bell Pepper Cultivar Evaluations for Yield and Quality in Central Kentucky

Brent Rowell, April Satanek, and John C. Snyder, Department of Horticulture

Introduction

After completing a two-year (2000-01) evaluation of bell pepper cultivars under induced bacterial spot infection (*Xanthomonas campestris* pv. *vesicatoria* or *Xcv*) and in a bacterial spot-free environment, we began a new series of trials in 2003 to compare new cultivars with a previously recommended, highly resistant cultivar with very attractive fruits (Aristotle). While nearly 100% of the pepper acreage in the state is planted with spot-resistant cultivars having the *Bs2* gene (resistance to *Xcv* races 1, 2, and 3), many new resistant cultivars have been released since 2001. Three of the cultivars in this trial (Revolution, Alliance, and PS9915776 (hereafter referred to as "PS...5776"), reportedly have some tolerance to *Phytophthora capsici*, which is becoming more of a problem in the state. Two cultivars (Heritage and Excursion II) reportedly have resistance to tomato spotted wilt virus (TSWV). This thrips-transmitted disease has become economically important in Illinois and in some southern states in the last few years. All varieties tested have resistance to bacterial spot races 1, 2, and 3, but many have not been tested under epidemic conditions in Kentucky.

Bell cultivars were tested in replicated trials at two locations in 2005 (central Kentucky at Lexington and eastern Kentucky at Quicksand). See also the trial report for the same varieties grown in eastern Kentucky.

Materials and Methods

This trial was planted at the Horticulture Research Farm in Lexington. All 12 cultivars were seeded on 21 March. Seedlings were grown in 72-cell plastic trays and transplanted to the field on 13 May.

The trial field received 57 lb N/acre prior to planting, supplemented by an additional 54 lb N/acre divided into 13 weekly fertigations (111 lb N/acre season total). Potassium was applied prior to planting according to soil test recommendations. Plots consisted of 20 plants in double rows with four replications in a randomized complete block design. All were planted on raised beds with black plastic mulch and drip irrigation. Plants of all cultivars were spaced 12 in. apart in the row with 15 in. between the two rows on each bed. Beds were 6 ft apart from center to center. A tank mix of maneb plus fixed copper was applied biweekly until mid-August for bacterial spot protection. Three applications of synthetic pyrethroid insecticides and one application of spinosad were made for European corn borer control.

Eleven new bell cultivars with the *Bs2* gene were compared with main season control Aristotle (Table 1); six of these were also tested in 2004. Mature green fruits were harvested only three times from 11 July to 10 Aug. Marketable fruits were graded and weighed according to size class (U.S. No. 1 extra large, large, medium). We also weighed misshapen fruits that could be marketed to foodservice as "choppers."

Incomes. Yields in each size class were multiplied by their respective wholesale market prices to determine gross returns (income) for each cultivar. Weekly wholesale prices from Cumberland Farm Products Cooperative for 2004 were used to calculate incomes from the different cultivars. The income variable has been a good indicator of a cultivar's overall performance, taking into account yields of the different size classes and their price differentials. Earlier maturity usually results in higher prices and incomes.

Fruit appearance ratings. All pepper fruits harvested from two replications at the second harvest (26 July) were laid out on tables for careful examination and quality ratings on July 28. Overall appearance ratings took several things into account including, in order of importance: overall attractiveness, shape, smoothness, degree of "flattening," color, and uniformity of shape.

Results and Discussion

Total marketable yields, gross incomes, and fruit quality characteristics are shown in Table 1. The 2005 growing season was unusually hot and dry, and total marketable yields were low, ranging from 9 to 16 tons/acre (600 to 1066 boxes/acre). Consequently, incomes were also lower than in previous years ranging from $2131 to $3703/acre. The group of highest yielding and highest income varieties included Double-up, Socrates, Heritage, Aristotle, and PS...5776 (Table 1). Unlike 2004, yields of Revolution were very low in 2005—perhaps a result of a large percentage of culls due to flattening of fruits in response to hot weather.

Fruit quality characteristics for bell cultivars are also shown in Table 1. The hot weather resulted in flattening of a large percentage of fruits in some varieties (see "Comments" in Table 1) which resulted in lower appearance scores. Aristotle, with no flattening, received the highest appearance rating while PS...5776, Heritage, and Telestar had little flattening and high appearance scores. Other cultivars that received acceptable ratings of 5.0 or better included Double-up, Excursion II, Patriot, Alliance, E41.8338, and Mahi; one-fourth to one-third of the fruits of these varieties were flattened. Socrates and Revolution appeared to be most susceptible to flattening (up to 50%) and received the worst appearance scores (Table 1). While heat-related flattening will not be a problem every year, growers should be aware that some varieties are much more susceptible to this problem than others.

Table 1. Yields, gross returns, and appearance scores of bell pepper cultivars in Lexington, Ky.; yield and income data are means of four replications.

Cultivar	Seed Source	Total Mkt. Yield[1] (tons/A)	% XL + Large[2]	Income[3] ($/acre)	Shape Unif.[4]	Overall Appearance[5]	No. Lobes[6]	Fruit Color	Comments
Double-up	SW	16.1	76	3703	3.2	5.0	3-4	Med	25% flattened; many 3-lobed
Socrates	S	15.7	63	3586	2.5	4.5	4	Lt-med	50% flattened, pumpkin-shaped
Heritage	HM	15.3	72	3843	3.5	5.8	4	Med	Very few flattened
Aristotle	S	14.5	67	3323	3.7	6.5	4	Med-dk	No flattening
PS...5776	S	14.4	67	3142	3.5	6.0	3-4	Med	Very few flattened
Excursion II	AC	13.6	69	3063	3.2	5.0	3-4	Med-dk	33% flattened; some 3-lobed; nice color
Patriot	HM	12.7	67	2777	3.2	5.0	4	Med-dk	25-33% flattened
Alliance	HM	12.1	62	2775	3.0	5.5	4	Med-dk	33% flattened, otherwise nice
Telestar	HA	11.7	62	2581	3.7	6.0	3-4	Med	Many 3-lobed; few flattened
E41.8338	E	11.1	74	2670	3.0	5.5	4	Lt-med	10-25% flattened
Mahi	E	10.1	64	2131	2.5	5.5	4	Med	25% flattened, otherwise nice
Revolution	HM	9.0	56	2131	2.5	4.5	4	Med-dk	33-50% flattened
Waller-Duncan LSD (P = 0.05)		2.9		777					

1 Total marketable yields of U.S. Fancy and No. 1 fruits of medium (>2.5 in. diameter) size and larger plus misshapen, but sound fruit that could be sold as "choppers" to foodservice buyers.
2 Percentage of total yield that was extra-large (>3.5 in. diameter) and large (>3 in. diameter but ≤3.5 in. diameter).
3 Income = gross returns per acre; average 2004 season local wholesale prices were multiplied by yields from different size/grade categories: $0.17-0.19/lb for extra-large, $0.09-0.14/lb for large and mediums, and $0.05-0.11/lb for "choppers," i.e., misshapen fruits.
4 Average visual uniformity of fruit shape where 1 = least uniform, 5 = completely uniform.
5 Visual fruit appearance rating where 1 = worst, 9 = best, taking into account overall attractiveness, shape, smoothness, degree of flattening, color, and shape uniformity; all fruits from two replications observed at the 2nd harvest (26 July).
6 3-4 = about half and half 3- and 4-lobed; 3 = mostly 3-lobed; 4 = mostly 4-lobed.

Cultivars that had the highest yields, incomes, *and* acceptable or better fruit quality ratings were Aristotle, Double-up (but many 3-lobed fruits), Heritage, and PS...5776. Aristotle and Heritage fruits were mostly 4-lobed and appeared to tolerate heat without flattening; Telestar and PS...5776 were also heat tolerant but had larger percentages of 3-lobed fruit. Growers should consider these results together with those reported in 2004 and from the sister trial in eastern Kentucky in 2005.

Acknowledgment

The authors would especially like to thank Darrell Slone and the farm crew for their hard work and generous assistance with this trial.

HORTICULTURAL CROPS—VEGETABLES

Bell and Jalapeño Pepper Evaluations for Yield and Quality in Eastern Kentucky

R. Terry Jones, Charles T. Back, and John C. Snyder, Department of Horticulture

Introduction

As a result of several multi-year studies evaluating bell pepper cultivars for resistance to bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria* or Xcv) and fruit quality, nearly 100% of Kentucky's pepper acreage is planted to resistant bell pepper cultivars with high fruit quality. As new pepper cultivars are released we try to test them for leaf spot resistance, as well as fruit yield and quality under Kentucky conditions. Because Kentucky farmers are planting more vegetable crop acreage, new disease problems like Phytophthora blight (*Phytophthora capsici*) and tomato spotted wilt virus (TSWV) are becoming more prevalent. Past studies have shown that some pepper cultivars with leaf spot resistance to at least three races of Xcv (races 1, 2, and 3) perform well even under high disease pressure. Several of the cultivars in this study contain resistance or tolerance to TSWV or Phytophthora blight in addition to bacterial spot resistance.

In addition to the bell peppers, we evaluated two jalapeno pepper cultivars. Bell pepper cultivars were tested in replicated trials at three Kentucky locations in 2004 (western, central, and eastern).

Materials and Methods

Eight new bell cultivars with the Bs2 gene for bacterial spot resistance were compared with main season and early-season control varieties, Aristotle and Red Knight, respectively (Table 1). Mature green fruit were harvested four times from late June to mid-August. Fruit were graded and weighed according to class size (U.S. No. 1 extra large, large, medium). Yields in each size class were multiplied by their respective wholesale market prices to determine gross returns (income) for each cultivar. Wholesale prices from Cumberland Farm Products Cooperative for 2004 were used to calculate incomes for the different varieties. The income variable has been a good indicator of a cultivar's overall performance, taking into account time of harvest as well as yields of the different size classes and their price differentials.

Fruit appearance ratings. All pepper cultivars harvested on two separate occasions (7/01 and 7/08) were laid out on the ground and evaluated for fruit appearance. Overall appearance ratings were the result of several factors listed in order of decreasing importance: overall attractiveness, shape, smoothness, degree of flattening, color, and uniformity of shape.

Results and Discussion

Total marketable yields, gross incomes, and fruit quality characteristics are shown in Table 3. Total marketable yields based on four harvests ranged from 10.4 to 14.7 tons/acre. The growing season was very wet, and temperatures were cool with overcast skies on many days. Incomes were lower than in previous years and ranged from around $3,100 to $4,500 per acre. Aristotle was once again the top yielding and income return-per-acre pepper. However, it was only significantly better than Red Knight and Patriot. Yields and returns for Excursion II and Revolution were not significantly different from Aristotle but were not included in the analysis because of differences in transplant production methods and planting date.

Table 1. Seed company descriptions of bell cultivars tested at Quicksand and Lexington, 2004.

Cultivar	Source	Days to Maturity	Comments
Socrates	SW	64	Very early, blocky, green to red, sturdy, medium-sized plants, BLS 1,2,3
Patriot	HM	70	Early red, blocky concentrated fruit, BLS 1,2,3,5, and PVY
Conquest	HM	70	Blocky, green to red fruit, phytophthora tolerant
Red Knight X3R	Ru	63	Large, blocky, green to red fruit, medium-tall plants, BLS 1,2,3, PVY
Heritage	HM	75	Green to red fruit, tall plant, TSWV resistant, BLS 1,2,3,5
Alliance (HMX2643)	HM	70?	Blocky, green to red fruit; BLS 1,2,3,5, "intermediate resitance" to phytophthora, PVY, PepMoV, CMV
Aristotle (X3R)	Ru	72	Very large green to red, BLS 1,2,3 and PVY, TMV
Olympus	SW	71	Sturdy plants, heavy yield dark green to red fruit. BLS 1,2,3, some phytophthora resistance
Jalapeno P109	PF		BLS 1,2,3
Ixtapa X3R	Ru	75	Thick, dark green to red jalapeno fruit, BLS 1,2,3
Excursion II	Ru	75?	Large blocky fruit; BLS 1,2,3, TSWV, PVY, and TMV
Revolution (HMX 1660)	HM	72	Large to XL blocky fruit, tall plants. BLS 1,2,3,5, CMV and phytophthora tolerant, cool tolerant

The eight bell and two jalapeno peppers were seeded in 72-cell trays in the greenhouse at the Robinson Station on 18 March and were transplanted to the field on 7 May. Revolution (HMX 1660) was also seeded in 72-cell trays at the Robinson Station greenhouse on 6 May and was planted on 6 June. Excursion II transplants were seeded in 128-cell trays on 2 March near Owensboro. After we received them in early May, they were fertilized and grown for one week in 72-cell trays at Quicksand before transplanting on 15 May.

Based on the soil test results shown in Table 2, 50 lb of actual nitrogen along with 70 lb of P_2O_5 and 60 lb of K_2O/A were applied the day before planting. Ninety additional pounds of nitrogen/A were applied to the peppers during the growing season for a total of 140 lb actual N/A.

Each plot contained 16 plants in double rows with eight plants/row. The in-row spacing was 14 in. with 20 in. between rows. One empty space/row was left between plots. Plots were replicated four times in a randomized complete block design.

Table 2. Soil test results for pepper trial plot at Quicksand, Kentucky, 2004.

pH	Buf-pH	P	K	Ca	Mg	Zn
6.42	6.88	20	308	2426	517	15.2

Aristotle produced significantly more pounds of extra large peppers than six of the other cultivars (Olympus, Conquest, Patriot, Heritage Socrates, and Red Knight). It was similar to Alliance and Revolution in pounds of extra large fruit.

Fruit quality ratings showed that Aristotle, Patriot, Heritage, and Excursion II fruit had the best overall appearance. Conquest had the lowest overall fruit quality rating.

All of the bell peppers except Excursion II had 80% or better extra large or large fruit. One difference between Excursion II and the other nine bell peppers was the cell size used to produce the transplants.

Growers should also see results from similar trials in 2004 from central and western Kentucky.

Results of these trials and additional Kentucky research on pepper cultivars can be viewed in annual Fruit and Vegetable Crops Research Reports on the Web at: www.uky.edu/Ag/Horticulture/comveggie.html

Table 3. Yields, gross returns and appearance ratings of bell and jalapeno pepper cultivars in Quicksand, Kentucky									
Cultivar	**Seed Source[1]**	**Tot. Mkt. Yield[2] (tons/A)**	**Lb XL Fruit/A[2]**	**% XL + Large[4]**	**Income ($/A[5])**	**Overall Appearance[6]**	**No Lobes[7]**	**Fruit Color**	**Comments**
Aristotle	S	14.75	20,710	84.9	$4510	6	3-4	Dk green	Good yield
Alliance	HM	12.7	19,304	88.7	$4165	5	3-4	Pale-med green	High yielder, some misshapen fruit
Olympus	EZ	12.46	15,635	94.1	$3900	4.3	3-4	Mostly dk green	Pale green on shaded side of fruit
Heritage	HM	12.2	14,923	82.9	$3461	5.5	4	Med green	
Conquest	HM	11.32	14,933	82.6	$3323	3.5	3		numerous misshapen fruit
Socrates	S	11.1	14,187	82.9	$3289	5	3-4	Pale med. green	Some misshapen fruit
Patriot	HM	10.4	14,923	86.5	$3164	5.5	3-4	Mostly dk green	Shaded side of fruit pale green
Red Knight	S	10.5	12,635	78.9	$3129	4.5	3-4	Pale green	Low yield
Waller-Duncan LSD (P< 0.05)		2.95	4,952	-	1344				
Revolution	HM	12.7	17,087	87.5	$3184	-	-	-	Did not evaluate because of late planting
Excursion II	AC	12.7	13,398	65.3	$3222	6	4	Dk green	Attractive
Jalapenos:	**Seed Source[1]**	**Tons/A**	**Fruit weight avg. (oz)**	**Fruit no./A**	**Fruit length (in.)**	**Fruit width (in.)**	**Comments**		
Ixtapa X3R	S	16.9	1.34	408,960	3.3	1.5	Smooth, many purple colored		
Pace 109	PF	13.2	1.28	335,195	3.6	1.2	Cracked		
Waller-Duncan LSD (P< 0.05)		ns	ns	ns	ns	ns			

1 Seed source identification and address information are listed in Appendix A of this publication.
2 Pounds of extra large peppers (> 3.5 in. diameter).
3 Total marketable yield includes the yields of U.S. Fancy and No. 1 fruits of medium (> 2.5 in. diameter) size and larger misshapen but sound fruit that could be sold as "choppers" (i.e., misshapen fruits) to foodservice buyers.
4 Percentage of total yield that was extra large (> 3.5 in. diameter) and large (> 3 in. diameter but < 3.5 in.).
5 Income + gross returns per acre: average 2004 season local wholesale prices were multiplied by yields from the different size/grade categories: $0.17 to 0.19/lb for extra large; $0.09 to 0.14/lb for large and mediums, and $0.05 to 0.11/lb for "choppers."
6 Visual rating: 1-9 scale where 1 = worst, 9 = best, taking into account overall attractiveness, shape, smoothness, degree of flattening, color, and shape uniformity; all fruit from two separate replications were observed on 7/01 and 7/08 respectively. A rating of 5 was considered commercially acceptable.

HORTICULTURAL CROPS—VEGETABLES

Bell and Jalapeño Pepper Evaluations for Yield and Quality in Central Kentucky

Brent Rowell, April Satanek, and John C. Snyder, Department of Horticulture

Introduction

After completing a two-year (2000-01) evaluation of bell pepper cultivars under induced bacterial spot (*Xanthomonas campestris* pv. *vesicatoria* or Xcv) and bacterial spot-free environments, we began a new series of trials in 2003 (western Kentucky) to compare some new cultivars with a previously recommended, highly resistant cultivar with very attractive fruits (Aristotle). While nearly 100% of the pepper acreage in the state is planted with spot-resistant cultivars having the *Bs2* gene (resistance to Xcv races 1, 2, and 3), several new resistant cultivars have been released since 2001. One of the cultivars in this trial (Conquest), supposedly has high tolerance to *Phytophthora capsici*, which is becoming more of a problem in the state. The variety unfortunately does not have bacterial spot resistance. Two new cultivars (Heritage and Excursion II) reportedly have resistance to bacterial spot and tomato spotted wilt virus (TSWV). This thrips-transmitted disease has become economically important in Illinois and in some southern states in the last few years.

In addition to bells, we also observed performance of a jalapeno cultivar from Pace Foods (non-bacterial spot resistant) and compared it with a recommended bacterial spot resistant cultivar (X3R Ixtapa). Bell cultivars were tested in replicated trials at three locations in 2004 (central Kentucky at Lexington, eastern Kentucky at Quicksand, and western Kentucky in Owensboro).

Materials and Methods

This trial was planted at the Horticulture Research Farm in Lexington (LEX). Eight of the ten bell and two jalapeno pepper cultivars were seeded in the greenhouse in eastern Kentucky at the Robinson Station at Quicksand on 18 March. Seedlings were grown in 72-cell plastic trays and transplanted to the field at LEX on 25 May. Two cultivars, Revolution and Excursion II, were obtained from the West Kentucky Growers Cooperative. These had been seeded earlier than the other cultivars and the transplants were older and in poorer condition at transplanting. For this reason, these two cultivars were not included in the statistical analyses, and growers should use caution interpreting their yields.

The trial field received 64 lb N/acre prior to planting, supplemented by an additional 58 lb N/acre divided into nine weekly fertigations (122 lb N/acre season total). Phosphorus and potassium were applied prior to planting according to soil test recommendations. Plots consisted of 20 plants in double rows with four (bells) and two (jalapenos) replications in a randomized complete block design. All were planted on raised beds with black plastic mulch and drip irrigation. Plants of all cultivars were spaced 12 in. apart in the row with 15 in. between the two rows on each bed. Beds were 6 ft apart from center to center. A tank mix of maneb plus fixed copper was applied weekly until 23 July for bacterial spot protection. A pheromone trap for adult male European corn borers was placed adjacent to the trial field. Only two applications of synthetic pyrethroid insecticides were made in August for corn borer control.

Eight new bell cultivars with the *Bs2* gene were compared with main season and early-season controls Aristotle and Red Knight, respectively (Table 1). Mature green fruits were harvested five times from 2 July to 8 Sept. Marketable fruits were graded and weighed according to size class (U.S. No. 1 extra large, large, medium). We also weighed misshapen fruits that could be marketed to foodservice as "choppers." Yields in each size class were multiplied by their respective wholesale market prices to determine gross returns (income) for each cultivar. Weekly wholesale prices from Cumberland Farm Products Cooperative for 2004 were used to calculate incomes from the different cultivars. The income variable has been a good indicator of a cultivar's overall performance, taking into account yields of the different size classes and their price differentials.

Fruit appearance ratings. All pepper fruits harvested from all four replications at the fourth harvest (Aug. 17) were laid out on tables for careful examination and quality ratings on Aug. 20. Overall appearance ratings took several things into account including, in order of importance: overall attractiveness, shape, smoothness, degree of "flattening," color, and uniformity of shape.

Results and Discussion

Bell cultivars. Total marketable yields, gross incomes, and fruit quality characteristics are shown in Table 1. Although the 2004 growing season was unusually cool, cloudy and wet, total marketable yields were relatively high, ranging from 17 to 30 tons/acre. Incomes, however, were considerably lower than in previous years because of low wholesale prices. In addition, unexplained plant losses in some of the plots made it necessary to use correction factors to equalize the number of plants per plot; this made it more difficult to detect statistical differences among the cultivars tested.

Aristotle was once again the top-yielding (total marketable yield) cultivar, although yields of Red Knight were not statistically different from Aristotle (Table 1). Yields of Revolution and Excursion II, although not included in the statistical analyses, appeared

Table 1. Yields, gross returns, and appearance of bell and jalapeno pepper cultivars in Lexington, Kentucky; yield and income data are means of four replications.

Cultivar[1]	Seed Source	Tot. Mkt. Yield[2] (tons/A)	% XL +Large[3]	Income[4] ($/A)	Shape Unif.[5]	Overall Appear.[6]	No. Lobes[7]	Fruit Color	Comments
Aristotle	S	29.8	83	4359	4	6	3	dk green	
Red Knight	S	27.4	76	4197	2.5	5	4	med green	some silvering and 'pumpkin' shapes
Patriot	HM	24.1	80	4007	2	6	3-4	med dk green	
Socrates	S	22.6	78	3680	2	5	3-4	lt-med green	
Conquest	HM	24.0	76	3671	2	5	3	lt-med green	many "apple"-shaped
Alliance	HM	21.6	77	3458	2	5.5	3-4	med green	
Heritage	HM	22.2	83	3870	3	6	4	med green	
Olympus	EZ	17.5	78	2802	2.5	4.5	4	med-dk green	
Waller-Duncan LSD (P<0.05)		5.0	13	974					
Revolution	HM	26.8	79	3525	3	6	3-4	med green	nice blocky shape
Excursion II	AC	28.5	83	3407	3	6	4	dk green	
Jalapenos:									
Ixtapa	S	32.7	50% of fruits with purple coloring; very little cracking compared with Pace 109; very uniform						
Pace 109	PF	26.8	Most fruits showing extensive cracking, very uniform. Longer (3.4 in.) than Ixtapa (3.0 in.)						

1 Cultivars Revolution and Excursion II were from older transplants and were not included in statistical analyses.
2 Total marketable yields of U.S. Fancy and No. 1 fruits of medium (> 2.5 in. diameter) size and larger plus misshapen, but sound fruit that could be sold as "choppers" to foodservice buyers.
3 Percentage of total yield that was extra-large (> 3.5 in. diameter) and large (> 3 in. diameter but < 3.5 in. diameter).
4 Income = gross returns per acre; average 2004 season local wholesale prices were multiplied by yields from different size/grade categories: $0.17 to 0.19/lb for extra-large; $0.09 to 0.14/lb for large and mediums, and $0.05-0.11/lb for "choppers" (i.e., misshapen fruits).
5 Average visual uniformity of fruit shape where 1 = least uniform, 5 = completely uniform.
6 Visual fruit appearance rating where 1 = worst, 9 = best, taking into account overall attractiveness, shape, smoothness, degree of flattening, color, and shape uniformity; all fruits from all four replications observed at the fourth harvest (Aug 17).
7 3-4 = about half and half 3- and 4-lobed; 3 = mostly 3-lobed; 4 = mostly 4-lobed.

to be as high as Aristotle, in spite of the older transplants used for these cultivars.

Fruit quality characteristics for bell cultivars are also shown in Table 1. Aristotle, Patriot, Heritage, Revolution, and Excursion II received the highest fruit appearance ratings. The other cultivars received marginal ratings with Olympus receiving the worst rating of 4.5. Aristotle and Excursion II had the darkest green fruits among cultivars in the trial.

Cultivars that had the highest yields *and* acceptable or better fruit quality ratings were Aristotle, Patriot, Revolution, and Excursion II. Growers should consider these results together with results reported from the other trials in eastern and western Kentucky in 2004. In contrast to our results, Olympus was the highest yielding cultivar in the 2003 trial in western Kentucky. Revolution was also among the top yielding/highest income cultivars in that trial.

Jalapeños. Yields of the Pace Foods cultivar (Pace 109) were acceptable under our conditions, although not as high as from the bacterial leaf spot-resistant Ixtapa. Fruits of the Pace cultivar were longer and thinner but cracked more than Ixtapa. Ixtapa had many fruits with purple coloring, especially when temperatures were cooler. These cultivars were not exposed to bacterial spot in this trial. Many other jalapeño pepper cultivars were tested at LEX and in eastern Kentucky in 2000-2001. Results of these trials and additional Kentucky research on pepper cultivars can be viewed in annual Fruit and Vegetable Crops Research Reports on the Web at: www.uky.edu/Ag/Horticulture/comveggie.html

Acknowledgment

The authors would especially like to thank Darrell Slone and the farm crew for their hard work and generous assistance with this trial.

HORTICULTURAL CROPS—VEGETABLES

Development of *Capsicum baccatum* as an Ornamental Plant

John Snyder and Angel Santos, Department of Horticulture

A few years ago we discovered dwarf plants in a grow-out of seed of an accession of *Capsicum baccatum*. Variegated plants were also noted. The accession was originally obtained from the USDA Regional Plant Introduction Station in Georgia. The main activities pursued under the New Crop Opportunities grant were evaluation of whether the dwarf phenotype had potential as an annual in the landscape and the genetic control of the dwarf phenotype. The approach taken was to select seed from open–pollinated plants and then grow out progeny the following year. Evaluation included notation of plant form, segregation for dwarf and normal stature, fruit color, earliness, disease and insect problems, and fruit pungency. In addition, the plants were evaluated by landscape professionals and Master Gardner volunteers.

For the first year in the field, plants segregated 3 tall:1 dwarf, suggesting simple Mendelian inheritance. Seeds from all dwarfs were harvested and grown-out in the greenhouse to insure that the progeny arising from field pollination were similar to the maternal parent. Approximately 17 lines were tested, with approximately 20 plants per line. Very little evidence of cross pollination was observed. Frequency of tall, non-dwarf plants was very low (less than 3%). This observation suggested a high degree of self-pollination because the plants in the field had segregated in a 3:1 ratio, (tall: dwarf). If cross pollination had occurred, the plants in the greenhouse trial should have also segregated for dwarf and tall.

Based on the greenhouse observation, a ¼-acre plot of dwarf plants consisting of 17 families were grown in the field in 2004. All but one of these families were dwarf; however, there was a great deal of variation for dwarf plant form, fruit size, fruit presentation, fruit shape, color ripening pattern, and earliness. There were few to no insect or disease problems. The main variation in form was due to early branching. For some lines, the first three or four nodes produced branches, which then terminated when they were about 1 foot long. This produced a wide, low-growing plant. All plants were very fruitful. Plants were evaluated by landscape professionals and by Master Gardeners having an interest in landscape annuals. Nearly all evaluators expressed less preference for certain phenotypes, especially single-stem plants that bore fruit mainly on the stem, and single-stem plants having a tuft of conical fruit at the plant apex. More preferred were the spreading type plants, with erect visible fruit. Another phenotype that was preferred was the larger, later flowering, showy phenotypes. Lastly, a fruit ripening pattern of green to orange to red was considerably more visible than the more predominant change of green to red. All lines were very pungent.

Based on the prior year's experience that indicated most of these plants would self-pollinate in the field, we selected fruit from individual plants and also bulked seed from most plants of two selected families. Selection was based on presence of characteristics having high value as indicated by the evaluators.

In 2005, approximately 3/8 acre of progeny of single plant selections and a small representation of bulked families were grown at the University of Kentucky Horticulture Research Farm in Lexington. All plants were dwarf, but by the middle of summer it was apparent that the expected phenotypes were not present in the field. Also, close observation revealed extensive bee visitation to the flowers. These results suggest that most of seedlings in the field had arisen by cross pollination in 2004, unlike the field-produced seed in 2003. Clearly, pollination had occurred mainly among dwarf types, because nearly all seedlings were dwarf. However, most of the desirable phenotypes that had been present in the 2004 experiment were not present, unlike the previous year. Consequently, selection could not be practiced on these progeny, and to recover the desirable phenotypes we will have to rely on remnant seed.

Although most of the seedlings in the 2005 field plot arose by cross pollination, these pollinations represented a narrow gene base, and consequently there was a degree of inbreeding. New characters were uncovered, two of which may be very valuable in the overall success of this project. One character is ripe fruit that are yellow to dark yellow. Another character is purple foliage in these determinant lines. The yellow fruit are very visible from a distance. Seed of these lines are in hand, obtained by self-pollination in the greenhouse. Future work will need to rely on self-pollination of lines.

Also in 2004, we screened a number of other lines of *C. baccatum* for pungency and identified several that had no pungency. These lines have been selected, and if interbred with the determinant phenotype, would allow production of non-pungent, determinant phenotypes.

Development of Uba Tuba

During the period covered by the grant, the effects of fertility and plant spacing on fruit-set and yield of Uba Tuba were examined closely. The hypothesis that early fruit set in Uba Tuba was inhibited by excessive N fertilization was unequivocally rejected. The hypothesis that close intraplant spacing inhibited early fruit-set was also unequivocally rejected. Pro-Gibb was demonstrated to have a positive effect on total fruit yield but not on early fruit-set. Early planting had little impact on early fruit-set. Geographic location had little impact on early fruit-set. Fruit can be stored for at least three weeks. Future work must be aimed at providing a better understanding of the lack of fruit-set during June and July on Uba Tuba.

HORTICULTURAL CROPS—VEGETABLES

High Tunnel Winter Spinach Production in Central Kentucky

Amanda Ferguson, Darrell Slone, Robert Houtz, and Brent Rowell, Department of Horticulture

Introduction

Dr. E. M. Emmert developed high tunnel plasticulture over 50 years ago at the University of Kentucky. Although the use of plastic tunnels has spread all over the world, this research is being revitalized at the University of Kentucky Horticulture Research Farm in Lexington. A high tunnel is a plastic-covered house, usually "Quonset-hut" in shape. There is no electricity for heating or ventilation, and the only external link is irrigation. Other universities are doing similar research while publishing plans and guidelines for large-scale high tunnels. The University of Kentucky high tunnels are low-cost and rely on commonly available materials. Kentucky's mild winter enables the use of simpler tunnels than those used in other parts of the country. The goal of our research was to develop and test a low-cost production system that allows Kentucky farmers to produce high quality produce off-season for local markets.

Materials and Methods

Four high tunnels were constructed in early November 2002 and December 2003 at the Horticulture Research Farm in Lexington. Each tunnel was built with a single layer of 6-mil clear plastic supported by painted PVC pipe and wooden endwalls. The tunnels measured 10 feet wide by 40 feet long by 6 feet high. Two beds were formed that ran the length of the each tunnel. One of the beds inside the tunnel was also protected by another tunnel (more like a row cover). These inner tunnels were made by bending PVC pipes into 4-foot diameter half circles and covering them with clear 6-mil plastic.

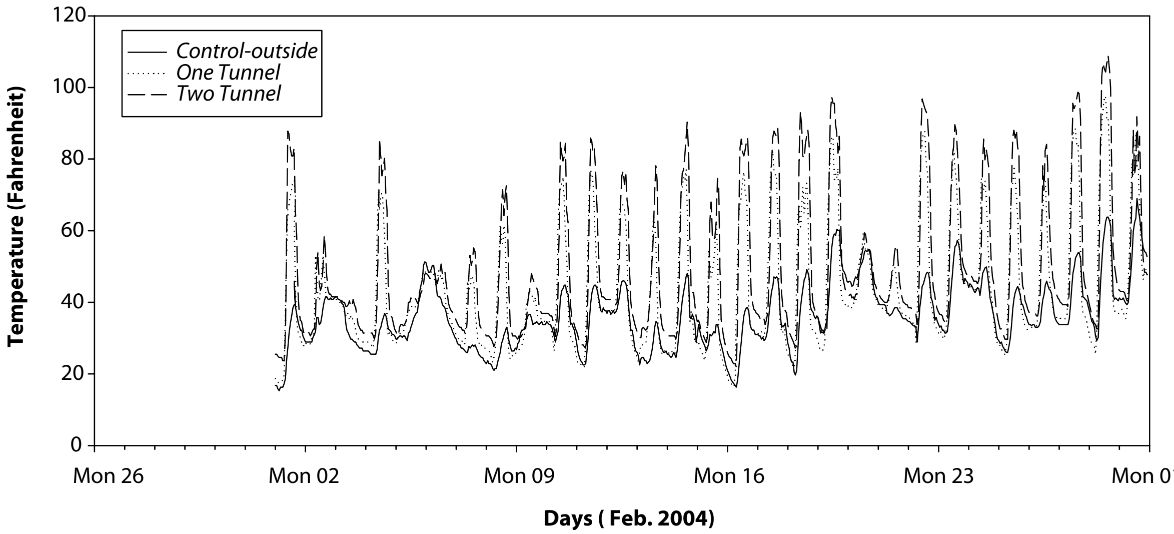
Each of the beds contained spinach, lettuce, and kale. These cool-season crops were seeded in mid-October in the greenhouse. The plants were transplanted (prior to tunnel construction) on black plastic mulch with trickle irrigation on December 15 (2002) and November 10 (2003) using a waterwheel setter with a custom-made waterwheel. Spinach and lettuce were planted at 8 inches between plants and 4 inches between rows. There were three rows of both spinach and lettuce in each main bed. The kale was spaced 1foot between rows and 17 inches between plants. There were two rows of kale in each main bed. These crops were also planted outside the high tunnels to provide an uncovered control. For each treatment (none, one cover, or two covers), ground and air temperatures were recorded, as well as photosynthetic active radiation at 30-minute intervals.

Results and Discussion

Air and soil temperatures. Although air and soil temperatures were measured in 2003 and 2004, only 2004 data are reported here because of sensor errors in 2003. Air temperatures (February 2004) among the two treatments and the control are shown in Table 1 and Figure 1. Air temperature was highest (maximum 109°F) in the tunnel-within-tunnel (two-tunnel) treatment, followed by the single-tunnel treatment (98°F) with the coolest temperatures from the outside control (69°F). Overall, the tunnel-within-tunnel treatment was 6°F higher than the one-tunnel treatment, which was 7°F higher than the outside control.

Soil temperatures did not fluctuate as much or as quickly as the air temperatures (Table 2 and Figure 2). The highest temperatures were in the tunnel-within-tunnel treatment, followed by the one-tunnel. The coolest 2004 soil temperatures occurred in the outside control

Figure 1. Air temperature for February 1-29, 2004, for three treatments (control, one-tunnel, and two-tunnel).



with a low of 29°F. In the tunnels, the lowest soil temperatures were in the mid- to high 30s. The highest soil temperature in the control was just above 50°F, while the highest temperature in the two-tunnel treatment was over 70°F. High temperatures reached the mid-60s in the single-tunnel treatment. The soil temperatures averaged 8 and 12 degrees higher in the single-tunnel and tunnel-within-tunnel treatments, respectively, compared to the control plot (Table 2).

Yields. The only crop that yielded marketable produce during this experiment was spinach. Lettuce and kale proved unsatisfactory for this type of growing environment during the months they were tested. The optimal growing temperatures for lettuce range from the 60s to lower 70s with night temperatures in the mid-40s. The average air temperature in our tunnels ranged from the upper 30s to the lower 40s. This most likely led to the poor growth of the lettuce crop. Kale has similar growing temperature requirements.

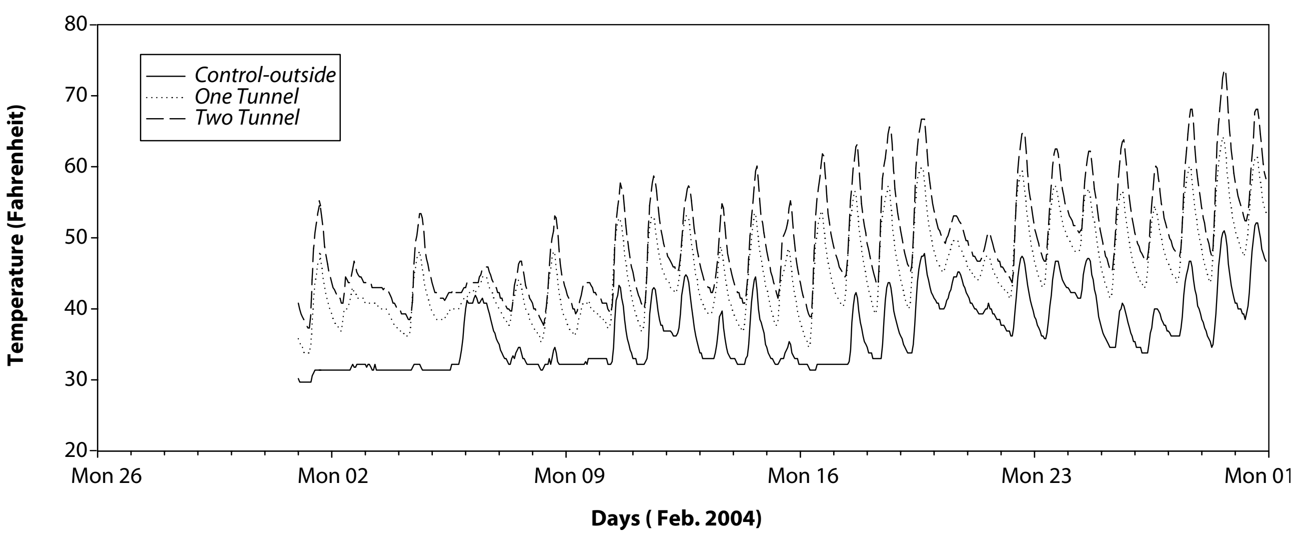
Table 1. High tunnel air temperatures (in degrees Fahrenheit) in 2004.

	Overall Average	Absolute High	Absolute Low
Control (outside)	36	69	15
One-tunnel	43	98	16
Two-tunnel	49	109	22

Table 2. High tunnel soil temperatures (in degrees Fahrenheit) in 2004.

	Overall Average	Absolute High	Absolute Low
Control	37	52	30
One-tunnel	45	64	34
Two-tunnel	49	74	37

Figure 2. Soil temperatures for February 1-29, 2004, for three treatments (control, one-tunnel, and two-tunnel).



Another problem experienced with kale was that it bolted (began to flower) quite suddenly as spring approached. Bolting occurs during periods of warmer temperatures as spring approaches. It may be possible to plant kale earlier to avoid bolting, which would allow it to reach a marketable stage. A hardier cultivar of lettuce may also work better in this environment.

Harvest dates for spinach grown within tunnels and outside are shown in Table 3. The average spinach yields over the two years of the experiment revealed a significant difference between the control and the tunnel treatments (Table 4). The average plant weight from the outside (uncovered) plots was only 18 grams, while the average weight of spinach plants from the one-tunnel and tunnel-within-tunnel treatments was over 90 grams. Both the one-tunnel and the tunnel-within-tunnel yields were significantly different from the control. The outside control plots yielded just over 3 lb of spinach per 10 feet of row over three harvests. The one-tunnel treatment, yielded 9 lb/10 ft row, while the two-tunnel treatment yielded 11 lb/10 ft over three harvests (Table 4). This difference was not statistically significant.

Table 3. Harvest dates of spinach in high tunnels in 2003 and 2004.

	Harvest Date	Days after Transplanting
1st	3 Mar '03	77
2nd	15 Mar '03	89
3rd	26 Mar '03	100
1st	6 Feb '04	88
2nd	10 Mar '04	120
3rd	2 Apr '04	143

Table 4. Average plant weight (in grams) and spinach yields, 2003 and 2004.

Treatment	Avg. Plant Weight	Total Marketable Yield (lb/10 ft row)*
Control (outside)	17.8	3.2
One-tunnel	92.1	9.1
Tunnel-within- tunnel	99	11.1
LSD (P = 0.05)	16.2	2.1
* Over three harvests		

MARKETING AND ECONOMICS

2006 Kentucky Restaurant Produce Buyer Survey

Tim Woods, Matt Ernst, and Jeffrey Herrington, Department of Agricultural Economics

Selling Produce to the Foodservice Sector

The foodservice sector includes restaurants and other institutions providing prepared meals away from home. This market channel has been growing for food consumption in the United States in general and for fresh produce in particular. A recent study estimated that 50% of consumer produce sales are through foodservice establishments.[1] This phenomenon is happening in Kentucky as well. Local restaurants provide a ripe market niche for Kentucky farmers selling fresh vegetables and fruit. Though sales to restaurants typically account for less than 15% of a grower's total sales, prices paid by restaurants are normally stronger than wholesale and auction prices. In particular, selling to restaurants is a way for growers who have had some success with on-farm or farmers' market stands to increase their sales volume.

This paper summarizes the produce marketing activity associated with the restaurant market channel in Kentucky. It also summarizes the results of a survey of restaurant chefs and owners who purchase produce, specifically exploring their demand for certain items and service needs from local suppliers. Finally, the paper explores restaurant interest in local sourcing and promotion programs in Kentucky.

The Restaurant Rewards Program

The Kentucky Department of Agriculture (KDA) and Partners for Family Farms initiated a cost-share program called *Restaurant Rewards.* It is designed to encourage restaurants to expand their purchases and promotion of locally sourced food products. The program sought to expand on initiatives first begun by the Kentucky State Parks program. The Restaurant Rewards program provided funds through the KDA to participating restaurants to promote products they were purchasing locally, reimbursing a share of the promotion costs proportional to the amount of product purchased. Part of the intended outcome was to encourage more restaurants and local producers in mutually beneficial marketing opportunities, ultimately building new long-term business relationships.

One of the difficulties with developing such a program is coordinating supply and demand. There were 27 restaurants that participated in the program in 2005. Many of the restaurants and state parks expressed frustration in not being able to secure the necessary supply. Farmers also were reluctant to pursue these markets because of the uncertainties of what products were being demanded, a lack of awareness of the interest in local produce, and an underdeveloped distribution network to move the products profitably from the farm to the restaurant.

One of the objectives of surveying Kentucky restaurant buyers was to provide better information on products and services demanded from local farmers. The survey also explored awareness of the Restaurant Rewards program among restaurateurs. Restaurants that already work to some extent with local producers could take advantage of the program to expand their promotion and merchandising. Other restaurants with patrons expressing high interest in local products have more incentive through this program to seek out sources of local produce they could promote.

Producers could use this information to help develop a production and marketing plan, perhaps implementing business practices that would more effectively serve their restaurant clients.

[1] P. Kaufman, C. Handy, E. McLaughlin, K. Park, and G. Green, "Understanding the Dynamics of Produce Markets," USDA-ERS AI Bulletin No. 758, August 2000.

Exploring Restaurant Demand in Kentucky for Local Produce

A single-mailing survey was sent to 280 restaurants and state resort parks in Kentucky, including the Northern Kentucky/Downtown Cincinnati area. Restaurants were selected from the Kentucky AAA restaurant directory. Usable responses were returned by 64 restaurants, a 23% response rate. The survey explored restaurant interest in specific vegetables, fruits, and herbs and sought to identify the barriers restaurants perceive in purchasing Kentucky-grown produce. A copy of the questionnaire is available at http://www.uky.edu/ag/newcrops/questionnaire.pdf.

Restaurant Demographics

Restaurants were asked to classify themselves in one of four categories: American casual, American white tablecloth, ethnic, and other.

Most of the restaurants (39, 62%) fell in the American casual category. There were 12 responses (18%) from white tablecloth American restaurants and five responses (8%) from ethnic restaurants. Eight (13%) of the restaurants responded that they were in the "other" category. Restaurants in this category identified themselves as bed and breakfasts, bistros, or cafés specializing in organic cuisine. Restaurants responded geographically in a similar proportion surveyed.

Demand for Locally Grown Vegetables and Melons

The percentage of restaurants indicating interest in each crop is listed in Figure 1. The survey instrument asked respondents to rank crops in terms of those which they would be "interested" or "very interested" in purchasing. Interest in fresh vegetables was particularly high. Regular tomatoes, bell peppers, and greens of all kinds were at the top of the list and widely used among most restaurants. Other items that may be less widely demanded may still have significant promotion opportunities among the restaurants that demand them, either as seasonable items or as part of a mix of items that could be promoted together.

Demand for Locally Grown Fruit

Blackberries, grapes, apples, and blueberries were the most popular fruit crops for over half of the restaurants surveyed. While interest was slightly less for fruits than for vegetables, there was still significant demand. Fruit crops tend to be higher value items, more perishable, and more difficult for many local restaurants to find locally. As with vegetables, most fruit products are going to be used as an ingredient. Qualities of ripeness and flavor are going to be at least as important as the physical appearance of the product. A summary of demand by fruit item is presented in Figure 2.

Herbs

Due to the volume of requests for information about selling herbs to restaurants, a particular effort was made to include an extensive listing of herbs in this survey. Herbs are relatively easy to grow, and many restaurants are interested in purchasing fresh herbs from growers. Herbs like basil, garlic, and cilantro that are used in comparatively greater quantities are most demanded by restaurants. The market for more minor herbs may be less, especially since many chefs grow their own herbs in small kitchen gardens.

A challenge for including these products is the relatively small amount of each product that is used by any one restaurant. It may be best to package certain herbs with other vegetables and fruits being delivered, either from one diversified farming operation or from several operations that specialize in production but can share in deliveries. Figure 3 summarizes restaurant interest in local herbs.

Barriers to Purchasing Locally Grown Produce

Many restaurants are interested in purchasing locally when possible and are aware that their own patrons respond favorably to promotions of local produce. Still, there are important barriers these buyers face when trying to source locally. A section of the survey specifically dealt with identifying these barriers.

Figure 1. Restaurant interest in local vegetables and melons. Based on 64 usable surveys.

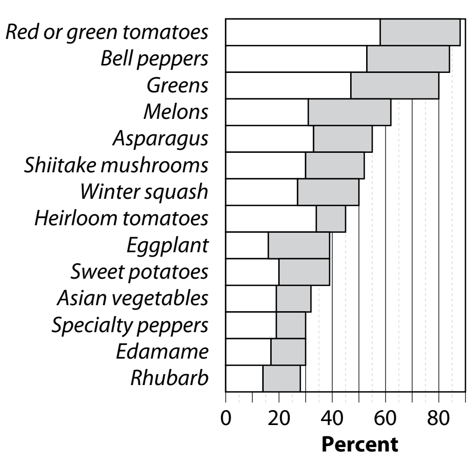


Figure 2. Restaurant interest in locally grown fruit. Based on 64 usable surveys.

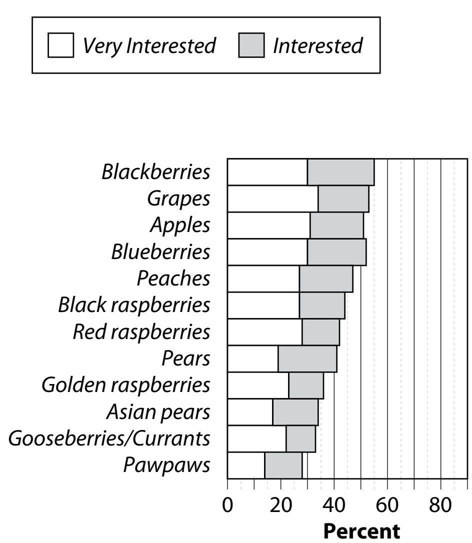
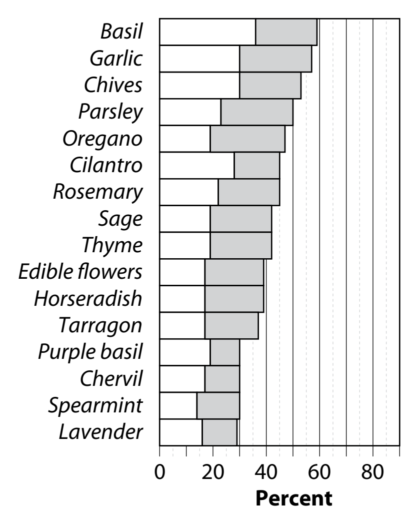


Figure 3. Restaurant interest in locally grown herbs. Based on 64 usable surveys.



Produce buyers for restaurants were asked an open-ended question about barriers that they perceived or experienced when sourcing local produce. Availability, quality consistency, and reliability of supply were cited as the most common barriers. Responses are summarized in Table 1.

Table 1. Barriers to Sourcing Locally.

Barrier	Percent Citing
Consistent availability of product	52%
Consistent quality of product	33%
Timing and reliability of deliveries	24%
Competitive pricing	14%
Locating local producers to source product from	10%
Lack of: Proper Invoicing Organic Products Properly prepared product (cleanliness)	5% each
Not wanting multiple vendors	3%

These barriers are also reflected in the responses to a Likert scale, in which restaurant produce buyers ranked, on a scale of 1 to 5, which business functions local growers most needed to focus on. Responses are in Table 2. Uniform quality and consistent *in-season* availability emerged as the key things for growers to deliver to potential restaurant customers. Services like packaging and contracts were of much less importance to these chefs. Although relatively few indicated organic produce to be prerequisite business function, many chefs do place a premium on such products and also have very high standards of quality in general.

Table 2. Product and Service Needs from Local Suppliers.

Business Function	Average Score*
Uniform Quality Product	4.6
Competitive Prices	4.6
Quality Assurance	4.6
Timing of Delivery	4.5
Quality Specifications at Delivery	4.4
Peak Season Availability	4.3
Documented Safety Assurances	4.2
Year-Round Availability	3.9
Variety of Products	3.8
Professional Business Communication	3.8
Single Source of Supply	3.4
Labeling for Traceability	3.2
Organic Product Choices	3.1
Packaging	3.0
Production Contracts	2.7

* 1=Not Important, 5=Very Important
Note: A few restaurants did not respond to all these questions.

In sum, quality and service are critical business functions that these buyers seek from local suppliers. Price is also an important factor. Many restaurants depend on large foodservice companies for their produce. These large firms are able to assure consistent supply and can keep their prices low through volume and sourcing nationally. Local growers can be competitive on freshness and other qualities, but they must also be competitive on price.

Kentucky Restaurants and Demand for Locally Grown Produce

The last part of the survey explored the demand for locally grown produce generally among Kentucky restaurants. These questions provided some perspective on the buyers' perceptions of their patrons' interests in local produce as well as the restaurants' related marketing programs.

A significant majority of restaurants replying (89%) indicated that it was at least "somewhat" important for their patrons to connect the restaurant's menu to the local agricultural community.[2] Specific responses are summarized in Table 3, below.

Table 3. How important do you believe it is for your restaurant clients to be able to connect your restaurant's menus to the local agricultural community?

Ranking	Number (Percent)
Not very important	7 (11%)
Somewhat important	23 (37%
Very important	33 (52%)

A surprisingly high number of restaurants (a majority) do some kind of promotion of locally grown produce on their menu (Table 4). While respondents did not have the opportunity to provide details of the extent of their marketing programs, many programs already exist. The majority of the restaurants responding were not aware of the program (Table 5).

Table 4. Do you advertise your menu as including locally grown produce?

Response	Number (Percent)
No	27 (44%)
Yes	35 (56%)

Table 5. Are you aware of the advertising cost-share program Restaurant Rewards, sponsored by the Kentucky Department of Agriculture?

Response	Number (Percent)
No	35 (56%)
Yes	28 (44%)

Some interesting comparisons between the data in Tables 3 through 5 reveal the following:

- Number of restaurants advertising menus with local food that were unaware of Restaurant Rewards: 11 of 34.
- Number of restaurants that said local food is very important that were unaware of Restaurant Rewards: 12 of 32.

The conclusion here is that there are quite likely many restaurants in Kentucky that have patrons that are at least somewhat interested and perhaps very interested in seeing more locally sourced produce. The Restaurant Rewards program has great potential to impact many more restaurants and growers. A promotion of the program that would include informing growers and restaurant buyers would be helpful. Sample merchandising tools that have been successful promoting local produce would be helpful to program participants as well.

[2] There is always a danger of response bias in surveys like this. It is conceivable that restaurants more interested in local produce were more likely to respond to the survey, given its subject. The percentages could therefore overstate somewhat the responses to client interest in local produce, for example, than would be observed from a full reporting of all the restaurants surveyed. Program awareness among non-respondents, however, is also apt to be higher.

2006 Kentucky Produce Planting and Marketing Intentions Survey and Outlook

Tim Woods, Matt Ernst, and Jim Mansfield, Department of Agricultural Economics

Summary

The 2006 Kentucky Produce Planting and Marketing Intentions Survey measured marketing practices and planting intentions of Kentucky fruit and vegetable growers, focusing primarily on commercial vegetable growers. This is the fourth consecutive year this survey has been conducted. This year's survey was returned by 269 produce growers, representing 1,814 commercial vegetable acres and 526 commercial fruit acres. This represents a 22% response rate and approximately 23% of commercial produce acreage in Kentucky.

Gross sales from Kentucky's commercial produce will remain steady or increase from the 2005 level of $32 million. Despite two vegetable marketing cooperatives closing in 2005, these sales continue to increase, bolstered especially by vigorous growth among Kentucky's farmers' markets. Commercial vegetable acreage will increase to about 8,100 acres in 2006, while commercial fruit acreage will decrease about 18% from its 2005 level to about 2,500 acres. Projections for specific produce items are presented in Appendix 4 at the end of this report. This survey indicates more producers are relying on direct sales at farmers' markets and more sales to retailers, bypassing the traditional middle level of the produce supply chain and keeping gross farm sales strong. Vegetable acreage formerly marketed through co-op facilities has been offset by growth in grower-shipper wholesale acreage and vigorous growth by two of Kentucky's four produce auctions. Though still minor parts of the Kentucky produce industry, direct sales to restaurants and subscription sales (community supported agriculture) also appear to be bolstering farm produce sales, especially among smaller producers.

Structural Changes: Co-ops

Citing poor weather and weak markets, the boards of directors of two of Kentucky's vegetable marketing cooperatives (West Kentucky Growers Co-op, Owensboro, and Green River Produce Co-op, Horse Cave) voted to close their doors after the 2005 season. These co-ops had received substantial support through tobacco settlement monies as opportunities for tobacco growers to diversify.

There were 19 producers responding to this survey who produced through a co-op in 2005. All but one of these producers planned to grow produce in 2006. The total decline in acreage among these producers was about 40%. There were 10 growers who had participated in co-ops in 2005 who indicated they would grow tobacco in 2006; all of these marketed 75% or more of their produce through co-ops in 2005. The percent of growers responding to this survey who used cooperatives to market any fresh produce decreased from 17% in 2002, to 11% in 2004, to 7% in 2005. *(Changes in co-op acreage, by crop, from 2002-2005 are reported in Appendix 1.)*

It is important to note that while the produce marketed through the cooperatives tended to involve larger producers and captured much of the media attention as the industry has been developing, it represents only a small fraction of the produce marketing activity in Kentucky. Only 8% of the producers who responded indicated they sold over 10% of their produce through a cooperative in 2005. Further, acreage projections continue to increase overall, despite the business closures observed. Direct marketing and other wholesale marketing channels remain vital to most growers.

Tobacco Production

Large numbers of Kentucky's tobacco growers exited tobacco production in 2005 in response to the national tobacco buyout program. The impact of this exit on total farm incomes is yet to be determined. Almost 25% of the producers responding to this survey said they grew tobacco in 2005, compared to about 45% in the previous five years. About one in three (37%) of those who grew tobacco in 2005 indicated they would *not* grow tobacco in 2006. Interestingly, nine of the growers who grew tobacco in 2005 indicated they would not grow tobacco in 2006, and five of these growers indicated that they would be expanding vegetable production.

New or Expanding Markets

In spite of co-op marketing uncertainty, the 2006 value of Kentucky vegetable and fruit production is projected to continue to rise as producers are discovering other profitable markets, including many direct markets.

Farmers' Markets

Kentucky farmers' markets have tripled in number during the past decade. There were 95 farmers' markets registered with the Kentucky Department of Agriculture in 2005, with estimated gross sales of $8 million. Farmers' markets account for about one-quarter of all Kentucky farm produce sales.

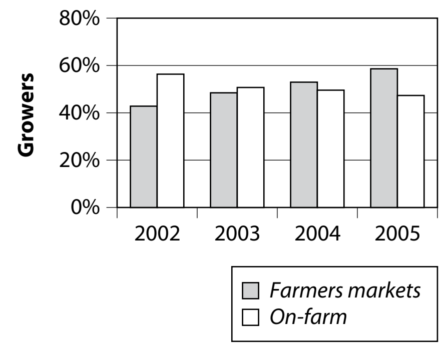
The percentage of respondents to this survey using farmers' markets to sell 10% or more of their produce has increased by at least 5% per year since 2002. In 2002, 42% of respondents indicated they sold 10% or more of their produce at farmers' market. In 2003, the level rose to 47%; in 2004, 52% of respondents said they sold 10% or more of their produce at farmers' markets. In 2005, 58% of respondents said they used farmers' markets to market 10% or more of their produce.

Farmers' markets also have the distinction of having a disproportionate number of growers marketing 100% of their produce through this market channel. In 2005, 46 of the respondents (17%) indicated that they sold 100% or more of their produce through farmers' markets.

Because the survey's anonymity does not guarantee the same producers respond each year, the actual percentage of farmers' market participation may vary. When compared with a more rapid rate of growth in the number and gross sales at Kentucky farmers' markets since 2002, the 5% annual increase in farmers' market participation suggests that farmers' markets are multiplying as growers participate in multiple markets. This is supported by anecdotal evidence and observations of member list information of farmers' markets around the state.

Another likely possibility for the increase in farmers' market sales and participation is a decrease in the number of growers reporting that they market produce from their farm, from 55% in 2002 to 46% in 2005 (Figure 1).

Figure 1. Percent of Growers Selling More than 10% in Market Channel.



Restaurants

The percent of Kentucky growers selling produce to local restaurants remained static from 2002 through 2004. However, in August 2004, restaurants at the Kentucky state resort parks began purchasing fresh produce from Kentucky farmers, and interest in selling to restaurants expanded. This initiative opened up a $500,000 market for fresh produce to growers in Kentucky. State park restaurants also want to source additional fresh product to replace frozen product. This program appeared to be popular with growers, as 16 reported selling to a restaurant for the first time in 2005 and cited the state park restaurants as their market channel. The Restaurant Rewards program also seemed to begin to show some contribution to developing these local markets. Growers frequently reported transportation costs as the most significant barrier to selling to restaurants. A more complete study of restaurant produce marketing activity is available in the 2006 Restaurant Produce Buyers Survey.[1]

Auctions

The percentage of respondents selling produce through auctions increased slightly during 2005 (15%). This is undoubtedly due to auctions that began in Lincoln, Bath, and Mason counties in 2004. The Fairview Produce Auction in Christian County continues to grow in popularity and sales volume. A noticeable trend in 2005 is the number of growers using an auction to market 10% or less of their total produce sales, number (27) and percent (5%).

All auctions have the dilemma of attracting enough buyers and sellers to create a vibrant local market. It remains to be seen if a preference for fresher produce and the renaissance toward eating locally produced food will expand enough in Kentucky to adequately support emerging produce auctions. Growers, especially in areas of newer auctions, appear to be using auctions sparingly. However, these produce auctions can currently fill a niche as part of a diverse direct and wholesale marketing plan.

Community Supported Agriculture

Direct marketers have found that community supported agriculture (CSA) can be an economically attractive marketing option, especially in areas with higher per capita incomes. Only three producers responding to this survey indicated that a CSA was currently part of their marketing program. Less than half (42%) of producers indicated that they had even heard of CSA production.

On-Farm Marketing: U-Pick

Interest in Pick Your Own (PYO), or U-Pick, continues to be significant. Thirty-five (14%) of the 257 growers responding to the questions about PYO indicated that they are not using PYO currently but are interested in making it part of their future marketing plan. About the same number of growers (33) are currently using PYO.

Produce Grower Demographics: 2001-2005

Grower demographics have changed somewhat during the past five years. Selected results from previous planting intentions and marketing are summarized here to demonstrate trends across several of these demographic variables.

Age and Experience

Significant expansion has occurred in Kentucky's produce industry since 1998. Kentucky's farm operator population continues to age, and this produce expansion has primarily occurred on farms operated by operators who are more than 50 years old. Responses to questions about age and experience this year, as in previous years, reflect these general assumptions (Table 1). Producer years of experience in growing produce shifted toward more experience after remaining static from 2001 through 2003 (Table 2), particularly among those new to growing produce. Although the survey represents a smaller percentage of growers for 2004 through 2005, the data show an aging trend.

Tobacco Production

For the past three years, this survey has asked produce growers if they raise tobacco. Responses have been similar for each year: 44 percent in 2001, 46 percent in 2002, and 41 percent of 2003 respondents said they had produced tobacco. For 2004, 45 percent of respondents replied that they had grown tobacco in 2004 (Table 3), while only 23% reported growing tobacco in 2005.

[1] Tim Woods, Matt Ernst, and Jeffrey Herrington, *2006 Kentucky Restaurant Produce Buyer Survey,* University of Kentucky, Department of Agricultural Economics Extension Numbered Series: 2006-01, April 2006.

Table 1. Surveyed Producer Age, 2001-05.					
	Under 30	**31-40**	**41-50**	**51-60**	**More than 60**
2001	7%	14%	31%	24%	23%
2002	5%	14%	29%	27%	25%
2003	6%	10%	30%	26%	27%
2004	4%	9%	31%	26%	27%
2005	4%	9%	26%	29%	31%

Table 2. Years of Experience Growing Produce, 2001-05.				
	Less than 3	**3 to 6**	**7 to 10**	**More than 10**
2001	25%	23%	14%	38%
2002	15%	32%	15%	38%
2003	15%	33%	13%	38%
2004	6%	28%	15%	48%
2005	9%	28%	19%	42%

Table 3. Percent of respondents growing tobacco.		
	Grew Tobacco and Produce	**Anticipating Tobacco Production in Coming Season**
2001	44%	
2002	46%	
2003	41%	
2004	45%	28% of respondents (62% of 2004 tobacco growers)
2005	23%	21% of respondents (93% of 2005 tobacco growers)

Certified Organic Production

Certified organic production of fruits and vegetables has decreased in Kentucky since 2001, primarily because of producers unwilling to renew organic certification after changes in certification requirements. However, as in previous years, a significant number of growers (30%) said they were interested in future organic production. Nearby market potential and new administrative support for Kentucky's organic certification process could bode well for growers interested in organic production.

Conclusions/Outlook

Primarily fueled by growth in direct marketing, gross sales from Kentucky's produce industry will increase by at least 5% in 2006. Produce continues to emerge as an additional source of income for many Kentucky farms and, as marketing and management expertise are increasing annually, this sector should continue its modest rate of a 5 to 10% increase in gross sales. Large, private wholesale expansion, particularly in the small fruit sector, could dramatically increase both acreage and sales for produce over the next five years.

Acknowledgments

Thanks to this publication's reviewers and additional contributors: Lee Meyer, Agricultural Economics; John Strang, Brent Rowell, Kaan Kurtaral, and Chris Smigell, Horticulture.

Thanks to the Kentucky growers who have taken time to complete this survey.

Appendix 1. Vegetable co-op acreage changes.					
	2006	**2005**	**2004**	**2003**	**2002**
Broccoli	0	253	70	75	35
Cabbage	44	70	150	175	166
Cantaloupe	0	25	80	78	83
Sweet Corn	10	378	700	718	712
Cucumbers	60	65	61	77	49
Peppers	70	200	310	290	295
Potatoes	0	25	0	150	120
Pumpkins	25	166	90	195	264
Squash (Summer)	36	27	29	41	46
Tomatoes	12	25	52	57	68
Watermelon	0	73	22	20	10
Eggplant	5	10			
Hard Squash	5				
Total Acreage	267	1,317	1,564	2,075	1,848

Appendix 2. Percent of growers reporting 10% or more gross sales from specific markets.				
	2002	**2003**	**2004**	**2005**
Farmers' Markets	42%	47%	52%	58%
On-Farm Direct Markets (U-Pick, Farm Stand)	49%	44%	37%	46%
Direct to Grocery	21%	14%	15%	16%
Wholesale, Non Co-op	17%	15%	17%	15%
Wholesale, Cooperatives	17%	15%	11%	8%
Direct to Restaurants	5%	7%	7%	17%
Auctions	9%	8%	10%	16%
CSA/Subscription	3%	2%	2%	1%

Appendix 3. Percent of growers reporting any quantity of gross sales from specific markets.				
	2002	**2003**	**2004**	**2005**
Farmers' markets	47%	53%	55%	63%
On-Farm Direct Markets (U-Pick, Farm Stand)	55%	50%	45%	46%
Direct to Grocery	28%	21%	20%	16%
Wholesale, Non Co-op	20%	17%	20%	15%
Wholesale, Cooperatives	18%	15%	11%	8%
Direct to Restaurants	14%	12%	14%	17%
Auctions	9%	9%	12%	16%
CSA/Subscription	3%	3%	2%	1%

Appendix 4. Vegetable and fruit planting intentions for Kentucky, 2006.

	2002 USDA Estimated Acreage (Ag Census)	2005 Acreage Estimate	2006 Acreage Forecast	2005-06 Percent Change
Vegetables				
Asparagus	44	40	**45**	**13%**
Beans, Snap	541	200	**405**	**103%**
Beets	8	10	**45**	**350%**
Broccoli	49	250	**260**	**4%**
Cabbage	262	200	**225**	**13%**
Chinese Cabbage	25	<10	**<10**	**--**
Cantaloupes	575	500	**460**	**-8%**
Corn, Sweet	2010	2000	**2664**	**33%**
Corn, Ornamental	N/A	40	**159**	**298%**
Cucumbers, Fresh	146	120	**142**	**18%**
Eggplant	2	25	**25**	**0%**
Garlic	8	10	**27**	**170%**
Greens (Collards, Kale, Mustard, Turnip)	81	80	**66**	**-18%**
Lettuce (Leaf, Head, Romaine)	14	20	**18**	**-10%**
Lettuce (Greenhouse)	N/A	10	**<10**	**--**
Okra	12	15	**20**	**33%**
Onions (Dry & Green)	13	25	**30**	**20%**
Ornamental Vegs.	N/A	45	**45**	**0%**
Peas	6	10	**45**	**--**
Peppers, Bell	348	325	**435**	**34%**
Peppers, Jalepeno	52	55	**125**	**127%**
Peppers, Other	N/A	40	**85**	**113%**
Potatoes, Red	N/A	130	**60**	**-54%**
Potatoes, White	N/A	275	**75**	**-73%**
Pumpkins	1524	1000	**1260**	**26%**
Squash, Summer	136	105	**145**	**38%**
Squash, Winter	N/A	25	**40**	**60%**
Sweet Potatoes	N/A	25	**60**	**140%**
Tomatoes, Field	911	575	**615**	**7%**
Tomatoes, Greenhouse	N/A	10	**15**	**--**
Watermelons	450	500	**435**	**-13%**
Herbs	12	70	**20**	**-71%**
Other Vegetables	69	65	**60**	**-8%**
Fruit				
Apples	1920	1800	**980**	**-46%**
Blackberries	86	110	**130**	**18%**
Blueberries*	61	62	**120**	**94%**
Grapes**	489	250***	**410*** **	**64%**
Peaches*	408	500	**600**	**20%**
Pears	74	50	**50**	**0%**
Raspberries*	20	40	**30**	**-25%**
Strawberries	216	210	**175**	**-17%**
Other Fruits	26	25	**5**	**-80%**
Total Vegetable Acres	**7,298**	**6,810**	**8,131**	**+19%**
Total Fruit Acres	**3,300**	**3,047**	**2,500**	**-18%**
Total Produce Acres	**10,598**	**9,847**	**10,611**	**+8%**

* Survey results adjusted from additional information from UK fruit extension specialists.
** 505 acres of grapes planted.
*** Estimate for 2005 and forecast for 2006 are for bearing acreage.

Produce Marketing Intentions Survey—Direct Marketing Continues to Grow

Matt Ernst and Tim Woods, Department of Agricultural Economics

Introduction

The Kentucky Produce Planting and Marketing Intentions Survey was conducted for the fifth consecutive year in 2005. Results of the survey allow producers, researchers, and others involved in Kentucky's produce industry to get a general sense of trends in individual crop acreage and marketing methods.

Responses to the 2005 Kentucky Produce Planting and Marketing Intentions Survey, combined with a decrease in acreage contracted by Kentucky's four vegetable marketing co-ops, indicated that direct marketing would continue to drive growth in Kentucky's produce industry during 2005. As in 2004, gross sales of Kentucky fruits and vegetables increased by about 5% in 2005, with total farm produce sales projected to fall between \$30.5 and \$35 million.

Materials and Methods

Surveys were mailed to 1,178 growers in February 2005. The survey was returned by 235 producers representing 2,433 commercial vegetable acres and 403 commercial fruit acres. An additional 50 surveys were returned but were unusable. The 24% response rate is considered good for a mail survey, but was down from past years.

Results and Discussion

Producer Demographics

Age and experience. Kentucky's farm population continues to age, and produce expansion has primarily occurred on farms operated by those over 50 (Table 1). Many new and inexperienced growers began growing produce between 1998 and 2002. Despite the efforts directed at helping new producers diversify into horticultural crops, the proportion of new growers has declined substantially since 2002; only 6% of those surveyed this year had less than three years of experience growing produce.

Table 1. Years of experience growing produce.

	2001	2002	2003	2004
Less than 3	25%	15%	15%	6%
3-6	23%	32%	33%	28%
7-10	14%	15%	13%	38%
Over 10	38%	38%	38%	48%

Tobacco production. The tobacco buyout was expected to cause significant producer exit from tobacco production in 2005. In the spring of 2005, UK estimated about a third of tobacco growers would exit the industry this season. Responses to this survey, which was conducted before planting, indicated that 37% of produce growers that produced tobacco in 2004 did not plan to grow tobacco in 2005.

The survey indicated a significant number of produce farmers (45%) still growing tobacco (Table 2). While some of these growers indicated that they were interested in expanding produce acreage, it was beyond this survey's scope to pinpoint the effects of tobacco industry changes on possible produce acreage expansion. However, many growers appear to still be treating produce and tobacco as complementary enterprises.

Table 2. Percent of surveyed produce growers also producing tobacco.

	2001	2002	2003	2004
Grew tobacco	44%	46%	41%	45%

Organic production. Past surveys have suggested that grower interest in organic production is likely tied with their perception of the ease of entry into certified organic production. In this year's survey, 20% of the growers surveyed indicated that they were interested in future organic production (Table 3). This is up sharply from the previous year's survey, where only 2% of growers indicated interest. This renewed interest in organic production may be due to increased awareness of support available in the organic certification process. Regulatory difficulties have been addressed through recent educational programs, and buyer demand continues to grow.

Table 3. Interest in growing organic produce.

Are you interested in growing organic produce in the future?	2003	2004	2005
Yes	20%	2%	20%
No/No response	80%	98%	80%

Market Use: Direct Marketing

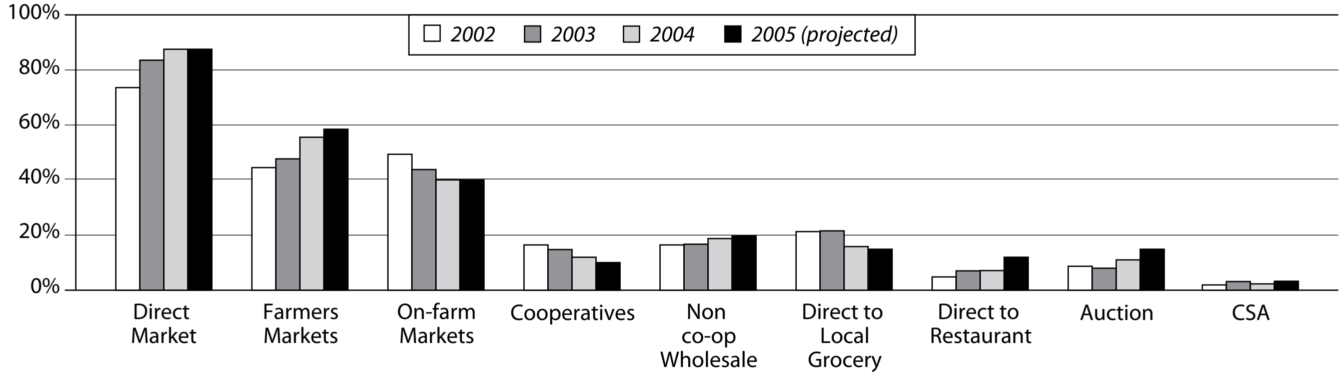
For the purposes of reporting this survey, "direct marketing" includes sales directly to consumers on and off the farm (farmers' market, pick-your-own, roadside stand, CSA), as well as sales directly to groceries or restaurants. The frequency of surveyed growers using some form of direct marketing in 2004 was 88%, the highest ever observed in this survey (Figure 1).

Farmers' markets. The number of community farmers' markets has nearly tripled in Kentucky over the past 10 years. More than 94 farmers' markets operated in Kentucky during 2005 with projected sales of \$7 to \$8 million and more than 1,500 registered vendors.

More than half (59%) of the respondents to this survey indicated that they used farmers' markets to sell some of their produce; 56% indicated that 10% or more of their sales occurred at farmers' markets (Figure 1).

On-farm markets. The next most frequently used market channel was the on-farm market, used by half the respondents. These mar-

Figure 1. Frequency of market use, 2002-2004 and 2005 estimates (percent of surveyed growers indicating 10% or more of sales through channel).



kets include roadside stands and pick-your-own. While producers continue to indicate interest in developing on-farm markets, this year's survey indicated a possible decline in this interest. Producers continue to cite location and liability concerns as barriers to entering on-farm marketing efforts like pick-your-own.

Restaurants. Selling directly to local restaurants has become more popular with produce growers in Kentucky since the state park restaurants initiated a program to purchase in-season local produce in 2004. More than 20 new growers began selling to the park restaurants in 2005, doubling the number of growers who indicated marketing to any restaurants in 2004. The state parks alone indicate the capacity to purchase at least $250,000 of local produce in season. Restaurants and related foodservice buyers are a niche market that may fit into several kinds of marketing plans.

Community Supported Agriculture (CSA). CSA marketing was used by 3% of respondents. This market channel is quite popular with certified organic producers. Though currently minor, sales volume through the CSA channel is expected to increase as organic acreage increases

Market Use: Wholesale Marketing

Non-co-op wholesale and direct to grocer. Behind farmers' markets and roadside stands, wholesale marketing (not through a co-op) was the third most common market channel that Kentucky produce growers used in 2004. This channel was used by 19% of the survey respondents. This category includes larger foodservice, repackers, and other intermediate produce handlers.

Sixteen percent of respondents indicated selling 10% or more of their produce direct to a local grocery in 2004. This market channel is often managed as part of a deal with a larger chain that allows direct delivery to a local store. Independent grocers are also still a viable market for producers in communities where an independent grocer is located.

Cooperatives. Co-ops were used by 12% of the respondents to this survey. Co-op acreage and sales leveled out in 2003 after rapid expansion from 2000-2002 and declined in 2004. Through 2003, less than 20% of Kentucky's produce growers belonged to a vegetable co-op, but these co-ops contributed more than 25% of Kentucky gross sales. For the 2004 season, the percent of growers using co-ops as a marketing mechanism and the percent contribution by co-op sales to gross income from produce in Kentucky were approximately even (10 to 15%). Both these numbers are projected to decrease in 2005.

Auctions. Nine percent of respondents indicated that they used auctions to market some of their produce in 2004. Kentucky's sole produce auction until 2004 was the Fairview Produce Auction in Christian County. This auction, which also sells hay, straw, and small-scale farm equipment, reported an estimated $1.5 million in sales. The Lincoln County Produce Auction began in 2004 with estimated sales of $300,000.

New auctions emerged in Bath and Mason counties in 2005. Produce sales from all auctions were expected to total $2 million in 2005 with more than 300 growers expected to market produce through an auction

Crop Changes

Each year, this survey asks respondents to indicate anticipated changes in crop acreage. While not every produce grower in the state is surveyed, these anticipated changes in acreage provide general indications of what crops are viewed favorably or unfavorably for expansion (expansion potential).

Survey respondents indicated increases in commercial broccoli and hot pepper acreage in 2005; this was confirmed by co-op and independent grower shipper increases during the season. Other minor vegetable crops (under 50 acres each) with projected acreages increases greater than 20% included sweet potatoes, winter squash, eggplant, okra, and ornamental corn. These are all crops with both direct and wholesale market potential for Kentucky growers.

The survey also indicated increases in bearing blueberry acreage, which increased from 15 acres in 1997 to 60 to 65 acres in 2005. Bearing acreage of wine grapes has also continued increasing to 220 bearing acres in 2004 and 250 acres estimated for 2005.

Summary

Producers using direct markets comprise the majority of fruit and vegetable growers and generate most of the sales volume in Kentucky. Wholesale production has shifted more to auction and grower-shippers and is expected to continue to do so in 2005, when Kentucky's commercial produce sales will increase again. The industry continues to work through significant marketing challenges and is impacted by changes across all of agriculture. Volume requirements in wholesale production, infrastructure for direct marketing, and delivery of quality products to market represent the biggest marketing issues facing Kentucky growers.

Price Trends for Selected Kentucky Vegetable Crops from Different Market Channels in 2004 and 2005

Matt Ernst and Tim Woods, Department of Agricultural Economics

Introduction

Increased price reporting has come with the growth in Kentucky's commercial vegetable industry. The USDA Agricultural Marketing Service now reports Kentucky produce in terminal market prices from St. Louis and Atlanta. Reports from Kentucky's produce auctions, farmers' markets, and links to terminal market prices are available in-season from the UK New Crop Opportunities Center (*www.uky.edu/Ag/NewCrops*) which also publishes a farmers' market price report. The Kentucky Department of Parks also publishes electronically a weekly list of prices state park restaurants pay for local produce. This list is available for producers to receive by e-mail and may be obtained by contacting Jessica Patton in the state parks foodservice office (Jessica.Patton@ky.gov).

The purpose of this report is to compare each of these market channels with regard to prices paid for selected major vegetable crops (tomatoes, bell peppers, and melons) throughout the 2004 and 2005 seasons. These prices are primarily reported as market "High" and "Low," the top and bottom prices during a given day or week. Terminal market prices are also reported as weekly average prices which are calculated based on daily reported weekly price ranges.

State Park Wholesale vs. Other Wholesale Market Channels for Tomatoes (2004)

An analysis of the prices paid for vine-ripe staked tomatoes by Kentucky's state parks versus other market channels from July 28 to September 23 was completed for marketing meetings during the winter of 2005. This analysis is illustrated in Figure 1 (State Park and Atlanta Terminal Prices), Figure 2 (State Park and Fairview Auction Prices), and Figure 3 (State Park and Farmers' Market Prices).

These figures reveal what was expected: local wholesale prices from a restaurant will usually be higher than other wholesale options. This is because the restaurant is typically paying farmers what they would pay a produce distributor who has to cover several markups from the farm level, including transportation. Surprisingly, state park prices approached some farmers' market prices during some weeks.

Atlanta Terminal Market Prices for Kentucky Bell Peppers (2005)

Peppers have become a major wholesale crop for Kentucky co-ops and grower-shippers. Figure 4 reports Atlanta Terminal Market price ranges for large green bell peppers from 28 July through 30 August, indicating Kentucky price ranges that fall consistently in the mid- to top ranges at this market. Again, these prices are f.o.b., meaning that is the price received for product being delivered in Atlanta. Grower prices at the farm gate or co-op are less due to shipping expenses.

Figure 1. State park and Atlanta terminal market prices for vine-ripe tomatoes, 2004.

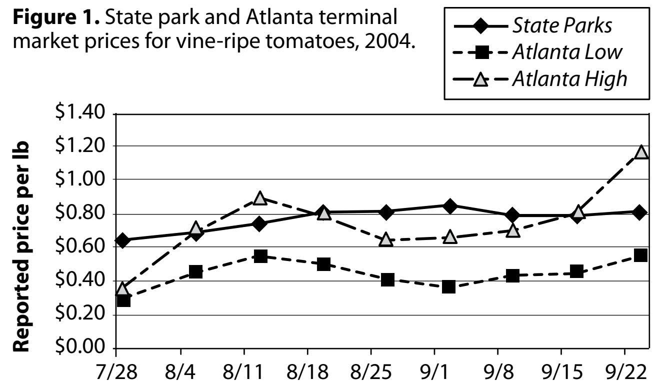


Figure 2. State park and Fairview Produce Auction prices for vine-ripe tomatoes, 2004.

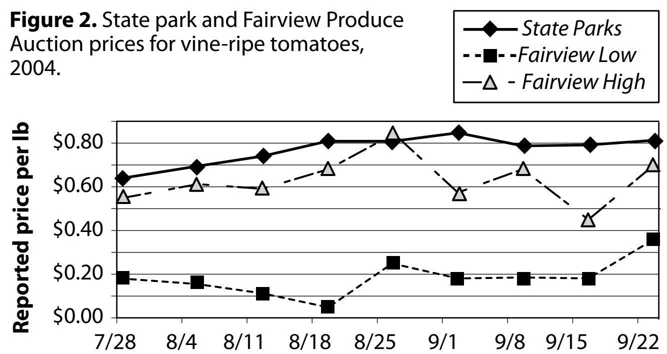


Figure 3. State park and farmers' market prices for vine-ripe tomatoes, 2004.

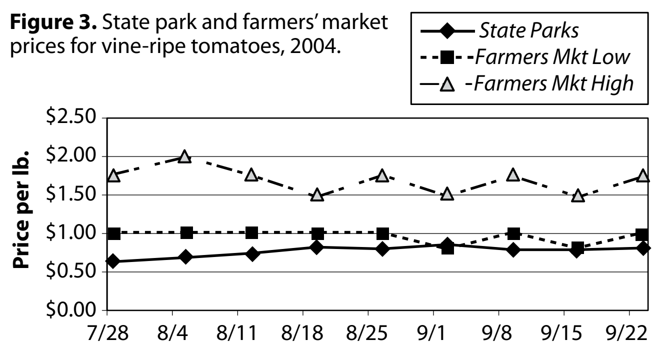
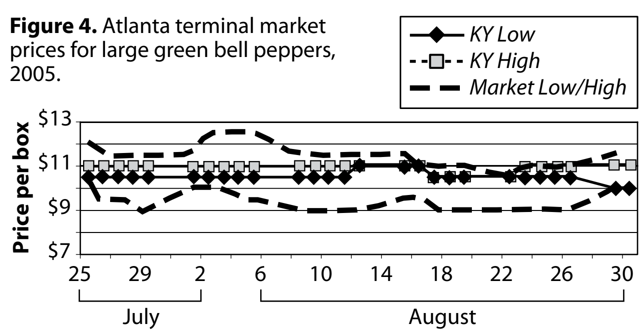


Figure 4. Atlanta terminal market prices for large green bell peppers, 2005.



Fairview Auction Price Trends (Cantaloupes 2004-05)

The Fairview Produce Auction has become a significant point of delivery for Kentucky cantaloupes. Melon acreage in Christian and surrounding counties more than doubled between 1992 and 2002 (Census of Agriculture), and many of these melons are being marketed through the auction. Figure 5 indicates similar price trends for the second week in August through the first of October for large melons in both 2004 and 2005.

Figure 6 indicates wholesale terminal market prices for half-cartons of cantaloupes (12s) in Atlanta during the same time period tracked in Figure 5. While there are many differences between these two market channels, general price trends up and down through July and August are similar between the two markets. For 2004 and 2005, terminal market prices do not reflect as great a trend downward (in terms of percentage of price) during the first part of September.

Summary/Recommendations

Market price information is more available than ever for Kentucky produce market channels. The existence of historical market data for a variety of markets—terminal wholesale, auction, farmers' market, and restaurant—can be used by producers to project profitability and manage risk throughout the season. Produce growers should study and monitor each market to anticipate price trends, especially to identify where earlier or later marketing can capture higher prices, lower risk, and maximize profitability.

Figure 5. Fairview Produce Auction cantaloupe prices for 2004 and 2005.

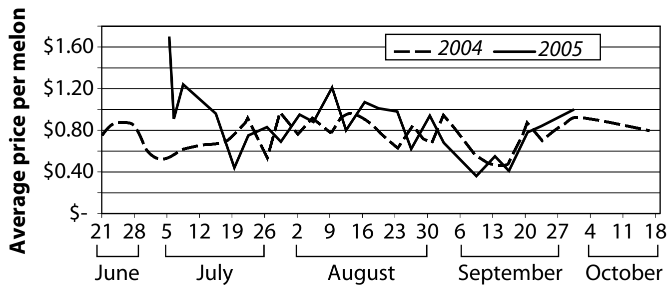
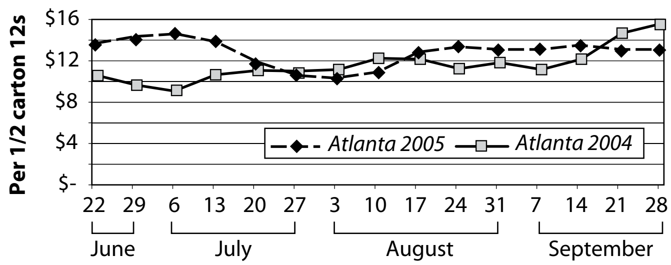


Figure 6. Atlanta terminal market prices for cantaloupes in 2004 and 2005.



MARKETING AND ECONOMICS

2004 Kentucky Produce Planting and Marketing Intentions Survey

Matt Ernst and Tim Woods, Department of Agricultural Economics

Introduction

The Kentucky Produce Planting and Marketing Intentions Survey was conducted for the third consecutive year in 2004. The results of the survey allow producers, researchers, and others involved in Kentucky's produce industry to acquire a general sense of the trends in individual crop acreage and marketing methods.

Significant expansion has occurred in Kentucky's produce industry since 1998. The U.S. Census of Agriculture reported a 31% increase in the number of farms growing vegetables in Kentucky between 1997 and 2002 and a 53% increase in the number of acres marketed. This was the second largest percentage increase in marketed vegetable acreage of any state.

The number of farms marketing fruit, tree nuts, and berries increased similarly (34%) according to Census of Agriculture estimates. The census estimated that the value of fruit sales more than doubled between 1997 and 2002, from $2.7 million to nearly $6 million.

Responses to the 2004 Kentucky Produce Planting and Marketing Intentions Survey, combined with a decrease in acreage contracted by Kentucky's four vegetable marketing co-ops, indicated that direct marketing drove modest growth in Kentucky's produce industry in 2004. Gross sales of Kentucky fruits and vegetables increased by about 5% in 2004 with total sales projected to fall between $28 and $35 million in grower receipts.

Materials and Methods

More than 1,200 surveys were mailed in February 2004, with a second reminder mailing following in March. The survey again returned a strong response rate from Kentucky's growers, with 34% of the surveys returned. This accounted for 401 produce growers, 2,917 commercial vegetable acres, and 886 commercial fruit acres across Kentucky. An additional 5% of surveys were returned from addresses that did not market produce in 2003 or were unusable.

Producer Demographics and Marketing Trends

Age and Experience

Responses to this survey suggest much of Kentucky's produce industry growth has occurred among producers new to produce. Half of these respondents (48%) indicated that they have been growing produce for six years or less. This is nearly identical to the percentage in the 2003 survey. Producers also reflect similar age demographics as in past surveys, with only one-fifth of respondents 40 years old or younger (Table 1).

Tobacco Production

For the past three years, this survey has asked producers if they also grow tobacco. Responses have been similar in each year. In 2002, 44% of respondents replied that they produced tobacco, and in 2003, 46% respondents said they produced tobacco. This year, 41% of respondents replied that they had grown tobacco in 2003.

This trend may be due to significant updating of the producer database for this year's survey, but a similar decrease in 2005 could quantify the exit of some tobacco producers in favor of alternative enterprises. The tobacco buyout will undoubtedly affect the number of producers planting both tobacco and produce crops for harvest in 2005.

County Agricultural Diversification Programs

In 2002 and 2003, similar proportions of fruit and vegetable growers reported having participated in County Agricultural Diversification Programs. About 40% of producers report participating in these programs in 2003. Furthermore, a number of respondents to this year's survey indicated that they had applied for County Agricultural Diversification Funds but had been turned down or had not yet received funding.

Organic Production

In last year's survey, a significant number of producers (20%) reported that they were interested in future organic production. Only 2% of producers this year responded that they had future plans to grow organic produce.

This sharp decline in organic interest appears to be related to changes in certified organic production guidelines and producer perception of difficulty to enter certified production. In addition, since many producers are marketing locally, the economic premium for certified organic production may not be great enough to warrant going through the certification process.

Table 1. Age of producers surveyed (to nearest percent).

	2002	2003	2004
Under 31	7%	5%	6%
31-40	17%	14%	10%
41-50	31%	29%	30%
51-60	22%	27%	26%
Over 60	23%	25%	27%

Table 2. Do you grow tobacco on your farm?

	2002	2003	2004
Yes	44%	46%	41%
No	56%	54%	59%

Direct Marketing

Farmers' Markets

The number of community farmers' markets has nearly tripled in Kentucky over the past 10 years. More than 95 farmers' markets operated in Kentucky during 2004 with projected sales of $5 to $6 million.

More than 50% of the respondents to this survey indicated that they used farmers' markets to sell some of their produce; 47% indicated that 10% or more of their sales occurred at farmers' markets (Figure 1).

On-Farm Markets

The next most frequently used market is the on-farm market, used by half the respondents. These markets, including roadside stands and Pick-Your-Own (PYO), will account for $7 to $10 million of commercial produce sales in 2004. PYO marketing is generating much interest in Kentucky. Of the 401 producers surveyed, 63 (16%) reported they are currently using PYO. Twice this many producers (31%) said they are interested in using PYO marketing in the future.

Other Direct Markets

Selling directly to local restaurants is also popular with some produce growers in Kentucky; 12% of respondents indicated they had done so in 2003. Community Supported Agriculture (CSA) was used by 3% of respondents. Both these market channels are popular with certified organic producers, but such production has decreased in popularity with Kentucky producers in 2004. This decrease is primarily due to changes in federal organic certification guidelines.

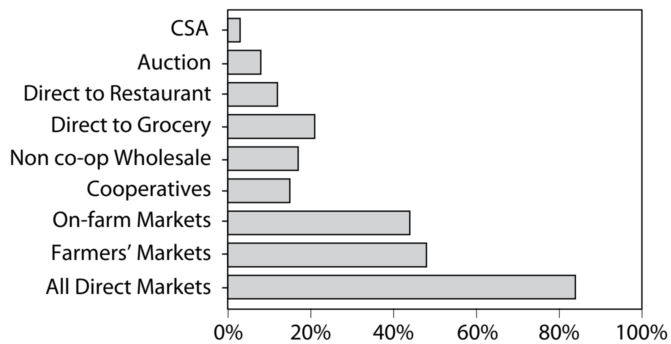
There continues to be a lack of enthusiasm among growers about future organic production; only 2% of the growers surveyed said they had plans to grow organic produce, while the same number said that they might be interested in organic production. In 2003, due to changes in the organic certification process, a number of Kentucky producers switched from certified organic production to marketing their produce as "sustainably grown" or using other similar descriptions.

Wholesale Marketing

Direct to Local Grocer

Behind farmers' markets and roadside stands, wholesaling directly to a retailer was the third most common market channel that Kentucky produce growers used in 2003. This channel was used by 21% of the survey respondents.

Figure 1. Percent of producers selling 10% or more produce into market channels, 2003.



Other Wholesale Channels

Other wholesale channels, excluding sales to co-ops, were used by 17% of respondents. These include direct sales to grocery chains. Developing wholesale markets accessible to an individual grower or group of growers is a growing market channel for produce sales in Kentucky.

Co-ops

Co-ops were used by 15% of the respondents to this survey. Co-op acreage and sales leveled out in 2003 after rapid expansion from 2000-2002. Co-op production, while used by a relative minority of Kentucky's fruit and vegetable growers, still accounts for a major portion of Kentucky's commercial vegetable sales–approximately $6 million in 2004.

Auctions

Nine percent of respondents indicate that they use auctions to market some of their produce. Kentucky's sole produce auction until 2004 has been the Fairview Produce Auction in Christian County. This auction, which also sells hay, straw, and small-scale farm equipment, grossed over $1 million in sales during 2003.

Additional auctions opened in Kentucky during 2004 in Lincoln, Bath, and Mason counties. They operated at different times and volumes during their first season. It is quite possible that the market environment in Kentucky can support some additional produce auctions to increase market channels for wholesale produce.

Acreage Changes

Because this survey does not include all produce growers in Kentucky, responses indicating change in specific produce acreages must not be taken as sole indicators in annual increases or decreases in specific crop acreage around the state. Rather, this survey serves as a general indicator of what crops may be viewed favorably or not by growers for expansion opportunities.

Survey respondents indicated aggressive increases in specialty and jalapeño pepper acreage for 2004; this increase was confirmed by increases in wholesale production of these peppers. Growers may also be harvesting more winter squash in 2004, a crop viewed by some as having marketing potential for Kentucky growers.

The survey also indicated increases in bearing blueberry acreage, which has increased from 15 acres in 1997 to 60 to 65 acres in 2004. Strawberries may also be regaining some popularity in Kentucky. All of the small fruits have outstanding market potential for producers willing to invest the necessary time and management into their marketing and production.

Summary

Producers using direct markets comprise the vast majority of produce growers in Kentucky. While some co-op and wholesale producers continue acreage expansion, expansion in 2004 came from Kentucky's direct marketers. This is a shift from recent trends and can best be explained by the profits producers made by marketing directly to a variety of consumers desiring fresh, locally grown produce.

MARKETING AND ECONOMICS

2004 Nursery Products Buyer Survey

Andrea Basham, Tim Woods, and Matt Ernst, Department of Agricultural Economics

Nature of Work

A survey of the nursery industry in Kentucky's seven-state area was conducted to assess regional industry trends during the summer of 2004. Approximately 500 retailers, landscapers, and wholesalers from the nursery industry in Kentucky, Tennessee, Ohio, Indiana, Missouri, Illinois, and West Virginia were questioned by mail. Over 30 percent (150) of the surveys were returned; of these, 126 surveys (25 percent) were complete and available for analysis.

Firms surveyed are operating primarily as retailers or landscapers. Approximately 56 percent of businesses reported some retailing activity while 75 percent reported landscaping services contributing to gross sales. While 52 percent of those surveyed reported wholesaling activity, the average sales volume from wholesaling was only 20 percent of a firm's gross sales. Thus, "wholesaler" trends cannot be properly identified from this sample set, which is most representative of nursery businesses whose primary functions are retailing and/or landscaping.

Results/Discussion

Evergreen trees, evergreen shrubs, and flowering shrubs accounted for the largest sale volumes by retailers and landscapers. Flowering, ornamental, and shade trees accounted for relatively low sales volumes (less than 1,000 units annually). Three main trends are identified from the survey results:

- Demand for specific cultivars
- Demand for specific plant size
- Importance of characteristics in wholesale purchases

1. Demand for Plant Varieties

The survey asked respondents to rate the demand for 12 tree cultivars. Respondents rated demand as decreasing, stable, or increasing on a three-point scale. Both retailers and landscapers noted stable to decreasing demand for sweetgum, honey locust, and ash (Table 1). Stable to increasing demand was indicated for magnolia (retailer), oak (landscaper), and maple (both).

2. Demand for Plant Sizes

The study focused on trends in balled and burlap sales as well as container plants. Among B&B sizes, there were increases in quan-

Table 1. Demand table for selected trees.		
Decreasing to Stable	**Stable**	**Stable to Increasing**
Retailers		
Sweetgum	Birch	Maple
Honey Locust	Oak	Magnolia
Ash	Serviceberry	
Flowering Pear	Dogwood	
Flowering Cherry	Flowering Crabapple	
Landscapers		
Sweetgum	Birch	Oak
Honey Locust	Magnolia	Maple
Ash	Dogwood	
Serviceberry	Flowering Cherry	
Flowering Pear	Flowering Crabapple	

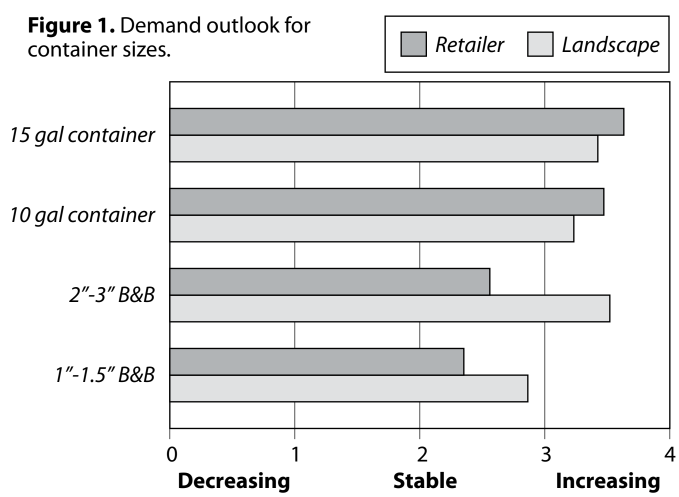
tity demanded for larger sizes (Figure 1). For example, landscapers showed a stable or increasing demand for 1.75-inch to 3-inch B&B plants. Both retailers and landscapers expected decreasing demand for smaller sizes (1 inch to 1.5 inch).

Container plants also followed the larger size/larger quantity demanded rule. Landscapers indicated stable to increasing demand for 10- and 15-gallon sizes and an increasing demand for 25-gallon container plants. Retailers indicated an increasing demand for 10-gallon containers and stable demand for 15- and 25-gallon sizes. The significance of this trend is reinforced by comments from many respondents that they have difficulty locating 1-inch to 3-inch B&B as well as 10- and 15-gallon container plants.

3. Characteristics of Wholesale Purchases

The survey attempted to determine which characteristic of a purchase between wholesalers and retailers/landscapers is most important. Retailers and landscapers, in general, reported product quality as the most important factor in a transaction (Figure 2). Other important factors were: 1) variety/selection/volume; and 2) ease/speed/cost of delivery. Price was least important to landscapers, while relationship with the wholesaler was least important to retailers.

Figure 1. Demand outlook for container sizes.



Kentucky Responses

In addition to the three trends above, some observations can be made about Kentucky businesses that responded to this survey. There were 33 businesses from Kentucky returning completed surveys, representing one-quarter of all respondents. On average, operations in Kentucky conducted 38 percent of their gross sales from retailing, 47 percent from landscaping, and 15 percent from wholesaling. Other highlights from Kentucky's respondents included:

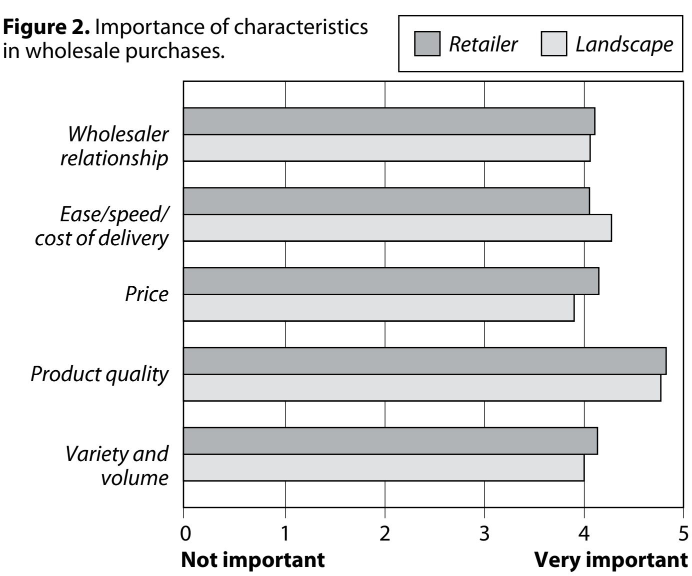
- 20 percent to 50 percent of nursery stock sold by Kentucky businesses was grown in Kentucky
- Highest sales volumes are from evergreen shrubs, flowering shrubs, and shade trees
- Respondents expected the quantity demand to increase for magnolia and maple trees
- Respondents expected the quantity demand to decrease for flowering crabapple, ash, and honey locust

Kentucky respondents expected increases in demand for larger B&B sizes (2-inch to 3-inch), as well as 15-gallon container plants. Decreases were expected for 1-inch and 1.5-inch B&B plants. Lastly, in wholesale purchases, Kentucky businesses reported that the most important characteristic is product quality. Least important are the ease/speed/cost of delivery. This was similar to trends noted across all respondents.

Significance to Industry

This survey indicates that consistently high product quality is most important in the minds of the buyers surveyed. Growers should therefore pay careful attention to market products of the highest quality. Although Kentucky nursery stock is not currently regarded as the lowest price stock in our region, Kentucky growers may be able to capitalize on buyer preferences for high quality stock. Exactly how much more buyers are willing to pay for higher quality stock from Kentucky is yet to be determined and will be key to developing successful regional markets for Kentucky nursery producers.

Figure 2. Importance of characteristics in wholesale purchases.



Evaluation of High-Value Traits for Corn in Kentucky

William Pearce, Ron W. Curd, and Chad Lee, Department of Plant and Soil Sciences

Introduction

TC High Oil Blend® corn has both disadvantages and advantages in the cropping system. It costs more per bag, needs isolation from other corn, has uncertainty of pollination, and has the possibility of lower yields and test weights. TC Blend high-oil corn can have several advantages for the farmer. It has 80% more oil, 4-5% more energy, 6-8% more protein, 15% more lysine and 11% more methionine than No. 2 yellow corn. All of this means an improved feed conversion for TC Blend high-oil corn versus No. 2 yellow corn.

Food-grade white corn generally has a 10% yield loss as compared to No. 2 yellow corn. It usually will have a premium of from 25 to 50 cents per bushel above No. 2 yellow corn. However, the premium can be as high as $2.00 per bushel above No. 2 yellow corn.

TC High Oil Blend®

Tests for TC high-oil corn were conducted at three locations in 2003 and 2004 and at two locations in 2005. There were nine entries for 2003, eight entries for 2004, and six entries for 2005. The average yield data for 2003 is presented in tables 16A thru 16F in the 2003 Kentucky Hybrid Corn Performance Test (1). The chemical composition is presented in table 16G (1). The average yield data for 2004 is presented in tables 16A thru 16F, and the chemical composition is presented in table 16G in the 2004 Kentucky Hybrid Corn Performance Test (2). The average data for 2005 is presented in tables 16A through 16E, and the chemical composition is presented in table 16F in the 2005 Kentucky Hybrid Corn Performance Test (3).

In the tables for each year, the annual mean yields presented are averages of the three replications of data at the test site. To decide if a yield difference between two hybrids is real, use the LSD (least significant difference) provided at the bottom of each table. In a yield column, a hybrid followed by an asterisk does not differ significantly (less than or equal to one LSD) from the highest yielding hybrid in that column. The coefficient of variation (C.V.) is a measurement of unexplained variation. The C.V. is expressed as a percentage of the mean.

Grain from a 20- to 25-plant hand-pollinated sample from each replication at the Lexington test for each year was analyzed by the Kentucky Grain Quality Lab at Lexington (4) using NIRS.

Four hybrids (Agrigold 6490TC, Agrigold AA6445TC, Wyffels W7355TC, and Wyffels W7185) were tested over all three growing seasons (2003-2005). There were no significant differences between Agrigold 6490TC and Wyffels W7355TC (Table 1). In the two-year data (2004-2005) the results were the same, with no significant differences between Agrigold 6490TC and Wyffels W7355TC. In 2003, all blends were significant except for Wyffels W7185 in the across-location average. In 2004, only Wyffels W7355TC was significant in the annual across-location average.

The TC Blend high-oil yield and composition information will be useful to farmers feeding high-oil (high-energy) grain to livestock and to those participating in the high-oil, value-added grain market.

Food-Grade White Corn

In 2003-2005, the food-grade white corn test was conducted in a separate test at each Kentucky location instead of being tested with the regular yellow corn hybrids. The data for each location is provided in tables 9W, 10W, 11W, 12W, 13W, 14W and 15W of the 2003(1), 2004(2) and 2005(3) Kentucky Hybrid Corn Performance Test. The annual, two-year, and three-year summaries are provided in tables 7W-1YR, 7W-2YR, and 7W-3YR, while the chemical composition data is provided in Table 8W for all three years 2003(1), 2004(2), and 2005(3).

Of the white hybrids tested in 2003(1), Pioneer Brand 32T78 and the medium check were the highest-yielding hybrids in the across-location average. In 2004(2), Pioneer Brand White Hybrids 33V62, 33B10, and 32T78 were all significant, as was the medium check, in the across-location average. In 2005(3), Pioneer Brand 32R38 and 33V62 were both significant in the across-location average. Even though Zimmerman 1851W was not significant in the across-location three-year average, the hybrid has been a consistent high-yielding white hybrid for many years. The three-year summary for white hybrids is shown in Table 2.

Conclusion

TC Blend high-oil corn can have a 10% yield loss compared with No. 2 yellow corn. TC Blend high-oil corn can either be fed to animals or sold on the open market. Because it is a higher energy source than No. 2 yellow corn, it can be used effectively for feed. Farmers often will contract with a company to sell TC Blend high-oil grain at harvest for a premium. The grain needs to be at least 6% oil or higher to get this premium.

Table 1. Three-Year Summary, 2003-05, High Oil Blends (113-117 Days to Maturity), Two Locations.

BRAND/HYBRID	YIELD BU/AC 2003-05		MOIST % 2003-05	STAND % 2003-05	LODG % 2003-05	TEST WT LBS/BU 2003-05
AGRIGOLD 6490TC	169.9	*	15.3	86.5	2.2	55.3
WYFFELS W7355TC	167.5	*	15.0	86.0	4.4	55.5
AGRIGOLD AA6445TC	162.3		15.0	83.3	3.0	53.3
WYFFELS W7185	158.0		14.4	85.9	3.7	53.9
HIGH OIL AVERAGE	164.4		14.9	85.4	3.3	54.5
LSD (0.10)	7.5		0.6	1.0	2.2	0.6

* In any column, a hybrid mean that is followed by an asterisk does not differ significantly (less than or equal to one LSD) from the highest yielding hybrid in that column.

Food-grade white corn can also have a 10% yield loss as compared to No. 2 yellow corn, but a premium between 25 and 50 cents per bushel can help offset the expected lower yields.

Research on TC Blend high-oil and food-grade white corns can offer farmers an alternative to regular No. 2 yellow corn. The high-oil corn can offer a better energy source, especially for lactating animals.

Table 2. Three-Year Summary, 2003-05, White Hybrids (113-117 Days to Maturity), Six Locations**

BRAND/HYBRID	YIELD BU/AC 2003-05		MOIST % 2003-05	STAND % 2003-05	LODG % 2003-05	TEST WT LBS/BU 2003-05
PIONEER BRAND 32T78	180.7	*	19.1	99.2	2.5	57.5
MEDIUM CHECK	178.3	*	17.1	99.1	2.7	56.8
ZIMMERMAN 1851W	172.6		20.2	99.7	2.9	55.4
WHITE AVERAGE	177.2		18.8	99.3	2.7	56.6
LSD(.10)	4.5		0.4	1.5	1.2	0.4

* In any column, a hybrid mean that is followed by an asterisk does not differ significantly (less than or equal to one LSD) from the highest yielding hybrid in that column.
**Waverly data not included.

Web Sites

- 2003 Kentucky Hybrid Corn Performance Test: http://www.ca.uky.edu/agc/pubs/pr/pr485/pr485.pdf
- 2004 Kentucky Hybrid Corn Performance Test: http://www.ca.uky.edu/agc/pubs/pr/pr503/pr503.pdf
- 2005 Kentucky Hybrid Corn Performance Test: http://www.ca.uky.edu/agc/pubs/pr/pr518/pr518.pdf

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2. Pearce, William L., R.W. Curd, and Chad Lee 2004. 2004 Kentucky Hybrid Corn Performance Test. Kentucky Agricultural Experiment Station Progress Report 503. pp. 30.
3. Pearce, William L., R.W. Curd, and Chad Lee. 2005. 2005 Kentucky Hybrid Corn Performance Test. Kentucky Agricultural Experiment Station Progress Report 518. pp. 27.
4. The Grain Quality Laboratory, under the direction of Michael Montross, Ph.D., is a service provided by the University of Kentucky Department of Biosystems and Agricultural Engineering. Funding is provided by the Kentucky Corn Growers Association.

SPECIALTY GRAINS—CORN

Evaluating Soil Fertility Recommendations in Terms of Corn Grain Quality

John H. Grove and Antonio A. Marchi, Department of Plant and Soil Sciences

Corn (*Zea mays L.*) is an important component of row crop rotations in Kentucky. Management of soil-borne nutrition is an important production cost for most growers. Fertilizer and lime often account for about one-third of corn's production expenses. Applications of these inputs are usually guided by professional recommendations, which usually take into account the cost-benefit of fertilization and/or liming. Nonetheless, there are different conceptual philosophies behind these recommendations, with the dominant approaches being crop sufficiency (feed the crop) and soil nutrient balance (feed the soil).

In Kentucky, these two approaches have resulted in very different per-acre nutrient management costs. The soil nutrient balance approach to fertilizer recommendations often costs corn growers more. Those costs can only be paid by greater crop value in the form of greater yield per acre or greater grain value to the end-user—greater grain quality. Giving added value to Kentucky corn means giving that corn greater compositional and physical quality—greater suitability for the animal feed end user.

One of the challenges lies in defining corn grain quality. Grain with higher levels of protein, etc., should be more valuable to the swine producer and to the corn grower. Further, other corn grain constituents have feed value, including the mineral nutrients (phosphorus, calcium, zinc, and copper). Feed grain quality has a physical dimension in addition to chemical composition. Fungi can more easily infect grain that is broken or merely contains fine cracks.

Optimal nutrition management for maximum economic corn yield is reasonably well understood in Kentucky. Recommended nutrient source, rate, timing, and placement practices have been keeping pace with the improved productivity of new cultivars and changing soil management systems. The crop sufficiency philosophy underlies many land-grant university lime and fertilizer recommendations. This results in recommendations more conservative than those based on the soil nutrient balance philosophy, widely used by consultants, agribusiness, and the fertilizer industry. Earlier research has shown little or no difference in corn yield due to the different recommendation philosophies. Now, the research challenge is to document and understand any differences in corn grain quality due to the different soil nutrient management strategies. Premiums for better corn grain quality are not yet paid in Kentucky. Premiums for corn grain grown with a particular nutrient management philosophy should not be paid without demonstrated quality benefits.

The overall objective of this research is to give added value to corn produced in Kentucky by determining the relationship between the fertilizer recommendation philosophy and corn grain quality. Specific objectives are: 1) to determine whether fertilizer recommendations based upon the philosophy of crop sufficiency result in inferior corn grain quality as compared to quality resulting from a philosophy of nutrient balance, 2) to determine the relative importance of basic cation (calcium, magnesium, and potassium) fertility recommendations on corn grain quality, and 3) to determine the relative importance of micronutrient (iron, manganese, zinc, copper, and boron) fertility recommendations on corn grain quality.

The recommendation systems were examined at four locations over two years. There were six treatments: 1) UK recommendation, 2) UK plus boron, 3) UK plus copper, 4) UK plus zinc, 5) UK plus extra phosphorus and potassium, 6) complete nutrient balance recommendation. The following corn crop parameters were measured: a) leaf and grain chemical composition, b) grain yield, c) grain moisture, d) grain breakage during combine harvest, e) grain breakage susceptibility.

Leaf and grain chemical composition were sometimes modified by added nutrients (data not shown), but although these changes were consistent with the treatment protocol, they did not occur at all locations. There was no grain yield response to nutrients added above and beyond what was recommended by UK. There were some differences in grain moisture; but again, these differences were not consistent across all locations. Grain breakage at harvest varied strongly with location. Breakage was greater when corn was either drier or wetter than optimal. Grain breakage susceptibility, measured with a Wisconsin Kernel Breakage Tester, was not related to soil fertility treatments but was related to cultivar and/or the combine used to harvest the individual experimental sites.

The overall conclusion is that nutrient balance approaches to corn fertilizer recommendations, relative to the standard UK recommendation, offered no benefit in measurable grain quality while adding considerable cost to soil nutrient management.

SPECIALTY GRAINS—DRYING, STORAGE, AND GERMINATION

Drying and Storage Properties of Selected Specialty Grains

S.G. McNeill and M.D. Montross, Department of Biosystems and Agricultural Engineering

Background and Motivation

Specialty grains have received much attention by Kentucky farmers recently because they have fetched attractive premiums compared to prices offered for traditionally grown crops. Farmers always consider the trade-offs between yield potential and any additional handling, drying, or storage costs of new crop hybrids before they can fully evaluate an economic comparison between new crops and historically grown grains. However, drying and storage characteristics of most newly developed specialty grains are rarely reported and may be substantially different than the varieties that are historically grown. For example, a recent drying study at Purdue University showed differences up to 15% in the drying time between two high-oil corn varieties (Maier and Watkins, 2001), and although stress cracks were observed for both products, equilibrium moisture content levels were not measured.

Equilibrium moisture content (EMC) and equilibrium relative humidity (ERH) data are essential for the design and operation of drying and storage processes. Yet little data exists for specialty grains, which have been shown to be significantly different than traditional/historical crops. A recent study compared the relative storability of high-oil corn to conventional corn where CO_2 production was used as an indicator of dry matter loss (Ileleji, et al., 2003). Moreover, a hysteresis phenomenon has often been found in grain that produces a difference between drying/desorption and wetting/adsorption isotherms. The primary motivation of this work involves desorption, which is important in drying and storage applications.

This study was initiated to compare drying and storage properties between specialty grains and traditionally grown crops to help farmers and grain conditioning managers protect seed quality. The objectives were to:

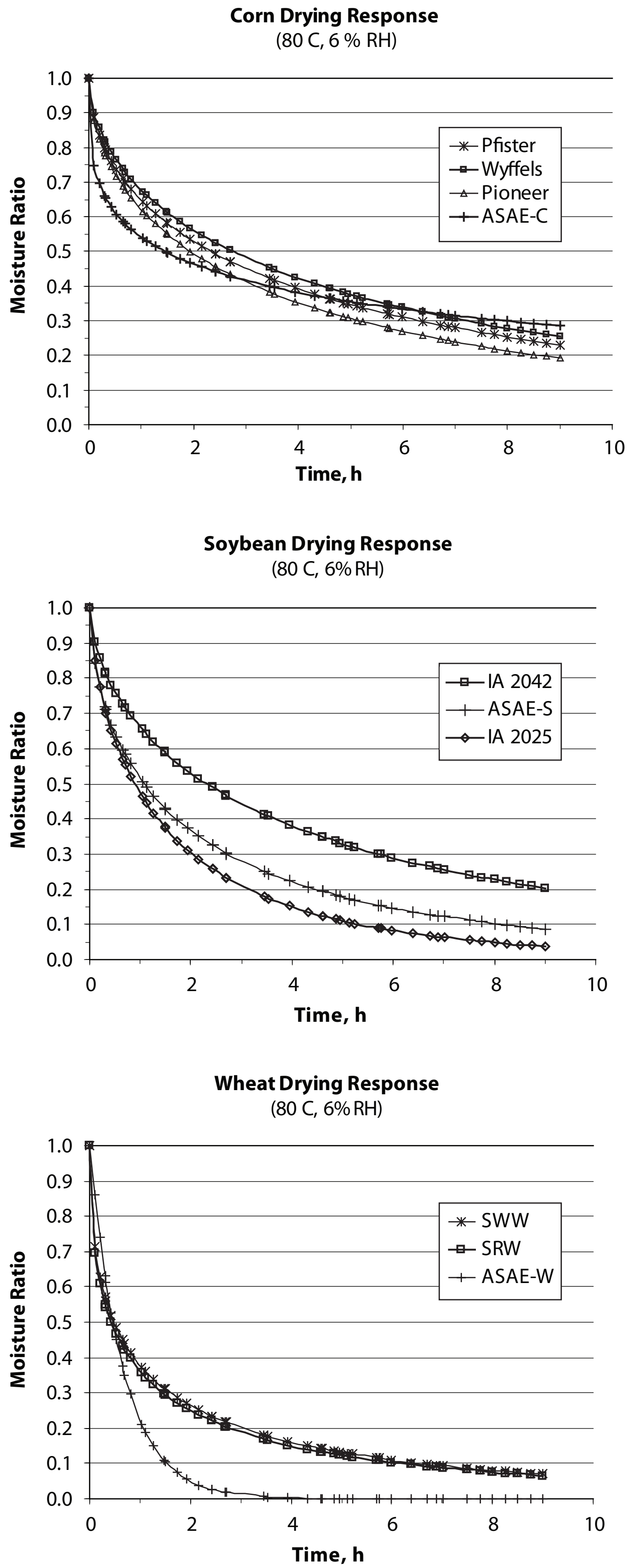
1. Conduct drying tests with specialty varieties of high-oil corn, triple-null soybeans, soft white winter wheat (SWWW), and historically grown/traditional yellow corn, soybean, and soft red winter wheat (SRWW) to determine respective drying rates.
2. Measure the equilibrium moisture content of the same specialty corn, soybean, and white wheat varieties and traditional yellow corn, soybean, and red wheat varieties to determine if there are differences between specialty grains and popular varieties.
3. Use existing mathematical models to describe the drying behavior and equilibrium moisture content level of these selected specialty crops and compare equation parameters between like products.

Materials and Methods

Drying experiments were conducted to simulate two typical types of on-farm systems: high-temperature bin dryers and high-temperature automatic batch or continuous flow units. Temperature and relative humidity levels chosen were 65 C (149 F) and 10%, and 80 C (176 F) and 6%, respectively. Specialty grains selected were high-oil corn, triple-null soybean, and soft white winter wheat because they are alternative crops with higher potential profits due to food-grade markets. Thin-layer, fully exposed drying tests were conducted in controlled environment for three to eight hours. Weight changes were recorded periodically during drying. Dry matter content was determined by oven-drying method (ASAE Standard S352.2). Tests were replicated three times and repeated for different temperatures (65 and 80 C). Drying parameters from the Page equation (ASAE Standard S448) were determined from the experimental data and compared with values for grains that are traditionally grown in the region (yellow corn, soybean, and soft red winter wheat).

Storage conditions evaluated for the same specialty grains included temperatures of 10, 25, and 40 C (50, 77, and 104 F) and relative humidities between 40% and 80%, which are typical of fall, spring and summer climatic conditions in the region, respectively. The dew-point method of moisture equilibration was selected to determine grain EMC (Flood and White, 1984). Grain samples were fully exposed in a constant temperature and relative humidity environment with weight changes recorded during several days of exposure. Three replicate tests were conducted for each set of test conditions. Average experimental EMC values were compared to those generated by published equations (ASAE Standard D245.5)—the modified Halsey equation for soybean and the average of the modified Chung-Pfost and modified Henderson equations for corn and wheat.

Figure. 1. Predicted drying response curves for specialty and traditionally grown corn, soybeans and wheat at a temperature of 80 C and relative humidity of 6%.



Results and Conclusions

Drying Tests

Representative predicted drying response curves for the high temperature test (80 C and 6 % relative humidity) is shown in Figures 1a, 1b and 1c for specialty and conventional corn, soybean and wheat, respectively. The remaining graphs for other drying tests are shown in a companion report available on the Web (http://www.uky.edu/Ag/NewCrops/dsg.pdf). The Page equation with newly generated regression parameters (k and n) (Table 1) adequately described the drying behavior of all products tested. Regression equation parameters for high-oil corn at 80 C were similar to those found for conventional corn but different than those found in the ASAE Standard (Table 1). Regression equation parameters for specialty soybean were slightly higher than the ASAE Standard for 65 and 80 C. Regression equation parameters for SRW wheat and SWW wheat were very similar but less than half the corresponding values in the ASAE Standard for wheat at 65 C. The Page equation with k- and n- values from ASAE Standard S448 did not satisfactorily describe the drying behavior of the products tested under these conditions (Figure 1 and Table 1).

Overall results showed that drying parameters for specialty grains were higher in some cases and lower in others for high-oil corn, soybean, and soft white wheat, depending on test conditions. Further study is needed to investigate the differences found between published drying parameters for the Page equation and those found by regression for the products tested and environmental conditions used in this study.

Storage Tests

Graphs for all measured and predicted EMC tests are shown in a companion report posted on the Web (http://www.uky.edu/Ag/NewCrops/dsg.pdf). In general, observed differences between measured and predicted values varied by less than a point of moisture (% wb) for some conditions, yet by more than 3 points of moisture at high temperatures and relative humidity levels. For

Table 1. Summary of drying test conditions, regressed and published parameters for Page equation (MR = exp (- k * t ^{n}), and sum of squares for estimates.

Variety	Temp C	RH %	Average MO % db	Average EMC % db	Average Time, h	Regression-Page k	Regression-Page n	Sum of Squares MR	Sum of Squares M % db	ASAE k	ASAE n	Sum of Squares MR	Sum of Squares M % db
Corn													
Wyffels 7355	80	6	20.5	1.27	3.35	0.388	0.574	0.0004	1.04	0.613	0.305	0.199	79.2
Pioneer 2563	80	6	23.1	1.27	4.57	0.477	0.565	0.0065	1.61	0.613	0.326	0.066	25.6
Pfister 2550-19	80	6	20.9	1.27	3.25	0.434	0.554	0.0015	2.60	0.613	0.308	0.138	54.4
Soybean													
IA 2025	65	10	17.2	3.40	7.39	0.613	0.649	0.0102	1.96	0.502	0.556	0.275	1.96
IA 2042	65	10	13.1	3.40	7.14	0.587	0.676	0.0370	2.96	0.502	0.556	0.323	30.4
IA 2025	80	6	18.1	3.20	3.63	0.750	0.670	0.0014	0.30	0.665	0.592	0.048	10.7
IA 2042	80	6	18.7	3.20	7.63	0.415	0.612	0.0223	4.71	0.665	0.592	5.983	152.8
SRW Wheat													
Pioneer 2552	65	10	17.2	2.00	7.69	0.859	0.477	0.0054	1.93	2.05	1.00	1.010	235.3
Pioneer 25W60	65	10	20.9	2.00	7.36	0.900	0.500	0.0028	0.74	2.05	1.00	0.864	307.2

corn, the absolute differences between observed and published EMC values ranged between 0.5-2.7, 0.1-1.8, and 0.1-1.8 % wb, for 10, 25 and 40 C, respectively. Differences between average EMC values for high-oil corn and conventional corn were less than those for published values, especially at 10 and 25 C. Absolute differences between observed and published EMC values for soybean ranged between 0.2-2.8, 0.7-2.8, and 0.0-0.4 % wb, for 10, 25, and 40 C, respectively. Differences between average EMC values for specialty soybean were less than those for published values, especially at 10 and 25 C. For wheat, absolute differences between observed and published EMC values ranged between 1.4-4.0, 0.1-3.1, and 0.1-3.1 % wb, for 10, 25, and 40 C, respectively. Differences between average EMC values for SRW wheat and SWW wheat were less than those for published values, especially at 10 and 25 C.

Average observed EMC values for specialty corn, soybean and wheat were within practical limits for many portable moisture meters (0.5% wb) when compared to published values, especially at 40 C. Absolute differences between observed and published EMC values for corn, soybean, and wheat ranged between 0.1-2.7, 0.0-2.8, and 0.1-4.0 % wb, respectively, for all temperatures. Differences in observed and published EMC values were generally higher at lower temperatures and higher humidity conditions for all products. Further study is needed to address the differences found between measured EMC values and those predicted by the equations for corn, soybean, and wheat given in ASAE Standard D245.5.

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SPECIALTY GRAINS—ORGANIC PRODUCTION

Organic Grain Crops Field Research Initiative

Larry Grabau, Department of Plant and Soil Sciences

When this project was funded by the New Crop Opportunities Center in 2004, the following two objectives were declared:

1. To establish two field locations for continuous, multi-disciplinary research, instruction, and extension activities in support of organic grain cropping systems in Kentucky
2. To provide the stimulus for ongoing investment in the development of organic grain cropping systems for Kentucky producers.

As of early 2006, we have established two locations to support the development of organic grain cropping systems. In the fall of 2004, we began our first location on Maine Chance Farm (just north of Lexington) with the first plantings of winter annuals (wheat, rye, and hairy vetch), and biennials (red clover and orchardgrass). In the summer of 2005 we followed with plantings of corn and soybeans at the first location. We began our second location at the West Kentucky Research and Education Center near Princeton in the fall of 2005 with the first plantings of winter annuals and biennials. This summer (2006) we will plant corn and soybeans at our second location. Thus, we are well on our way toward achieving the first objective.

Achieving our second objective will require two major steps: 1) effective management of these research projects, with an eye toward developing systems that could work under "real-farm" constraints, and 2) effective presentation of such results to county extension and producer audiences. In order to make progress on the first of these steps, we will need to generate additional projects that "dig into" various aspects of the cropping systems we have begun to establish; such projects will require collaborations with other research and extension faculty as well as the recruitment of graduate students in support of this initiative.

We are establishing three distinct cropping systems, each of which works with a two-year rotation. Both locations include replicated tests (four replications at Lexington, three replications at Princeton) of each of the three cropping systems. Here's how the cropping systems work:

a) CF—corn/forage. A red clover/orchardgrass mix is seeded in the early fall and harvested regularly during the entire following growing season. The next spring (approximately 19 months after planting), this forage mix is plowed down and corn is planted.
b) CSCC—corn/soybeans/cover crops. In the fall, rye and hairy vetch cover crops are planted. In the following spring, these cover crops are plowed down, after which corn (behind the hairy vetch) and soybeans (behind the rye) are planted. In the following fall, rye will be planted after corn, while hairy vetch will be planted after soybeans, making this a two-year rotation.
c) CWS—corn/wheat double-crop soybeans. Corn is planted in the spring, followed by winter wheat in the fall, then by double-crop soybeans the next summer.

These three rotations all include a corn crop for direct comparison; however, they vary in the number of grain crops over each two-year increment of the rotation. While CF has only one grain crop (corn) in two years, CSCC has two grain crops (corn and soybeans) in two years, and CWS has three grain crops (corn, wheat, and soybeans) in two years.

As part of the above cropping systems, we are also looking at other combinations of treatments, for example:

- nitrogen rates on corn
- nitrogen rates combined with planting rates for wheat
- planting rates for soybeans
- cover crop residue rates for both corn and soybeans.

SPECIALTY GRAINS—SOYBEANS

Edamame Production Systems for Extended Harvest

Todd Pfeiffer, Department of Plant and Soil Sciences

Objectives were to 1) extend harvest of fresh edamame in Kentucky from July 1 to October 31, and 2) produce a constant supply of fresh edamame during this production window.

Edamame production techniques were developed for spring, summer and fall production. Spring production required using soybean transplants. Use of low tunnels covering soybean plants transplanted as early as April 1 increased pod yield 29% (12,700 kg/ha vs. 9,800 kg/ha) compared to uncovered treatment. First harvest was on June 15, 2003, and May 21, 2004. First harvest with yield greater than10,000 kg/ha was on June 23, 2003, and May 21, 2004. Extended photoperiod was not profitable when raising transplants.

Summer production ranged from 25,000 to 14,000 kg·ha^{-1}. Harvest period lasted from August 12 until September 30.

In fall production, harvest of fresh edamame was extended to October 31. High tunnels increased yields 22% compared to unprotected plants.

Conclusions

- Fresh market edamame can be harvested in Kentucky between June 1 and October 31.
- Use of row covers in early spring and high tunnels in fall production extends the harvest of economically significant yields for fresh market edamame.
- Edamame variety from MG 3 was the most suitable for consecutive planting and harvest throughout the production season.
- The following table showing recommendations for extended production of fresh market edamame was developed:

Table 1. Recommendations for extended production of fresh market edamame.

Planting Date	System	Varieties	Estimated Harvest Date
4/1	Transplant	BeSweet 292	6/1
4/15	Transplant	BeSweet 292	6/15
4/30	Transplant	BeSweet 292	6/23
5/15	Transplant	BeSweet 292	6/30
		Gardensoy 31	7/5
		Gardensoy 41	7/26
5/1	Seeded	BeSweet 292	8/12
		Gardensoy 31	8/22
5/15	Seeded	Gardensoy 31	8/26
5/29	Seeded	Gardensoy 31	9/4
6/12	Seeded	Gardensoy 31	9/13
6/26	Seeded	Gardensoy 31	9/16
7/10	Seeded	Gardensoy 31	10/4
7/24	Tunnels	BeSweet 292	10/10
8/8	Tunnels	BeSweet 292	10/20
8/22	Tunnels	BeSweet 292	11/1

Breeding Triple-Null Lipoxygenase Soybean Cultivars

Todd Pfeiffer, Department of Plant and Soil Sciences

The first objective was to backcross the lipoxygenase null alleles lx1, lx2, and lx3 into '7499,' the most recently released maturity group IV commodity cultivar from the University of Kentucky. Backcrossing was completed in 2000, and lipoxygenase-free lines were tested in subsequent years in the Kentucky Soybean Performance Tests. The line most similar to '7499' was KY00-10-126. A 1-acre seed increase field was grown in 2004. Forty-three units with 82% germination are stored at Kentucky Foundation Seeds. An interested contract producer has not been identified.

The second objective was to develop a black-seeded soybean for organic production. A black Stressland was selected as a mutant from the maturity group IV variety Stressland. A 1-acre seed increase was grown in 2004. Thirty-eight units with 89% germination are stored at Kentucky Foundation Seeds.

The lipoxygenase null alleles lx1, lx2, and lx3 were crossed into Black Stressland. In 2005, 28 Black Stressland LF (lipoxygenase-free) lines were yield-tested at Lexington. Ten lipoxygenase-free black seed lines will be advanced from the 2005 production tests into the second year's testing in 2006. Testing will be conducted at five locations through the Kentucky Soybean Performance Test program. Releasing Black Stressland LF is anticipated following the 2006 season, with a seed increase in 2007.

The objective in the lipoxygenase-free breeding program has shifted slightly during the past four years. The program is focusing on developing edamame varieties that will fit in the production systems developed in the companion New Crop Opportunities grant "Edamame (green vegetable soybean) production systems for extended harvest." The following additional genetic materials have been produced in this program:

1. In 2005, we tested 25 lipoxygenase-free lines in edamame production. Five lines will be continued in testing in 2006.
2. One hundred lipoxygenase-free BC1 derived lines of three current edamame varieties (Emerald, Gardensoy 22, and Gardensoy 41) will be initially tested in 2006.
3. 2000 F2-derived lines from multiple-parent crosses are available for selection based on seed size, powdery mildew resistance, and presence of the <u>ln</u> allele.

Management and Production Potential of High-Protein and Tofu Soybean Cultivars in Kentucky

Saratha Kumudini, Larry J. Grabau, Todd W. Pfeiffer, and Colleen C. Steele, Department of Plant and Soil Sciences

Most commodity soybean production in the United States is destined for industrial use or for animal feed. With the emerging markets in Asia and the growth in popularity of soyfoods in the United States., the soyfood industry is growing at a faster rate than the commodity soybean sector. Although soybean production for the food industry accounts for a small fraction of the national soybean market, this niche market is highly profitable. High-protein and tofu-type soybean are grown for the food industry because protein concentration is an important quality component of many soyfoods. In North America, growers of value-added soybean cultivars are generally under contract with a particular manufacturer of tofu and related products. These growers are usually required to grow specific cultivars with known seed color, protein concentration, and other characteristics. In return, the farmers are given premiums for their food-grade soybean.

Faced with the status of commodity prices and the decline of tobacco production in the region, farmers in Kentucky are looking to options for improving their profitability. Food-grade soybean production is of particular interest because it is a crop that is familiar to growers and can be grown with farm equipment readily available to farm operators in the region.

Despite the price advantage of value-added soybean, the ability of growers to make a profit will depend on the production potential and the cost of management. Until recently, little was known of the production potential and optimum management practices to grow these cultivars in Kentucky. Funded by a USDA Special Grant for New Crop Opportunities, we published, in the May-June 2005 issue of *Agronomy Journal,* the results of a study conducted at two locations in 2000 and 2001 on the production potential and management options of high-protein and tofu-type soybean cultivars.

We took into consideration that the production potential of high-protein and tofu soybean may be lower than standard soybean cultivars, since seed protein concentration is usually negatively correlated with seed yields. Protein formation requires relatively more nitrogen than other seed components. For this reason, nitrogen applications were part of both the high-protein soybean study and the tofu soybean study.

For the high-protein test, six soybean cultivars were included: a maturity group II, III, and IV high-protein cultivar and a maturity group II, III, and IV commodity cultivar (Table 1). The objective in producing high-protein soybean is to increase protein per bushel and protein per acre if possible. Management treatments compared the application of 40 lbs/acre N at growth stage R5 (beginning seed fill) with no N application.

The cultivars differed significantly for protein concentration, with the high-protein cultivars having higher protein concentrations than the commodity cultivars (Table 1). The six cultivars differed significantly in yield. All three of these high-protein cultivars were near the bottom of the yield list in their respective maturity groups in the 2001 Kentucky Soybean Performance Tests. K1431 was the lowest yielding of all six cultivars in this test; however, K1431 had by far the highest protein concentration of any novel soybean that we tested in the 2000 and 2001 Kentucky Soybean Performance Tests. The R5 nitrogen application did not affect seed yield or seed protein concentration (data not shown).

Table 1. Cultivar characteristics in the high-protein management test.

Cultivar	Maturity Group	Type	Yield bu/acre	Seed Size mg/seed	Protein %
U97-207427	II	High Protein	62	150	38.5
Jack	II	Commodity	59	130	37.2
NE3396	III	High Protein	64	101	38.6
Pioneer 93B11	III	Commodity	64	155	35.5
K1431	IV	High Protein	56	151	44.3
CF461	IV	Commodity	64	131	36.2

Table 2. Cultivar characteristics in the tofu management test.

Cultivar	Maturity Group	Type	Yield bu/a	Seed Size mg/seed	Protein %
FG1	III	Tofu	68	221	36.7
IA 3011	III	Tofu	62	208	39.2
Pioneer 9305	III	Tofu	65	166	36.1
Pioneer 93B01	III	Commodity	65	121	35.1

For the tofu test, four maturity group III soybean cultivars were included: three tofu cultivars and one commodity cultivar (Table 2). The objective in producing tofu-quality soybean is to produce a large seed with moderately high protein. Management treatments compared the application of 40 lbs/acre N at growth stage R2 (mid-flowering) with no N application.

The cultivars were significantly different for seed size and protein concentration, with the tofu cultivars having a larger seed size and a higher protein concentration than the commodity cultivar (Table 2). The cultivars differed significantly in yield, but the commodity soybean cultivar was only in the middle of the range (Table 2). In the 2001 Kentucky Soybean Performance Tests, however, these three tofu cultivars all yielded below the maturity group III one- and two-year average yields. The R2 nitrogen application did not alter seed yield, seed protein concentration, or seed size (data not shown).

In conclusion, there was no benefit to seed yield or quality from the low-rate nitrogen application. However, additional nitrogen is not needed to produce high-protein and tofu specialty soybean with acceptable protein concentrations. There is good production potential for value-added soybean cultivars in Kentucky, even when grown with current equipment and management practices utilized for commodity soybean crop production. The production of value-added soybean cultivars may offer a profitable alternative for farmers. We do advise farmers to be prepared to combine these specialty cultivars very soon after reaching maturity because some tended to be prone to shattering. Furthermore, growers might consider giving priority to these cultivars over commodity cultivars when it comes to management practices such as herbicide applications in order to give these value-added cultivars every possible advantage.

SPECIALTY GRAINS—SOYBEANS

The Effects of Changes in Seed Protein Concentration on Seed Growth Characteristics of Soybean

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The value of seeds harvested from grain crops comes from the oil, protein, and carbohydrates they contain. Their value could be increased by manipulating seed composition to create a more desirable and useful product. Plant breeders have changed seed composition in many crops using traditional breeding methods, but new techniques from molecular biology are making manipulation easier and may increase the magnitude and type of changes possible.

Manipulation of seed composition frequently causes changes in other components of the seed and in yield. For example, increasing seed protein concentration often results in reductions in oil concentrations and yield. Such compensatory changes make it difficult to develop cultivars with both high seed protein concentrations and commercially acceptable yield. The syntheses of protein or oil requires more energy and assimilate per unit weight of product than carbohydrates, so, with constant photosynthesis and assimilate supply, there must be offsetting changes in composition or yield to maintain the same total energy content in the seed fraction.

The lower yield of high protein genotypes may also be a result of a shorter seed-fill duration. It is thought that the higher N requirement of seeds on high protein genotypes may accelerate the loss of N from the vegetative plant, increasing the rate of leaf senescence, shortening the seed-fill period, and decreasing yield.

The physiological processes responsible for the negative relationship between soybean yield and seed protein concentrations are not well understood. Investigations of dry matter production by individual seeds made major contributions to a better understanding of the yield production process. We felt that studying the accumulation of protein by individual seeds would, therefore, lead to a better understanding of the interactions between seed protein levels and yield.

We compared three soybean genotypes that had high seed protein concentrations with three genotypes having normal protein levels for three years in the field. Seed protein concentration had no effect on the rate of dry matter accumulation (mg $seed^{-1}$ day^{-1}) by individual seeds. However, the rate of N accumulation (mg N $seed^{-1}$ day^{-1}) was closely associated with seed protein levels ($r = 0.87^{**}$, $n = 18$) and it varied from 0.44 mg N $seed^{-1}$ day^{-1} for the genotype with the highest protein level to 0.29 mg $seed^{-1}$ day^{-1} for the genotype with the lowest protein level. Increasing the seed protein concentration did not shorten the seed-filling period of any of the high protein genotypes (mean filling period of high protein was 32.1 days compared with 32.3 days for the normal genotypes). These results suggest that the negative relationship between seed protein concentrations and yield cannot be explained at the single seed level, but apparently it is a whole plant phenomenon, possibly involving reductions in the assimilate supply to the seeds as the plants accumulate more N before or during seed filling.

Reference

Egli, D.B., and W.P. Bruening. 2006. Accumulation of N and dry matter by soybean seeds with genetic differences in protein concentration. Crop Sci. (Submitted).

SPECIALTY GRAINS—SOYBEANS

Testing Novel Soybean Varieties

Eugene Lacefield, Department of Plant and Soil Sciences

Introduction

The novel soybean varieties being tested are just a few of the many that are emerging from both the public and private sectors. Some of these value-added soybean types will supply relatively small market niches, while others may be of a much broader market value. Novel soybeans generally yield less, so testing them will enable soybean producers to determine whether premiums for a given trait offset possible yield lag/drag. Examples are triple-null soybeans, designed for edible soy products (this variety lacks three enzymes that produce off-flavors); natto soybeans, a small-seeded soybean used for food and export; and tofu, a big-seed/high-protein soybean also used for food and export. Other big-seed/high-protein types are used for animal food, which potentially has a large U.S. market.

Materials and Methods

Firms and institutions that possess novel soybean varieties are contacted and asked to supply seed for testing in Kentucky. Sufficient seed is requested of each emerging novel variety for planting two replicated plots at five locations. The novel soybeans are planted as part of the current soybean variety testing program. Management practices are those used for the standard soybean varieties and are conducted over a wide range of soil series and environmental conditions. Novel varieties are blocked by maturity group, as are the standard varieties, to allow for more timely harvest. After harvest each novel variety is analyzed for protein and oil content by the Iowa State University Grain Quality Laboratory, using near-infrared (NIR) analysis. In each case, the 100-plus varieties in the Kentucky variety test will be run through the same quality characteristic screening, providing a basis of comparison of novel soybeans with current top-yielding varieties grown in Kentucky. This information will allow us to learn about both the actual levels and stability of a given novel quality characteristic under Kentucky conditions.

Results and Discussion

Twenty-three novel soybean varieties were tested at five locations across the state in 2005. The locations were Fayette, Caldwell, Warren, Marshall, and Henderson counties. Twenty-seven were tested in 2004, 28 in 2003, 22 in 2002, 19 in 2001, and 11 in 2000. Data (yield, lodging scores, maturity dates, plant height, and oil and protein percents) for the last three years can be found in the Kentucky Soybean Performance Tests publication for each year. Novel soybeans are indicated by an "NS" prefix in all tables. A Web page provides access to all Kentucky variety test publications. The URL is: http://www.uky.edu/Ag/GrainCrops/varietytesting.htm

Conclusion

In general, the measured yields of the novel soybean varieties were lower than those of standard soybean varieties of corresponding maturity groups (Table 1) for all test years. Soybean producers need to have reliable data on grain yield along with solid information on market value before they take steps to adopt novel soybean varieties on their farms.

	Kentucky Soybean Variety Trials (partial list of entries - see Web site for complete list)								
	Table 1. 2005 Summary: Variety Test Tables 5-9								
		YIELD (BU/AC)[A]			**LODGING**			**PROTEIN**[B]	**OIL**[B]
	BRAND -- VARIETY	**2005**	**04-05**	**03-05**	**2005**	**04-05**	**03-05**	**%**	**%**
	EARLY (GROUP III)								
~	ASGROW AG3905*	56.0	63.0	61.9	2.1	2.0	1.9	35.8	19.8
~	ASGROW AG3906*	55.1			2.4			36.3	20.5
~	UNISOUTH GENETICS USG 7393nRR**	54.3			2.6			36.1	21.0
~	SOUTHERN CROSS STEPHEN 3.8 N, RR*	54.1	62.1	62.1	2.6	2.2	2.1	36.0	21.0
~	EBBERTS 1385RR	53.5	63.3		2.4	2.4		36.4	20.7
~	PIONEER VARIETY 93M90*	52.1	62.1	62.5	1.9	1.9	1.8	35.8	19.1
~	DELTA KING DK3968*	51.7	61.0	61.3	2.4	2.1	1.9	35.5	20.7
NS	IA3022 (large seed, high protein)	39.5	47.6		3.0	2.7		39.0	18.9
P	IA 3023	36.5	49.8		2.3	1.9		34.7	20.7
NS	IA3012LF (lipoxygenase free)	32.8	43.5	45.4	2.7	2.3	2.4	35.7	20.8
NS	IA3008LF (lipoxygenase free)	32.7	41.7		3.3	3.3		35.1	18.6
NS	IA3006PR	30.8			2.5			39.0	19.3
	(high protein, phytophthora resistance)								
NS	IA3021 (large seed, high protein)	29.9	42.2		2.2	1.8		38.5	19.8
	GROUP III AVERAGE	44.5	53.6	58.6	2.5	2.3	2.0	36.4	20.0
	LSD (0.10)	2.5	1.9	1.7	0.2	0.2	0.1		
	MID-SEASON (GROUP IV)								
~	SOUTHERN STATES RT 4451N**	62.7			2.3			35.4	20.3
~	SOUTHERN STATES RT 4808N	61.6			2.4			35.7	19.4
~	VIGORO V48N5RR*	61.2	66.2		2.8	2.9		36.3	20.4
~	ASGROW AG4903	61.2			2.2			36.5	20.0
~	STEYER 4700 RR SCN**	61.1	67.4	65.1	2.2	2.1	2.2	35.7	20.7
~	GARST SEED 4612RR/N	61.1			2.3			36.5	20.0
~	VIGORO V49N6RR	61.0			2.8			37.8	18.6
~	ASGROW AG4703	60.8			2.1			37.2	19.4
~	DYNA-GRO 3443NRR**	60.6	66.1	65.5	2.2	2.2	2.1	34.6	21.4
~	SOUTHERN STATES RT 4551N	60.5			3.1			37.7	18.7
~	NK BRAND S49-Q9**	60.4	64.4	64.0	2.2	2.4	2.4	37.1	18.8
~	ASGROW AG4801*	60.3	64.7		2.2	2.0		37.1	20.2
~	HORNBECK HBK R4724	60.1			2.3			35.3	19.5
~	DYNA-GRO 35Z49**	60.0			2.4			35.5	19.4
~	HELENA BRAND SEED 4875**	59.8	65.8		2.7	3.1		35.4	19.1
~	UNISOUTH GENETICS USG 7484nRR**	59.7	66.2		2.6	3.0		34.9	19.6
~	DELTA KING DK4763*	59.6	65.7	66.2	2.3	2.6	2.4	37.2	19.6
~	SOUTHERN CROSS DAN 4.8 N, RR**	59.4			2.5			35.9	19.5
~	DELTA KING DK4967*	59.1	65.8	66.7	2.3	2.4	2.5	36.7	20.0
~	DYNA-GRO 3481NRR**	59.1			2.2			37.5	19.4
~	EXCEL BRAND 8493NRR*	59.1			2.5			37.4	18.7
~	GARST SEED 4512RR/N	59.0	66.0		2.1	2.1		35.4	21.2
~	DELTA AND PINE LAND DP 4724 RR*	59.0			2.3			38.4	19.5
~	UNISOUTH GENETICS USG 7494nRR**	58.9	67.0		2.5	2.8		36.9	19.9
NS	S02-7955 (natto)	58.9	59.8		2.0	2.0		37.1	17.8
NS	S02-1001 (tofu)	57.4			3.4			34.5	18.8
NS	V97-1346 (high protein)	52.2			1.9			44.2	15.1
~	VIGORO V42N3RR**	52.0	64.8	65.3	2.1	1.9	1.7	36.2	20.2
~	BIO GENE BG 4206RN*	52.0			2.1			34.9	20.5
NS	ADLER 435* (high protein, food grade)	51.9			2.3			36.4	19.4
NS	KS4303sp (small seeded variety)	45.7	49.3		2.8	2.5		35.7	19.2
NS	KS4103sp (high protein variety)	41.7	48.5	49.7	2.4	3.1	2.9	43.4	15.8
NS	ADLER 405 (high protein, food grade)	41.3			2.7			37.2	19.7
NS	IA4003 (large seed, high protein)	39.3			2.6			39.7	18.1
	GROUP IV AVERAGE	57.0	63.2	63.2	2.4	2.5	2.3	36.3	19.9
	LSD (0.10)	2.8	2.8	2.1	0.2	0.2	0.2		

	Kentucky Soybean Variety Trials (partial list of entries - see Web site for complete list)								
	Table 1. 2005 Summary: Variety Test Tables 5-9								
		YIELD (BU/AC)[A]			**LODGING**			**PROTEIN[B]**	**OIL[B]**
	BRAND -- VARIETY	**2005**	**04-05**	**03-05**	**2005**	**04-05**	**03-05**	**%**	**%**
	LATE (GROUP V)								
	UNISOUTH GENETICS USG 5002T	67.3	65.8	65.6	2.3	3.0	3.1	36.1	19.8
	UNISOUTH GENETICS USG 5601T	66.6	68.6	66.5	2.3	2.6	2.8	38.0	18.4
~	DYNA-GRO 33X55**	65.5			2.3			36.9	18.9
~	DELTA KING DK5567	65.0	62.0		2.5	3.1		36.3	18.9
~	DYNA-GRO 33B52**	63.9	61.9	61.7	2.6	3.3	3.4	35.5	19.8
P	HUTCHESON	63.6	60.6	59.5	2.6	2.9	2.9	36.1	19.4
NS	V98-9005 (low 18:3, high protein)	63.0			2.3			37.6	18.7
P	TEEJAY	62.7	63.6		2.3	2.5		36.5	19.2
~	DELTA KING DK5366	62.3	57.5	57.6	2.8	3.4	3.4	37.5	19.2
~	DELTA KING DK55T6**	61.9	57.6		2.8	3.1		35.1	19.4
~	UNISOUTH GENETICS USG 510nRR**	61.4	62.3	62.5	2.2	2.5	2.5	35.6	18.9
~	DELTA KING DK5066*	61.3			2.4			38.1	19.2
P	ANAND**	60.7	60.0	60.9	1.9	2.0	2.2	35.7	19.0
NS	KS1613sp (low linolenic acid)	60.7			2.4			34.5	19.7
NS	V00-4272 (low 18:3)	59.7			2.7			36.4	19.1
NS	S02-11303 (natto)	59.5			2.6			36.4	18.0
NS	S00-1434 (tofu)	55.6			2.9			36.9	18.2
NS	KS5005sp (large seed, high protein)	54.0	57.2		2.2	2.6		38.3	18.3
NS	V01-6348 (low saturate, low 18:3)	49.9			2.4			38.0	18.7
NS	KS1642sp (low linolenic acid)	48.4			3.0			34.5	19.8
NS	KS5003sp (small seeded variety)	46.7	47.7		2.6	2.4		35.8	19.3
NS	SOUTHERN STATES TARA (forage)	42.8	49.7		2.6	2.7		37.0	17.9
	GROUP V AVERAGE	59.2	59.6	62.0	2.5	2.8	2.9	36.7	19.0
	LSD (0.10)	2.8	2.7	2.0	0.2	0.2	0.2		
	GRAND MEAN	20.6	27.5	31.6	0.9	1.2	1.3	36.4	19.7
~	Roundup Ready variety								
P	Entries with a P prefix are public varieties.								
NS	Entries with a NS prefix are novel soybean varieties that are emerging from both the public and private sectors. Some of these value-added soybean types will supply relatively small market niches, while others may be of much broader market value. Testing novel soybeans will enable producers to assess whether premiums for a given trait offset possible yield lag/drag.								
*	Resistant to the soybean cyst nematode (Race 3)								
**	Resistant to the soybean cyst nematode (Race 3 and Race 14)								
A	Within a maturity group, shaded yields are not significantly different (0.10 level) from the highest yielding cultivar (bold data) of that maturity group and year column.								
B	Variety protein and oil concentration was determined at the Caldwell Co. location (all test locations for NS entries) and expressed on the basis of 13% moisture. These data were provided by the Iowa State University Grain Quality Analysis Services using near-infrared (NIR) analysis.								

Sweet Sorghum Improvement

Todd Pfeiffer and Morris Bitzer, Department of Plant and Soil Sciences

The overall objective of this project is to improve sweet sorghum production in order to increase the number of farms participating in the enterprise. The specific objective is to breed earlier-maturing sweet sorghum varieties that have disease resistance and juice Brix characteristics of current late-maturing varieties. Other objectives are to produce small quantities of seed of sweet sorghum varieties and to predict the need for enzymes during processing based on juice composition.

Our first approach has been to evaluate the potential for male sterile hybrid sweet sorghum varieties to provide an immediate benefit to sorghum syrup producers. Our questions are: Does sterility increase stalk sugar because the carbohydrates are not needed for seed growth? Will hybrid varieties produce more syrup (stalk juice x stalk sugar) than pureline varieties?

Fertile pureline varieties and sterile pureline and sterile hybrid varieties were compared. The four pureline varieties (both fertile and sterile) were Dale, A3 Dale, Sugar Drip, A3 Sugar Drip, Wray, A3 Wray, N100, and A3 N100. The 12 hybrids (each male sterile pureline crossed with each of the other three fertile purelines) were A3 Dale x Sugar Drip, A3 Dale x Wray, A3 Dale x N100, A3 Sugar Drip x Dale, A3 Sugar Drip x Wray, A3 Sugar Drip x N100, A3 Wray x Dale, A3 Wray x Sugar Drip, A3 Wray x N100, A3 N100 x Dale, A3 N100 x Sugar Drip, and A3 N100 x Wray.

Four replications of 20 entries were planted in three row plots (20 feet x 30 inches) May 11 at Lexington, KY Sixteen plants per plot were bagged at heading, but heading date was recorded prior to pollen shed to maintain sterility. Plots were rated for lodging and leaf plus stalk diseases at harvest. Twelve plants per plot were harvested (10/4 to 10/7), and the following variables were measured: plant height, stem diameter, stalk weight, juice weight, and Brix. Juice fraction was calculated as (juice weight)/(stalk weight).

Sterility had little effect on the variables measured. While the sterile purelines were five days earlier in maturity, they were also shorter. Male sterility did not increase stalk sugar (Brix) or juice. On the other hand, hybrids matured earlier, were taller, and had thicker stems. The hybrids produced more juice than purelines. This increased juice resulted from increased plant height and stem diameter, not from increased juice percentage. Hybrid sweet sorghum varieties may be a first step to increasing sorghum syrup production without increasing the production area or production labor.

The breeding effort produced 18 crosses between early and late maturing sweet sorghum cultivars. Crosses were grown in 2005, and F2 seeds were produced. The F2 plants will be selected in 2006 for early maturity, and F2:3 lines will be screened in 2007 for resistance to maize dwarf virus and stalk red rot caused by anthracnose.

Sorghum plant introductions obtained from the USDA germplasm collection at Griffin, GA, are being screened for stalk sugar. All lines in the collection with early maturity and juicy stems will be screened. In the past two years we have screened 100 plant introductions. Five of these had greater than 18% Brix. These will be investigated for the potential for different genes producing high sugar that may be valuable in increasing stalk sugar in sweet sorghum varieties.

The objective to select for genetic uniformity in older varieties is progressing. In 2005, we grew progeny row seed increases of Simon and Della. These rows were selected for trueness to type and will be grown again in 2006. Purification grow-outs of Keller and Sugar Drip will begin in 2006. Similarly, our objective to produce quantities of seed of sorghum varieties no longer being produced by foundation seed organizations is progressing. In 2005, we produced 65 kg of Sugar Drip, 118 kg of Simon, and 150 kg of M81E. This followed our production of M81E, Keller, and Top 76-6 in 2004. All seed produced in 2004 was distributed, and seed produced in 2005 is now being shipped. There is a demand worldwide for small quantities of seed of these sweet sorghum varieties, primarily for ethanol research.

We have made no progress on the last objective of predicting the need for enzymes during processing based on juice composition, primarily due to our inability to mimic syrup production on a small research scale.

Development of White Wheat Cultivars from a Red Wheat Breeding Program

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Wheat can be placed into two classes based upon a seed coat color, red or white. Kentucky producers predominately grow soft red winter wheat. White wheat can be used to produce the same products as red wheat; however, white wheat has several advantages. Red wheat bran contains tannins, which produce a bitter flavor in wheat products. White wheat bran does not contain the bitter tannins. Consequently, white wheat produces more flour because it can be milled closer to the bran without negatively affecting color or flavor. The bran of white wheat can be used in breakfast cereals. White wheat can also be used to produce more appealing whole wheat products that lack the bitter flavor produced by red wheat bran. Many red wheat breeding programs have initiated white wheat breeding programs because of the advantages that white wheat possesses. However, problems impede the successful introduction of large scale white wheat production.

Seed coat color in wheat is controlled by three genes; red seed color is dominant to white seed color. There is a range of seed coat color intensities based upon the number of red genes present; white wheat occurs when there are no red genes present. Red wheat breeding programs generally do not characterize or select lines for a specific seed coat color; therefore, soft red winter wheat cultivars and experimental breeding lines that possess one, two, and three red genes are likely to occur. As a result, white-seeded progeny from red by red crosses can and frequently do occur; theoretically, white wheat breeding programs could be established relatively easily in an existing red wheat breeding program. Unfortunately, the difficulty in developing such a breeding program is unknown.

Materials and Methods

In 2000 and 2001, approximately 300 crosses between red and white seeded parents were made in order to develop populations that would produce white-seeded progeny. In the summer of 2003, 19 populations were chosen based upon agronomic characteristics to be advanced for further testing. Approximately 300 heads from each population were harvested. A single kernel from each head was randomly selected and planted into in the greenhouse in December 2003. At maturity the heads were harvested, and again a single kernel from each head was planted in the greenhouse in June 2004. Mature heads were harvested, and approximately 3,400 heads (Table 1) were planted into heads hills at Lexington in Fall 2004. In the summer of 2005, three populations (Table 2) were chosen based upon agronomic characteristics and disease resistance to be advanced. In Fall 2005, the white-seeded lines were planted at two locations (Lexington and Princeton, KY) with two replications. These lines will be evaluated for yield, test weight, disease resistance, and other agronomic traits. Milling and baking quality also will be assessed. Gluten strength was evaluated on lines from one population in 2005. We are particularly interested in gluten strength as a potential value-added trait that may be combined with the white-seeded trait. Strong gluten strength lines are ideal for crackers, while weak gluten types are suitable for cookies, cakes, and pastries. Preliminary results from one population indicated a threefold variation in gluten strength among lines within this population (Table 3). Sedimentation volume is used to measure gluten strength; low sedimentation values indicate low gluten strength, while high sedimentation values indicate high gluten strength.

Table 1. Number of heads planted into heads hills at Lexington, KY, per population.

Population	Number Heads Planted
KY00C-2274	163
KY00C-2276	211
KY00C-2708	213
KY00C-2710	233
KY00C-2762	241
KY00C-2779	195
KY00C-2780	196
KY00C-2921	155
KY00C-2927	269
KY01C-1110	236
KY01C-1111	194
KY01C-1112	216
KY01C-1539	211
KY01C-1576	182
KY01C-1583	165
KY01C-1584	106
KY01C-1585	104
KY01C-1650	169
KY01C-1651	165

Table 2. Populations chosen in 2005 for advancement.

Population	Number of Lines	
	White	Red
KY00C-2276	24	187
KY00C-2779	14	181
KY01C-1112	136	80

Table 3. Gluten strength of selected lines.

Line	Sedimentation Volume (mL)
2780-86*	5.25
2780-193	6.00
2780-180	6.75
2780-188	7.50
2780-181	8.75
2780-157	9.50
2780-2	10.25
2780-151	11.00
2780-122	12.00
2780-118	12.25
2780-126	13.00
2780-65	13.75
2780-3	14.25
2780-112	15.00
2780-83	15.25
2780-50	15.50
2780-55	16.25
2780-43**	17.00
LSD (0.05)	0.42

* Weak gluten
** Very strong gluten

Straw Yields from Six Small Grain Varieties

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The retail wheat straw market commands about $70 to $100 per ton. Some farmers are receiving about $30 to $40 per ton in the wholesale market. Two basic assumptions about straw production are 1) taller wheat means more straw, and 2) more grain means more straw. A study was conducted to determine if either of these assumptions is true. In addition, varieties were compared for yield, and planting date effect on straw yield was determined.

Five soft red winter wheat varieties and one triticale variety were planted at different planting dates over two years at University of Kentucky Spindletop Farm, Lexington, KY. The varieties are listed in Table 1. Seed from each variety was planted on Oct. 13, Oct. 31, and Nov. 26, 2003, and Nov. 11 and Dec. 16, 2004, at a target

Table 1. Small grain varieties, species, head type, and statewide average yield and height from the *2002-2003 Kentucky Small Grains Variety Trials Report*.

Variety	Type	Head Type	2002-2003 Yield (bu/a)	2002-2003 Height (in)
Pioneer 25R23	Wheat*	awned	83	36
Pioneer 25R49	Wheat	awnless	82	34
KAS Allegiance	Wheat	awned	82	40
Exsegen Sarah	Wheat	awnless	79	39
Trical 336	Triticale	awned	78	48
NK Coker 9663	Wheat	awnless	68	41

* Wheat = soft red winter wheat.

population of 35 seeds/ft^2. Soil fertility was conducted according to soil tests and *Lime and Fertilizer Recommendations* (AGR-1). Weeds were controlled with appropriate herbicides. Whole plants were harvested and weighed for total weight. Heads were removed and weights were taken, then the head weight was subtracted from the whole plant weight to determine straw weights. The yields reported here may be slightly higher than yields obtained with typical farm equipment, since more loss from the harvester and baler might be expected.

When yields were averaged over planting dates, the five winter wheat varieties produced similar straw yields during the 2003-2004 growing season (Table 2). The triticale variety yielded more straw (nearly 2 tons/acre) than any of the wheat varieties (which averaged nearly 1.2 tons/acre). During the 2004-2005 growing season, the triticale variety yielded over 2 tons/acre in straw production. This was significantly greater than straw yield from any of the wheat varieties. Four of the wheat varieties (Exsegen Sarah, KAS Allegiance, NK Coker 9663, and Pioneer 25R49) had yields that were not significantly different from each other in 2004-2005 growing season. Pioneer 25R23 produced significantly lower straw yields than Exsegen Sarah and KAS Allegiance.

The two October 2003 planting dates resulted in straw yields that were not significantly different from each other (Table 2). The November 2003 planting date resulted in straw yields that were significantly less than straw yields from the earlier planting dates. The December 2004 planting date resulted in lower yields than the November 2004 planting date. However, all yields from all planting dates were close to or above 1 ton/acre.

As plant height increased, straw yield increased (Figure 1). Straw yields had very poor to no relationships with grain yield (Figure 2).

Results from this study indicate that taller wheat provides more straw per acre. However, higher grain yields do not always translate into higher straw yields. Late planting dates reduce yield, but yields were close to or above 1 ton/acre in for all planting dates, which is \$30 to \$40 per ton value for the wholesale market. If a farmer is raising a small grain primarily for straw, then triticale may be the better option.

Table 2. Straw yields for each planting date.

		Planting Date, 2003							
		13-Oct		31-Oct		26-Nov		Average	
Variety	Type[1]	Straw Yield (tons/acre)							
Exsegen Sarah	SRW	1.35		1.59		0.89		1.28	b
KAS Allegiance	SRW	1.22		1.32		0.93		1.16	b
NK Coker 9663	SRW	1.40		1.44		0.84		1.23	b
Pioneer 25R23	SRW	1.42		1.52		0.77		1.24	b
Pioneer 25R49	SRW	1.36		1.35		0.74		1.15	b
Trical 336	Triticale	1.93		2.16		1.77		1.95	a
LSD (0.05)								0.17	
Average		1.44	a	1.56	a	0.99	b		
LSD of AVG (0.05)		0.12							
		Planting Date, 2004							
		11-Nov		16-Dec		Average			
Variety	Type	Straw Yield (tons/acre)							
Exsegen Sarah	SRW	1.92		1.07		1.49	b		
KAS Allegiance	SRW	1.66		1.35		1.51	b		
NK Coker 9663	SRW	1.40		1.37		1.39	bc		
Pioneer 25R23	SRW	1.45		1.00		1.22	c		
Pioneer 25R49	SRW	1.76		1.17		1.47	bc		
Trical 336	Triticale	2.30		1.82		2.06	a		
LSD (0.05)						0.26			
Average		1.75	a	1.29	b				
LSD of AVG (0.05)		0.15							

1 SRW = soft red winter wheat.
2 For means averaged across planting dates, different letters within a column denote significant differences. For means averaged across variety, different letters within a row denote significant differences.

Figure 1. Small grain plant height affects straw yield.

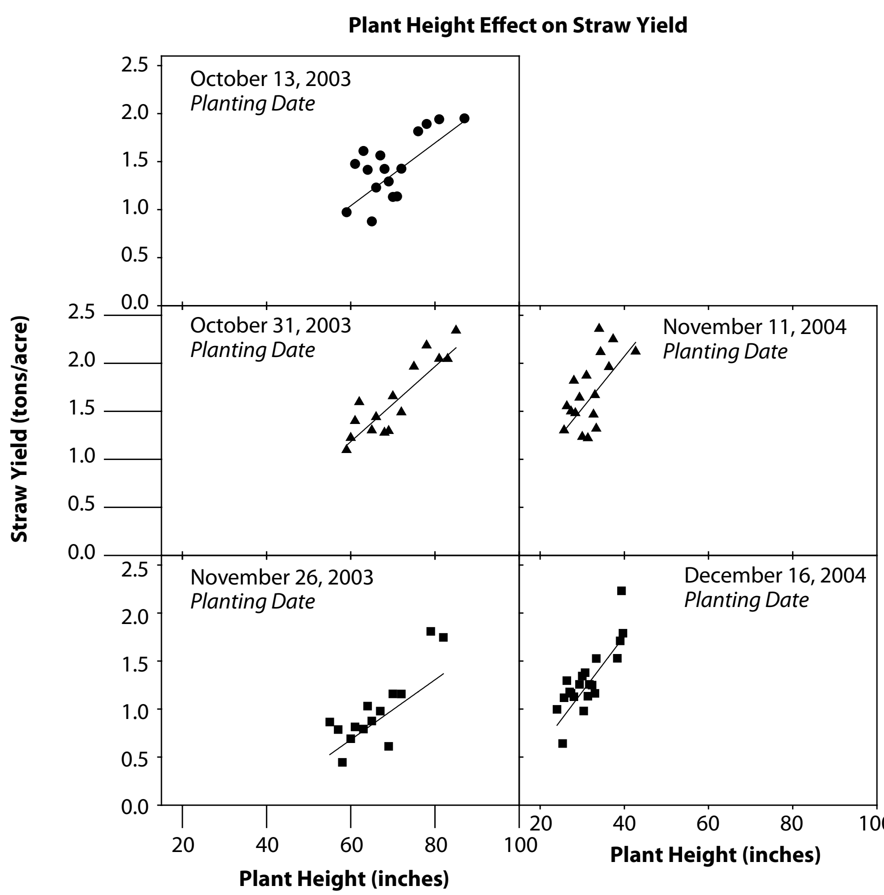
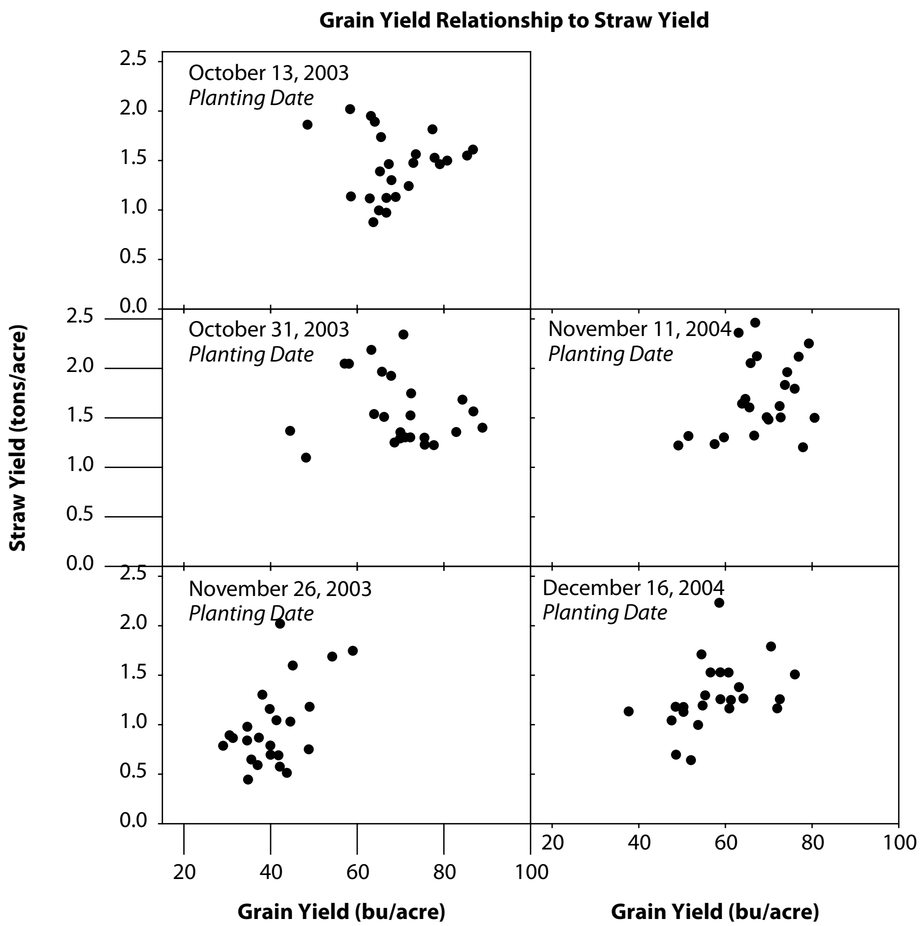


Figure 2. Small grain straw yield has a very poor to no relationship with grain yield.



SPECIALTY GRAINS—ECONOMICS

Economic Assessment of Specialty Grain Crops

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The General Economic Assessment Project includes two components to be used to develop budgets and guidelines that can help producers decide whether they should grow "new crops" on their farms in the future. The first is a producer survey to identify several factors:

- what crops have been grown
- what problems were encountered, both in production and marketing of the crop
- what expectations were for increased net returns, and
- what advice the past producers would give producers considering these types of crops for the first time.

The second project component will be to develop enterprise budgets for various new crop opportunities and compare them to conventional crops traditionally grown in Kentucky. Data will be used from the producers surveyed who have grown these new crop alternatives.

Some of these crops have been grown in the past and are not new, but they have not been present in any significant acreage in the past several years and are now being considered again. Most of the crops that would be considered "new crops" would fall into the category of "identity preserved" (IP) crops. IP is a system of production and delivery in which the grain is segregated based on intrinsic characteristics (such as variety or production process) during all stages of production, storage, and transportation (Rial, 1999).

Crops grown as an alternative to grain crops sold at the commercial markets that are similar to commercially grown crops require segregation from commercially grown crops when stored on-farm. Such crops typically command a price premium above the commercial market price. These crops are normally grown under some contractual arrangement with the buyer, but not exclusively. These crops are typically non-GMO in origin and include the following:

- Commercial Seed Bean Production
- Commercial Seed Corn Production
- Commercial Seed Wheat Production
- Food-Grade Wheat
- Food-Grade White Corn
- Hard Endosperm/Food-Grade Yellow Corn
- High Extractable Starch Corn
- High-Amylose Corn
- High-Oil Corn
- High-Oleic Soybeans
- High-Protein Soybeans
- High-Sucrose Soybeans
- Lipoxygenase-Free Soybeans
- Low-Saturate Soybeans
- Non-GMO Corn
- Non-GMO Soybeans
- Popcorn
- STS Soybeans
- Waxy Corn

The data has not been gathered in entirety, but several comments are being made consistently. One is that these contracts are not available every year. Kentucky is a fringe production state for most of these crops, and if the product is readily available in traditional corn-belt states, the contract will not be offered that year in Kentucky. The other is the inability to always meet quality levels necessary to earn the premium offered. Not achieving the necessary quality level may make the crop no more profitable than conventional crops. Also, the contractor may not take all of the production if a large crop is produced.

The Risk Management Analysis of Low Phytate Corn in Kentucky Project is in its final stages of analysis. It is known and widely published that low phytate corn (LPC) has many environmental benefits. However, a problem arose trying to find suitable yield data for LPC. Pioneer Seeds has performed some studies concerning expected yields of LPC. Pioneer was the primary producer of LPC seed as of the late 1990s and has since pulled the project because of the low expected yields. However, Pioneer can not disclose the yields from its trials.

Currently, there are no producers of LPC seed, making it impossible to establish a market for the corn. This has created a second problem—lack of price premiums. Lower yields and no price premiums will make it difficult to convince farmers in Kentucky to grow LPC. Although these findings might limit further research on LPC, the project has been modified to include other new types of corn. High-oil corn, for example, does have a price premium established and scholarly yield trials. Using some findings from high-oil corn, results will be applied to LPC. Furthermore, sensitivity analysis can be conducted to determine different yield and price combinations needed by farmers to produce LPC in the event the market should rise again.