



The Berry Basket

Newsletter for Missouri Small Fruit and Vegetable Growers

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From the Editors

by Marilyn Odneal

Spring has sprung and we have been running to catch up ever since. In this newsletter we are already picking blueberries and growing pumpkins! It is always good to schedule some breaks in the busy growing season. Keep in mind that upcoming events are highlighted on our websites. Check out <http://mtngrv.smsu.edu/Calendar.htm> for the upcoming workshops and conferences. Also see <http://outreach.missouri.edu/greene/> to see the calendar of programs.

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“It’s Blueberry Time”

By Ben Fuqua

Professor, Soil Science, SMSU

Blueberry plants have been pruned and fertilized, fungicides applied (as needed), and the irrigation system has been readied for use, so now it's time to get down to serious business-PICKING BLUEBERRIES. Although the ripening dates of blueberry varieties (cultivars) tend to differ slightly from one variety to another, blueberry harvest in Missouri generally begins in early/mid-June and extends until mid/late-July. During this 6-8 weeks of berry harvest, managing the harvest operation often becomes more than a full time job. While fresh blueberries practically “sell” themselves, the following tips can make “berry picking” a fun time for both growers and customers.

A Quantity of Quality: Most blueberries in Missouri are hand picked and sold as fresh fruit via U-Pick or pre-picked berries. U-pick customers harvest their own berries and thereby provide all labor for picking, grading, packaging, transportation, etc. Pre-picked berries are usually sold from on-farm facilities or local farmers' markets, making growers responsible for all labor needed to get the berries from the bush to the consumer. Regardless of the method of marketing used, one key to keep customers returning for more blueberries is having an ample supply of high quality berries available for purchase.

Blueberries are borne in clusters, but not all berries in the cluster ripen at the same time. Therefore, each blueberry bush must be picked several times during the harvest season. The harvest

interval, usually 5 to 7 days in Missouri, has a major impact on berry quality. Picking berries too early results in immature, unripe, poor quality fruit being harvested. On the other hand, allowing berries to remain on the bush too long will result in soft, overripe, poor quality fruit. Trying to continually balance the number of pickers with the quantity of ready-to-pick berries is a difficult (if not impossible) and time-consuming job.

Ripe berries only: A major challenge to harvesting good quality berries is making sure all pickers can identify “ready-to-pick” blueberries. Highbush blueberries are somewhat unique in that berry size and sweetness greatly increase after the fruit turns blue. Allowing blueberries to remain on the bush for 7 to 10 days after they turn blue will increase both yield and overall berry quality.

Most U-pick customers seem to appreciate some training (and retraining!!) on how to pick ripe blueberries. Growers or their representative should mingle with customers to show by color, feel, and/or taste how to choose ripe berries. Berries that are fully ripe are easy to harvest. In hand harvesting, ripe blueberries should be rolled from the cluster into the palm of the hand with the thumb, not plucked off as is done with most other fruit crops. This method insures that only the ripe berries are picked, leaving unripe fruit attached in the cluster for harvest at a later time. Placing an experienced picker with a novice is another excellent way to teach customers how to harvest quality berries. The presence of green berries or pink “shoulders or butts” on the stem end of the blueberry indicate that unripe fruit is getting picked.

Blueberry’s Multiple Uses: Consumers need to be reminded of the many ways that blueberries can be used. The shelf life of fresh blueberries varies greatly with temperature; therefore berries should be cooled to remove the “field” heat as soon as possible after being harvested. Blueberries can generally be safely stored in a refrigerator for up to two weeks without serious deterioration. However, neither berry quality nor sweetness improves after berries have been removed from the plant.

Fully ripe blueberries have a sugar content (sweetness) between 14-16%, making them a popular fresh fruit for snacks or delicious toppings on pancakes, cereal, or ice cream. Blueberries can be also be processed into tasty pies, cakes, muffins, jams, sauces, etc. or frozen for use at a later time. Consumers always seem to enjoy getting recipe cards or other printed information on new ways to utilize blueberries. Many growers also use these recipe cards or printed brochures as advertisements for their blueberry enterprise.

Blueberries - Good for you! One of the best and most targeted selling points today centers on the health aspects of blueberries. Blueberries are now the second most popular berry in the United States and one of most nutritious fruits you can eat. A half-cup of blueberries contains 2 grams of fiber, less than 0.5% total fat, 0% cholesterol, and only 42 calories. Blueberries also are a rich source of Vitamins A and C, and contain significant amounts of iron, phosphorus, and potassium. Blueberries are very high in antioxidants, complex compounds that have been shown to reduce cancer, heart disease, and other problems associated with the aging process (including memory loss!!). Blueberries have also been shown to be beneficial in fighting urinary tract infections and to improve eyesight. Recently, blueberries have been recognized as “Fruit of the Year” by the *Eating Well Magazine* and included as one of the berries listed as “Fruit of the Month” in the *5 A Day* program of the National Center for Chronic Disease Prevention and Health Promotion. Since the benefits of eating blueberries are being touted by health professionals almost on a daily basis, a sign or other printed material reminding customers of the health benefits of blueberries would certainly be in order.

KISS: Keep things simple! June/July is Blueberry Time in Missouri. The large, flavorful, sweet blueberry has become a favorite among fruit consumers in Missouri. Consumers often travel 25-50 miles for fresh blueberries, many returning two or three times during the harvest season to buy more berries. Although most customers prefer to pick their own berries, there is still a viable market for consumers

that prefer to purchase pre-picked berries. Growers are still the best promoters of their blueberries. Even within a hectic schedule, time spent with customers is time well spent. Making the harvest season an enjoyable experience for consumers is a goal that will reap rewards for many years.

Conclusion: Thirty years ago, highbush blueberries were virtually nonexistent in Missouri. Today over 100 acres are in commercial production throughout the state. Missouri growers have done an excellent job of growing, educating consumers, promoting, and selling blueberries. When asked what was the easiest part of harvesting and marketing blueberries, one grower replied, “Open the gate and they will come”. Happy Picking!

Horticulture in Uzbekistan

By Patrick Byers

Fruit Grower Advisor, SMSU

In the fall of 2003 my colleague, Andrew Thomas, of the University of Missouri and I took part in a two week assignment to Uzbekistan. Our scope of work was to consult with farmers producing a wide range of horticultural crops. This article will present general information related to horticulture in Uzbekistan, while an article in the next issue of *The Berry Basket Newsletter* will describe our experiences in this fascinating part of the world.

Uzbekistan is one of the five independent nations collectively known as the Central Asian Republics. All of these nations were previously associated with the Soviet Union until the early 1990s, when all became independent following the collapse of the USSR. Of these five nations, Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan, Uzbekistan has emerged as the most influential and has developed into a regional power. This region of the world is of increasing strategic interest to the U.S., in part because of its geographic location relative to China, Russia, and countries such as Afghanistan and Iran.



Uzbekistan is located in the heart of central Asia.

Uzbekistan can be divided into three regions. The eastern part of the country is comprised of the Ferghana Valley, which is bordered by the Tian Shan Range on the north and the Pamir Alai Mountains on the south. The central region, which includes the famous historic cities of Samarkand and Bukhara, is a rolling steppe. In the western region, which is largely a level desert, a distinctive feature is the Aral Sea, once the 4th largest body of fresh water in the world. Other water resources in Uzbekistan include the Syr Darya River, which arises in the Tian Shan Mountains and empties into the Aral Sea, and the Amu Darya River, which arises in the Pamir Mountains and also empties into the Aral Sea.

Uzbekistan's climate is a typical midlatitude desert, with an average rainfall of 203mm (8in) per year. Over 80% of the agriculture production is irrigated. Summers are long and hot, with average July temperatures of 25-35°C (77-95°F) and maximum temperatures often well over 42°C (108°F). Winters can be cold, but the average minimum winter temperature is -8°C (18°F).

Agriculture is a dominant portion of the economy, responsible for 36% of the national Gross Domestic Product (GDP) in 2001. Cotton is by far the dominant crop. The dominance of cotton is a legacy of the Russian and Soviet eras, when Uzbekistan was designated the primary supplier of cotton for the Soviet Union. In the 1960s, Soviet planners set out to increase Uzbekistan's cotton production through a system of vastly increased

irrigation, which meant tapping the rivers flowing into the Aral Sea, in the north of the country. As a result, the sea has lost 75% of its volume and its area has reduced by half. The area's fishing industry has been destroyed, and the resulting salination of soil and water as well as chemical residues from decades of cotton farming have caused serious health problems in the population. Native flora and fauna have also been devastated. Irrigation projects in the steppes of Uzbekistan have degraded the soil, polluted the water, and caused large-scale erosion, aridity and salinity. Cotton production remains a critically important part of the national economy, however, and Uzbekistan is a leading exporter of cotton. Cotton production is highly controlled by the Uzbek government, and exports are an important source of "hard currency". The diversion of agricultural capacity to cotton has made Uzbekistan a net importer of food. Following cotton, the leading agricultural crops are wheat and rice, also under tight government control. Uzbekistan has sizeable livestock and beekeeping industries.

The climate, fertile soils, and availability of irrigation water have encouraged the development of a fascinating and diverse horticulture in Uzbekistan. Important fruit crops include apricot,

apple, peach, pomegranate, quince, fig, grape (for table use and wine), persimmon, and many others. Vegetable crops include tomato, potato, melon, and many others. Melons deserve special mention. The Andijon province of the Ferghana valley is internationally renowned for the quality and variety of melons grown in this region. Important nut crops include almond and Persian walnut. Uzbekistan also produces a range of ornamental plants, including nursery stock, potted plants, bulbs, and cut flowers.

Land tenure in Uzbekistan is complex and in transition. There is no private property in Uzbekistan in the sense that we know private property. There are, however, varying degrees of control over property, with direct effects on horticulture. In general, farms and farmers fall into one of three categories: the Shirkat farm, the Firmer hojalik farm, and the Dehkan hojalik farm. It is useful to understand these three types of farms when discussing Uzbek horticulture.

Following independence, the collectivized state farms (kholkoz) of the Soviet era evolved into the shirkhat farms. In most cases the shirkhat is a continuation of the kholkoz, including the same leadership. Certain shirkhats are innovative, while others are indistinguishable from Soviet times.

Shirkhat farms are typically the largest farms, and produce much of the nation's cotton, rice, wheat, and other large scale crops. Shirkhat farms are under tight government control in many cases, with production quotas, government priced inputs and commodity prices, and government managed irrigation resources. Many shirkhat farms are in a process of transitioning to other types of farms.

A product of land reform are firmer hojalik farms. In many cases the firmer hojalik farm, which



The melon market at Andijon bazaar.

is typically 5-100 hectares in size, includes land from a local shirkhat that is leased on a long term basis. Often the hojalik farmer was formerly connected with state farm leadership and obtains land through wealth and political connections. The long term leases may be inherited. Although nominally independent, firmer hojalik farms often rely on a neighboring shirkhat for inputs, and may be subject to production orders. A wide range of horticultural crops are produced on firmer hojalik farms.

Also a product of land reform, the dehkan hojalik farm is often characterized as the household plot. Limited by law to less than 1 hectare, these farms are critically important, as they produce more than 75% of non-wheat food crops in Uzbekistan and the majority of horticultural crops. These farms



The bazaar is an important local market for Uzbek horticulturists.

are often permanent sites, such as a courtyard plot, or they may include temporary production areas. Dehkan hojalik farmers are able to market their production, often at a local bazaar, or to wholesale markets.

The local bazaar is an important market outlet for horticultural crops, particularly fruits and vegetables. Wholesalers purchase crops from dehkan hojalik and firmer hojalik farms, and sell to markets within Uzbekistan and neighboring countries. More durable crops, such as nursery stock and bulbs, are marketed to Russia and other parts of the world. Processing is an important market for several fruits and vegetables, though processing facilities in Uzbekistan are lacking.

See next issue for Part II.

Note: 1 hectare = 2.47 acres.



A crop of table grapes in a dehkan hojalik courtyard garden.

Midwest Gardening Symposium I

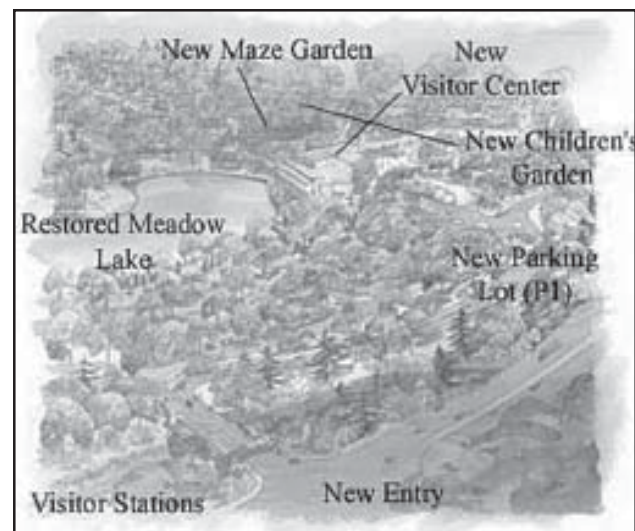
By Marilyn Odneal

Horticulture Outreach Advisor, SMSU

The Midwest Gardening Symposium was held at the Morton Arboretum in Lisle, Illinois (just west of Chicago) on March 19 and 20 and was organized by Jan Little, the education director for the Arboretum. I attended the symposium in order to learn more about historical gardens since we are developing a vintage garden border at Mountain Grove to commemorate the SMSU Centennial in 2005. I came away with much more great information and ideas than I bargained for. With so much information to cover, my report on the symposium is divided into two parts. The first part will include information on the Morton Arboretum and the first day of lectures while the second part will include information on the second day of lectures and a behind the scenes tour of the Chicago Flower and Garden Show on March 21st. The symposium was sponsored by the Morton Arboretum and *Fine Gardening Magazine*.

The Morton Arboretum originally was the Thornhill Estate of Mr. Joy Morton, founder of the Morton Salt Company. The Morton Arboretum was formally established on December 14, 1922. Joy's father, Julius, was the originator of Arbor Day (1872) and was the Secretary of Agriculture under President Grover Cleveland. In fact, the family motto of the mother, father and four sons was "Plant Trees". After visiting the Arnold Arboretum, a non-academic property of Harvard University, Joy became concerned about the funding for the Morton Arboretum. Joy decided to endow the Morton Arboretum so it would remain independent of a controlling institution that may not keep trees a priority. "The Morton Arboretum is a Ginkgo and a Ginkgo it will remain", Joy emphasized, since the Ginkgo is unrelated to any other plant and the Morton Arboretum is unrelated to any other institution.

Today, the Morton Arboretum is engaged in a \$43 million site development project, "Branching Out!", designed to connect more people with trees and to accommodate projected growth from 415,000 to 750,000 annual visitors within the decade. I drove through the new entry gate and through much of the construction to reach the lecture destination. Branching Out! affects the Arboretum's central area while preserving the 1,700-acre site's plant collections and natural landscapes. Approximately 35,000 woody plants and 100,000 perennials are to be planted this spring.



The Branching Out! development project under development at the Morton Arboretum includes a maze garden, a children's garden, a new visitor's center and a pervious parking lot.

Photo from http://www.mortonarb.org/branching_out/projects_map.htm

The Arboretum has received partial funding from the Illinois Environmental Protection Agency to construct and collect data on a "pervious" parking lot, where water will not run off but will soak through. In spring, "bioswales" will be planted between the curb-like channels that emerge across the lot. Bioswales are natural filtration systems; living plants with root systems that can help cleanse parking lot run-off water. Using interlocking, pervious paving blocks instead of asphalt, the lot will direct water run-off through the series of bioswales before it enters the adjacent Meadow Lake, helping to safeguard the Arboretum's plants

and ecosystem. The Arboretum is among the first in the Chicago area to develop such a system. A wetland will be created nearby to further filter run-off.

Although we were mostly sitting in the lecture hall, there was some time to walk around the arboretum since the weather was clear and pleasant. In March we found witch hazel and black pussywillow in bloom. It was also a nice time to look for shrubs and trees that maintained interest throughout the winter. Several of the crabapples and other shrubs retained berries throughout the season and the red-stemmed dogwood added color to the landscape.



The yellow flowers of witch hazel.



A walking trail at the arboretum.

Steven Silk, a renowned photographer, presented the first lecture, “The Quest for Color”.

His beautiful photography can be seen in the book *The Gardener’s Palette: Creating Color in the Garden* by Sydney Eddison. Steve described the color white as eye catching but somewhat difficult to use. He did mention that his white gravel paths could be seen at night and helped walkers at night to see their way in the dark. Other colors that were mentioned as difficult to use included chartreuse and some yellows. Good colors to use to blend plants together are burgundy and gray green. Some plants he noted were the shrub ninebark ‘Diablo’ for its burgundy foliage that doesn’t fade, *Canna arabis* for its “self-cleaning” nature (you don’t have to take the spent blooms off), and the shrub *Kerria picta* for its nice white variegation.

Pam Duthie, garden designer and author, presented “Shrubs and Trees in Bloom”. Pam uses only plants that have interest in at least two seasons. Her books *Continuous Color: A Month-by-Month Guide to Shrubs and Small Trees for the Continuous Bloom Garden* and *Continuous Bloom* highlight plants showy in two seasons or more. Pam talked about many plants, but two that I took note of since they are or will be on our campus were ‘Knock Out’ rose and ‘Pink Diamond’ Hydrangea. The ‘Knock Out’ red shrub rose blossoms all year and she reported that it tolerates some shade. Pam advised to prune this rose back to 6 inches tall in the spring. ‘Pink Diamond’ hydrangea blossoms on new wood so you can prune it anyway you wish for the size you want since you will not be taking flower buds off.

Virginia Small, Senior Editor of *Fine Gardening Magazine* presented “Learning from Legendary Landscape Designers” highlighting the ideas of seven people who were major influences in “American” landscape design.

Thomas Jefferson (1743-1826) blended the geometric order that was prevalent in European gardens with the “law of the land” adapting design principles to a site. He promoted the “ornamental” farm concept on his own estate by beautifying areas that produced food crops. He also designed the University of Virginia campus and promoted the “academic village” concept.

A. J. Downing (1815-1852) promoted the beautiful and picturesque. He didn't imitate Europe and the geometry of those gardens but promoted the public park idea and the American landscape. He designed Central Park in New York with Calvert Vaux.

F. L. Olmsted (1822-1903) continued the natural landscape and public park idea and was noted to have developed the parkway, a transition from the street to the park. He designed Lake Park in Milwaukee, Wisconsin. Olmsted was concerned with landscape architecture and emphasized the structure over the actual planting material.

Beatrix Farrand (1872-1959) on the other hand, emphasized the plants and used them to blend the formal with the informal. Her Arts and Crafts style can be seen at Dumbarton Oaks Research and Study Center in Washington, D.C., administered by Harvard University, around which she designed the garden. She was a charter member of the American Association of Landscape Architects.

Jens Jensen (1860-1951) was the maker of natural gardens and used perennial wildflowers transported from nearby woods and prairies in his designs. Having been a groundskeeper early in his career, he promoted democratic ideas in his designs. He used the "council ring", an outdoor gathering area that promotes open discussion by affording a circular (equal) seating arrangement. Jensen acquired a property in Ellison Bay, Wisconsin in 1919 for use as a summer home. Here Jensen founded "The Clearing" as a place where city people could come to enjoy nature. Jensen is associated with the Prairie School of Architecture.

Fletcher Steele (1885-1971) was a creator of "artistic" landscapes where he considered the land as "sculpture". He used a modernist approach in his designs and is associated with the development of Art Deco and Modernism in American gardens.

Finally, Virginia talked about **Thomas Church**, (1902 - 1978), the California landscape architect who continues to influence landscape design to this day. Educated at Berkeley and Harvard, he traveled to Spain and Italy and noted the way in which the people in these countries used their gardens as additional living spaces. With this concept in mind he returned to California in 1930. Church designed

over 4000 gardens in his lifetime and wrote the book *Gardens are for People*, promoting the landscape as a functional living space as well as a thing of beauty. His book is still in print today.

The last lecturer on the initial day of the symposium was Bill Aldrich, author and publisher of *Chicagoland Gardening*. He presented "Illinois in Bloom" and talked about many new and popular plants. He mentioned that the Icicle series of pansies can be planted in the fall and will come through to spring. He also noted *Diascia*, *Bacopa*, and *Calibrachoa* (mini petunias). You can look for these this spring at the garden centers.



A photo of the blue steps in Naumkeag's Gardens designed by Fletcher Steele. Photo from the Fletcher Steele Archives SUNY-ESF.

I drove through the Arboretum on the way back to my motel and saw several people out taking photos, walking and jogging. I had quite a lot to think about from the lectures I heard and was looking forward to the rest of the program. I will continue my report of the symposium in the next issue of *The Berry Basket*.

For more information on the educational programs at Morton Arboretum, contact:
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So You Think You Want to Grow Pumpkins

Gaylord Moore

Horticulture Specialist, UMC

Whether you are planting a back yard garden or embarking on a large commercial operation, pumpkins are often considered to plant for fun or profit. The potential for fall sales at farmers markets, roadside stands, sales to local stores or direct farm sales is expanding. The thought that pumpkins are without cultural problems, however, is a myth. Several challenges await the grower who seeks a profitable enterprise. Pumpkin growing may not be as intensive as some other horticultural enterprises, but knowing what you are doing is important in regard to variety selection, knowing when to plant, soil preparation and fertility, and pest control (weeds, insects and diseases). Pollination is a must since the plant produces separate male and female flowers. Male flowers outnumber female flowers 2-3 to 1 and usually appear first. Bees are the primary source for pollination and a strong hive of bees for every 3 to 5 acres of pumpkins is suggested to ensure adequate pollination.

Varieties

The type of market may determine characteristics that a producer looks for in selecting varieties. Most wholesale markets want pumpkins with strong, dark-colored 'handles', a deep or bright orange color, while local markets or specialty markets may want other features to fit their customer needs. Therefore, it is best to have them sold or at least have a developed market plan before planting. Depending upon the variety or type of pumpkin, days to maturity can vary from 95 to 120 days from planting. The giant pumpkins such as Big Max or Prizewinner take longer to mature whereas the miniature or baby varieties such as Munchkin or Baby Bear are the shortest.

Soil Preparation and Fertilization

Select areas with no perennial weed problems

and good internal water drainage for growing pumpkins. Avoid fields where a previous herbicide application may carryover.

A soil test is certainly needed to determine phosphate and potash requirements. These materials should be broadcast and incorporated. Pumpkins will require from 75 to 100 pounds of total nitrogen. It is best to apply about 50 lbs/acre of nitrogen at planting and another 40 lbs/acre along the rows when the vines begin to run.

Planting and Spacing

Most varieties of pumpkins are planted around June 10. However, you may do the math to calculate the planting time in reference to proposed harvest of your specific variety. Generally, the market season starts around mid-September. Determine your planting date to correspond to your marketing plan. Of course weather factors can play a key role. Cool temperatures during the summer could slow the maturity date by a week or so.

Pumpkins are usually grown in rows 4-6 feet apart for bush types and 6-8 feet apart for vining types and a direct seeding of a seed every 2 feet in the row. Closer in the row spacing encourages a quicker vine cover and better weed control.

Weed control

Weed management is the most critical practice for growing pumpkins. Herbicides use and mechanical cultivation need to be combined for best weed control. Herbicides such as Command 3ME, Curbit 3EC, Strategy, Prefar 4E, Poast 1.5E, and Select 2EC are available for pumpkins. However, before using any herbicide, be aware of the limitations, precautions and proper uses before applying. Read the label carefully or get help from your University of Missouri Extension horticulturalist or agronomist.

Diseases

Powdery mildew is the most common pumpkin disease and can cause significant yield losses. Generally, powdery mildew infection starts in early August if favored by warm daytime temperatures, cool nights, and high relative humidity. For effective

control, make the first fungicide application in late July or early August before symptoms appear. Make a second application in mid-August. Fungicides such as Cabrio, Flint, Pristine, Amistar and Quadris are available. Procure and Nova are labeled for powdery mildew, and so is Topsin. Avoid consecutive applications of products with the same mode of action to reduce risk of fungal resistance.

Insects

Cucumber beetles, squash bugs and squash vine borers are three major insect problems. Aphids can be detrimental to pumpkin production because of their ability to transmit several important virus diseases, however insecticides will not prevent the spread of viral diseases from aphids. Some suggested insecticides for cucumber beetle control are Admire as a preplant or Furadan applied directly into seed furrows or as a 7-inch band over the top. Other materials such as the permethrins Ambush and Pounce or Capture are effective. Fields should be monitored frequently (2-3 times per week) to detect mass emergence of beetles in the spring.

Harvest and Storage

Pumpkins are ready for harvest when the rind or skin has toughened and the stems have lost their succulence. A light freeze before harvest is not damaging. However, temperatures in the mid- to low 20s should be avoided. Store pumpkins in a well-ventilated, cool location.

Commercial pumpkin production can be a challenge. You need all the tools to produce high quality and yielding pumpkins. To assist your knowledge, I highly recommend the 2004 Midwest Vegetable Production Guide for commercial growers. It is available through your local University of Missouri Extension Centers.

The Development and Practical Management of Insecticide Resistance Part II

By Daniel Waldstein

*Assistant Research Professor,
Integrated Pest Management, SMSU*

Since growers are faced with the reality of fewer novel insecticides to use for pest control in the future, it is important to lengthen the effective life of insecticides already being used. This strategy for delaying resistance of currently used insecticides has been termed insecticide resistance management. It emphasizes a shift from continuous application of one insecticide to control a pest, to alternating insecticides with different modes of action and distinct chemical structures.

There are four major ways in which insecticides can be alternated in a spray program. These include tank mixing of the insecticides, alternating them within a pest generation, alternating them among pest generations, and spatial variation, also referred to as use of mosaics.

Insecticides can be tank mixed for a number of reasons. Synergists are a classic example. A synergistic combination exists when the toxicity of the two compounds is substantially greater than what would be expected from their additive toxicities (i.e., $2 + 2 = 10$) (Klaassen and Eaton, 1991). An example of a synergistic combination is the use of piperonyl butoxide with pyrethrin insecticides. Insecticides should not be included in a tank mix if they are not effective or have poor efficacy when used alone. Insecticide resistance management is best achieved with mixtures when the insecticides have high efficacy against the target pest and are used at a full rate. Using mixtures of highly effective insecticides at full rates may not be economically practical, especially when newly registered, expensive insecticides are used.

The second variation of different insecticides, alternating within a pest generation, has been widely

used to slow the onset of insecticide resistance. Generally there are no more than a few insecticides available for proper control of a pest that are also economically viable for the grower. For example, if I had three different insecticides and sprayed three times per generation for a particular insect pest, I would apply insecticide x, y, and z, for one generation and use the same combination for each subsequent generation. This type of spray program manages for a variable population of insect pests because different parts of each generation are exposed to different insecticides. This manages for a heterogeneous population of pests that will eventually develop resistant to all three insecticides.

The third variation of insecticides in a spray program is the use of the same insecticide throughout one generation and a switch to a different insecticide on the next generation. For example, if there were three generations of a pest and three applications required per season, I could spray compound x, x, x on the first generation, y, y, y on the second, and z, z, z on the third generation. Insects with genes resistant to insecticide x will survive in the 1st generation. In the 2nd generation, individuals with resistance allele x will be killed by insecticide y (assuming no cross-resistance between insecticide x and y). In the 3rd generation, individuals with resistance alleles x and y (rare individuals) will be killed by insecticide z. Individuals with resistance alleles for insecticide x and y are rare because the probability of having both is multiplicative. In other words, if the probability of an insect having x or y alone is 1 in 10,000, the probability of having both is 1 in 100,000,000. This type of spray program manages for a homogeneous pest population where low levels of resistance to one insecticide develop but resistant insects are killed by alternating with non-cross resistant insecticides in the next generation. Use of this tactic keeps the proportion of resistant insects in a population low over time by decreasing the competitive advantage of insects with resistance genes.

The fourth means for alternating insecticides is spatial variation or use of mosaics. In this case part of a field is sprayed with insecticide x, another part

with y, and another with z. This may result in a variable population where resistance to multiple insecticides develops, unless insect mobility is low or insecticides are applied over a large area. An example of a mosaic is with Bt (*Bacillus thuringiensis*) corn where a certain percentage of the field is planted in non-Bt corn.

It is important to remember that insecticide resistance is not the only means for insects to survive insecticide applications. Problems with timing, rates, precipitation, and spray coverage can also decrease the efficacy of insecticide applications.

Poor spray coverage can leave “lethality gaps” in the leaf canopy. Pests may be exposed to sub-lethal concentrations of an insecticide that are high enough to induce resistance combative mechanisms, but too low to cause mortality. Spray coverage can be maximized by not driving sprayers too quickly and using adequate volumes of water. The appropriate spray volume per acre can be determined using row volume calculations shown in the Midwest Commercial Fruit Spray guides. It is also important to prune in a manner that opens the plant leaf canopy. In addition to improving spray coverage, this contributes to increased light penetration for leaf photosynthesis and even fruit coloring.

Delaying resistance through resistance management techniques does not solely consist of alternating insecticide use. Whenever possible it is important to implement non-insecticide management techniques. This includes use of pesticide alternatives, cultural and biological controls.

Pheromone mating disruption is a good example of a pesticide alternative that can be used to decrease insecticide resistance pressure. Female insects emit a species-specific blend of chemicals known as a pheromone that attracts males for mating. The composition of many of these blends has been determined by analytical chemists, and the pheromones have been produced synthetically. Releases of synthetic pheromone can be used to mask the female’s pheromone and make it difficult

for males to locate females for mating. This decreases mating success and causes a population reduction in the next generation of insect pests.

An example of a cultural management technique is the use of non-broadleaf ground covers (especially fescue) in row middles and mowing to decrease tarnished plant bug damage. Nature's way of controlling one population of organisms such that it does not overtake the entire system is through biological control. This involves interactions between species to regulate populations and maintain a sustainable balance in the ecosystem. Biological control is more practical for insects that feed on foliage and not fruit. Foliage feeder control can be managed in a non-absolute manner unlike fruit feeding damage in which one hundred percent control is the desired outcome. A good practical example of biological control is the use of predatory mites for control of the European red mite. The use of selective insecticides that preserve predatory mites and other insect natural enemies is an important part of integrated pest management.

Although much has been learned in the past twenty years about insecticide resistance development and its management, there are many concepts that have yet to be fully understood. The sources of variation provided by the insecticides as well as the target pests create a complex interaction that contributes to management challenges. I have purposely kept the focus of these two articles on insecticide resistance rather than pesticide resistance in general. Although fungicide and herbicide resistance have some factors in common with insecticide resistance, the numerous differences do not allow for broad generalizations applicable to all types of pesticide resistance.

When all is said and done, the development of new, non-cross-resistant insecticides remains an important aspect of insecticide resistance management. The goal of resistance management in light of the decreasing availability of new, effective, and affordable insecticides is to maximize the effective life of currently used products.

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Rose Rosette Disease

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Rose rosette disease (RRD) is a virus, or virus-like, disease that is a danger to all ornamental roses. This contagious, incurable, fatal rose disease is spreading unchecked through the wild rose population of the Midwest, South, East and parts of Canada. From infected wild roses, it spreads to cultivated roses.

RRD is vectored by the microscopic wingless eriophyoid mite, *Phyllocoptes fructiphilus*, often found on roses. After the mite feeds on an infected rose, it can be blown to another rose by a puff of wind and transmit the RRD pathogen when it feeds there. RRD symptoms may not appear for weeks or even months. Infected roses may die quickly or linger for years as sources of infection in gardens or in fields upwind of gardens.

Some of the more recognizable symptoms include rapid elongation of new shoots, followed by development of witches' brooms or clustering of small branches. Leaves in the witches' broom are small, distorted, and may have a conspicuous red pigmentation, although red pigmentation is not a consistent symptom. Canes on some species or cultivars develop excessive growth of unusually soft and pliable red or green thorns, which may stiffen

later. When this symptom is present, it is diagnostic for rose rosette disease. Symptomatic canes may also be noticeably thicker than the parent cane from which they emerged or they may grow in a spiral pattern. Flowers may be distorted with fewer petals than normal, and flower color may be abnormal. For example, flowers that are normally a solid color may be mottled. Buds may abort, be deformed, or be converted to leaf-like tissue (See photo, lower left). Infected rose plants often die within one to two years. No effective control is available for rose rosette. This disease is of great concern to the nursery industry and to many home gardeners because it is known to be lethal to the wild multiflora rose (*Rosa multiflora*) and it is potentially lethal to many ornamental rose species and cultivars.



Chemical Control

Although there is no compound that will control the causal agent of rose rosette directly, effective control of mites with certain miticides can reduce the risk of spread. Be aware that miticides registered for control of spider mites do not control the eriophyid mites that transmit rose rosette disease.

Some researchers have obtained reasonable control with Sevin; however, mites are very small and it can be difficult to get complete coverage. Also, use of Sevin to control eriophyid mites can lead to outbreaks of spider mites. The insecticide, Avid, is registered for control of both eriophyid and spider mites on roses. Use of miticides in the absence of cultural controls is not recommended. One way to use a miticide as an additional tool in a control program is to focus sprays on plants that surround spots where diseased plants have been removed. These are the most likely plants to which mites from within a planting would have moved. Spraying every two weeks from April until September should significantly reduce the mite population and the risk of transmission. Additional sprays may be needed during hot, dry weather when eriophyid mites are most active.



Symptoms of rosetting; deformity, reddish pigmentation and excessive thorns. Courtesy George Philley. TAES - 1995.

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