PROCEEDINGS

of the

21st ANNUAL HORTICULTURE INDUSTRIES SHOW*

JANUARY 11-12, 2002

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The 2002 Horticulture Industries Show was certainly a success for everyone involved. The weather cooperated and we had a good turnout for the meeting. The sessions had excellent speakers and the two general sessions covering conservation were well received.

We appreciate this year's exhibitors providing us with the availability of products used by our industry and also for their Show support. We would like to thank all the speakers that provided papers for this proceedings and hope you find the information valuable to your operation. Also, a special thank you to Horticulture Industries Show board members and supporting personnel that worked to organize and facilitate this show.

Most importantly, we appreciate all the attendees for their support and ideas. If you have any questions or comments concerning the Show, please contact any of the board members.

Hope to see everyone back in Springdale, January 10-11, 2003.

Sincerely,

Craig Andersen
President
Horticulture Industries Show

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General Session

Better Crops
Through Soil
Conservation

Back to the Future in Soil Conservation

George W. Stunkard
Operations Manager
Sanders Nursery and Distribution, Inc.
and
Past President Oklahoma Association of Conservation Districts

George Stunkard has been a farmer and rancher most of his life. George grew up on a farm on the outskirts of Tulsa. He graduated from Oklahoma State University in 1961 with a BS in Animal Husbandry with a minor in Agronomy. George and his wife, Phyllis, have owned and operated a farming and cow/calf operation located in Wagoner County since 1961. Various crops grown have included wheat, soybeans, alfalfa, corn, spinach, purple hull peas, green beans and watermelons. For the past 26 years, George has served on the Board of the Wagoner County Conservation District. He served as President of the Oklahoma Association of Conservation Districts and currently serves as reporter for the Wagoner County Cattlemen'sAssociation. He is also active in the Wagoner County Farm Bureau and serves on various committees for the First United Methodist Church in Coweta. In addition to farming, George is Operations Manager at Sanders Nursery & Distribution, Inc., a retail/wholesale nursery located South of Broken Arrow. George and Phyllis have been married for 43 years, have three Children and 5 grandchildren (all boys!).

As we observe the landscape around us we can see examples of conservation projects that are impressive. A couple of examples are the TV commercials being aired relating to the cleanup of abandon oil and gas well sites. The reclaiming of abandon strip pits is another graphic example of large-scale reclamation, taking a virtual wasteland area and converting it to an attractive and useful land resource. You've undoubtedly heard the slogan "Conservation doesn't cost, it pays". I am certain that this is a true statement, but for us as individual producers, the dividends from our investments of conservation practices can be described as long term investments or investments for the future. When we really think about it, the need for installing conservation measures is, for the most part, the result of man creating environmental problems in the first place. The natural ecosystems of our part of the country probably worked well before we entered the picture and westward expansion occurred. Can you imagine what your farm may have looked like 200 years ago? The conservation movement in this country began as a result of the "dirty thirties". Several years of extended drought and farming practices that were not conservation oriented resulted in the worst erosion in our history. Out of this era was born the "conservation movement in this country".

It's been my privilege for the past several years to be associated with conservationists at the local, state and national level. I've been amazed at the time and dedication of literally thousands of people, who are willing to donate their time, talents and personal resources to make our world a better place. Conservation of Natural Resources is not a subject that most of the population gets very excited about. It doesn't have the appeal of a Super Bowl party, or a healthy income tax refund, however, many

agriculture producers spend a lifetime quietly practicing conservation, with little or no recognition for their efforts. I would like to give you some of my own personal background and talk about how conservation has changed even in our lifetime.

I would like to take you back in time to when I was growing up on the farm. You might say that my background was rural with some urban influence. I grew up on a farm in Tulsa County that was just a few miles outside the city limits. My parents owned and operated a "real farm" but we were not isolated from neighbors, since we had neighbor hoods within blocks of our farm. The crops my parents raised consisted of alfalfa, wheat, corn, oats, soybeans, Hereford cattle, Duroc hogs, anywhere between 12-15 milk cows (that were milked the old fashioned way), black & white speckled chickens and two mean roosters. Also, since the proximity of our farm was near Tulsa, I attended Tulsa Public Schools. I was the envy of all my city friends because I lived on the farm, and I was envious of them because they lived near all the conveniences of the city. As I look back to my youth, I realize that I grew up in an absolutely perfect environment. Although I didn't realize it at the time, I had "Pleasantville and Happy Valley" all rolled into one. Once the farm chores were done, I had access to the "neighborhoods nearby, and in the neighborhood were five or six boys about my same age. Spanky McFarland didn't have a thing on us because we had our own bunch of rascals. Actually it may have been more like a bunch of thugs. One incident that I'll never forget happened when I was about eight years old; I committed my first act of crime. It all happened because one of the neighbors had planted a patch of watermelons. The "gang" decided that he wouldn't miss just one so the stage was set. If you can get a mental picture of this situation, everyone in the neighborhood was pretty close knit. I told the "gang" that I was going to have no part of this watermelon thing, because the owner was a good friend of my parents. Then one of my friends reached into his pocket and pulled out a beautiful, official Boy Scout knife and said, "its yours if you go with us." What 8-year-old could refuse a deal like that? Needless to say, we stole a watermelon, ate it, got caught, paid the price, and I didn't even get to keep the knife.

As soon as I was old enough to join, I became active in 4-H club. I believe my first exposure to soil conservation was in 4-H club work. One of the events that I became active in was a "tractor driving contest." If you're not familiar with these, it involved driving a tractor and grain drill through an obstacle course, both forward and reverse while a judge timed you with a stopwatch. After a few years of knocking over barrels and running out of time, I was able to compete in this event at the state contest, held in Stillwater. During this competition, I got acquainted with another contestant from Texas County in the Oklahoma Panhandle. As we were visiting about the differences in our cropping systems, he told me of his worst nightmare on the farm. It was to have his Dad get him out of bed, in the middle of the night, go to the field to harrow ground, because the wind had come up and it was blowing the soil away. This was new stuff to me. We had wind on our farm but very little wind erosion. This tillage operation did two good things to control erosion. It brought moisture to the surface and created small ridges on the surface to catch the blowing soil. The list of detrimental effects probably outnumbered the benefits, but that was their line of defense against erosion at that time. Another conservation event that I participated in during my 4-H club years was a contest

called a "No Burning Contest". This was a contest whereby 4-H club members would have a ranchers pledge not to burn pastures, rangeland and crop residue because of the negative effects of exposing land to erosion and removing wildlife habitat. We realize now that prescribed burning is a common and recommended conservation practice. There are other conservation practices that I grew up with; remember sericea lespedeza? Many referred to it as a poor man alfalfa, an excellent legume soil builder, but now listed as a noxious weed in Oklahoma because of its invasiveness. Times have certainly changed, and conservation practices have changed, as well. It saddens me somewhat to think that my five grandsons may never have the opportunity to be flogged by a barnyard rooster or to be chased out a pigpen by an old sow with a new litter of pigs.

As I continued on in my journey of life, after high school graduation, I attended OSU and graduated in 1961 with a degree in Animal Husbandry with a minor in Agronomy. Upon graduation, I had an opportunity to do what very few of my classmates could do, I returned to the family farm. By this time the city had engulfed our farm and my parents had acquired a farm in western Wagoner County where my wife and I moved directly to the farm. To supplement the farming operation, my wife and I both worked off the farm and then in 1967, I began farming and ranching on a full time basis.

I believe the decade of the sixties began one of the biggest changes in agriculture, because of manufacturers of farm equipment started building larger tractors and equipment. Tractors were being built that were 100 plus horsepower. During the 60's we had hippies and yippies, long hair, demonstrations, rebellion, Woodstock and all the while, a steady decline in the number of farmers tending the land. The farms remaining had to get larger and more efficient to stay in business. As a result of bigger equipment, to make farming faster and more efficient, many conservation practices that had been in place since the dust bowl days, such as terrace systems and shelterbelts were destroyed.

The decade of the 70's also brought big changes in production agriculture. Remember the recommendation that farmers plant "Fence Row to Fence Row." We were blessed with a few short years of uncommonly high commodity prices, but it didn't take long before we were faced with overproduction and surpluses, due to embargoes and foreign competition. I believe this was also a time in our history that the need to do a better job of conservation of our resources became paramount. It was recognized that thousands upon thousands of acres were being farmed that was marginal cropland at best. Farm policies actually created conflicts between incentives to increase production and conservation programs seeking to reduce environmental problems from expanded production.

It was also during the 70's that I was elected to serve on the Wagoner County Conservation District Board and received a great deal of insight on conservation programs, problems and diversity that we have in agriculture both in Oklahoma, as well as Arkansas. Its been stated that Conservation Districts are Americas best kept secret. I hope that's not the case in this audience, but I would like to clarify how the district functions, and its relationship with our partners. By definition a conservation district is a sub-division of state government, comprised of five local board members, either elected

or appointed, and who volunteer their time to transact the conservation needs within their district. The employees of the conservation district are state employees who are under the guidance of the Oklahoma Conservation Commission. In most cases the local conservation district is housed with the Natural Resources Conservation Service, the technical advisory agency of USDA. This is the best example that I am aware of in a local, state and federal partnership. As I mentioned earlier, the conservation movement was a result of the "dust bowl" years, and in 1933 Congress established the Soil Erosion Service, which later became Natural Resources Conservation Service. It soon became evident that changes were needed because farmers simply did not trust someone saying to them, "I'm from the Government and I'm here to help! It was decided that farmers would be more willing to work with their neighbors than a stranger representing the government. So, in 1937, Congress passed the Soil and Water Conservation Act and conservation districts began forming across the Nation. Every acre of land in the United States as well as Puerto Rico and the Dominion Republic is within the boundaries of a conservation district. In order to speak as one voice for the cause of conservation every state also has a statewide association, as well as a National Association to have a grass roots voice with legislative issues. I had the opportunity a few years ago to serve as president of the Oklahoma Association of Conservation Districts. It was a wonderful experience and I've said many times that the best part of serving the association were the lifelong friendships we have made across our state and the nation. Conservation folks are special. I would like to invite you to visit your conservation district. Attend a board meeting, (they all meet monthly), and are open to the public. I promise you that you will be welcomed.

In the early 70's I, like possibly many of you, began looking for alternative crops that might be more profitable than the conventional crops being grown in the area. I experimented with watermelons, green beans, northern field beans, spinach, sweet corn and purple hull peas, and continued to grow spinach and purple hull peas for about twenty years, contracted to Allen Canning Company.

Traditionally, farmers by nature could be described as strong willed individuals. "Bull Headed" might even be a better description. Something happened in the 80's that challenged our ability to make our own decisions. It was called the 1985 Farm Bill or the Food Security Act of 1985. For the first time ever, we had to alter some of our farming methods or risk being out of compliance with the conservation provisions of this new law. The penalties of non-compliance were no benefits of any kind from USDA. If your farming operation included highly erodible soil, certain crops could not even be grown if they would leave the soil exposed to erosion certain times of the year. Highly erodible land, wetland protection, mandatory crop insurance, and a plan to wean farmers away from government support programs were some of the requirements that challenged us all to do a better job of protecting our valuable resources. As we speak, language is being written for the next farm bill to come out of Congress early this year. Conservation will be an important part of this legislation. The conservation incentives program recommended by Conservation Districts and other organization could be a very positive part of the new farm bill if it is adopted. The overall objective is to protect our precious resources and preserve our quality of life.

Getting back to the subject at hand, how will your crops benefit from conservation practices? The most obvious result of good conservation practices is to save precious topsoil, the lifeblood of our existence. When we control erosion, we achieve other important benefits, such as water quality, lower siltation, improved wildlife habitat, cleaner air and the list goes on and on. I once had a professor who described the "plant" as the food machine for the world. All other forms of life are consumers that take nutrients from the plant either directly or indirectly. He also stressed that if we did a good job of management of four critical areas (1) soil air, (2) soil water, (3) decay of crop residues, and (4) soil fertility, abundant crop production would take care of itself. The key to all of these areas of good management is to keep the topsoil where it belongs, then manage it for good production. Conservation tillage systems have become popular for many producers over the past several years. The primary objective of these systems, whether it be no-till, minimum tillage, ridge till, is to keep most of the crop residue at or near the surface. The top few inches of soil is where all the action is. The decay process of building humus and organic matter requires oxygen, moisture, microorganisms and fertility. These are the same principals that cause fence posts to rot off at the top of the ground, rather than a foot deep. It seems that we, in our part of the country are about seven or eight years behind the upper mid-west in adopting these practices, or maybe we are just smarter by letting them work all the bugs out of these systems before we try them. Nevertheless, with the technology of today involving genetically altered seed, global positioning systems as well as the need to produce crops as economically as possible, conservation tillage has become commonplace in our production techniques. In reality, most farmers may have turned to conservation tillage because of economic reasons; of fewer trips across the field, fuel and labor saving, but an indirect benefit has been millions of tons of soil saved by controlling erosion. Needless to say "we've come a long way baby", but what does the <u>future</u> hold for us in crop production? For young producers my advice is to buckle your seat belt and get ready for a fast ride. Technology is coming faster than most of us can keep up with. I saw a web-site recently that is aerial photography taken from a satellite that you can continue to reduce in size that you could almost count your cows in the pasture from. Infrared photography, global positioning will all become commonplace in agricultural production.

Another relatively new term you've heard is "carbon sequestration" whereby farms will have an accurate measurement of the carbon stored in the soil. Research is currently underway to determine the benefits of sequestering carbon for environmental benefits as well as production benefits. Production agriculture has not changed in one respect. We are still at the mercy of the marketplace when we sell our product. Supply and demand dictates what we receive regardless of our input costs. So maintaining good conservation practices and being good stewards of our natural resources will enable us to continue to grow quality products at an affordable price for consumers, and maintain a healthy environment.

A person once approached me and said, " I understand that you're an environmentalist." My immediate knee jerk reaction was that I was being insulted. But

my delayed response was, yes, I guess that I am. I certainly believe in protecting the God given resources that we have been blessed with, so I will gladly accept that title.

As Howard mentioned in my introduction, in addition to farming, I also work for Sanders Nursery and Distribution, Inc. The nursery is located on a farm that I operated for several years. Since I was ready to downsize my own farming operation, I accepted the offer to become the Operations Manager with Sanders. Our new nursery facility is located south of Broken Arrow and it includes a state of the art green house, covering about 3 ½ acres with retractable roof and walls. The nursery sits on approximately 80 acres of land, includes a 5,000 sq. ft. retail and wholesales office and showroom and we will have approximately 60 acres of growing trees in a 4 year rotation program. The products that we have available include everything from bedding plants to large trees and most of your landscape needs. We are open to the public for retail sales as well as wholesale to professional landscapers. The nursery has been a wonderful opportunity in my life and a tremendous learning experience. I invite you if you haven't been to our nursery to visit us at anytime. It's probably the largest facility of this type in the southwest.

There are many sources of assistance available to you for your conservation needs. There is a tremendous pool of knowledge and assistance that you may go to and receive help with your conservation needs. Some of these include, Cooperative Extension Offices, local Conservation District offices, Kerr Foundation, Farm Service Agency, Vo-Techs, Natural Resources Conservation Service, Conservation Tillage Information Center, TCC, Resource Conservation and Development Councils, to name a few. Some of these sources will be able to furnish information only, while some may be able to furnish financial assistance for your conservation requirements. I have also handout material that you are welcome to take with you for information relating to conservation assistance, cost share programs, etc. In closing I would like to give a short demonstration with this apple. Assuming this apple represents the earth, we learned from 5th grade geography that ¾ of the earth is covered by water. Of the ¼ remaining, 2/3 of that is either deserts or mountains and is not suitable for crop production. Of the remaining 1/3 left approximately ½ of it is covered by cities, town, highways, railroads, and the like. When we realize that this amount is all that is left to feed a hungry and growing world population, and the only productive portion is the topsoil, it behooves us all to be the best stewards we can be. This is all we have to work with. Let's conserve it for future generations.

Common Sense Conservation

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Soil erosion control is an essential part of any sustainable farming system. To be adopted, conservation measures must be understandable and cost-effective. The four tools that I will focus on are: (1) Reduced-tillage, (2) Cover crops, (3) Vegetative buffers, and (4) Grade control structures (terraces and pipes). These are not the only effective conservation practices; crop rotation, tile drainage, nutrient management, and integrated pest management are also important. But, the four I mentioned can be combined to control erosion in just about any farming situation.

Reduced tillage refers to farming systems in which the amount of tillage is reduced so that the soil surface remains protected by crop residues throughout the year. Residues absorb raindrop impact and slow runoff, thereby increasing infiltration, making more water available to crops, and reducing runoff and soil erosion. "No-till" refers to a form of reduced tillage in which there is no soil disturbance except that associated with seeding or transplanting. On some soils and with some crops, no-till results in both the highest yields and the lowest costs, and so is the most profitable system. No-till can reduce soil erosion tremendously (Meyer et al., 1999). In order to be eroded, soil must first be detached. Soil that has been tilled is much easier to detach than undisturbed soil (Dabney et al., 1993). Also, soil organic matter builds under no-till. In contrast, tillage encourages its breakdown the same way that stirring a fire makes it burn hotter. Under no circumstances that I know of does plowing down manure or cover crops increase soil organic matter compared to leaving the same materials on the soil surface where natural biological activity of fungi, ants, beetles, mites, and earthworms can feed on the material and gradually incorporate it into the soil. By feeding these beneficial soil organisms, no-till may gradually increases soil productivity over time.

The main reasons why no-till may not be practical are: (1) weed control, (2) soil compaction, and (3) rutted fields. A badly rutted field must be tilled. Plow pans and traffic pans can restrict water infiltration and root growth. Some soils, particularly sandy soils in the coastal plain, naturally compact so that some form of deep tillage is needed to enable roots and water to penetrate into the soil. In these situations, conservation subsoilers, like the Paratill plow, can solve the problem while preserving residue cover.

Cover crops can reduce runoff in tilled and no-tilled systems (Dabney, 1998) and also assist in weed control (Dabney et al., 2001). Weed control is the most difficult problem for no-till management, and is even more difficult where herbicides are not available or cannot be used. A competitive cover crop can crowd out other vegetation that may be difficult to kill, yet a good cover crop should be easy to kill when the time comes. Cover crops are a particularly important part of weed control programs in warm climates where weeds can grown most of the year. In our region, a cereal rye (*secale*

cereale L.) cover crop is particularly effective in suppressing weeds. When soil nitrogen is low, rye growth may be increased by seeding rye and a legume together.
Cover crops take time and money to plant, which may be why cover crops are not widely grown. One approach to lowing the cost is to use a cover crop that seeds itself. Winter weeds are one such cheap cover crop. 'Paradana' balansa clover (*Trifolium michelianum* Savi) is a particularly good reseeding legume cover crop and contributes 70 lbs N/a to cropping systems. It is adapted to hardiness zones 7A and warmer and may be ordered from Kamprath seeds (800-823-6242) at a cost of about $1.00/lb. Because of small seed size (>1000 seed per gram), planting 5 lbs of seed per acre gives a dense stand. If a hard seed crop is made, by allowing growth to continue into early May, balansa clover will volunteer back without replanting for three subsequent years if summer cultivation and deep plowing are avoided. The delay of summer crop planting to allow hard seed formation is often the largest cost with the reseeding cover crop. On farms where some field are periodically rested because labor is more limiting than land, this cost would be lower.

Mowing or roll-chopping can sometimes kill cover crops without tillage or herbicides (Creamer et al., 2002). Roll-chopping involves pulling a roller over the cover crop that has bars or blades attached to its circumference that crush the stems. This leaves the cover crop residues laying flat on the ground and oriented in the direction of roller travel. Some farmers have successfully seeded or transplanted into the resulting mulches. Growth stage and cover crop type are affect the effectiveness of mowing and roll-chopping in killing a cover crop. Most tall and long-stemmed winter cover crops can be killed with these methods. Summer cover crops that have been killed by rolling include nearly mature German foxtail millet (*Setaria italica* (L.) P. Beauv.), Japanese millet (*Echinochloa frumentacea* (Roxb.) Link),and buckwheat (*Fagopyrum esculentum* Moench). Fall broccoli has been successfully be no-till transplanted into these residues.

Heavy cover crop mulches can interfere with seed placement. If residues "hair pin" into the seed slot, seedling disease will be increased. Generally speaking, it is safest to wait 3 to 4 weeks after killing a cover crop, especially a legume, before seeding the subsequent crop. However, when residues are dry and brittle, planter mounted row cleaners can greatly reduce this problem and allow successful direct seeding of large-seeded crops corn and beans from 2 to 5 days after mechanically killing of cover crops (Creamer and Dabney, 2002). Tined-wheel row cleaners should be set so that they do not dig a trench, but some soil contact may improve performance. Row cleaners will not work well when the planter's depth-control bands are wider than the row cleaner because the depth bands will ride on piles of residues. Spoked or tined-wheeled press wheels are also useful for closing the seed slot to without causing compaction above the seed.

Vegetative buffers are useful conservation practices that are easy to understand and to apply, and that simultaneously produce multiple benefits of improved soil, water, and air quality, wildlife habitat, and landscape aesthetics. Buffers come in a variety of sizes and types. The USDA-Natural Resources Conservation Service (NRCS) has a National Handbook of Conservation Practices (NHCP) that includes at least 10 distinct types of buffers that help control wind and water erosion. Depending on the county

where you live, some of these may be eligible for government cost sharing for their establishment and some may qualify for enrollment in the Conservation Reserve Program (CRP). General descriptions of the buffer practices may be found at http://www.ftw.nrcs.usda.gov/nhcp_2.html, however, these practices are usually modified for local conditions in each state, so you should contact your local district conservationist to get specific practice descriptions for your farm.

The newest type of water-erosion control buffer in the NRCS NHCP, added in March 2001, is called "Vegetative Barriers" (Dabney and Glennon, 1999). This practice involves narrow (~3 to 6 ft wide) strips of tall coarse grass that are generally planted close to the contour and perpendicular to the direction of runoff. Vegetative barrier grasses can withstand larger amounts of runoff without getting submerged than can the lower-growing grasses typically used in other buffers like filter strips and grassed waterways. The upslope edge of the vegetative barrier is very important to the functioning of this practice. At the edge, the vegetative growth is densest because plants get more light, water, and nutrients. During runoff, the edge becomes compressed by the forces of the runoff water, and plant residues may be trapped against the grass. This gives the edge of the barrier greater hydraulic resistance and causes deeper and slower runoff flow in the field upslope of the vegetative barrier. Instead of runoff cutting an ephemeral gully, sediment will deposited in the field where it can contribute to soil fertility and crop production in the future.

Leaving edge-of-field turn rows vegetated improves field access and water quality. NRCS calls this practice a Field Border. In-field vegetative buffer types include: Contour Buffer Strips, Vegetative Barriers, and Grassed Waterways. The first two of these are generally aligned close to the contour while waterways are generally oriented up-and-down the slope. Contour buffer strips and vegetative barriers can serve a guides for contour farming, which reduces erosion. When field slopes are not uniform, it may be desirable to vary the width of the vegetated strips so that cropped rows stay close to the contour while cropped strip widths remain uniform and point rows are avoided. To do this, the vegetated areas must be widest on the least steep parts of the field and narrowest in the steepest parts.

Getting vegetative barriers established across concentrated-flow areas is challenging. Some large-stemmed grasses, such as switchgrass (*Panicum virgatum*), can be seeded with conventional equipment. Others, like *Miscanthus sinensus*, must be propagated vegetatively. If a barrier is seeded, you can expect that some seed will be washed away in the concentrated flow areas, and that the next year maintenance will be required. The washouts will need to be filled, and plants from nearby intact barrier segments dug up and used to repair the washouts. Faster establishment of vegetative barriers in concentrated flow areas can be achieved by transplanting sod across the critical areas. The production and delivery of transplantable vegetative barrier sod to construction sites is a potential horticultural product. One approach that is being developed by NRCS in Michigan involves making coco-fiber mat sandwiches (4-inches wide, 6-inches deep, 3 to 4-feet long) that contain soil mix and propagated *Miscanthus*. When needed, the resulting sod segments are placed, instead of silt fence, into shallow

trenches and become an attractive part of the permanent landscaping. A word of caution about *Miscanthus*, which is not a native plant: be sure you choose a cultivar that is not invasive (some are).

Structural practices like terraces and drop pipes come in a variety of types with strict design criteria established by NRCS. However, small terraces always develop over time at the edges of tilled fields as a result of tillage moving soil downslope and into the non-tilled vegetated strips. When buffers divide fields into segments, these mini-terraces cannot be avoided without periodically moving the location of the vegetated strips. The development of terraces and benches due to the permanent location of buffers is an intentional part of the vegetative barrier practice, but not of the other buffer practices in the NHCP.

Runoff frequently concentrates into a few discrete places before it leaves fields. Concentrated flow erosion may form rills or small gullies at these points. The effectiveness of edge-of-field buffers (Riparian Forest Buffer, Field Border, and Filter Strip), is reduced by flow concentration. Vegetative barriers may be used in combination with these other buffers to protect them and improve their functioning and longevity.

Grade control pipes are becoming popular to control edge-of-field runoff and erosion. Usually, a small terraces, berm, or "pad" is constructed around the edge of the field to channel runoff to a low point where a pipe is installed to carry water to the receiving ditch or stream in a way that does not cause a gully to form. The terrace or pad is used as a turn row and must be high enough to contain expected amounts of runoff without breaching. The pipe must be large enough to discharge this volume within 24 hours to avoid crop injury. In some cases, a box inlet is be attached to the upslope edge of the pipe, allowing water to be retained in the field during the winter by adding boards to the box inlet ("slotted board riser") to provide wildlife habitat and winter weed control. Placing a vegetative barrier around the inlet to the pipe may reduce summer sediment loss from the field.

The practices described work best when used in combination with each other. For example, cover crops may make no-till more productive and profitable, where adequate moisture is available, by increasing water infiltration and by displacing weeds. Reduced tillage systems leave residues on the surface that may be trapped on vegetative buffers and contour rows, thereby improving their efficiency. Buffers planted around pipes can improve sediment trapping efficiency, while pipes and terraces can keep buffers from being washed away. Combinations like these are most effectively developed in a site-specific basis by applying common sense. It is just common sense that conserving soil will make farms more profitable and farmers and their children more prosperous.

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Fruit Session

Better Crops
Through Soil
Conservation

Weather Decision Support for Fruit and Nut Producers

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Albert serves as area extension horticulturist for 20 southwestern Oklahoma counties. He is also serving in a temporary assignment as OSU Mesonet Liaison to provide information and educational materials on Oklahoma Mesonet. Albert is an OSU triple-dipper. He received a BS in horticulture from Oregon State University, an MS in horticulture from Ohio State University, and has worked for the No. 1 OSU, Oklahoma State University since 1989. Albert has national certification as a Certified Professional Horticulturist and Certified Crop Advisor.

Introduction

The Oklahoma Mesonet is an automated network of environmental monitoring stations operating around-the-clock across the entire state. These stations, at least one in each county in Oklahoma, report current weather conditions every 15 minutes. The network, a cooperative venture by Oklahoma State University and the University of Oklahoma, is designed to provide up-to-the-minute critical weather information to citizens and agencies in Oklahoma. Oklahoma State University personnel that have helped develop and manage the Oklahoma Mesonet are Ron Elliot, OSU Biosystems and Agricultural Engineering Department Head, Steve Stadler, OSU Geography Professor, and J.D. Carlson, OSU Agricultural Meteorologist, Gerrit Cuperus, OSU Entomology Professor, and Albert Sutherland, OSU Area Horticulturist.

Data from the network is available via the Web, as well as upon request via the Oklahoma Climatological Survey. The Mesonet is largely state-funded, with additional operating fees generated from subscriptions, federal grants, and contracts with both public and private sector organizations.

The basic measurements collected at each Mesonet site include:
Air temperature
Barometric pressure
Rainfall
Relative humidity
Soil moisture
Solar radiation
Soil temperature
Wind speed and direction

From these basic weather measurements a number of products are created and displayed over the Internet to provide information for making management decisions. Different data formats and data display products have been developed for agricultural and non-agricultural industries to meet their unique needs. The following is a listing of the

Mesonet pages and products that can be used for making decisions for commercial fruit growers.

Climate

Fruit crops are planted with the expectation of maintaining production over many years. This makes climate data of particular importance in selecting fruit types and varieties adapted to the planting location. Climate data helps provide information on the economic feasibility of a commercial fruit operation planted in a particular location. The Mesonet provides a number of products related to climatic conditions.

Climate Products
Oklahoma statewide statistics
Station statistics
Yesterday's statistics
Meteograms – 24-hour running colored weather graph
Monthly Climate Data (MCD) – daily summaries of weather data

Fertilizer and Herbicide Applications

Wind and rainfall are the most important weather factors to consider for making fertilizer and herbicide applications. It is important to avoid drift onto nearby crops and farmsteads. The Oklahoma Mesonet offers a number of current weather, weather statistics, and forecast products that can help avoid weather impacts during a fertilizer or herbicide application.

Fertilizer and Herbicide Application Decision Support
Wind speed
Wind direction
Air temperature
Dispersion conditions and forecast
Weather radar
Color-Filled Animations in Quicktime
MOS 60-hr. Forecasts – provides a text based forecast for wind and rain
MOS 60-hr. Forecast Map – a state map showing air temperature, wind speed, wind direction, and rainfall

Irrigation

Water is a valuable resource that can be applied through irrigation systems to supplement rainfall. Crop quality and quantity are highly dependent on water availability during critical crop stages. In addition to being a valuable resource, the amount of water applied through an irrigation system can dramatically impact crop profit and thus net farm income. The Oklahoma Mesonet offers a number of products for assisting with irrigation scheduling and quantity of water applied.

Irrigation Decision Support
Rainfall
Evapotranspiration model

Evapotranspiration
Rainfall Accumulations
Color-Filled Plot
Rainfall Summary-Calendar Year

Pest Management

The Oklahoma Mesonet provides a Pecan Nut Casebearer model to assist growers with management of this insect. The life cycle of a number of pests are highly dependent on the weather. Several insects, including the alfalfa weevil and pecan nut casebearer, develop based on the heat units. By monitoring the heat units in degree-days, it is easy to determine the stage of the insect. This allows the producer to know when to scout for the pest insect and implement integrated pest management strategies.

Disease outbreak requires a susceptible host, presence of the pathogen, and a conducive environment. The Oklahoma Mesonet has developed a Pecan Scab Model that monitors air temperature and air moisture conditions throughout the growing season and identifies when the environment is right for a disease outbreak. The products listed below help growers determine when a control product needs to be used and when it is most effective.

The Oklahoma Mesonet provides the latest weather information for all Oklahomans on its free access Web site at *www.mesonet.ou.edu/public*. The most current information for the entire state is presented and updated every 15 minutes. The special pages on this free site include the Oklahoma Fire Danger Model, Oklahoma Dispersion Model, computer-generated (60-hour MOS) forecasts, seasonal rainfall maps and tables, and an archive of the Mesonet Ticker.

Subscription services are also available that provide extensive data formats for analyzing Oklahoma weather data from different perspectives. A Limited Edition subscription provides access to the agricultural models, soil temperature 1, 3, and 7-day averages, meteogram charts, weather trends that show air and rain changes and rainfall intensity, and monthly climate data sheets. The fee for a Limited Edition subscription is $29.95 for 6 months and $44.95 for 12 months of data access.

The Basic Subscription provides access to software that creates maps and charts on the users computer, once the current Mesonet data is downloaded over the Internet. With the graphics created on the user's computer, the user can select geographical areas of interest to zoom into to access more data per site. This zoom feature is also utilized on the Nexrad radar data to allow the user to view storm intensity down to a clarity of 0.5 miles by 0.5 miles. The Basic subscription fee is $12.95 per month, $59.95 for 6 months, or $99.95 for 12 months of data access.

For more information on the Oklahoma Mesonet visit the Web site at site at *www.mesonet.ou.edu/public* or call a Mesonet operator at 405-325-3231.

Georgia's Peach Industry: Reflections on Past and Present Progress

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Phillip M. Brannen obtained a Ph.D. degree in Plant Pathology from Auburn University. After working in industry research for 6 years, he accepted a faculty position with the University of Georgia in 2000. Responsibilities include extension efforts directed toward disease control of peaches, blueberries, apples, strawberries, wine grapes, muscadines, and blackberries.

Kathryn C. Taylor earned Masters and Ph.D. degrees from Clemson University and the University of Florida, respectively. After 15 years of research in citrus physiology in Florida and Arizona, she now has extension and research responsibilities with peach culture and physiology at the University of Georgia.

Current Industry Statistics

Peach production in the United States is highly concentrated, with five states (California, South Carolina, Georgia, New Jersey, and Washington) accounting for 77% of total production in 2000 (Anonymous, 2001a). With 17,000 bearing-age acres, Georgia, the "Peach State," ranks second only to California in the area planted to peaches. Since 1992, statewide peach acreage has decreased by 19% (Anonymous, 2001b), more than the national average decline of 14% (Anonymous, 2001a). Total utilized production in 2000 was 110 million lbs; Georgia thus ranked third in production behind California (801 million lbs freestone peaches) and South Carolina (140 million lbs).

Nearly all peaches produced in Georgia are utilized for the wholesale fresh market, with only a small percentage sold at roadside markets and no significant processing use. Because of the early harvest window and high-quality fruit production, average seasonal prices received by Georgia growers in 2000 were 2.4 and 1.8 times higher than those for fruit from the main competitors California and South Carolina, respectively (Anonymous, 2001a). With a total value of $41.7 million, peach is the state's most important fruit crop.

Georgia's peach industry is heavily concentrated in Crawford, Peach, Taylor, and Macon counties, centered around the middle-Georgia town of Ft. Valley (Fig. 1). This area is located far enough north to receive sufficient winter chilling in most years, while at the same time being far enough south to guarantee early harvest dates and associated premium prices. In addition, soils are more favorable here than in the north Georgia Piedmont (heavy clays) or the south Georgia Coastal Plain (light sands). Disease pressures from leaf curl, bacterial spot, scab, and phony peach are lower than those observed in other parts of the state.

Historically, considerable peach production occurred in the northern and southern districts of the state (Hubbard and Purcell, 1986; Hubbard *et al.*, 1990; Savage, 1983), but acreage declined in north Georgia due to frequent freeze damage and relatively late harvest dates and in south Georgia due to low fruit quality and high phony peach disease incidence. Through an active low-chill peach breeding program, the University of Florida, University of Georgia, and USDA are developing early-maturing, high-quality peaches with non-melting flesh (Rahn, 1997); if successful, this program may lead to a rebound of production in the south Georgia district centered in Brooks County (Fig. 1).

Historical Development of the Industry

Peaches were first introduced to St. Simons and Cumberland islands along the Georgia coast in 1571 by Franciscan monks (Savage, 1983). Subsequent records from the mid-18th century document peaches and plums being cultivated by Cherokee Indians. Before the Civil War, increasing numbers of home orchards were planted. These orchards were initially established from seeds, but starting around 1825, they were increasingly developed from budded trees. The first Georgia peaches were shipped to the New York market between 1858 and 1860, albeit on a small scale. Transport occurred by wagon to Augusta, by shallow-draft boat to Savannah, and from there by steamship to New York (Savage, 1983).

The three decades after the Civil War witnessed Georgia's ascent to the "Peach State." A considerable expansion in acreage and production during that time was fueled by several interacting factors (Savage, 1983):

- The abolition of slavery. This forced farmers to search for alternatives to the traditional, labor-intensive cotton crop. Peaches in particular benefitted from this transition from the past agricultural routine.
- The discovery of the 'Elberta' variety by Samuel H. Rumph, a Marshallville peach grower, in 1870. This yellow-fleshed peach was of superior quality and shipped better than previous varieties. 'Elberta' was to remain the leading peach in Georgia until 1960 (Myers *et al.*, 1989).
- The founding of the Georgia State Horticultural Society in 1876. Under the leadership of Prosper J.A. Berckmans, a nurseryman and noted pomologists, this organization promoted the introduction and testing of many fruit varieties and their distribution throughout the state.
- Improvements in the rail transportation network and the development of the refrigerated rail car. These allowed rapid shipments to northern markets on a large scale.

Since its beginnings, Georgia's commercial peach industry has been characterized by extremes B growers experienced either considerable profits or crushing losses, with little or no intermediates (Savage, 1983). These extremes are reflected in the production figures (available since 1899), which show substantial fluctuations superimposed on periods of high or low production (Fig. 2). Production generally was lowest in years with mid-March to mid-April freezes coinciding with bloom or early fruit development of the crop; examples of years with serious freeze-related losses include 1943, 1955, 1996, and 1998 (Okie *et al.*, 1998; Savage, 1983). In other years, such as 1949 and 1974, insufficient chilling due to warm winter temperatures was responsible for considerable yield reductions. In 1950 and 1964, low winter chilling, late spring freezes, and rainy weather during bloom and harvest conspired to result in substantially below-average production (Savage, 1983).

As for general trends (Fig. 2), production was highest during the overproduction phase of the late 1920s and 1930s (which was prompted by substantial peach acreage expansion following the establishment of the cotton boll weevil) and lowest during the 10-year period starting in 1948 (due to weather-related production losses). There was a declining trend during the 1960s and 1970s, when some producers were unable to recover from the losses experienced during the previous decade. In addition, this period was marked by rapid technological advancements (e.g., shift to yellow-fleshed varieties, use of hydrocoolers, changes in shipping containers), and not all producers were willing to invest in this new technology. Despite the relatively stable production of the last two decades, the number of producers has continued to decline, resulting in the management of very large numbers of acres by a few family farms. Indeed, more than 90% of the commercial peach acreage in Georgia is now managed by six farms.

Current Challenges

Given its volatile history, it should come as no surprise that Georgia's peach industry continues to confront numerous challenges. A few selected examples are discussed below:

- Increased competition from California, whose fresh-market production has nearly doubled since 1981 (Anonymous, 2001a). Sensory quality of Georgia peaches is generally considered superior to those produced in California, but the ongoing development of optimized postharvest ripening programs in California may reduce this competitive advantage.

- A shortage of locally adapted red-colored varieties, which are preferred by many consumers. This prompted producers either to plant more red-colored California varieties, which require an expensive bacterial spot control program, or to employ cultural practices such as summer-pruning or use of reflective films to improve light penetration and fruit coloring (Layne *et al.*, 2001). Active breeding programs to improve peel color in new varieties adapted to southeastern production conditions are currently ongoing in Georgia and South Carolina.

- The lack of a significant market for 2 to 2.25-inch peaches. This has forced producers to employ cultural practices that reduce fruit number and increase size. In addition, some typically undersized varieties are no longer planted.

- A shortage of skilled labor. Most orchard and packinghouse workers are now Hispanics recruited through the H-2A program. Increased labor costs have prompted more widespread adoption of high-density training systems (such as quad-V and perpendicular-V), which tend to be more labor-efficient.

- The reduced availability of effective and affordable insecticides. The most prominent example is the loss in 1999 of methyl parathion (Hanson, 1999), which had been a key chemical for control of plum curculio and other insect pests since its introduction in 1948. Phosmet and azinphos methyl, two other important peach insecticides, are currently undergoing review. This has prompted fears of increased levels of secondary pests and of increased resistance risk in key pests such as the plum curculio.

- The continued threat of diseases that are difficult or impossible to control with pesticides. This includes bacterial spot (caused by *Xanthomonas arboricola* pv. *pruni*), for which control costs on susceptible cultivars can amount to more than $300 per acre (Layne *et al.*, 2001). In addition, the use of antibiotics, a main component of bacterial spot management, faces an uncertain regulatory future. Phony peach disease (caused by *Xylella fastidiosa*) and peach tree short life (a disease complex caused by *Mesocriconema xenoplax*, *Pseudomonas syringae* pv. *syringae*, *Leucostoma persoonii*, and cold injury), continue to limit peach tree longevity, particularly in the southern region of the state. In recent years, the threat of the latter disease has been reduced due to the availability of Guardian, a tolerant rootstock (Okie *et al.*, 1994). Armillaria root and crown rot (caused by *Armillaria tabescens* and *A. mellea*) is an emerging problem, particularly on replant sites and where peaches follow pecans. The selection of resistant and/or tolerant rootstocks is an ongoing process (Beckman and Pusey, 2001). With plum pox virus detected in Pennsylvania (Levy *et al.*, 2000) and Ontario, Canada (Thompson *et al.*, 2001), there is a real threat of introduction of this quarantine pathogen into other peach-producing states. In response, a voluntary budwood virus testing program for *Prunus* nursery stock was developed and implemented by a consortium of southeastern peach producer organizations, nurserymen, and university scientists. Since nursery stock is the main route for long-distance movement of plum pox virus, this program significantly reduces the likelihood of accidental introduction of this pathogen, thereby ensuring the economic viability of the industry.

Conclusions

Although competition is gaining ground, Georgia peach production continues to enjoy many production and marketing benefits, including proximity to the very large eastern markets. Most importantly, Georgia is the first eastern state to produce peaches of marketable size each year. The industry leaders are fourth-generation peach growers, who - based on the long history of their farms, their rich knowledge-base, their perseverance, and strong research and extension support - will be able to confront and overcome future challenges as their predecessors have in the past. In addition, these growers have a view

that goes well beyond peach production in their home state: they collaborate with other southeastern producers to solve regional problems, they support research at regional universities and with USDA scientists, and they interact with legislators and regulatory agencies to confront issues that impact peach production nationwide. With the adoption of new technologies and varieties, these virtues will allow Georgia to rightfully continue its claim as the A Peach State.

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Blueberry Production in Georgia: Growth and Maturation of an Industry

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Current Status of the Industry

The Georgia blueberry industry has enjoyed considerable growth during the past five decades, with acreage increasing from essentially zero in 1955 to 4,600 bearing-age acres in 2000 (Fig. 1). Based on an average yield of 4,130 lbs/acre, total utilized production in 2000 was 19.0 million lbs with a monetary value of $18.5 million (Anonymous, 2001a, b). After peaches ($41.7 million value in 2000), the blueberry is the state's second most important fruit crop. Georgia's blueberry industry is also significant on the national level, with the state ranking third (behind Michigan and New Jersey) in acreage and fourth (behind Michigan, New Jersey, and Oregon) in total utilized production (Anonymous, 2001b). It is noteworthy that production in Georgia surpassed that of North Carolina for the first time in 2000.

Around 90% of the state's blueberry acreage is located in the southeastern and south-central districts of the state, primarily in Appling, Bacon, Clinch, and Ware counties (Krewer and NeSmith, 2002; Scherm *et al.*, 2001). This region, which is part of the Lower Coastal Plain (Fig. 2), is characterized by very sandy soils with a high water table, ideal for blueberry production. Smaller producers, who grow the crop primarily for local markets and/or pick-your-own, are scattered throughout the state, with a higher density near the population centers in northeastern Georgia. The total number of producers in the state exceeds 200 (Krewer and NeSmith, 2002).

More than 90% of the state's blueberry acreage is planted to rabbiteye (*Vaccinium ashei*) cultivars, with the remainder in southern highbush (*V. corymbosum* hybrids) cultivars (Krewer and NeSmith, 2002; Scherm *et al.*, 2001). The rabbiteye blueberry is native to southern Georgia, northern Florida, and southeastern Alabama and has been in cultivation for more than 100 years (Austin, 1994; Lyrene and Sherman, 1979). This species performs well on relatively poor (i.e., low-organic matter) sites, has relatively few

pest problems, and yields a firm fruit with excellent fresh-market shelf life (Table 1). The southern highbush blueberry has received considerable interest since the mid-1990s, primarily because of its early harvest and associated favorable price windows for fresh-market fruit (Table 1). Production of southern highbush blueberries is challenging, however, due to the species' disease susceptibility and its requirement for high-organic matter soils. Currently, 25 growers are engaged in the production of southern highbush blueberries, mostly on spodic sand soils in the Flatwoods, on pine bark-amended loamy sands, or in beds of pure pine bark.

In 2000, about two-thirds of the Georgia blueberry crop was frozen for use in processing and one-third was sold as fresh-market fruit (Anonymous, 2001b). The proportion of processed fruit is relatively high because heavy rainstorms, a common occurrence in the Coastal Plain during the harvest period of rabbiteye blueberries, often result in cracking of the fruit, thus forcing growers from the fresh to the frozen market. The main products made from frozen blueberries are yogurt and bakery products. Fruit destined for freezing is typically harvested mechanically. There are currently eight packinghouses handling frozen fruit and 16 for fresh fruit. About 75% of the state's blueberry crop is sold through MBG Marketing, Inc., a grower cooperative headquartered in Michigan; membership of Georgia growers was negotiated in 1983 to capitalize on the cooperative's technical and marketing expertise and its access to world markets (Krewer and NeSmith, 2002). Only a small percentage of the fruit is typically utilized for the pick-your-own market (Scherm *et al.*, 2001).

Driving Forces for Past and Future Growth

The foundation for the development of the state's blueberry industry was laid with the establishment of an active rabbiteye blueberry breeding program at the University of Georgia's Coastal Plain Experiment Station in Tifton in the 1940s (Krewer and NeSmith, 2002). Among others, this program resulted in the release of the cultivars 'Tifblue' (1955), 'Woodard' (1960), and 'Climax' (1974), all of which were critical to the early development and maturation of the industry. A major impetus for expansion came in the early 1970s with the establishment of the Georgia Blueberry Association (active until 1994); at the same time, a packinghouse was built and the first mechanical harvesters purchased with grant money obtained by the city of Alma through the Model Cities program (Krewer and NeSmith, 2002), a federal program supporting economically disadvantaged areas. Driving forces for the continued rapid expansion during the following two decades were membership in the MBG Marketing cooperative (1983) and the development of an emerging southern highbush industry in the mid-1990s, initially with cultivars from the Florida and North Carolina breeding programs.

The expansion of Georgia's blueberry industry is expected to continue in the future based on increased acreage and improved yields from existing plantings. Increased consumer demand, fueled in part by the recent documentation of health benefits of blueberries (McCord, 1999); reduced revenues from traditional field crops in the region; and moderate land and irrigation water costs all contribute to a continued interest among growers in expanding the size of their plantings. In addition, the acreage planted to southern highbush blueberries is expected to grow, given the high value of this crop and

the availability of new, well-adapted cultivars from the Georgia and Florida breeding programs. A recent producer survey indicated that the state's total blueberry acreage may increase by as much as 35% within the next 5 years (Scherm *et al.*, 2001).

Traditionally, rabbiteye blueberry has been considered a low-input crop and optimal yields were not attained because only limited efforts were made to manage yield-reducing factors (Table 2). As this paradigm shifts toward higher production intensity, yield increases will result. Freeze injury during bloom, the most important horticultural problem affecting blueberries in Georgia (Scherm *et al.*, 2001), is being managed by increased use of overhead irrigation for freeze protection and by use of the growth regulator gibberellic acid to rescue freeze-damaged flowers (NeSmith *et al.*, 1995, 1999). Low fruit set is being overcome by bloom-applications of gibberellic acid (Williamson *et al.*, 1995), use of supplemental bees to improve pollination (Dedej *et al.*, 2002), and by insecticidal control of flower thrips which have only recently been recognized as being associated with serious fruit set problems in the South Mummy berry, traditionally considered the most important disease problem in Georgia blueberries (Table 2), is now being managed through few, well-timed fungicide applications during bloom, with or without a single pre-bloom application depending on cultivar phenology (Scherm and Stanaland, 2001). Management recommendations for newly emerging disease problems (e.g., leaf spots and dieback diseases on southern highbush cultivars) are being developed through joint research-extension projects (Brannen *et al.*, 2001).

Conclusions

Georgia's blueberry industry has experienced exponential growth during the past five decades, and the state now ranks third in acreage and fourth in total production in the United States. This growth was accompanied by significant changes in production practices during the past two decades. A new southern highbush blueberry industry has developed, yielding a high-value crop at a time when traditional southern row crops face an uncertain future. Production for the fresh market is rising, and inputs for pest management have increased. Overall, the industry is healthy and expanding, with a projected increase in acreage by up to 35% by 2005.

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Table 1. Features of rabbiteye and southern highbush blueberries grown in Georgia.

	Blueberry species	
Feature	Rabbiteye (*Vaccinium ashei*)	Southern highbush (*V. corymbosum* hybrids)
Site requirements	low soil pH and sufficient soil moisture	high organic matter content (spodic sand soils or pine bark culture), well-regulated soil moisture, freeze protection
Main disease problems	mummy berry	Phytophthora root rot, leaf spots, dieback diseases
Harvest season	late May through July	mid-April through May
Recent wholesale price for early-season fresh-market fruit [z] ($/lb)	>1.50	>3.00
Recent wholesale price for processed fruit [z] ($/lb)	>0.53	none processed

[z] Prices before subtraction of costs for production, harvest, packing, and marketing.

Table 2. The most important production problems in Georgia blueberries, based on a producer survey conducted in 1999 (modified from Scherm *et al.*, 2001).

Problem	Percent of producers considering problem		
	major	moderate	none
Horticultural			
Freeze injury	69.0	31.0	0.0
Poor fruit set	28.6	39.3	32.1
Drought	44.8	34.5	20.7
Diseases			
Mummy berry	41.4	37.9	20.7
Twig and stem blight	14.3	50.0	35.7
Botrytis flower blight	7.1	57.1	35.7
Arthropods[z]			
Gall midge	10.7	32.1	57.1
Scale	7.1	35.7	57.1
Thrips	7.1	32.1	60.7

[z] The fire ant, a nuisance pest that does not cause direct yield losses, was listed as a "major" or "moderate" problem by 75.0% of survey respondents.

Results From Freeze Protection Studies In Oklahoma Peach Orchards

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Introduction

Although there are relatively few commercial peach growers in Oklahoma, the economic value of production (6.4 million dollars) placed peaches as the 13th most important agricultural commodity in the state in the year 2000; for that year, Oklahoma was also 15th in the nation in terms of peach production with 14 million pounds. In high production years, such as 1991 and 1995, production was around 30 million pounds, giving Oklahoma a ranking of 9th in U.S. peach production.

In Oklahoma the most limiting factor in peach production is the weather - in particular, ***untimely late winter or early spring freezes***. During the 1990's there were 4 years out of 10 in which such freezes resulted in production at or below 8 million pounds. Adding the 1980's to the analysis, production figures showed 11 years out of 20 had peach production well below the "average", indicating that the chances of having a good or even average crop in Oklahoma in any given year are less than 50/50. As of 1997, there were 1244 acres of peaches in the state, with the two largest concentrations being located in the Stratford area (34% of the peach trees) and in the Porter area (21% of the peach trees).

Given the potential and impact of damaging freezes, it is surprising that little if any freeze protection measures are actually used by Oklahoma peach growers. One such reason for this may be the perception that no such measures actually work under Oklahoma weather conditions (and, in reality, up until the studies to be reported, there has been no research in Oklahoma orchards as to the degree of temperature protection afforded by various methods). Other reasons may be lack of knowledge about these methods and also the proper times to apply them. This paper reports on certain freeze protection studies that have occurred in Oklahoma orchards over the past two years. Before that, however, it is important to understand two different types of freezes and which type under which freeze protection measures may be utilized.

The Meterolgy of Freezes

An *advective* freeze typically occurs after passage of a cold front. Skies are usually cloudy to partly cloudy, and winds are moderate to strong (> 10 mph). In such a freeze, air temperatures decrease with height above the surface; under these conditions, the higher sections of an orchard will have the cooler temperatures. Except for physically covering low-lying crops, freeze protection measures under advective freezes are NOT effective and should be avoided.

A *radiative* freeze, which often follows the night after an advective freeze, is a completely different situation. Here the region is near the center of a high pressure zone with mostly clear skies and light winds (at night the winds approach near-calm conditions (< 5 mph)). These freezes are characterized by *temperature inversions*, in which temperature increases with height above the surface to a certain level (the inversion top) before decreasing again. During the course of a night, the inversion typically grows in height, forming around sunset and growing in height until sunrise. Under these weather conditions, the lowest sections of an orchard will be the coldest. Freeze protection methods in this type of a freeze ARE effective and can be used (the stronger the inversion and the lighter the wind, the better),

Results from Freeze Protection Experiments

In late 1999 a portable oscillating wind machine was purchased with funds from two OSU departments (Biosystems and Agricultural Engineering; Horticulture and Landscape Architecture) and the Oklahoma Agricultural Experiment Station. During the early months of 2000 and 2001, experiments were performed during appropriate nights at Livesay Orchards near Porter, OK. In addition, during the early months of 2001, sprinkler irrigation experiments were performed at the Oklahoma Fruit Research Station in Perkins, OK. Results from these latter experiments proved inconclusive and the experiments are being redesigned (larger sprinklers, more dataloggers) for testing in 2002. This paper will report on the wind machine results.

The portable wind machine (Figure 1), which was purchased for about $10,000 from Phil Brown Welding Corp. in Conklin, Michigan, is powered by a 60-80 hp tractor. When raised from its horizontal resting position, the 5.4 ft diameter fan stands about 20 feet above the ground and, at full power, rotates at about 1200 revolutions per minute. The fan is pitched downward at 10 degrees to help bring warmer inversion air down from above. It also oscillates through a 180-degree arc with a complete cycle taking between 2-4 minutes (the user can control the rate).

To assess the spatial and temporal temperature effects from this wind machine, 26 small automated temperature dataloggers (8K "Hobo" temperature dataloggers from Onset Corp.), each enclosed in a radiation shield, were evenly placed throughout the orchard area at standard 5-foot heights. Four experiments were conducted in 2000 during the early morning hours of March 12, March 20, April 5, and April 9; two experiments were

conducted in 2001 on March 25 and April 18. The experiments on April 5, 2000 and March 25, 2001 showed little if any protection due to high wind speeds during the first morning and lack of temperature inversions in the orchard during both mornings; thus, they will not be discussed.

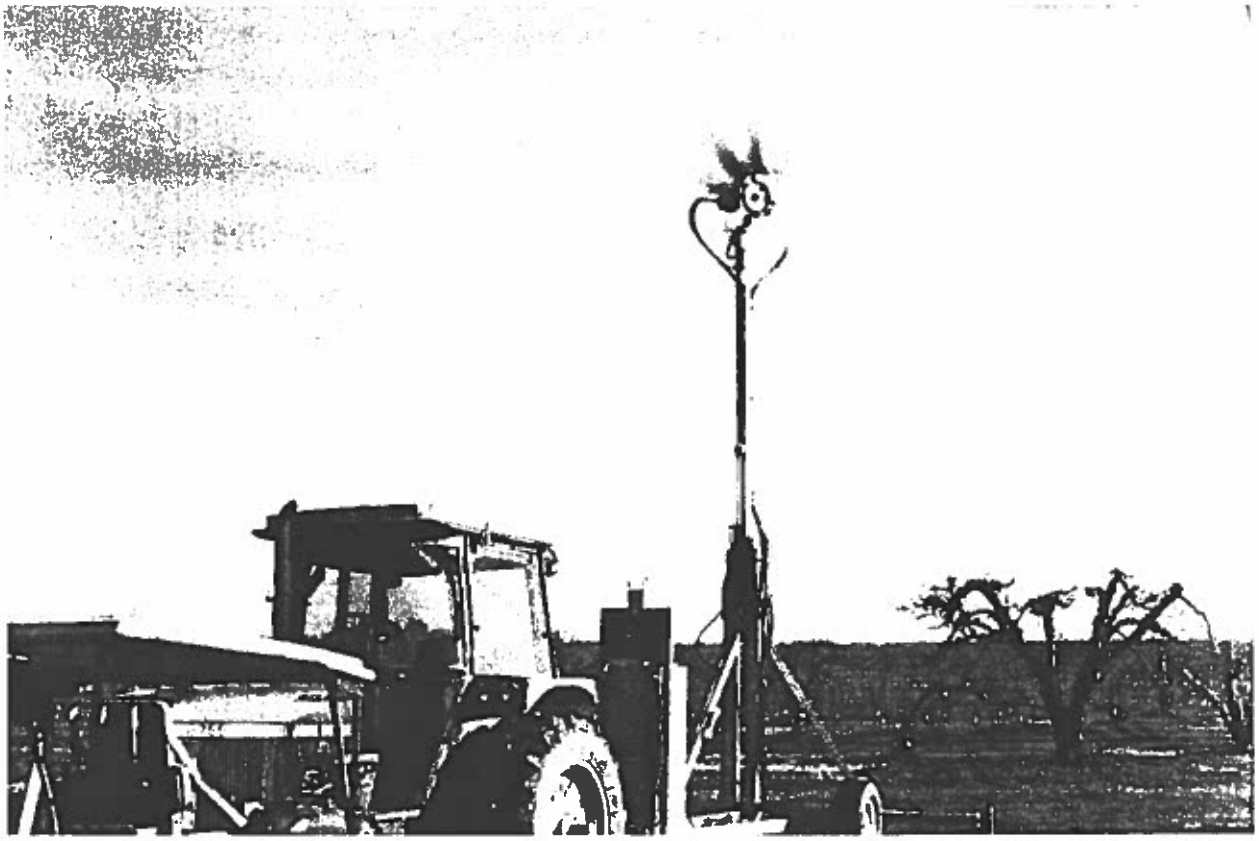

Figure 1. *Portable oscillating wind machine used in freeze protection experiments.*

We begin with the experiment on the morning of March 12, 2000. Prior to the wind machine being turned on, the automated weather station at the center of the orchard area showed an inversion of almost 4F from the 5-ft level to the 21-ft level. At the nearby Mesonet tower (about 1 mile away), winds at the 33-ft level were light (4 mph) out of the southeast.

Figure 2 shows the 5-ft temperature behavior (thickest line) at a datalogger site 200 feet to the northeast of the wind machine (within its arc of oscillation); in addition, the bottom light line (unlabeled) shows the temperature behavior at a datalogger site largely unaffected by the machine, and the other light line represents temperatures at the Porter Mesonet tower about 1 mile away. After the wind machine was turned on, temperatures rose by about 2F at the site to the northeast and remained steady through sunrise. The other datalogger site shows fluctuating temperatures through the same period, but averaging about 3-4F lower than the other site. This indicates the wind machine was providing 3-4 degrees of protection to the site to its northeast. Finally, as shown by the

temperature traces before the wind machine was turned on, note that temperatures in this particular orchard can be 3-5 degrees cooler than temperatures at the Mesonet tower.

A way of looking at the spatial temperature protection pattern on that same morning is shown in Figure 3. This represents a top view of the orchard area. All 26 datalogger locations are depicted. The wind machine is located at the solid arrow and was blowing in the direction shown (with a 180-degree oscillation pattern). The values plotted at the datalogger locations represent the difference between the hourly average temperature after the wind machine was turned on and the hourly average temperature before it was turned on (e.g., a value of 2 means the hourly average temperature rose 2F after the machine was turned on). Note that about 8 acres (8 of the 200' x 200' squares on the chart) show temperature rises of 2F or higher, with an even larger area over 1.5F. Given that temperatures normally would have fallen another degree or so during this hour, the actual protection afforded on this morning would have been even higher. It's also interesting to note how the ambient southeast wind displaced the center of the protection pattern to the north and a bit west of the wind machine.

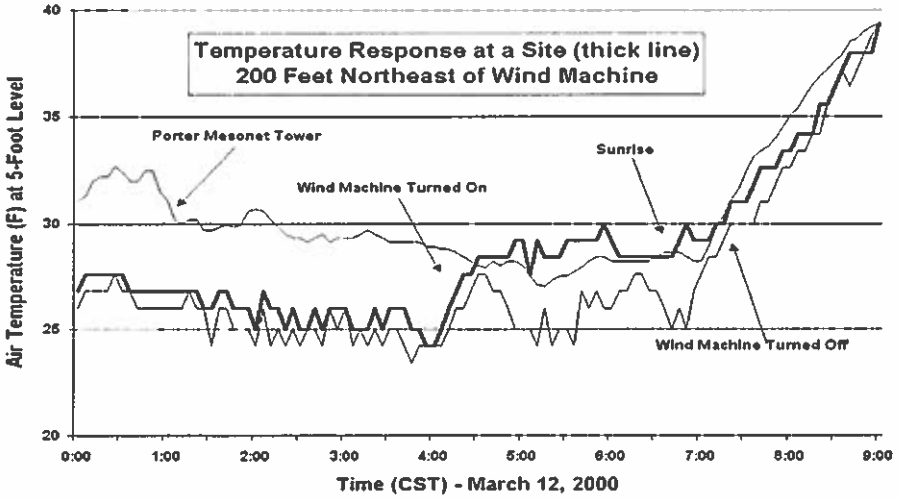

Figure 2. *Temperature response over time at a site 200 feet northeast of the wind machine during the experiment of March 12, 2000.*

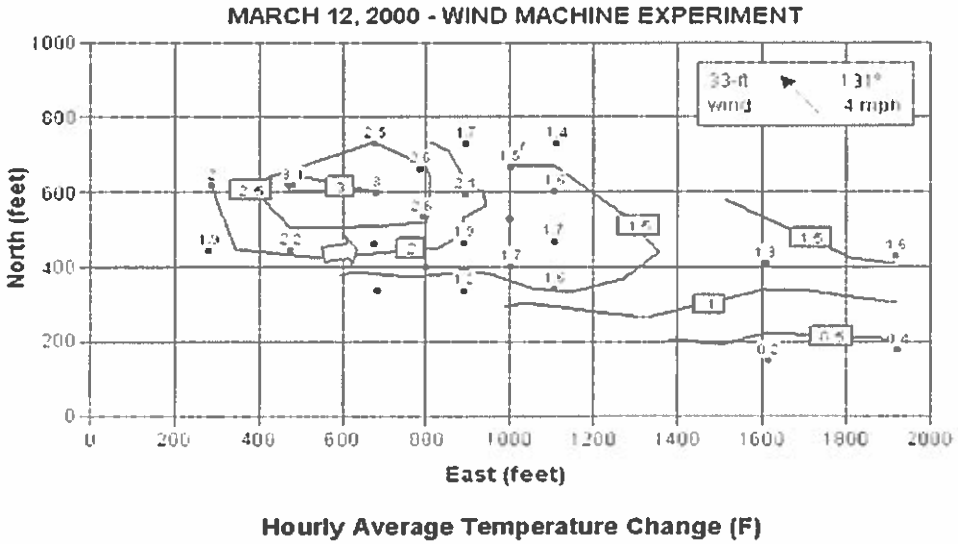

Figure 3. *Top view of temperature protection pattern during the first hour of the wind machine experiment of March 12, 2000.*

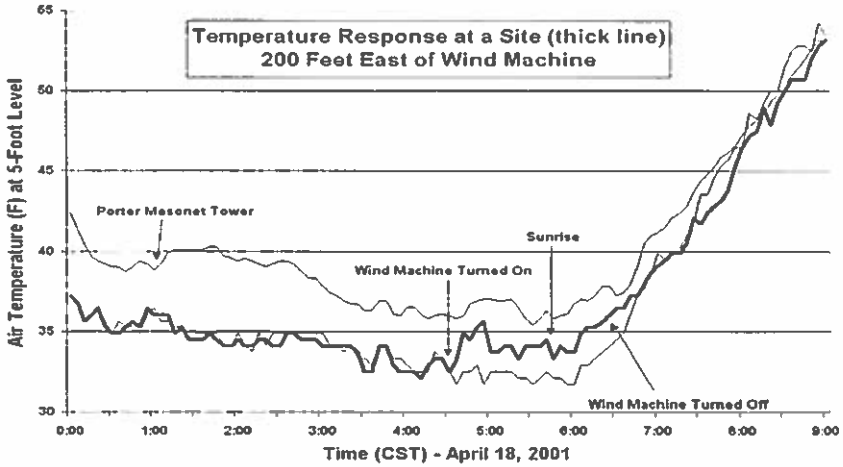

Figure 4. *Temperature response over time at a site 200 feet east of the wind machine on April 18, 2001.*

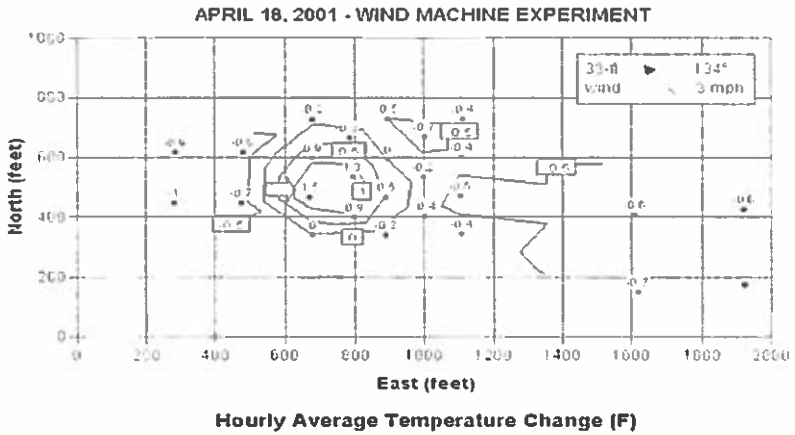

Figure 5 *Top view of temperature protection pattern during the first hour of the experiment on April 18, 2001.*

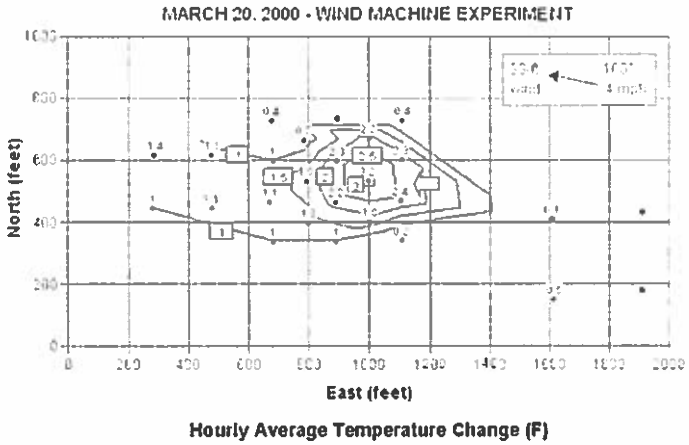

Figure 6. *Top view of temperature protection pattern during the first hour of the experiment on March 20, 2000.*

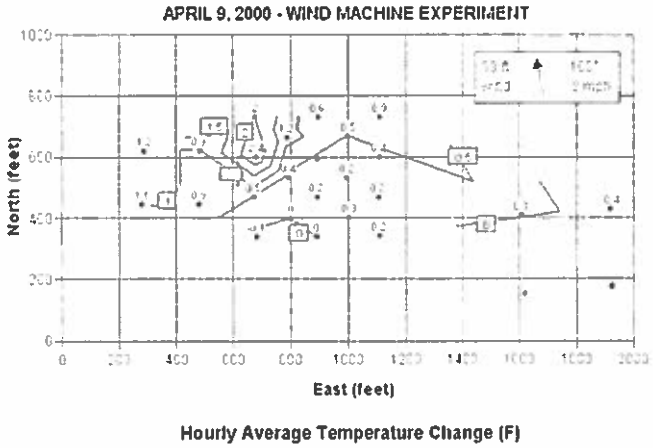

Figure 7. *Top view of temperature protection pattern during the first hour of the experiment on April 9, 2000.*

Figures 4 and 5 are similar to the last two, but for the wind machine experiment of April 18, 2001. Prior to the wind machine being turned on, the orchard weather station showed an inversion of about 2.5F from the 5-ft level to 21 feet. At the nearby Mesonet tower winds were light (3 mph) out of the southeast. After the machine was turned on, temperatures at a datalogger site 200 feet to the east rose by about 3F over the first 30 minutes, then dropped a bit and stayed steady through sunrise (Fig. 4). The other datalogger site (in an area unaffected by the machine) had temperatures steady but slowly dropping during the period (averaging 2-3F colder than the other site). This indicates the wind machine was providing 2-3 degrees of protection to the site to the east. Note again that this orchard tends to be 3-5F cooler than the Mesonet tower on nights with inversions and light winds. Figure 5 shows the spatial protection pattern was smaller in magnitude on this morning with about 4 acres showing a temperature rise during the first hour. Since temperatures would normally have fallen another degree during this period, the amount of protection in this area really was 1 to 2.5F. Note, however, that the inversion on this morning was not as strong as in the last case (and, as in the last case, the wind direction was in opposition - more than 90 degrees - to the orientation of the wind machine).

Finally, Figures 6 and 7 show the spatial protection patterns from two other experiments. On March 20, 2000 there was a good inversion in the orchard (about 3.2 F between the two tower levels) and the easterly winds, although light, were oriented in the same direction as the wind machine. A very strong protection pattern resulted (Fig. 6), with about 8 acres having from 1 to 3 degrees of temperature rise the first hour (more actual protection probably occurred, however, as temperatures may normally have dropped a degree during this period). On April 9, 2000 there was also a good inversion in the orchard (about 2.9 F between the two tower levels), but winds were fairly strong (8 mph) out of the south. Note how the temperature protection pattern is displaced northward with the wind; only about 4 acres show rises of 1 degree or higher. But temperatures would have normally fallen a degree during this hour, so the protection pattern was actually larger than shown.

Summary

The two years of experiments with the portable wind machine show promise for Oklahoma peach growers. During nights with inversions and light winds, the device can afford varying degrees of temperature protection to as much as 8-10 acres. If possible, it is best to align the machine with the ambient wind direction. As seen in the four examples above, the temperature rise over the first hour of the machine's operation can range from 0-3 F, depending on the distance from and relative location to the wind machine. Given that temperatures normally fall a degree or so, the protection is really more in the range of 1-4 F. On inversion nights when the minimum temperature falls below the critical temperature for 90% flower bud kill by several degrees, use of this wind machine could save the peach crop in the area protected or at least mitigate the amount of kill if the temperature fell by larger amounts. In 2002 we will continue the freeze protection work and experiment with burning hay bales behind the wind machine to give added heat to the orchard.

The hope in all these freeze protection experiments (be they wind machine or sprinkler irrigation) is to offer peach growers several documented methods for protecting their crop from freeze damage. To successfully apply these methods, the grower first needs to know the critical flower bud kill temperatures for the current stage of the peach crop (these temperatures are usually listed as 90% kill and 10% kill temperatures). Next the grower would need to know whether the temperature in the orchard to be protected is expected to fall below these temperatures and whether light-wind inversion conditions are expected that night. Finally, during the freeze night, it is important to monitor orchard temperatures and the presence or absence of inversion conditions.

To assist in real-time monitoring of orchard temperatures and inversions, growers in Oklahoma can utilize the Oklahoma Mesonet, the statewide automated weather station network operated by Oklahoma State University and the University of Oklahoma. For this purpose, a special "inversion conditions" map has been developed (Figure 8) and is available in near-real-time every 15 minutes at ***http://agweather.mesonet.ou.edu/current-recent-weather/6hrarchive.html***

This map shows the 5-ft air temperature in brown (bottom left) at a given Mesonet site as well as whether an inversion exists at that site (upper right) and its strength in red (the temperature increase from the 5-ft to 30-ft level). At the bottom right of the station plot, the dew point is shown in green, which is often a measure of how low the temperature may fall during nighttime hours. In addition, wind speed and direction is shown in light grey. Besides this map, growers can use the "weather conditions" map to see temperature, relative humidity, and winds at a greater number of Mesonet sites.

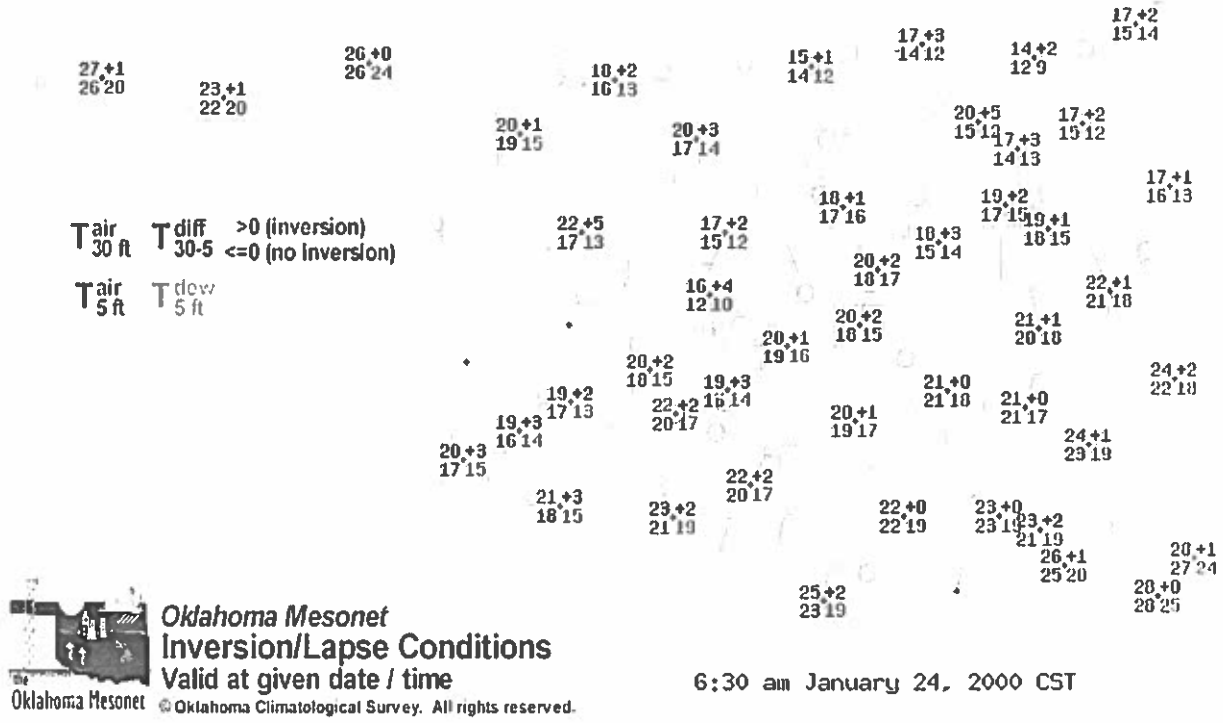

Figure 8. *Sample map of temperatures and inversion conditions at Mesonet sites*

In applying the inversion condition map, two things should be noted. First, research has shown that inversions at Mesonet towers correlate very well with inversions in nearby orchards (i.e., if there is an inversion at a nearby Mesonet tower, there is most likely one in your orchard, although the strength may vary). Second, as Figures 2 and 4 indicate, one needs to "calibrate" the temperature in a given orchard to the nearby Mesonet tower on nights with inversion conditions. In the Livesay orchard used in the wind machine experiments, temperatures are typically 3-5 degrees cooler than those at the nearby Mesonet tower.

Finally, with respect to forecasts of low temperatures over the next two nights, Oklahoma peach growers can use another product that has been developed: the 60-hour NGM MOS digital forecast located at
http://agweather.mesonet.ou.edu/forecasts/digiforecast.html.

A grower can click on the site nearest the orchard (e.g., Tulsa) and obtain a forecast of various weather variables in 3-hour increments out to 60 hours in the future. In the example shown (Figure 9), for Clayton, NM, one can see that the temperature was predicted to dip into the mid to upper 20's on the morning of March 17 and into the low 30's on the morning of March 18. One can infer that inversion conditions would most likely occur on the first morning (as light winds and clear skies are predicted) but would be unlikely during the second morning (strong north winds with scattered to overcast cloud conditions). Thus, a grower can use this forecast tool in planning ahead as to whether any

freeze protection might be needed, and if so, if weather conditions would be suitable (i.e., an inversion with light winds).

Forecast for Clayton, NM based on data taken on March 16, 2000, at 06:00 am CST

	/Mar 16				/Mar 17								/Mar 18						
HOUR OF DAY (CST)	12	15	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18
MAX MIN TEMPS (F)							26				56				30				49
TEMPERATURE (F)	28	31	31	26	26	28	30	40	50	55	53	40	35	33	32	36	45	43	46
RELATIVE HUMIDITY (%)	71	63	63	78	71	68	60	50	34	29	32	54	69	69	69	64	45	43	45
WIND DIRECTION	N	N	NE	UNW	WNW	W	WSW	SW	SW	S	SSW	NNE	N	N	N	N	NNE	NNE	ENE
WIND SPEED (MPH)	18	16	13	4	4	6	5	11	11	11	20	19	13	14	14	16	5	4	16
DISPERSION CONDITION	MG	MG	MG	VP	VP	VP	VP	MG	G	G	G	MG	MG	MG	MG	MG	EX	G	MG
DOWNWIND POLLUTION INDEX	5	6	6	117	117	78	94	8	3	3	4	5	6	5	6	6	2	3	6
SKY CONDITION	OV	OV	BK	CL	CL	CL	CL	CL	SC	SC	BK	SC	SC	OV	SC	BK	SC	SC	SC
CEILING	5	5	6	7	7	7	7	7	7	7	7	7	7	7	6	6	5	6	6
CHANCE OF PRECIP (%)			20		2		0		0		0		1		8		8		8
AMOUNT OF PRECIP (in)			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
PRECIP TYPE (if any)	S	S	S	S	S	S	S	S	S	R	S		S		S		S		S
DEW POINT TEMP (F)	20	20	20	20	20	19	18	23	23	24	24	25	26	24	23	25	25	25	26

SKY CONDITION	PRECIPITATION TYPE	DISPERSION CONDITION	DOWNWIND POLLUTION INDEX	CEILING
CL = Clear	R = Rain	EX Excellent	< 2	1 = < 200 ft
SC = Scattered	Z = Freezing Rain	G Good	2 - 4	2 = 200 - 400 ft
BK = Broken	S = Snow	MG Moderately Good	4 - 10	3 = 500 - 900 ft
OV = Overcast		MP Moderately Poor	10 - 23	4 = 1000 - 3000 ft
		P Poor	23 - 53	5 = 3100 - 6500 ft
		VP Very Poor	> 53	6 = 6600 - 12000 ft
				7 = > 12000 ft

Figure 9. *Example of a 60-hour NGM MOS forecast*

Regulatory Changes For The Fruit Grower

Jim T Criswell, Pesticide Coordinator

Criswell has been with OSU for over 20 years working in the area of pesticide information and education. He has worked with industry, growers, state and federal regulatory agencies on pesticide issues. In his previous life, he worked for a food processor in Delaware.

Much has occurred over the last five years. In 1996, Congress passed the Food Quality Protection Act (FQPA). This legislation mandated EPA review all pesticide registrations by 2003. EPA was instructed to start with the "worst first", to consider cumulative affects, to consider pesticides with the same mode of toxicity together and to place more protection on infants, children and the elderly.

FQPA resulted in the "risk cup" concept. This is where a given pesticide has a certain amount of risk associated with its use on food, its presence in water and its use in the residential area. If the risk exceed the acceptable amount (cup), then that pesticide's risk cup is overflowing. The company then must either cancel the product, cancel uses or complete new scientific studies that demonstrate the risks are less than calculated by EPA. The latter is a very expensive endeavor. EPA has been working on FQPA since 1996 and is in the final stages of setting up all its guidelines and finishing the mandated reviews.

At the same time, EPA has been working on complying with the 1988 FIFRA Amendment that required EPA to review the registration status of all pesticides registered prior to 1984. EPA has been doing this simultaneous with FQPA.

The results of these two pieces of legislation has been the voluntarily cancellation of many older and seldom used pesticides. Many of the old inorganic insecticides and fungicides have been dropped by the companies. The other major occurrences has been the deletion of uses (crops) from pesticide labels. Many of the companies have removed many fruit crops from the labels for two major reasons. First is they represent a small market area for the pesticide. Second the use on certain fruits represent a high risk estimate due to those fruits being a mainstay of children's diets.

Fruits eaten by children less than one year of age include apple juice, orange juice, pears-fresh and peaches-fresh. Pesticides used on these fruits receive considerable inspection by EPA because EPA is concerned about possible residue on these fruits. EPA is concerned even if the residues are found at the limit of detection (usually parts per trillion). This is compounded if the pesticide is then used in the residential area as EPA will do risk assessments for exposure to children in this area. These risk assessments are then "added" together and if the risk assessment exceeds EPA's limit there must be major changes to the pesticides label to reduce these assessed risks.

Recent, activity has moved from old products to newer and more utilized pesticides. Some of these include Lorsban, Diazinon, Thiodan, lindane and Benlate. The first three have had a number of fruits removed from their labels while Benlate was voluntarily canceled by DuPont.

EPA is presently moving into the assessment of the triazine and carbamate (atrazine, simazine, Ro-Neet) herbicides and dithiocarbamate fungicides (maneb).

It should be noted that through both the 1988 FIFRA Amendment and FQPA, EPA has not canceled one pesticide. The companies have "voluntarily" canceled the products or uses.

On other issues, EPA has released a Pesticide Registration Notice that allows companies to place of their product label wording regarding pesticide resistant management. This is important because the new fungicides, herbicides and insecticides all work at the enzyme level of the pest. With this site of action, the pest has the ability to develop resistant to the pesticide. Thus, it is not wise to use the same type of pesticide over and over. To this end, EPA is allowing companies to put on their product label instructions to rotate between different classes (types) of pesticide. This is good pest management. The possible draw back is the label will also require the pesticide to be used under a Comprehensive Pest Management Plan. This is not an option and a grower must have a comprehensive pest management plan in place, written down and followed to use these pesticides. No one knows what this is exactly, but most university and state regulatory folks think a comprehensive pest management plan is simply what many growers have been doing for years - following good pest management procedures.

The other major activity is EPA has a draft Pesticide Registration Notice on how spray drift will be defined and the label restrictions that will limit spray drift. Some of these label requirements include, not spraying when wind speeds are less than 3 mph or greater than 10 mph. When using an airblast sprayer, the sprayer must be shut off at the end of the rows and the spray must not be directed above the horizontal. EPA is also proposing having a no-spray zone for certain pesticides. It is not clear if pesticides could be sprayed up wind from the no-spray zone and allowed to move into the no-spray zone. Also, it is not clear if the no-spray zone would be required for all of the orchard or just on the downwind side. EPA is proposing that wind readings be taken with an anemometer prior to spraying the orchard.

OSU's Pesticide Applicator Education program works with many of you and with the research and extension staff at OSU to ensure that various pest management tools are available. This includes working with IR-4 to obtain use of new pesticides for use on fruits. This effort is done in conjunction with the Universities of Arkansas and Texas A&M. Many of the newer pesticides are moving into the market areas that are being created by the loss of the older pesticides. These newer materials, as a general rule, have a much narrow spectrum of pests controlled and must be used at a more precise time to

obtain good control. This means the grower must be more knowledgeable of the pests and pesticides to make the most of the new pesticide applications.

Antioxidant Content of Blackberry Cultivars and Breeding Selections

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Dr. Clark is a professor in the Horticulture Department at the University of Arkansas. He directs the fruit breeding effort and works in blackberry breeding in addition to breeding of grapes, peaches and nectarines, and blueberries. Dr. Howard is Associate Professor of Food Science and a major focus of his research program is in nutraceuticals of various crops.

Introduction

Interest in phytochemical content of small fruits, including species of *Rubus*, has increased in recent years. Several studies have reported on these health-promoting properties, including antioxidant capacity [as measured by oxidation radical absorbance capacity (ORAC assay) most commonly], total phenolics, total anthocyanins, and additional phenolic components. More reports have dealt with *Rubus* species of various raspberries and to a lesser extent to blackberries.

Information on antioxidant capacity and phenolic content of blackberry cultivars is limited, and values reported in the literature were obtained from analysis of several United States Dept. of Agriculture (USDA)-released cultivars. Ripe berries of 'Chester Thornless', 'Hull Thornless', and 'Triple Crown' had ORAC values of 22.2, 24.6, and 20.3 ~mol Trolox equivalents/g fresh weight, respectively (Wang and Lin, 2000). Also, ripe fruits of 'Hull Thornless' contained the highest levels of anthocyanins (171.6 mg/100 g expressed as milligrams of cyanidin 3-glucoside per 100 g fresh weight) and total phenolics (248 mg/100 g expressed as milligrams of gallic acid equivalents per 100 g of fresh weight). High correlations were found between ORAC values and anthocyanins and ORAC and total phenolics.

The University of Arkansas blackberry-breeding program has been ongoing since 1964, and has focused on fruit size, fruit quality, thornlessness, and disease resistance in cultivar development. Recently, an interest has developed in determining the antioxidant and phytonutrient content of genotypes in the program. The objectives of this aspect of the program are to determine variation in antioxidant and related variable levels in cultivars and breeding selections, and to evaluate year-to-year variation in these levels.

Procedures

A sample of fully-ripe (shiny or glossy black, not overripe) fruit (2400 g) of each genotype was collected on a single harvest date. In 1999, samples included the cultivars Apache, Arapaho, Chickasaw, Choctaw, Kiowa, Navaho, Shawnee, and Triple Crown, and five breeding selections, and in 2000 all cultivars except 'Apache' were again analyzed in addition to eight breeding selections (Table 1). All of these were harvested from plants grown at the University of Arkansas Fruit Substation, Clarksville or the Arkansas

Agricultural Research and Extension Center, Fayetteville. The fresh fruit samples were transported to the Department of Food Science, where they were stored at -20 °C until analyzed.

Results and Discussion

ORAC for 1999 ranged from a high of 57.3 µmol Trolox equivalents per gram of fruit (fresh weight) for A-1859, to the lowest value of 28.6 for 'Choctaw' (Table 1). The cultivars with the highest ORAC values were 'Navaho' and 'Apache', both with values exceeding 50 µmol Trolox equivalents. In 2000, values ranged from a high of 67.9 for 'Kiowa' to a low of 17.3 for APF-12. 'Navaho' again had one of the higher values, but unfortunately 'Apache' was not analyzed in 2000, thus no data are available for the two years to compare its ORAC values. For genotypes measured for two years, values were very similar (within 5%) for 'Arapaho' and 'Navaho', generally similar (within 20%) for 'Chickasaw', 'Choctaw', and 'Triple Crown', but more variable for 'Kiowa', A-1905, and 'Shawnee'.

Highest total anthocyanin content was found for 'Kiowa', 3630.9 malvidin-3-glucoside equivalents in mg/kg fresh fruit in 2000 (Table 1). Most other values were in the range of 1100 to 1300, with the exception of the two APF selections that were below 1000. Year-to year variation for anthocyanins was minimal for some genotypes, but quite large for others with 'Kiowa' exhibiting the greatest difference between years. Total phenolics were over 10,000 chlorogenic acid equivalents in mg/kg of fruit mg/kg fresh weight for two genotypes in 2000, and most values for 2000 were higher than those for 1999 for genotypes measured both years (Table 1).

ORAC values reported here generally exceed those found by Wang and Lin (2000), as their average for three USDA thornless cultivars was 22.4 µmol Trolox equivalents per gram of ripe fruit while our overall 2-year average was 36.0. The common cultivar in their and our studies was 'Triple Crown', and it had an average for the two years of 36.0 in our study compared to the single-year value of 20.3 in the Wang and Lin (2000) report. This could be due to differences in laboratory techniques, although both studies were done based on the ORAC measurement technique of Cao et al. (1995). Juice was used for measurement in the Wang and Lin study, while our data were collected from whole-fruit (pulp, juice and seeds) samples; this may be the most significant factor in the differences in the values. Also, location and environmental effects could contribute to differences, but these have not been investigated in blackberry.

Major objectives in our work included characterizing variation in ORAC among genotypes and years. We found a wide range of ORAC values among genotypes each year, with a 2X range in 1999 and a near 4X range in 2000. This indicates that there is likely substantial genetic variability among the genotypes in ORAC, and this is an important finding for breeding to improve this characteristic. The year-to-year variation was generally not as great, but was substantial for some genotypes. Reasons for this could include environmental conditions, and variation in fruit maturity. Fruit in our study was harvested when fully ripe, but the possibility exists that some variation in fruit

maturity at harvest could have occurred since "maturity" in blackberries varies to some extent.

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Wang, S.Y. and H-S. Lin. 2000. Antioxidant activity in fruits and leaves of blackberry, raspberry, and strawberry varies with cultivar and developmental stage. J. Agric. Food Chem. 48:140-146.

Table 1. Antioxidant capacity, total anthocyanin, total phenolic and quercetin content of blackberry genotypes (± standard error) sampled at Clarksville and Fayetteville, Ark. in 1999 and 2000. Genotypes with "A" or "APF" are breeding selections and are not offered for sale and are not in commerce.

	ORAC [z]		Anthocyanin [z]		Phenolics [z]		Quercetin [z]	
Genotype	99	00	99	00	99	00	99	00
Apache	52.4±4.4	..	1295.6±60	..	6346.3±183	..	..	..
Arapaho	38.7±2.3	37.6±0.1	1496.1±46	1343.3±34	5339.8±106	6262.6±147	44.2±0.5	94.3±5.6
Chickasaw	37.7±1.6	30.7±0.1	1125.2±35	1242.5±31	5504.5±115	5950.9±61	50.3±1.0	28.2±8.1
Choctaw	28.6±1.0	33.4±0.8	1007.0±31	1001.8±254	4217.6±102	9723.9±192	33.7±0.5	14.9±2.3
Kiowa	34.2±1.6	67.9±0.4	1305.2±41	3630.9±17	5001.7±109	7844.0±166	36.5±0.6	59.1±11.3
Navaho	50.1±0.9	47.5±1.3	1112.0±22	1854.8±69	5754.3±171	5338.0±127	35.7±0.3	51.9±7.0
Shawnee	34.2±1.2	25.2±0.4	1275.4±39	1216.6±42	4555.5±158	6760.9±446	16.9±0.4	10.2±2.3
Triple Crown	40.1±0.7	31.9±0.2	1082.9±31	1761.7±17	5220.0±112	7493.2±66	22.6±0.5	40.4±6.7
A-1689	..	28.3±0.3	..	1072.8±34	..	9067.4±306	..	51.4±4.7
A-1817	47.8±1.5	..	1162.2±28	..	6449.4±158	..	40.2±0.4	..
A-1857	..	32.7±0.3	..	1311.7±23	..	9997.5±130	..	25.6±5.3
A-1859	57.3±0.7	..	1663.6±25	..	6232.5±154	..	50.9±1.5	..
A-1905	53.1±1.1	30.4±0.7	1209.1±24	1221.2±37	5071.9±107	5577.5±73	31.6±0.4	27.1±0.5
A-1942	..	19.9±0.3	..	1213.0±70	..	8749.2±204	..	17.8±0.1
A-1960	52.1±0.9	..	1427.7±20	..	6035.6±101	..	44.9±1.0	..
A-1963	49.8±2.5	..	1315.3±34	..	5723.0±110	..	37.1±3.3	..
A-2005	..	33.2±0.7	..	1745.7±45	..	5956.9±231	..	31.5±0.1
A-2049	..	29.3±0.6	..	1389.4±2	..	9462.8±284	..	33.7±9.5
APF-8	..	21.9±0.2	..	854.0±18	..	10298.2±105	..	23.9±1.5
APF-12	..	17.3±0.3	..	720.6±19	..	10580.8±218	..	39.7±4.2

[z] ORAC=µmol Trolox equivalents per gram of fruit (fresh weight); Total anthocyanins=malvidin-3-glucoside equivalents in mg/kg fruit; Total phenolics= chlorogenic acid equivalents in mg/kg of fruit.

Newly Released Cultivar Performance and Other Fruit Breeding Progress

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Dr. Clark is a professor in the Horticulture Department at the University of Arkansas. He directs the fruit breeding program which includes several crops. There are numerous contributors to this program also, including staff at the Fruit Substation, Clarksville (Dan Chapman, Kenda Woodburn, David Gilmore), Southwest Research and Extension Center, Hope (Manjula Carter), and Fayetteville (Eric Stafne and Phil Stewart).

Dr. Jim Moore began the Arkansas fruit breeding program in 1964, and the program has released nearly 40 cultivars thus far. This effort continues with major emphases on grape, blackberry, peach, nectarine, and blueberry. The following discussion provides some comments on the most recent releases from the program, and also some updates by crop on breeding progress in 2001.

Newly Released Cultivar Comments

Apache blackberry

Apache was released in 1999, representing the largest-fruited thornless blackberry from the program. It has other attributes including very firm fruit, very good plant vigor and erectness, and high yields. In 2001, I observed, as did others in Arkansas and Oklahoma, several concerns on Apache. First, two problems were seen on fruit: one was a blonde or white drupe occurrence, which is usually associated with stink bug feeding, and the second was a drying of some drupelets, probably caused by anthracnose. This combination was seen on many fruits early in the season, and I saw less of this on into July. Then in mid-summer, some dieback of primocane tips was seen, which upon closer examination appeared to be due to a large cane lesion associated with a leaf or node. The cause of this is not known, whether bacterial as appears to be the cause of a somewhat similar occurrence on Arapaho in some years and locations, or a fungal pathogen. I have a new graduate student, Phil Stewart, who has begun work with the cane dieback problem with the identification of this organism the first step in his research. I had not seen any of these problems in any years of observation of Apache, with the exception of the occasional blonde drupelet that is commonly seen scattered over the selection field. And, I do not have any control measures to suggest at this point for these concerns. Due to its many attributes, I still believe all interested in growing blackberries should consider evaluating Apache, but want you to be aware of these recent-appearing concerns.

Chickasaw blackberry

Chickasaw was released in 1999 as a replacement for Shawnee in that it was as high or higher yielding, larger, and firmer than Shawnee. Chickasaw continues to be very

high yielding and large-fruited in research trials, among the best of all breeding lines or cultivars. Reports are that it is very vigorous in grower plantings. No feedback has surfaced concerning fruit handling capability or susceptibility to rosette/double blossom. It is highly recommended for trial for those considering a thorny blackberry.

Kiowa blackberry

The cultivar was released in 1996, but has now been planted commercially. Most reports on Kiowa are outstanding, in that yields and fruit size are very good. It remains as the largest-fruited cultivar of the Arkansas group, a trait that is very appealing. From a postharvest standpoint, reports are mixed. Some have reported that good handling and storage has been achieved with Kiowa, while others have indicated some concern with firmness and berry leakage. Some reports of rosette/double blossom have surfaced, but it appears to be less susceptible than other thorny cultivars as many report not having this disease as yet. A finding on Kiowa in chilling requirement studies in 2001 was that it appears to be the lowest chilling cultivar of the Arkansas group, possibly as low as 200 hours. This is valuable for areas of the world that are trying to grow blackberries with little to no chill.

Ozarkblue blueberry

This blueberry was released in 1996 and has now been planted commercially to some extent. Most of the planting for production has been in Oregon, where it offers a late-season cultivar for shipping. Excellent fruit quality has been one its attributes in all evaluations, as well as precocity and high yields.

Neptune grape

The first white-fruited table grape from the program, Neptune offers a very attractive, flavorful seedless grape. No commercial production has occurred yet (the first few vines were sold in 2001) so there is no information on its value to growers thus far. An observation in 2000 in Fayetteville was the holding on the vine capability of Neptune. Fruit was retained in good quality until well into October on the vines. Although this practice is not recommended, it does indicate that this grape will likely hold on the vines longer than most other eastern U.S. cultivars. It was also noted this year as in previous years that the skin of Neptune is much thinner on fully mature fruit, a characteristic for growers to note. Slight fruit cracking was seen on Neptune in 2001, the first time that was ever observed. However, there were several rains during ripening and the selection pressure to produce cracking was very high. Finally, Neptune fared very well during the winter exposure to 8 ^{o}F, showing good hardiness. Vines of these are much more plentiful for 2002 in the nursery trade.

Jupiter grape

This new grape also continues to look good in trials, although commercial production has not occurred yet. Hardiness was good for 2001 after the low of 8 ^{o}F was experienced in the winter of 2000-2001. Flavor, a mild muscat, continues to be a major asset of this grape, along with excellent texture. Slight fruit cracking was seen in 2001 for

the first time also on Jupiter. As with Neptune, there should be numerous vines on the market now of Jupiter.

Arrington, Bradley, and Westbrook Nectarines

These new nectarines continued to look very good this year. Bacterial spot resistance was good, and quality and high production of all in research plantings continued. The first trees in limited quantity should be in the nursery market in the winter/spring of 2002.

UA Cultivar Descriptions on the Web

The UA Cooperative Extension website that lists licensed nurseries and describes cultivars has been revised. The revision included updating the licensed nursery lists, and adding sections for nectarines and peaches and the ornamental *Prunus* releases from the program. The website address is:http://www.aragriculture.org/commhort/default.asp. At this site is an icon for fruit and after that for the various crops.

2001 Season Breeding Update

The 2001 fruit evaluation season was very exciting. Winter lows were not extreme, although a low of 8 °F occurred in December 2000 at the Clarksville Fruit Substation. Spring frosts were avoided also, providing a full crop in general, especially for peaches and nectarines. The fruit ripening season began slightly early, but ended up being near average for ripening times. The summer was much more moderate this year compared to 2000, thus heat stress on mid to late summer crops, especially grapes, was less. A number of summer rains occurred in July and August also, further contributing to a moderate summer. A few comments by crop follow.

Blueberries

The blueberry crop was good overall. However, the previous-late summer and fall heat likely reduced the crop to some extent on some genotypes. However the evaluation period progressed at Fayetteville, Clarksville, and Hope. The most significant progress was in the trial of a group of advanced selections at all three locations. These fruited at Hope and Clarksville for the first time and some were very impressive for fruit quality, size, and season of ripening. These will be evaluated further for yield and other characteristics and it likely will be 2-4 years before the next release is made, based on which selections "come to the front of the line" in this process. In the field are approximately 2,000 seedlings for evaluation in the next two years.

Blackberries

Some winter injury was experienced at Clarksville and Fayetteville. This was not severe enough to substantially affect cropping except for those genotypes lacking hardiness. Approximately 4,000 seedlings were evaluated yielding 37 new selections. Nearly 7,000 seedlings from 2000 crosses were field-planted this year, and a large number of seeds resulted from 36 hybridizations conducted this year. Most of these crosses are for thornless, primocane-fruiting (PF), or F1s for PF that will be used in subsequent crossing to improve the PF quality and yield. The most important questions one might ask are: 1)

When will the next cultivar be released? and, 2) When will a PF cultivar be released? I can't give absolute answers at this writing, but I can share my thinking as of winter 2002. First, for non-PF selections, a group of advanced selections fruited for the second time in 2001. I will be examining data from these trials soon, and try to delineate the best ones in the group, and hopefully be near a decision on release or not among this group by next fall. No selections have jumped forth with spectacular performance over existing cultivars, although some offer better early fruit quality, a key focus now. As for the PF selections, this decision continues to be a difficult one. The two best of the original 14 selected in 1987 have been identified. These have been tested in Arkansas, Oregon and New York. I felt the first thing to verify was that the trait is expressed in a range of environments. I am happy to say that flowering and fruiting was expressed at all locations. In fact, these two selections tested in Oregon were spectacular when I saw them in mid-October 2001. They had numerous fruit on almost all primocanes, the fruit was large (7-8 g I estimate) and was of good quality. And there were many more fruit to come as a range of ripe fruit to blooms was seen. These two selections have not performed as well in Arkansas, at least in fruiting on the primocanes, with the major limitation the high heat in August and September resulting in poor fruit set and quality. So what is the bottom line on the PF release idea? I plan to make a decision on one or both of these being released by fall/winter of 2002, after one more year of observation is complete. I have a strong feeling that the first releases, if among these two selections, will be recommended for home garden production, not commercial fruit planting due to primocane fruiting performance observed thus far.

Grapes

Little winter injury was seen this year, somewhat surprising to me. Thus the crop was very good. Diseases were not common in 2001, owing to good disease control in the vineyards in addition to a lighter disease-pressure year. Impressive, however, was the amount of fruit cracking seen. This was due to three to five rains near and during fruit maturity. Cracking was more severe than I had seen in my 20 years of looking at seedlings and selections! Thus a good screening was experienced for this trait. Approximately 9,000 seedlings were evaluated this year resulting in 37 selections, all table grapes. Seventeen hybridizations were made also. A group of advanced selections is under close data collection, but these will require an additional 2-3 years of evaluation before release decisions are made. A final note concerns wine grape selections. The original group of 40 or more wine grape selections was reduced down to 12 this year via wine evaluation. These 12 have produced good quality wines and have good viticultural characteristics. Further evaluation may yield a new cultivar from this group but only further testing (wine quality and vine performance) will tell. This will require several more years of work.

Peaches and Nectarines

This was an absolute spectacular year for peaches and nectarines. The crop was excellent, and quality was good. On top of that, bacterial spot was extremely severe, providing a severe test to allow for resistance to be identified. I saw bacterial spot on fruit of genotypes that have never had this disease before. However, outstanding was the level of resistance observed in the program. Approximately 1,500 seedlings were evaluated resulting in 16 selections. The diversity of flesh types (melting and non-melting), colors

(white and yellow), acidity (low and standard or high acid) and the combinations of these are very exciting, just as one can observe in the variety choices on the market today. As of this writing, a melting-flesh, freestone white peach with excellent bacterial spot resistance is being considered for release, with final decision anticipated in the next 3-5 months. This will be the first white peach from the program. Look for information on this later in 2002.

An Attempt at a Reduced Fungicide Control Program For Oklahoma Peaches

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Introduction

Brown rot, scab, Phomopsis pocket rot, and bacterial blight are the four most important peach fruit diseases in Oklahoma. Field losses due to brown rot of peaches, caused by the fungus *Monilinia fructicola,* can be extensive if favorable conditions occur during the blossom period, shuck split to pit hardening, during pre-harvest (fruit begin to color), or harvest period. Favorable conditions for brown rot infection are: the optimum temperatures of 72° to 77° F with a range of 32° to 86° F, duration of wetness (3 to 15 hours), and is favored by high levels of inoculum. Control of brown rot involves the cultural practices of sanitation, thinning fruit before pit hardening, pruning to increase air circulation, balancing fertility between nitrogen and potassium, insect control, cultivar resistance and chemical control. Also, fungicides control different diseases infecting peaches including those that cause fruit rot such as brown rot. Fungicides prevent diseases and need to be applied prior to disease infection. Three critical infection periods occur for peaches and are: blossom infections, shuck split to pit hardening, and the pre-harvest periods. The pre-harvest period is defined as when fruit begins to color or about three weeks prior to harvest.

Scab caused by the fungus *Cladosporium carpophilum* is another important fruit disease of peach. Scab spores overwinter on infected branches and usually infect peach fruit from petal fall to pit hardening with the most critical period of infection at shuck split. The scab fungus requires rainfall for infection to occur and favorable conditions for scab infection are wet, warm weather. The incubation period for scab is 40 to 70 days so therefore symptoms of scab may never develop for late infections. Cultural practices are similar to those for control of brown rot and will aid in control of scab.

Little information is available for Phomopsis pocket rot disease, caused by the fungus *Phomopsis* sp. It is recommended that fungicides be applied beginning six weeks prior to harvest to control Phomopsis pocket rot. Bacterial spot is a bacterial disease, so therefore fungicides will not control bacterial blight. Varietal resistance and sanitation are the best control methods for bacterial spot.

In the past, fungicide recommendations for control of peach diseases were primarily a fixed spray schedule based upon growth stage of the peach fruit. Most fungi

require free water to germinate, therefore the timing of fungicide applications based upon wetness duration may improve disease control and/or reduce the number of fungicide applications.

The purpose of this study was to determine if timing of fungicide applications based on wetness duration would reduce fungicide applications and compare various fungicide programs based upon wetness duration to the recommended fixed spray program for control of peach fruit rots.

Methods and Materials

The fungicide trial was conducted at the Perkins Fruit Research Farm near Perkins, Oklahoma. Peach (*Prunus persica* cv. Bounty) trees were sprayed with a CO_2 wheelbarrow plot sprayer equipped with a hand wand at 40 psi at 85 gallons per acre. Plots consisted of single trees replicated ten times in a randomized complete block design. Each treated tree was separated by a non-treated border tree. Insect control consisted of insecticide applications of Asana (esfenvalerate) and were based upon population thresholds of plum curculio. The percent incidence of brown rot, Phomopsis pocket rot, and bacterial spot on the fruit was determined by counting number of infected fruit per tree and dividing by number of fruit counted and multiplied by 100. Also, the number of fruit that had fallen from each individual tree was counted. Peach fruit was harvested on 20-Jul, 2001 and diameter and weight of each size category determined. The size categories were as follows: #4 = less than 2 inches in diameter, #3 = 2.00-2.25 inches in diameter, #2 = 2.25-2.75 inches in diameter, and #1 peaches = greater than 2.75 inches in diameter.

The fungicides used in the fungicide trial are as follows: a dormant and bloom applications of Bravo 720 WS; shuck split application of Abound 2.1 SC; cover sprays of Microthiol; and three pre-harvest sprays of Elite. The following advisory systems were used: **Rainfall Advisory** - A fungicide application was conducted when a rainfall event occurred 14 days following the last application; **90% Humidity-14** - A fungicide application was conducted when 4 days of 90% humidity had accumulated 14 days following the last application; **90% Humidity-10** - A fungicide application was conducted when 4 days of 90% humidity had accumulated 10 days following the last application; **Peanut Leaf Spot Model (5 hrs)** - A fungicide application was conducted when ten days following the last application and the model had accumulated five infection hours. An infection hour is defined as one hour with relative humidity greater than or equal to 90% and temperature between 60.5° and 86° F. All data were analyzed using analysis of variance (ANOVA) and mean differences determined by Least Significant Difference (LSD).

A fungicide demonstration was also conducted at the Perkins Fruit Research Farm near Perkins, Oklahoma. The demonstration consisted of two peach cultivars 'Cresthaven' and 'Jayhaven'. Fungicides were applied with a FMC commercial sprayer at 56 gallons of water per acre. Plots consisted of three tree blocks replicated four times and were arranged in a split plot design with cultivar as the main plot and spray system as the sub-plot. All trees in the fungicide demonstration received a dormant and bloom spray of Bravo 720

WS; shuck split spray of Orbit 3.6 EC; cover sprays of Microthiol; and pre-harvest spray of Abound 2.1 SC. The advisory system for the demonstration was based upon a fungicide application being conducted after 4 days of a morning dew had accumulated, after a rainfall event (greater than 0.1 inch) had occurred, and/or after a rainfall forecast was greater than 40% occurred ten days following the last fungicide application. Insecticide applications based upon population thresholds of plum curculio were made with either Asana (esfenvalerate), Sevin (carbaryl), Imidan (phosmet), or Guthion (azinphos-methyl). The percent incidence of brown rot, Phomopsis pocket rot, and scab on the fruit was determined by counting number of fruit infected per 100 picked fruit. Yield was not taken in this demonstration. All data were analyzed using analysis of variance (ANOVA) and mean differences determined by Least Significant Difference (LSD).

Results and Discussion

The results of the fungicide trial indicated that the spray advisories had the same percent brown rot incidence as the calendar spray program and all spray programs significantly reduced the amount of brown rot when compared to no fungicide treatment. When spray advisories were compared, the data indicated that the spray advisories were equally effective in controlling brown rot. There was a reduction of one fungicide application in three of the four spray advisories with the exception of the **90% Humidity-10** advisory. The **90% Humidity-10** advisory had the same number of fungicide applications as the **fixed calendar sprays**, however application dates were different. The **fixed calendar sprays, the rainfall advisory,** and the **Peanut Leaf Spot Model** significantly reduced the number of fruit that had fallen from the tree prior to harvest. Fruit yields were statistically similar, however the lowest yield occurred in the no fungicide treatment. Fungicide treatments did not control the fungal disease of Phomopsis pocket rot and did not control bacterial spot a bacterial disease.

Control of brown rot was similar in the demonstration study on the Jayhaven and Cresthaven peach varieties as the fungicide trial. The advisory system using morning dews, rainfall events, and predicted rainfall events was as effective in controlling brown rot as the fixed calendar sprays. A reduction of two spray applications occurred in the demonstration as compared to one less fungicide application in the fungicide trial on Bounty peach trees. A lower percent incidence of scab and Phomopsis pocket rot occurred in the Cresthaven peach variety than in the Jayhaven peach variety indicating that the Cresthaven may have some varietal resistance to scab and Phomopsis pocket rot. Percent incidence of scab and Phomopsis pocket rot in the Jayhaven variety was similar in both the advisory and calendar spray programs.

In summary, it appears that fungicide applications based upon weather based criteria was as effective as a fixed calendar spray program for the control of brown rot. Control of pocket rot and scab were also similar between an advisory system and a fixed calendar spray, however incidences of disease was greater for these diseases than brown rot. A reduction of at least one fungicide application can result by using the advisory. More research is needed to determine the most practical and effective spray advisory and better methods to control Phomopsis pocket rot.

Comparison of the Application Dates of the Different Spray Systems,
Fungicide Trial, Oklahoma Research Fruit Station, Perkins, Oklahoma, 2001

Date of Application				
Calendar	10-day Humidity	14-day Humidity	Rainfall	Leaf Spot Advisory
2-Apr	2-Apr	2-Apr	2-Apr	2-Apr
18-Apr	18-Apr	18-Apr	18-Apr	18-Apr
1-May	7-May	7-May	7-May	7-May
14-May	24-May	24-May	22-May	22-May
31-May	7-Jun	**NFR**[1]	**NFR**	**NFR**
15-Jun	21-Jun	15-Jun	15-Jun	21-Jun
29-Jul	29-Jul	29-Jul	29-Jul	29-Jul
6-Jul	6-Jul	6-Jul	6-Jul	6-Jul
16-Jul	16-Jul	16-Jul	16-Jul	16-Jul

[1] NFR = No fungicide application required.

Comparison of Advisory Spray Systems for Control of Peach Fruit Rots ,
Fungicide Trial, Oklahoma Research Fruit Station, Perkins, Oklahoma, 2001.

Spray Program	% Brown Rot	% Pocket Rot	% Bacterial Spot	Number of Fallen Fruit	Yield lb/Tree
No Treatment	14	2.0	20	27	35
Calendar	0*	1.5	20	13*	46
Rainfall	2*	1.8	15	18*	42
90% Humidity (14 day)	0*	1.0	17	20	48
90% Humidity (10 day)	4*	2.8	23	20	56
Peanut Leaf Spot Model	2*	2.3	20	15*	43
LSD 0.05 Pr>F	5 <0.0001	ns[1] 0.2254	ns 0.6768	9 0.045	ns 0.1263

ns = treatment effects not significantly different
* = significantly different from no treatment

Comparison of the Application Dates of the Different Spray Systems,
Fungicide Demonstration, Oklahoma Research Fruit Station, Perkins, Oklahoma, 2001

Date of Application			
Jayhaven		Cresthaven	
Calendar	Advisory	Calendar	Advisory
3-Apr	3-Apr	3-Apr	3-Apr
13-Apr	13-Apr	13-Apr	13-Apr
26-Apr	2-May	26-Apr	2-May
9-May	**NFR**[1]	9-May	**NFR**
17-May	17-May	17-May	17-May
1-Jun	11-Jun	1-Jun	11-Jun
20-Jun	21-Jun	20-Jun	21-Jun
2-Jul	**NFR**	2-Jul	**NFR**
Harvest	Harvest	16-Jul	16-Jul
		3-Aug	3-Aug

[1] NFR = No fungicide application required.

Demonstration of an Advisory Spray Systems for Control of Peach Fruit Rot Diseases,
Oklahoma Research Fruit Station, Perkins, Oklahoma, 2001.

Percent Disease at Harvest						
	Calendar			Advisory		
Variety	Brown Rot	Pocket Rot	Scab	Brown Rot	Pocket Rot	Scab
Jayhaven	1.5	2.8*	5.7	0.0	2.9	5.5
Cresthaven	1.5	0.4	1.0	0.6	0.4	1.1

* = Jayhaven pocket rot value significantly different than Cresthaven's value.
No significant difference between calendar sprays and the advisory sprays

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Phenolic Content and Oxygen Radical Absorbing Capacity of Blueberries as Affected by Cultivar and Harvest Season

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Introduction

Blueberries (*Vaccinium corybosum* L.) have recently received much attention due to their high antioxidant capacity and anthocyanin content. Phenolics present in fruits and vegetables are effective antioxidants, and are thought to be protective against oxidative damage catalyzed by free radicals. It is well established that free radicals cause oxidative damage to lipids, proteins, and nucleic acids in human tissues, and free radical mediated damage is associated with numerous chronic disorders, including various types of cancer, heart, vascular, ocular, and neurological diseases.

Since antioxidants appear to confer protection against free radical damage, much attention has focused on assessing the total antioxidant capacity of foods. Several studies indicate that blueberries have exceptionally high oxygen radical absorbing capacity (ORAC) compared with other fruits and vegetables (Cao et al., 1996; Wang et al., 1996; Prior et al., 1998), and most studies show a significant positive relationship between ORAC and the total phenolic and total anthocyanin content of blueberries.

Although information is available concerning the effects of genotype and postharvest storage on ORAC and phenolic content of blueberries (Prior et al, 1998; Kalt et al., 1999; Ehlenfeldt and Prior, 2001; Kalt et al., 2001), the effect of growing season on ORAC and phenolic content of blueberries has not been studied. This study was undertaken to determine how diffferent growing seasons influence ORAC and phenolic content of commercial blueberry cultivars and advanced selections.

Materials and Methods

Fruit from five commercial cultivars and 13 advanced selections of blueberries were sampled in 2000 and 2001 from a field-grown collection at the University of Arkansas, Clarksville Experiment Station. During both harvest seasons, approximately 3 kg of fruit from each commercial cultivar and advanced selection were collected, placed in polyethylene bags, and transported in refrigerated coolers to the University of Arkansas, Food Science Department within 2 hr's. Samples received at the Food Science Department were stored at –20°C (for ~ 2 months) until analyzed.

Frozen samples (500 g in triplicate) taken from each blueberry cultivar were homogenized using a commercial blender. Pureed sub-samples were extracted (5g/20mL in triplicate) with ethanol:acetone:water:acetic acid (40:40:20:0.1). Samples were placed in a screw-cap vial to prevent solvent evaporation and heated for 60 min in a 60°C water bath. Samples were allowed to cool, then homogenized for 1 min using a tissuemizer. Extracts were filtered through Miracloth (CalBiochem, LaJolla, CA) and kept frozen (-20°C) until

analysis. Prior to ORAC and total phenolic assays, frozen extracts were thawed and diluted with phosphate buffer and deionized water, respectively

Extracts were analyzed for oxygen radical absorbing capacity (ORAC) using a modified version of Cao and Prior (1995) for use with a Perkin-Elmer HTSoft 7000 Plus Bio Assay Reader (Norwalk, CT), total phenolics were determined by the Folin-Ciocateu reagent according to the method of Slinkard and Singleton (1997), and total anthocyanins were estimated using the pH differential assay of Wrolstad (1976). Berry weight was determined by measuring the average weight (g) of 25 berries.

Results

Large differences in ORAC were observed among the blueberry cultivars over the two harvest years (Table 1). ORAC values of cultivars grown in 2000 ranged from a low of 20.5 μM TE/g in Magnolia to a high of 60.3 μM TE/g in US-497, reflecting a 2.94 fold difference among cultivars. In 2001, ORAC values ranged from a low of 20.9 μM TE/g in Bluecrop to a high of 73.1 μM TE/g in US-497, reflecting a 3.5 fold difference among cultivars. Four cultivars had higher ORAC values in 2001 compared with fruit grown in 2000, seven cultivars had higher ORAC values in 2000 compared with 2001, and seven cultivars had similar ORAC values over the two growing seasons.

Total phenolic content of cultivars grown in 2000 ranged from a low of 202.2 mg/100g in A-386 to a high of 585.5 mg/100g in US-497, reflecting a 2.9 fold difference among cultivars. In 2001 total phenolics ranged from a low of 226.9 mg/100g in Summit to a high of 554.8 mg/kg in US-497, reflecting a 2.4 fold difference among cultivars. Four cultivars had higher levels of total phenolics in 2001 compared with 2000, five cultivars had higher levels of total phenolics in 2000 compared with 2001, and nine cultivars had similar levels of total phenolics over the two growing seasons.

Total anthocyanin content of blueberry cultivars grown in 2000 ranged from a low of 49.5 mg/100g in Magnolia to a high of 248.5 mg/100g in US-497, reflecting a 5.0 fold difference among cultivars. In 2001, total anthocyanins ranged from a low of 64.9 mg/100g in Summit to a high of 228.5 mg/100g in US-497, reflecting a 3.5 fold difference among cultivars. Three cultivars had higher levels of total anthocyanins in 2001 compared with 2000, seven cultivars had higher levels of total anthocyanins in 2000 compared with 2001, and seven cultivars had similar levels of total anthocyanins over the two growing seasons.

Fruit weight of blueberry cultivars grown in 2000 ranged from a low of 15.1 g/25 berries in US-729 to a high of 67.4 g/25 berries in A-12, reflecting a 4.5-fold difference among cultivars. In 2001, berry weights ranged from a low of 15.5 g/25 berries in US-729 to a high of 61.5 g/25 berries in A-12, reflecting a 4.0-fold difference among cultivars. Over the two growing seasons, thirteen cultivars did not vary in berry weight, while two cultivars had higher berry weights in 2001 compared with 2000 and three cultivars had higher berry weights in 2000 compared with 2001.

Over both growing seasons, ORAC correlated highly with total anthocyanins ($r_{xy} = 0.88$), and total phenolics ($r_{xy} = 0.91$), while berry weight was inversely correlated with ORAC ($r_{xy} = -0.64$).

Discussion

Our results indicate that, in addition to genotypic and postharvest storage factors, ORAC and phenolic content of blueberries is also impacted by environmental growing conditions, and blueberry cultivars vary in their capacity to synthesize phenolics under different growing conditions. This is not surprising since both biotic (herbivory, disease) and abiotic conditions (temperature, moisture, irradiation) are known to influence phenolic content in plants (Jones and Hartley, 1999). Many cultivars behaved quite differently in their ability to synthesize phenolics over the two growing seasons, which impacted their antioxidant capacity. Thus, it appears that the genetic capacity of blueberry cultivars to synthesize anthocyanins can be modulated by environmental growing conditions.

Blueberries are reported to be one of the highest antioxidant containing fruit, due to their elevated total phenolic and anthocyanin content (Prior et al., 1999). Our results confirm previous studies documenting the high ORAC and phenolic content of blueberries. The ORAC values of blueberry cultivars in our study ranged from 20.5 μM/g to 73.1 μM/g, which are considerably higher then values reported by Ehlenfeldt and Prior (2001) (4.6-31.1 μM/g), Kalt et al. (2001) (33.2-58.2 μM/g), and Prior et al. (1998) (13.9-37.8 μM/g). The higher ORAC values obtained in our study may be due to increased recovery of phenolics by the 60°C extraction temperature. Extraction of blueberry fruit at 60°C has been shown to greatly increase recovery of phenolics resulting in increased antioxidant capacity (Kalt et al., 2000).

Several of the small-fruited blueberry selections, US-497, US-729 and A-98 had exceptionally high ORAC values over the two growing seasons (mean > 45 μM/g), while Cape Fear, A-23 and A-272 had intermediate sized fruit and ORAC values > 40 μM/g. Most large fruited cultivars and selections had ORAC values < 35 μM/g, with the exception of the largest fruited selection A-12, which had an ORAC value of 36.4 μM/g. Our results indicate that phenolic and antioxidant rich US-selections could be used by plant breeders to genetically modify blueberries for increased antioxidant capacity.

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Table 1.Oxygen radical absorbing capacity (ORAC), total phenolic and total anthocyanin content and berry weight of blueberry cultivars and selections harvested in 2000 and 2001.

Cultivar/ Selection	ORAC[1]		Total Phenolics[2]		Total Anthocyanins[3]		Berry Weight[4]	
	2000	2001	2000	2001	2000	2001	2000	2001
A-4	28.1 ± 1.42[5]	42.7 ± 1.56*[6]	219.6 ± 8.2	343.6 ± 30.3*	97.5 ± 1.1	135.7 ± 30.0	47.8 ± 0.4	49.1 ± 0.8
A-12	43.7 ± 0.46	31.5 ± 1.60*	406.0 ± 10.6	309.1 ± 7.3*	161.8 ± 0.5	145.1 ± 5.7	67.4 ± 1.7	61.5 ± 1.7*
A-23	44.4 ± 1.07	38.5 ± 0.84*	328.5 ± 12.1	346.4 ± 15.5	125.7 ± 4.8	170.9 ± 5.8*	35.3 ± 0.5	38.9 ± 1.1
A-98	51.2 ± 2.74	45.2 ± 2.93	420.1 ± 4.2	405.6 ± 13.7	162.3 ± 7.1	164.5 ± 18.9	31.6 ± 1.1	28.4 ± 4.0
A-179	32.9 ± 2.07	24.8 ± 0.48*	292.3 ± 8.4	262.5 ± 23.8	125.9 ± 6.4	87.1 ± 1.2*	31.3 ± 0.7	39.6 ± 0.6*
A-259	30.6 ± 0.78	30.6 ± 0.40	309.6 ± 7.5	342.0 ± 9.3	87.2 ± 9.2	108.4 ± 7.7	37.8 ± 1.2	38.4 ± 1.0
A-265	30.4 ± 1.60	34.1 ± 2.30	339.9 ± 8.9	313.8 ± 4.2*	112.2 ± 7.0	82.0 ± 7.7*	50.7 ± 0.8	46.2 ± 5.1
A-272	42.2 ± 2.04	40.3 ± 2.21	359.8 ± 6.5	370.7 ± 15.2	163.8 ± 6.1	94.5 ± 6.3*	32.9 ± 0.7	33.1 ± 1.6
A-342	41.6 ± 0.96	23.5 ± 1.21*	411.4 ± 3.7	352.5 ± 6.0*	234.2 ± 1.0	129.3 ± 10.8*	17.9 ± 0.8	18.5 ± 0.5
A-386	29.4 ± 2.07	22.1 ± 1.71*	202.2 ± 12.6	296.9 ± 8.5*	94.1 ± 1.2	96.2 ± 4.1	38.0 ± 1.2	38.2 ± 1.7
A-439	24.9 ± 0.47	34.3 ± 1.40*	273.5 ± 3.0	370.2 ± 15.9*	73.2 ± 4.0	90.6 ± 2.4*	40.3 ± 1.0	35.2 ± 0.5*
US-497	60.3 ± 3.13	73.1 ± 3.42*	585.5 ± 2.3	554.8 ± 30.5	248.5 ± 3.5	228.5 ± 4.9*	15.5 ± 0.5	16.7 ± 1.9
US-729	58.7 ± 0.20	59.9 ± 2.32	397.3 ± 11.4	514.6 ± 5.4*	241.3 ± 3.1	182.3 ± 3.2*	15.1 ± 0.1	15.5 ± 0.5
Bluecrop	37.8 ± 3.57	20.9 ± 1.93*	307.7 ± 1.2	314.8 ± 7.9	74.2 ± 1.1	73.2 ± 2.1	50.9 ± 0.8	42.1 ± 0.9*
Cape Fear	44.3 ± 0.99	39.6 ± 1.14*	404.7 ± 15.4	289.6 ± 16.9*	170.2 ± 2.4	137.2 ± 11.5*	42.7 ±1.1	43.1 ± 1.4
Ozarkblue	23.6 ± 0.41	23.9 ± 2.33	319.3 ± 4.9	322.4 ± 8.3	90.4 ± 3.7	101.7 ± 2.2	55.1 ± 1.1	38.8 ± 0.8*
Magnolia	20.5 ± 1.05	32.8 ± 1.59*	265.7 ± 10.3	265.5 ± 8.4	76.1 ± 6.0	124.2 ± 2.8*	55.2 ± 1.6	51.4 ± 2.0
Summit	28.2 ± 1.54	29.9 ± 1.59	301.2 ± 12.1	226.9 ± 10.5*	49.5 ± 0.9	64.9 ± 2.8*	47.4 ± 0.6	44.4 ± 2.3

[1] Oxygen radical absorbing capacity (ORAC) data expressed as micromoles of trolox equivalents per gram fresh weight.
[2] Data expressed as milligrams of gallic acid equivalents per 100 grams fresh weight.
[3] Data expressed as milligrams of cyanidin-3-glucoside equivalents per 100 grams fresh weight.
[4] Data expressed as grams per 25 fruit.
[5] +/- standard error of the mean (n=3).
[6] * Indicates significant change over the two growing seasons ($P \leq 0.05$).

Peach Harvest Maturity, Ripening and Postharvest Quality Concerns

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How exactly does a really good peach taste? What does this peach look like? Why is it so difficult to find this peach in the local supermarket fresh produce isle? While the answers to these questions may be obvious to those of us who have been fortunate enough to pick and eat tree ripened peaches, they aren't so obvious to the general public. According to a California Tree Fruit Agreement survey, more than 70 % of all consumers choose not to buy fresh peaches, plums and nectarines when they stop to look at them in the produce department. And the reason why they don't buy is because they don't trust that the fruit will taste good, probably because they or one of their acquaintances had previously bought poor quality (or what they perceived to be poor quality) fruit. If the peach industry as a whole, and yourself as a producer, are to turn this statistic around, the first step has to be to deliver high quality, juicy, sweet peaches to these consumers.

After you have grown your crop, the first step towards insuring high quality in fruit for sale is harvesting at the appropriate stage of development. The act of harvesting imposes a considerable stress for the fruit, very similar to the stress for a baby after being born. After removal from the tree, fruit no longer have a continuing supply of water, sugar and nutrients. Unlike a baby which can gain nourishment by eating, fruit have no way to resupply lost water and nutrients after they are picked. Since there is virtually no way to resupply these components for fruit, handling steps are geared towards conservation from harvest all the way to the consumer. If fruit are harvested at the correct stage of development, and handled with care to minimize loss of water and cellular components, high quality and consumer satisfaction will ensue. The remainder of this paper will highlight harvesting at the proper stage of development, summarize some handling steps to maintain peach quality and present some consumer handling tips to assure high quality and maintain your consumer base. If you have an internet-ready computer, you can find further information published by the California Tree Fruit Agreement at www.caltreefruit.com .

Harvest maturity

Peaches can be harvested when firm, but they must be allowed to reach full maturity on the tree before the fruit are competent to ripen normally. During the maturation process, all of the many different components necessary for ripening are "installed", and they can only be attained while attached to the tree. If any of the ripening components are missing, such as would happen if the fruit were picked too early, the fruit ripen abnormally - missing some of the flavors and/or odors we normally associate with high quality fruit. Unfortunately, the exact point in time when a peach reaches full maturity is difficult to pinpoint and the indicating characteristic differs for fruit from different varieties.

Useful maturity indexes

1. *Fruit background color* This is the color of the fruit under the red blush. Fruit go from a green color when immature to differing degrees of yellow when mature, and the particular color indicating maturity is variety specific. Background color is recognized as a good maturity index because it is non-destructive and can be accomplished with little to no equipment. Reference color chips can be matched with fruit color to assure harvest at uniform maturity. Multiple color chips are often necessary due to varietal differences in background color at maturity - 'Elberta' exhibits much less yellow coloration at maturity than 'Redhaven' or 'Fairtime'.

2. *Fruit firmness* Firmness of the flesh portion, or mesocarp (skin is cut away prior to measurement), of peaches changes as ripening is initiated and thus flesh firmness is an excellent indicator of fruit maturity. Flesh firmness, as compared to fruit background color, is much less variety specific as a maturity indicator. A fruit penetrometer is used to measure resistance to puncture of fruit flesh to an 8 mm diameter rounded tip probe to determine fruit firmness. Based on resistance to puncture, fruit should not exceed 14-16 lbs resistance to be considered well matured. Unlike background color, penetrometer firmness measurements are destructive to the fruit so they can only be done on a representative subsample, not the actual fruit offered for sale.

Not to be used as a maturity index

1. *Fruit size* Fruit size can vary within a tree, between trees and often changes between years of production. Fruit size can be effected by variety, but is more strongly influenced by tree fruit load. Fruit size can be used as a ballpark estimate of when fruit in a tree at a given fruit load will mature, but it is not in and of itself an indicator of maturity. Fruit size does increase for well matured versus immature fruit, providing some further benefit of allowing fruit to mature on the tree.

2. *Days from bloom* Like fruit size, days from bloom can provide a ballpark estimate of when maturity might occur, but it is not a reliable maturity index. Since fruit on the exterior and exposed portion of the tree tend to accumulate more heat and mature faster than those at the interior portion of the same tree, use of days from bloom alone would result in harvesting fruit at differing stages of development - some perhaps overmature, some mature, and many immature.

3. *Fruit blush* Fruit blush, or the red coloration formed over the characteristic background yellow color, is a very poor indicator of fruit maturity. Blush occurs mostly on the surface of the fruit exposed to direct sunlight so fruit at the exterior of the tree tend to be more blushed than those at the interior of the tree. The propensity to blush is a varietal characteristic, and formation of a red blush is not directly linked to maturation.

Peaches on the same tree will mature at different times and because of this trees need to be harvested multiple times, picking only well matured fruit at each harvest. Fruit towards the exterior of the tree tend to mature more quickly than those at the interior.

When harvesting, take care not to drop fruit into your picking bucket or bag. Instead, always place the fruit you just picked on top of the rest of the fruit before letting go to prevent bruising. Never place picked fruit in direct sunlight to prevent excessive heat absorption, and transport fruit to a central cool packing area as soon as practical after picking. When dumping fruit from picking containers, take the same care to prevent bruising as you did during picking - gently transfer fruit out of the container and avoid any free-falls onto hard surfaces which could cause bruising. Dumping fruit directly into sanitized and chilled water can speed up unloading, prevent impacts on a hard surface following the free-fall and provide a means to remove field heat.

Peach Handling

The key to successful handling of peaches between harvesting and sale to the consumer revolves around two facts: 1) Peaches are alive, still developing after harvest, and each fruit requires sustenance to fuel life processes, and 2) There is virtually no way to supply new inputs to the fruit - they must survive on whatever was inside the fruit at the time of harvest. A well matured peach is programmed to immediately initiate ripening - a key phase of development resulting in the vast multitude of changes necessary to convert an unripe, hard, barely flavored fruit into the soft, juicy, sweet ready-to-eat (or ripened) fruit consumers want. Successful peach handling involves control of ripening - while ripening can't be stopped, it can be slowed down long enough to get the fruit to market.

If the act of harvesting can be compared with a baby being removed from a mother's womb at birth, the process of ripening is probably best compared to this baby 12 to 15 years down the road as they reach puberty. Maintenance of peach quality for these well-matured fruit entering the ripening phase is like controlling acne for a teenager - it requires diligent effort and if appropriate measures are not taken you are fighting a losing battle.

Correct temperature management is the primary means to maintain quality of any harvested commodity, and especially for fresh peaches. Just following harvest, the major source of heat is that which was absorbed by fruit from its environment in the field - amply termed field heat. Rapid removal of this heat is necessary to control ripening and reduce fruit water loss. Since field heat accounts for the vast majority of heat load for incoming fruit (it commonly accounts for about 90 % of the total heat load), it is advisable to remove field heat by pre-cooling prior to storage. If pre-cooling is used, it effectively reduces the refrigeration capacity needed for a fruit storage facility, and by doing so reduces the total cost of operation. Use of such a system necessitates a two-stage cooling process in which can be separated into 1) pre-cooling, followed by 2) storage.

Pre-cooling

Pre-cooling is usually achieved by one or a combination of two ways: a) Hydrocooling, or cooling the fruit down in chilled and sanitized water, is commonly practiced. As eluded to in harvesting, a water-dump can serve a dual purpose of preventing impact bruise damage during unloading of field containers and can serve as a means to clean and pre-cool the fruit. Water should be changed or filtered as necessary to prevent

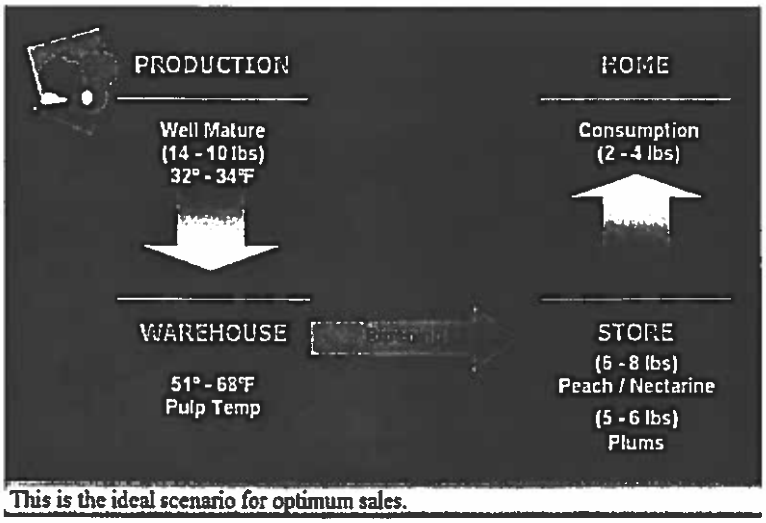
organic material buildup, and a sanitizing agent such as chlorine (100 to 200 ppm is usually sufficient) should be added and its concentration maintained to prevent spread of disease causing microorganisms. Well water may be sufficiently cool to remove a majority of incoming field heat, and could be used in combination with other pre-cooling methods to reduce refrigeration load. If well water is used, addition of a sanitizing agent is recommended and frequent changes may be necessary to maintain the coolest-possible temperature. b) Forced-air cooling is achieved by forcing air at the recommended storage temperature over fruit surfaces until fruit pulp is close to the air temperature. Prolonging air flow after the storage temperature is reached is not recommended since it will result in excessive moisture loss from the fruit.

Storage

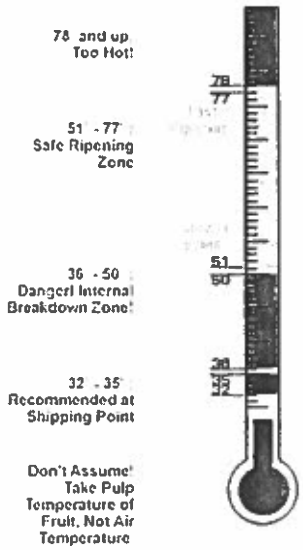
During storage of precooled fruit, the major source of fruit derived heat is that from respiration. In fact, 60 % of the energy derived from stored reserves during respiration is evolved as heat. Fruit are stored at cool temperatures to control respiration, and by doing so to slow all of the steps necessary for a fruit to ripen. By cooling the fruit, ripening is slowed and heat evolved is also decreased. Cool fruit are also firmer and can generally be handled with less damage. Mechanical refrigeration removes heat by passing air over the surface of cooling coils; the colder and greater surface area for the coil, the greater the capacity to remove heat. It also causes dehydration of air by ice formation (frost buildup) on the cooling coils. The colder the coils, the greater the degree of air dehydration. Since we have already established that peaches can't replenish lost water, and since the pull for water out of the fruit is proportional to the degree of dryness of the surrounding air, design of a fruit cold storage room should include large surface area for cooling coils which are maintained as close to the storage air temperature as practical (maintaining coil temperature at just 3 C below the targeted air temperature is recommended to prevent excessive frost buildup and moisture loss). Restricting air flow for pre-cooled fruit by placing a plastic sheeting loosely over the fruit (do not seal) will allow the fruit to create their own high humidity storage environment and help prevent excessive moisture interchange and loss from the fruit.

Temperature management should be a three stage process

Peaches are still alive after harvest and rely on life processes to fuel ripening. Ripening can be postponed by slowing down respiration with cool temperatures, but it



This is the ideal scenario for optimum sales.



can't be stopped. Once ripening has been initiated, it should not be interrupted by storage at cold temperatures. Proper temperature management should include cold storage following harvest to extend shelf life, and also storage at higher temperatures for controlled ripening prior to marketing. The California Tree Fruit Agreement supports the following temperature regime during fruit handling:

The three stages for temperature management coordinates peach fruit development with marketing, and can be separated into 1) Post-production and prior to ripening, 2) ripening and 3) post-ripening. In all cases, the recommended temperatures are flesh temperatures which will be close to, but which will normally be at least slightly warmer than air temperature.

Post-production storage prior to ripening

Fruit should be stored within a relatively narrow range of temperatures, between 32 and 35 F, for a period of up to two weeks. Storage at between 36 and 50 F can damage fruit, resulting in internal breakdown (dark internal color and/or mealy, dry texture), and should be avoided at all stages of fruit storage. Storage at temperatures below 32 F should be avoided since freeze damage can occur, which would make the fruit unmarketable.

Ripening during storage

Ripening is a necessary ingredient to providing consumers high quality peaches, and should be conducted at temperatures between 51 and 77 F. Ripening is normally initiated after delivery to a wholesaler or retailer, and since fruit will soften as a consequence of ripening, extra care to prevent impact and vibration should be exercised. Ripening can be modulated with temperature. A well mature fruit will ripen in approximately 3 days at 77 F, 4 days at 68 F and 6 days at 59 F. By reducing the temperature for ripening, within the recommended range of 51 to 77 F, shelf life can be extended and high quality fruit can be attained. Remember the comparison of ripening fruit to children going through pubescence? One reason why this comparison is valid is because of hormones - in the teenager they encourage a multitude of changes, usually impairing judgement. Produced primarily during ripening, the hormone ethylene encourages greater rates of respiration to fuel the multitude of changes involved in ripening of peaches (aren't you glad peaches don't have a brain?). Ethylene is gaseous and can escape to nearby produce and cause disorders such as yellowing of cucumbers, so ripening peaches should be segregated from other sensitive produce or from peaches which are to be held in a pre-ripe state. Ripening can be completed after purchase by the consumer, and this will be addressed later.

Post-ripened storage: Unlike the becoming of age, and beginning of a new phase of what will hopefully be a long, eventful life which happens for teenagers, ripening is a controlled initial phase of death for a fruit. Once ripening is completed, peaches quickly loose their natural defenses, succumb to their environment and die. Shelf life can be increased for ripened fruit by returning to the original storage regime. Ripe peaches should be stored at 32-35 F for greatest extension of shelf life. Note that essentially all peaches bought at retail are undergoing, but not yet through ripening. These fruit should not be placed into the

refrigerator at home, but they should be allowed to complete ripening and then be placed into the refrigerator.

Consumer Handling Tips

Some reasons why many consumers chose not to buy fresh peaches have been they are too hard, have little flavor and are not juicy. These are descriptors of non-ripe peaches. They are perceived as low quality fruit, when in fact they may be high quality if allowed to ripen to what the consumer probably wanted in the first place! In most cases, the consumer is not aware that they also participate in a successful peach handling program, and some education may be needed. The consumer is likely to be involved in two of the three handling phases referred to above: the ripening phase of handling, and depending on their appetite perhaps post-ripened storage.

Consumers don't need complicated gadgets to tell if peaches are ready to eat, but they should feel the fruit for desired degree of softness rather than use their hunger for the peach as an index of ripeness. Peaches can be set out inside a paper bag on the kitchen counter to ripen. For a relatively small investment, you can also print ripening instructions on the bag along with your advertisement for repeat sales. In most cases, fresh peaches should not be placed into the refrigerator. In most fresh peach marketing channels, ripening has already been initiated by the time the consumer buys the fruit and interruption of ripening by cold temperature storage will perturb the process and result in poorer quality when the fruit are allowed to finish ripening (or maintain the inferior quality of a less than ripe peach if consumed directly from the refrigerator). If you have customers who want to buy a large amount of fruit to be consumed later, sell them ones in post-production storage which have not been stored at ripening temperatures. These consumers should periodically remove fruit from their refrigerator to ripen, and they should realize that it will take longer for these fruit to ripen to a ready-to-eat state than for pre-ripened (in most cases partially pre-ripened) fruit. During ripening, a brown paper bag is recommended. If refrigerated storage is necessary, an unsealed plastic bag will reduce moisture loss and prolong usable life of the fruit. Ripening peaches will absorb odors and flavors, and in turn give off characteristic odors and flavors which may be absorbed by other products. Care should be exercised in preventing absorption of, or transmittance of, off flavors.

At the beginning of this paper I asked some basic questions, and although I can't put into words exactly how I think the perfect peach should look like or taste, much less what each individual consumer looks for, I hope that by following the guidelines set forth here consumers can at least be satisfied with fresh peaches. More times than not, the peaches offered for sale at your local supermarket are not ripe and really can't be expected to taste like the tree ripened fruit some of us have been able to enjoy. If that same fruit were picked mature, following the procedures set out here will enhance fruit quality, and might just make the consumers who normally walk past fresh peaches take a second look.

Use of Ultraviolet Light to Improve Shelf Life and Increase Antioxidants in Blueberries

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Blueberries are high in antioxidants that have been found to help prevent heart disease and cancers (Ames et al., 1993; Block et al., 1992). These antioxidants are phenolic compounds and include the anthocyanins which give blueberries their color, and proanthocyanidins (tannins) found in the seeds (Kalt et al., 2001). Light, such as fluorescent or ultraviolet, has been reported to reduce decay and promote antioxidants in some fruits and vegetables such as tomato and strawberry (Liu et al., 1993; Baka et al., 1999). Additionally, storage temperature can affect antioxidant levels in blueberries (Kalt et al., 1999). The objective of this study was to use light treatments and storage temperatures to induce antioxidant production in highbush blueberries.

'Collins' and 'Bluecrop' blueberries were harvested at two harvest dates each (early and mid season) in Arkansas and transported to Lane, OK on ice. Treatments for each variety consisted of a control (no light treatment), a handling control (placed under the light source), and low and high light treatments (~1000 and 2000 Joules of UV-C for 10 and 20 seconds, respectively) (Fig. 1). Fruit storage temperatures of 35°F and 41°F were used for each temperature. After 21 and 14 days at 35 and 41°F, respectively, one half of the berries were moved to 68 °F for 2 additional days. Four 2 pint plastic clamshells per treatment, temperature, cultivar, and harvest date were used.

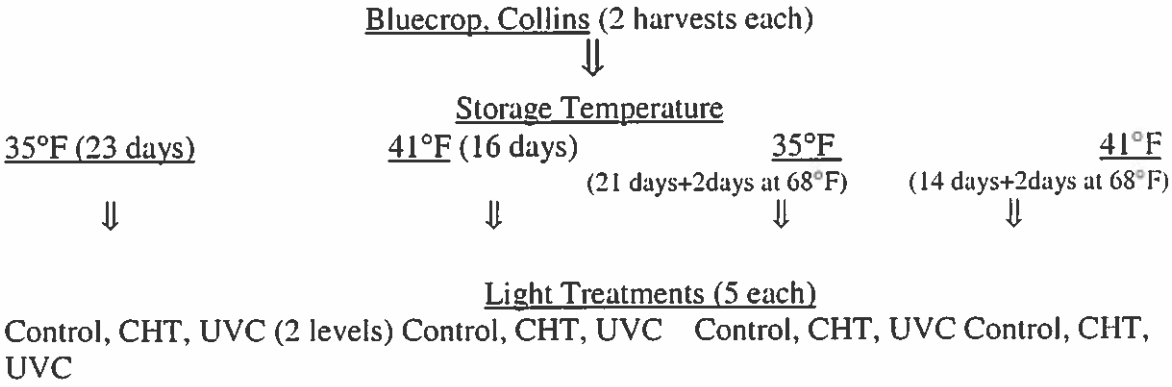

Figure 1. Schematic of treatments used for 'Bluecrop' and 'Collins' blueberries. CHT=control (handling), UVC=1000 and 2000 joules of ultraviolet-C (254 nm) light. Each

treatment was replicated 4 times (1/2 pint per replicate) for each cultivar and harvest date (a total of 320 boxes).

Each replicate (box) was weighed at 7, 14, 16, 21, and 23 days to determine weight loss and the number of decayed, leaky, and shriveled berries in each replicate was determined at 16 and 23 days. Firmness of berries from two replicates per treatment was measured on the side using a Firmtech II with a maximum compression force of 250 g. Soluble solids content, titratable acidity, and pH were determined on purees from each replicate using the method of Perkins-Veazie et al. (1996).

Control treatments did not differ in ratings, weight loss, or composition so an average of these treatments is presented in Tables 1 and 2. Storage temperature had more effect on blueberry quality than light treatment or cultivar. Decay was not reduced by light treatment, nor was it increased, indicating that 2000 joules of UV-C light did not induce deleterious wound effects (Table 1). Decay was much greater in fruit held briefly at 68°F after low temperature storage than those held at constant low temperatures of 35 or 41°F. Almost no leaky berries were found. Weight loss was greater in berries held at 41°F than those held at 35°F or at 68°F for 2 days. The percent berries with shrivel was high, ranging from 70 to 90%, and followed the storage effects seen with percent decay (data not shown). An interaction of storage temperature and cultivar occurred with fruit firmness. 'Bluecrop' fruit were firmer at 35°F or at 35 plus 68°F for 2 days, while 'Collins' berries held at constant 35 or 41°F were firmer than those exposed to the 68 °F treatment.

Compositional analysis was affected little by light treatment (Table 2). Soluble solids content tended to be slightly lower in 'Bluecrop' fruit held at 35 °F or at 35 plus 68°F for 2 days. Acidity was reduced and pH higher in blueberries held at 41°F compared to those held at 35°F or of fresh blueberries. The titratable acidity of berries given a high UV-C treatment was slightly higher in 'Bluecrop' compared to other treatments. Determination of total phenolics, anthocyanin content, and ORAC (oxygen radical absorbing capacity) are currently being done on these fruit by the University of Arkansas.

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Table 1. Ratings of blueberries after storage for 16 days at 41 °F or 23 days at 35 °F.

Cultivar	Storage Temp (°F)	Light Treatment								
		Control	UV-C (low)	UV-C (high)	Control	UV-C (low)	UV-C (high)	Control	UV-C (low)	UV-C (high)
			Decayed	*berries (%)*	*% Weight*	*loss (16*	*days)*		*Firmness (N)*	
Bluecrop	35	7.4a	9.2a	9.2a	2.5a	2.3a	2.0a	154.5a	155.8a	162.8a
	41	6.8a	7.5a	4.5a	5.7b	5.8b	5.5b	143.3b	140.9b	146.2b
	35/68	24.7b	17.2b	14.3ab	2.5a	2.2a	2.4a	158.8a	160.4a	157.6a
	41/68	22.1b	25.1b	32.8c	6.8b	6.6b	7.1b	134.4b	147.6b	147.1b
Collins	35	10.2a	9.5a	9.4a	2.6a	2.7a	2.5a	187.2a	181.0a	194.0a
	41	9.7a	9.2a	10.0a	5.3b	5.1b	5.1b	179.5a	177.8a	178.0b
	35/68	28.5b	34.5b	33.7b	2.2a	2.5a	2.3a	168.6b	165.2b	162.4c
	41/68	22.6b	25.4b	28.1b	6.8b	6.6b	6.5b	165.7b	160.0b	165.4c

Means separated within cultivar and treatment by LSD, P<0.05

Table 2. Composition of blueberries after storage for 16 days at 41 °F or 23 days at 35 °F.

			Light Treatment							
Cultivar	Storage Temp (°F)	Control	UV-C (low)	UV-C (high)	Control	UV-C (low)	UV-C (high)	Control	UV-C (low)	UV-C (high)
		Soluble	*solids*	*content (%)*	*Titratable*	*acidity*	*(%)*		*puree pH*	
Bluecrop	none	12.1b	12.1a	12.1a	2.63c	2.63c	2.63d	2.89a	2.89a	2.89a
	35	12.2b	11.9a	12.0a	2.24b	2.16bc	2.33c	2.97b	2.98bc	2.95b
	41	12.5bc	12.6b	12.6b	2.06a	1.93a	2.22b	3.04b	3.07c	3.00b
	35/68	11.6a	12.3ab	11.7a	2.14b	2.04b	2.23b	3.01b	3.02c	2.97b
	41/68	12.7c	12.8b	12.7b	2.10a	2.09b	2.15a	3.00b	3.04c	3.01b
Collins	none	13.3b	13.3b	13.3b	2.03d	2.03c	2.03b	3.02a	3.02a	3.02a
	35	13.3b	13.0b	12.9a	1.83b	1.86bc	1.81a	3.14b	3.14b	3.15b
	41	13.1b	13.6bc	12.8a	1.78a	1.79b	1.87a	3.18b	3.13b	3.12b
	35/68	12.4a	12.4a	12.7a	1.90c	1.81b	1.84a	3.10ab	3.13b	3.12b
	41/68	13.0b	13.3b	13.1b	1.73a	1.68a	1.81a	3.17b	3.17bc	3.12b

Means separated within cultivar and treatment by LSD, P<0.05

Treatments to Extend Post Harvest Life of Muscadine Grapes

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USDA-ARS, SCARL
Lane, OK

Dr. Perkins-Veazie works on postharvest quality and functional food properties of small fruits and watermelon at the Lane Center. She is a native of Maine and received her PhD. from the University of Florida.

Muscadine (*Vitis rotundifolia*) grapes are grown primarily in the southern United States (Olien , 1990). These grapes have a shelf life of one to four weeks at 32-35 °F. Sulfur dioxide can double shelf life but often causes bleaching or stippling on berries. Unlike table grapes (*V. labruscana or V. vinifera*), muscadine clusters have only one to 10 berries and berries have a wet stem scar. These characteristics pose shelf life challenges.

Gray mold (*Botrytis cinerea* Pers.), yeasts, ripe rot [*Colletotrichum gloesporioides* (Penz.) Penz. & Sacc.], Macrophoma rot [*Botryosphaeria dothidea* (Moug. Ex Fr.) Ces. & de Not.], bitter rot [*Greeneria uvicola* (Berk&Curt) Punithalingam.], powdery mildew [*Uncinula necator* (Schw.) Burr.] blue mold (*Penicillium* spp.) (Pearson and Goheen, 1988; Ballinger and McClure, 1983) are the pathogens most encountered in stored muscadines. Ripe rot and Macrophoma rot must be controlled primarily by preharvest sprays starting at bloom. For some postharvest diseases, such as gray mold, low temperature storage (<41 °F) successfully prevents mycelial growth and reduces spore germination. Some of these diseases appear to increase in severity as the soluble solids content (SSC) increases. A minimum SSC of 14% is needed for edibility, while a maximum of 20% appears to be the upper limit to maintain a postharvest shelf life of 7 to 14 days (Ballinger et al., 1982; Walker et al., 2001; Smit et al., 1971).

The USDA postharvest laboratory at Lane has been doing storage and variety evaluation of muscadines harvested from Clarksville and Hope, Arkansas in cooperation with Dr. John Clark, Dr. Luke Howard, and Dr. Keith Striegler at the University of Arkansas. The purpose of these studies was to determine effective and simple postharvest storage regimes that can be applied to local growers, and to determine the most suitable fresh market muscadine varieties. Sulfur dioxide applications can be done with muscadines with some success and have been reported by Dr. Justin Morris and colleagues (James et al., 1999); our goal was to look at other technologies for shelf life extension.

In 2001, 'Fry' and 'Summit' muscadines harvested twice from Hope, Arkansas were stored at 2° C (35 °F) for 4 weeks. These berries were placed in quart glass jars and humidified controlled atmospheres of 15% CO_2/10% O_2 or 0.03% CO_2 /21% O_2 (control) were provided. Fruit were rated for the number of decayed, shriveled, and soft berries in each treatment, and analyzed for titratable acidity (% malic acid) and SSC using the methods of Ballinger and McClure (1983).

In 2002, 'Cowart', 'Sterling', 'Carlos' and 'Black Beauty' were harvested once at Hope, Arkansas and placed in one pint vented plastic clamshells. Berries were given a treatment of UV-C light (1800 Joules) or fluorescent light (2 days at 35 or 58 °F) before storing at 35 °F for an additional 26 days (Table 2). Berries were rated and analyzed as described above. Only 'Carlos' and 'Cowart' data are presented here.

Use of high CO_2 storage (CA) helped reduce decay in muscadines in the first harvest, but had less effect in the second harvest (Table 1). Visual symptoms of ripe rot were very apparent on the grapes from the second harvest after storage. This disease often infects grapes in the later stages of ripeness but may not become visible until well after harvest (Krewer et al., 1994). The number of shriveled or soft grapes was not affected by treatment. All grapes were at 15% SSC. Titratable acidity (% malic acid) was slightly higher in most CA-stored grapes.

Weight loss and soft berries were higher in muscadines held at 58 °F under fluorescent light before storage at 35 ° F (Table 3). Decay was increased in 'Cowart' muscadines held at 58 °F under fluorescent light. The percent decayed or soft muscadines was not reduced by any of the light treatments relative to controls. The SSC of fresh and stored grapes was 15-17% and was not affected by storage treatment or length of storage (data not shown). The titratable acidity and pH of muscadines was not significantly affected by storage or treatment.

CA storage with 15% CO_2 may help reduce decay of muscadines, but is cultivar and harvest date dependent, probably because ripe rot is not effectively controlled by CO_2 . Light treatments, either UV-C or fluorescent, were ineffective at reducing decay development and did not affect SSC or titratable acidity.

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Table 1. Effects of controlled atmosphere storage on quality of muscadine grapes after 28 days at 35 ° F.

		% Decay		% Titratable Acidity	
	Storage			Harvest Date	
Cultivar	Treatment	8-21-01	8-28-01	8-21-01	8-28-01
Fry	-CA	40.3	38.4	0.63	0.52
	+CA	1.9*	16.6*	0.69	0.55
Summit	-CA	43.0	38.2	0.58	0.55
	+CA	8.4*	33.3	0.66*	0.49

* Means separated within cultivar and by Student's t-test, P<0.05.

Table 2. Treatments used for muscadines in 2001 experiments.

Treatment Number	Light Source	Temperature Treatment (F)	Days of Treatment
1 (UV-C Control)	None	35	0
2 (F. Light Control)	Fluorescent	35	0
3 (F. Light Control)	Fluorescent	58	0
4	UV-C	35	0
5	Fluorescent	35	2
6	Fluorescent	58	2
7 (Fresh)	None	None	0

Table 3. Effect of light treatment on quality of 'Carlos' and 'Cowart' muscadine grapes after 28 days storage at 35 °F.

Cultivar	Treatment No. Table (2)	% Wt Loss (Day 28)	% Decay	% Soft	% Titratable	pH
Carlos (Bronze)	1	3.1	12.4	44.4	0.25	3.22
	2	2.8	10.2	47.0	0.28	3.23
	3	2.6	9.1	39.5	.29	3.2
	4	2.8	14.9	46.5	0.27	3.22
	5	4.0	6.0	37.3	0.28	3.17
	6	6.0	9.9	62.2	0.28	3.17
	7	-	-	-	0.32	3.20
Cowart (Purple)	1	5.2	12.4	24.0	0.46	3.09
	2	5.2	17.2	46.2	0.49	3.05
	3	4.7	10.0	39.4	0.52	3.05
	4	4.8	12.7	31.4	0.50	3.10
	5	4.4	9.5	39.1	0.43	3.11
	6	6.5	25.6	57.8	0.52	3.02
	7	-	-	-	0.52	3.12

Oklahoma Peach IPM Program Update

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Introduction

Integrated pest management (IPM) is a sustainable approach to production agriculture that stresses pest population management rather than elimination. IPM combines biological, cultural, physical, and chemical methods of pest control and seeks to minimize economic, health and environmental risks. With an increasing demand by consumers for more organic produce, and an inherent fear of pesticides, the need for such an approach in peach production was inevitable. Environmental concerns associated with many currently registered pesticides continues to escalate and the Environmental Protection Agency (EPA) has begun the arduous task of reviewing and even eliminating many older, reliable chemicals which growers have depended upon. This concern from the regulatory arm of government has resulted in the loss of many chemicals and increased costs of those left remaining on the shelves. Growers have recognized the necessity of reducing chemical inputs and hope to thereby reduce costs and environmental concerns associated with their use. In turn, development of reduced spray schedules in peaches should have a profound effect on employee exposure and create an atmosphere of good stewardship for the orchardist and his business.

In 1996, this project was initiated in Oklahoma for a list of reasons. First, we needed to identify the primary pests that really should concern growers in our state. Second, we identified any natural and/or nonchemical methods of pest control that might provide alternatives to traditional pesticides. Next, we developed methods of monitoring for the significant pests associated with the orchard and attempted to determine an effective action threshold utilizing these methods. Finally, we are still in the process of trying to determine how much damage is too much in a fresh and/or U-pick market. Initially, our goals were relatively simple and revolved around grower acceptance to IPM concepts. We had hoped to refine and reduce the number of pesticide applications made to Oklahoma orchards, familiarize the growers with IPM concepts and improve the response position of our industry to market opportunities and/or legislative mandates.

Funding for many of these projects was provided by the Oklahoma Agricultural Experiment Station (OAES), the Oklahoma Cooperative Extension Service (OCES), Southern Region IPM Project, National Agriculture Pesticide Impact Assessment Program (NAPIAP) and the Oklahoma Fruit Growers' Association.

Materials and Methods

Monitoring sites for peach insects were established in Perkins, Porter, Harrah and Stratford Oklahoma, representing the major peach production locations in the state. At each

location, separate pheromone (Pherocon ICP) traps were deployed for monitoring oriental fruit moth, *Grapholitha molesta*, peachtree borer, *Synanthedon exitiosa* and lesser peachtree borer, *Synanthedon pictipes* (Jervis et al. 2000). In addition, two trap types were evaluated for monitoring plum curculio, *Conotrachleus nenuphar*. Pyramid traps and screen traps (Mulder et al. 1997) were deployed in equal numbers across orchards in Porter and Perkins, Oklahoma; however, in the other sites only pyramid traps were used for monitoring plum curculio. Comparative results on studies conducted using the two trap types are presented in Johnson et al. 2002. This paper will report the results of general monitoring conducted for all the significant pests only. While monitoring was conducted regularly (3 times/week) throughout each of the three years of this study, only the last year (2001) is presented here. For information concerning the results of previous years monitoring see Jervis et al. (2001).

Results and Discussion

Results of monitoring for the four primary insect pests are depicted in Figs. 1-6. These results suggest that timing of application is paramount and that insect populations vary dramatically from one orchard to the next. Of the two insects that have a direct impact on the marketability of the fruit, in Perkins and in all the other locations in previous years, the plum curculio was the dominate species. However, in Harrah in 2001 trap catches of plum curculio were extremely low and oriental fruit moth began to dominate the fruit feeders. This same trend was evident in Porter, Oklahoma on 30+ year-old Elberta peaches. Even in light of these differences from previous years, the primary insect recovered from damaged fruit in all locations was the plum curculio.

It was also evident from these studies that peachtree borer first emergence can vary considerably by several weeks, depending on location within the state. In intensively managed, older ochards (Porter), where tree limb injury is more likely, lesser peachtree borer was the dominate borer species recovered. In all the other locations, peachtree borer was most often encountered rather than lesser peachtree borer.

Some interesting results from some of these locations have surfaced over the years of this study. First, while lesser peachtree borer (LPTB) has become the dominant borer species in many of the sites, larval damage has not increased dramatically with one exception. At the Harrah site, even though no LTPB were recovered with the three traps, extensive damage was noted on the other side of the orchard. This may indicate the need for more thorough trapping across all parts of the orchard. Second, although specific orchards in the Perkins site have shown excellent management of insect problems, application timing is paramount to effective management of these insects. Third, insect populations vary considerably with each orchard, even within one site. Fourth, peachtree borer first emergence can vary by several weeks within the state, but is likely to occur before the end of May. Fifth, scouting can allow reduced sprays with only marginal increases (about 2%) in fruit damage. Finally, the question arises, "Is there a market for a reduced spray system in peaches and what is the level of consumer acceptance for damaged fruit?"

We hope to expand and continue IPM demonstrations at the Fruit Research Station in Perkins, further evaluate consumer acceptance of IPM produced product, continue to seek funds for pest monitoring off station and evaluate methods for avoiding freeze damage. Monitoring across the majority of the peach growing region of Oklahoma (other than Perkins) will be suspended in 2002 until further funds become available.

Figure 1. Trap captures from Harrah, Oklahoma, 2001.

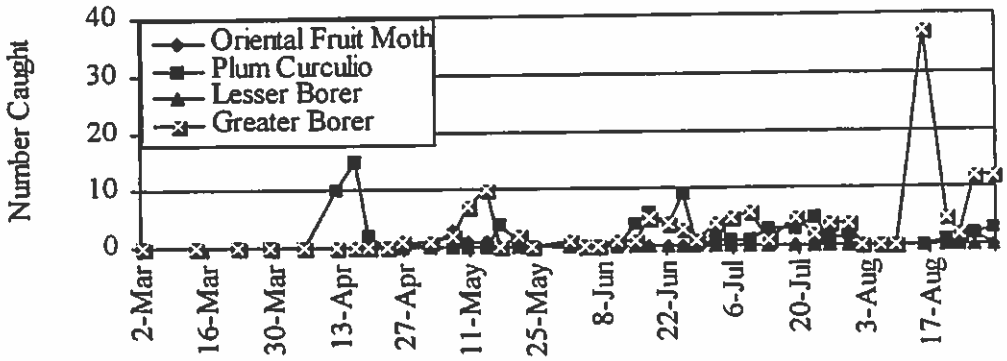


Figure 2. Trap captures from Perkins, Oklahoma, 2001. Flameprince/Ranger varieties.

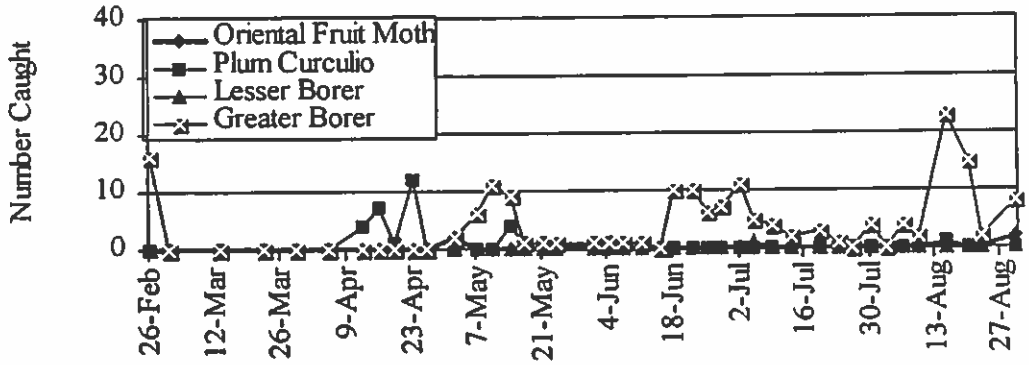


Fig. 3. Trap captures from Perkins, Oklahoma, 2001. Cresthaven/Jayhaven varieties.

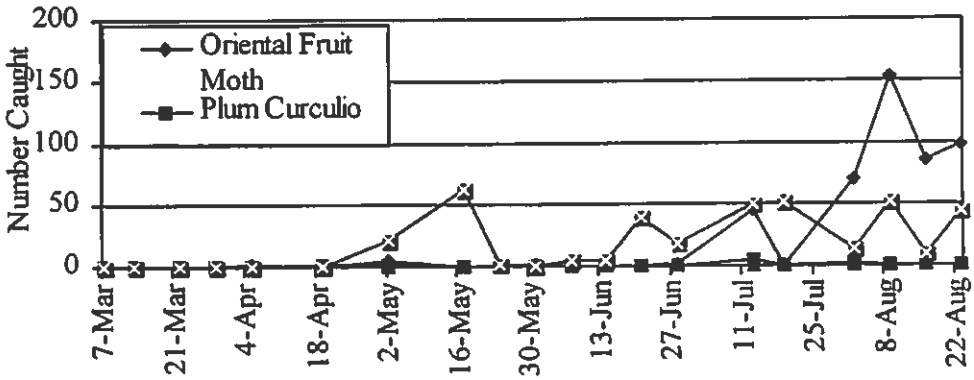


Fig. 4. Trap captures from Porter, Oklahoma in 10 year-old Loring peaches, 2001.

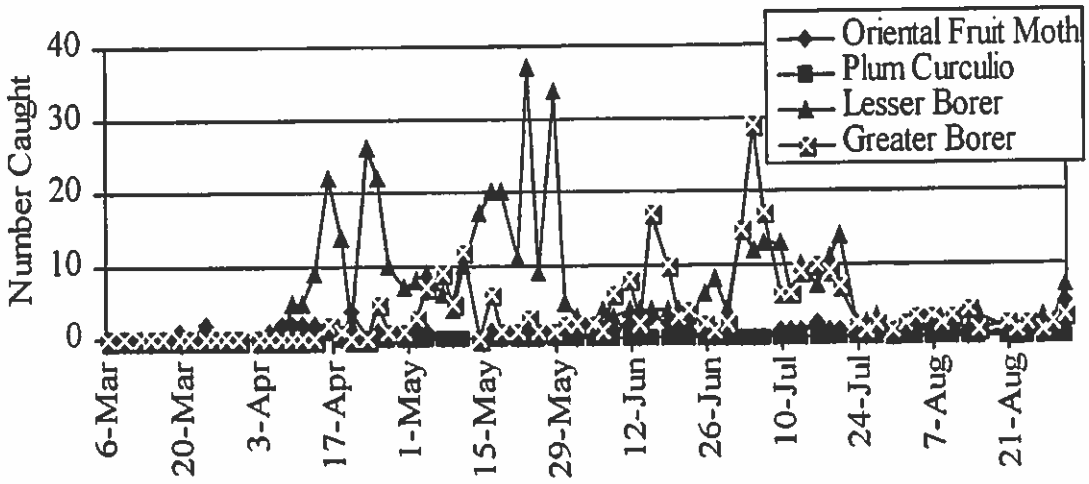


Fig. 5. Trap captures from Porter, Oklahoma in 30 year-old Elberta peaches, 2001.

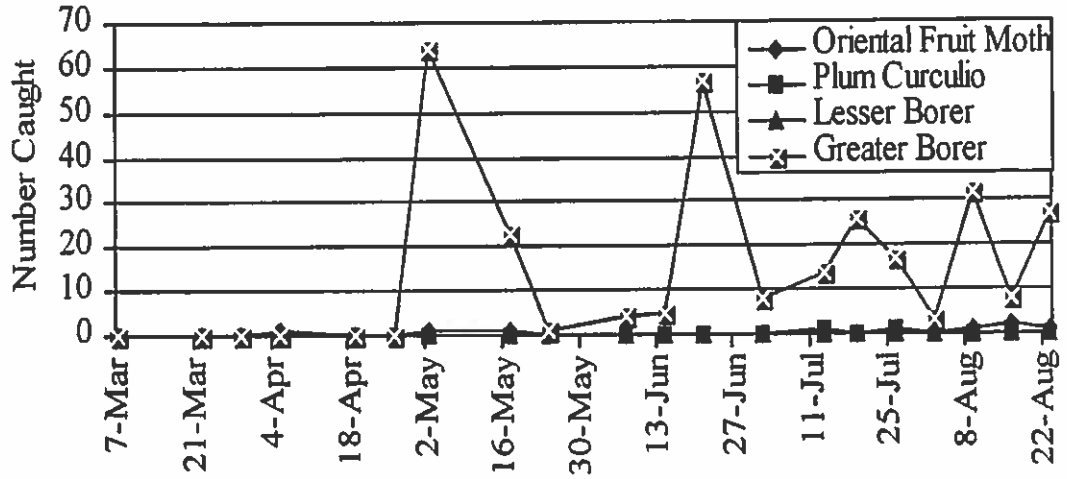
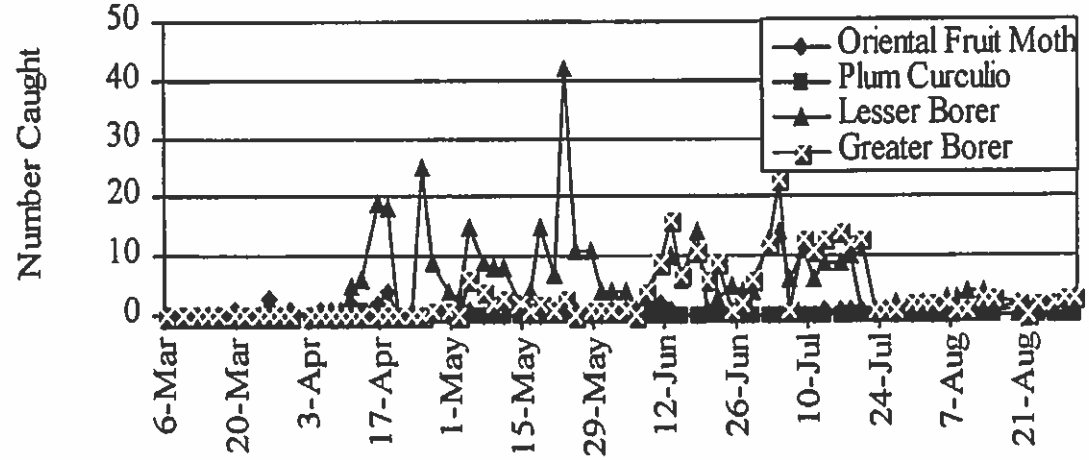


Fig. 6. Trap captures from Stratford, Oklahoma, 2001.



New Training Systems for Peach - Summary of a 9-season study: Success with the Perpendicular V system

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Introduction and Impact

In order for a peach orchard to be financially sustainable in the Arkansas-Oklahoma region, it must have high early yields, high cumulative yield, and be economically managed. Because of a lack of adapted precocious dwarfing rootstocks for peach, early yields for peach must be a result of higher planting densities. High density planting cannot be used without accompanying technology to manage the trees to encourage production.

In 1993, a study of 5 peach orchard systems was established using 'Redhaven'/Lovell seedling at the Fruit Research Substation, Clarksville, AR. During that time, the 2-scaffold Perpendicular-V training system for peach planted at 6.6 ft (2m) by 18 ft (5.5m), or a density of 375 trees/acre had higher yields in the first two harvests, and highest cumulative yield after 7 seasons; 40% higher than traditional open-center trees planted at 161 trees/acre. The increase in early yield was related to the amount of allocated orchard space occupied by the trees and cumulative yield was strongly correlated to tree density. The 2-scaffold perpendicular-V system also had among the best fruit size and color in each season. Although the palmette leaning-V system had greater cumulative yield, it was more difficult to manage. The minimally pruned untrained trees had acceptable yields but, along with the central leader trees had the smallest fruit size and poor fruit color. It is recommended that peach producers in the Arkansas-Oklahoma region consider utilizing the perpendicular-V training system.

Background

For modern orchards to be profitable, the orchard training system must produce fruit quickly in the life of the orchard, have high annual yields, and be relatively easy to manage. These traits allow growers flexibility in making decisions to change cultivars as demanded by consumers, replant older low-productivity blocks, and to return money to either the operation or pay loans for the establishment of the orchard.

Traditionally, open-center spreading peach trees are planted at 110-170 trees per acre. The traditional low density plantings are used because of the lack of adapted precocious size

controlling rootstocks, and by nature peach trees grow vigorously and start to bear in the third or fourth growing season. However, the trees in traditional systems do not fill their allotted space until they are six to eight years of age at which time tree loss may significantly reduce economic vitality of a block.

Because of the lack of rootstocks describe above, other methods, specifically pruning and training, must be used to control tree size and increase early and cumulative production. Many newer training systems have been developed around the world to accomplish this goal but few have been tested in this region. This report summarizes the results of peach tree training systems tested by the Horticulture Department and the Arkansas Agricultural Experiment Station.

Research Description

Peach Training Systems

In April 1993, an orchard system trial was planted at the Fruit Research Substation (FRSS) of the Agricultural Experiment Station, University of Arkansas. Trees of 'Redhaven' on 'Lovell' rootstock, 5/8"-3/4" diameter were planted. The site had a Linker fine sandy loam approximately a 3% slope. All trees received supplemental trickle irrigation (2 emitters/tree), similar annual fertilizer application, and annual weed control. The tree training and management of the planting has been previously described (Rom, 2000; Rom and Blackburn, 1998; Rom, et. al, 1999).

During the first growing season, trees were trained into one of 6 training systems based upon planting density and tree shape (Table 1), being: 1) Standard open center, 2) minimally pruned untrained trees, 3) 4-Scaffold V, 4) 2-scaffold perpendicular V, 5) a leaning palmette V, and 6) modified central leader. The minimally pruned, untrained trees were allowed to form their own shape and no specific system was imposed. No more than 6 scaffold limbs were allowed on a tree and the angle and direction of the scaffolds was not selected. Trees received only annual dormant pruning (no summer pruning) to stimulate fruiting wood, and reduce canopy crowding. The 4-scaffold V system allowed each tree to have 2 scaffold limbs extending into the drive row on each side of and somewhat perpendicular to the tree row (approx 60° angle from the row) while maintaining an open tree row with a V shape. Trees received both annual dormant pruning and summer pruning 2-3 weeks prior to harvest to remove watersprouts and suckers inside the canopy V. The 2-scaffold V system, modeled after work in California (DeJong, et al., 1994, 1999), allowed each tree to have 2 scaffolds, selected in the first dormant season, to extend perpendicular from the tree row into the adjacent drive row thus forming a "V" shape down the tree row. Along the scaffolds only fruiting wood, or short, semipermanent limbs were allowed to form and no side limbs were permanently maintained. Trees received both annual dormant pruning and summer pruning 2-3 weeks prior to harvest to remove watersprouts and suckers inside the canopy V. The leaning palmette V system was established so that every other tree down the tree row leaned into the adjacent drive row. Each tree was trained into a flat palmette shape with 3-5 scaffolds per tree. Trees leaned at approximately a 30° angle from the vertical. The effect of the alternatively leaning trees was a V-shaped tree row. Trees received both annual dormant pruning and summer pruning 2-3 weeks prior to

harvest to remove watersprouts and suckers inside the canopy V. For the 4-scaffold V, the 2 scaffold perpendicular V and the leaning palmette V systems, trees were grown essentially as a hedgerow form with the tree row center open. The modified central leader was pruned to encourage the most vigorous, upright leader as the central axis and annually headed to encourage branching and vigorous terminal growth. At the base of the canopy, approximately 2-3 feet from the ground a skirt of short (3-5') scaffold limbs was maintained from which fruiting wood originated. Along the central leader above the skirt of limbs, short semi-permanent limbs or fruiting wood were maintained. The trees receive annual dormant pruning.

Results

Tree Growth

After 9 seasons growth , average tree height of all trees was similar (Table 2). An attempt was made to keep all trees to a height of approximately 12 feet in order to facilitate management. However, tree spread varied significantly among the systems with the untrained trees having very spreading canopies, and the 2-scaffold V system having the narrowest canopy. As a result, although trees were planted at 18 ft between trees, trees in this system could have narrower row spacings. Trunk cross-sectional area (TCSA) is an indication of the total above-ground vegetative growth increment. Clearly, the trees in the traditional system were the largest while those in the most constrained by pruning, the central leader, had the smallest trunk size. The increment TCSA increase in 2001 was smallest in the 2-scaffold V system showing that they are slowing down in their vegetative growth and diverting increasing growth resources to fruiting.

Yield

Trees were not allowed to fruit in the first two seasons but did fruit in the third year, 1995 (Figure 1). In the first season, all trees produced nearly similar yields on a per tree basis. However, because of the density of the 2-scaffold V system, it achieved a yield of approximately 400 bushels per acre (Figure 1) while the traditional open center trees had approximately 1/3 of that level of production. No trees cropped in 1996 due to a severe late winter freeze. The 2 scaffold V system maintained high annual production for most years although, when over-cropped (as in 1997 and 2000), may be prone to biennial bearing reductions the following year. The traditional open center system achieved its maximum and highest yield in 1999. The leaning-V system and untrained system also tended to have very high yields. In the last 3 years, all systems had similar yields on a per acre basis (with some variation) indicating that all systems had achieved their production capacity. Differences in fruit size among the systems varied annually and was typically related to crop load on the trees. Commonly, the minimally pruned untrained trees and the central leader trees tended to have the smallest fruit. Also, fruit color and soluble solids was often lower in fruit from the minimally pruned untrained trees while often the best in the V systems.

Cumulative yield can represent the total economic return over time back to an enterprise. Cumulative yield of the traditional open center system was the lowest of all systems evaluated (Figure 2). Even with a frost resulting in no yields in the second cropping season (1996), after 7 harvest seasons, the 2-scaffold V had a 40% increase in cumulative yield compared to the

traditional open center system. The palmette leaning V system had the highest cumulative yield. However, this system was difficult to manage.

Other observations

No economic analysis of this study has been completed and the time used to plant, train, prune and harvest were not recorded. However, some deductions can be made.

If it is assumed that trees cost $2.50 at planting it would cost an additional $535 to plant the high density (375 trees/acre) perpendicular V compared to the traditional low density (161 trees/acre) open center. At a value of $20/bushel for mature fruit (or $0.45/lb), in the first harvest season where the perpendicular V would yield an estimated 400 bu/acre ($8000/acre) and the open center trees an estimated 150 bu/acre ($3000/acre), the difference in yield due to the planting density would produce an increase in net revenue of approximately $5000. This is almost a 10-fold return on the investment of purchasing the additional trees for the high density.

In discussions with the labor crew responsible for pruning and harvest in this trial, there was a very consistent response that the perpendicular V system was the easiest to prune and harvest. To the contrary, the most difficult to prune and harvest was the minimally pruned untrained and the central leader trees. Pruning the leaning V system was difficult because of the need to maintain the palmette scaffolds with good fruiting wood. However, the crew indicated the leaning V system was very easy to harvest because of ease of access to the fruit. Overall, the favorite system of the maintenance crew was the 2-scaffold perpendicular V system.

Observation of the fruit location within the canopy of the perpendicular V system suggests some concerns. First, fruit was (and should) be evenly distributed along the entire axis of the scaffolds - from top to bottom. In the traditional open center system, most of the fruit was in the upper third of the canopy. The location of fruit in lower portions of the canopy in the perpendicular V system indicates that frosts during bloom can be very problematic in this system. Thus, to take full advantage of the system and insure annual cropping, a frost prevention strategy must be planned and implemented; it is absolutely essential for this system.

The perpendicular V also requires summer pruning (see below). Although our research has demonstrated that summer pruning is useful in traditional open center trees to increase fruit size, color and soluble solids, it is essential to maintain fruiting wood and fruit quality along the scaffolds of the perpendicular V. This operation cannot be skipped.

Conclusion

From this study and from similar studies in peach growing regions, it is concluded that the 2-scaffold perpendicular V system offers significant opportunities to peach growers in the Arkansas-Oklahoma region. The primary advantages of the system are early and sustained fruit cropping, high fruit quality, and easy of management. Growers should start planting experimental blocks to gain experience with the system. Growers using the system must, because of the capital investment and risk of the system, insure annual cropping with a frost

prevention strategy. It should be noted that high density orchards, although having significant economic and horticultural benefits, also require higher management intensity.

Training the Perpendicular V

Year 1-2

Purchase high quality spring-budded nursery trees of approximately 3/8" diameter and 24-36" height from a reputable nursery. Trees should be healthy and have a good root system. It is not necessary or beneficial to purchase large nursery trees in this region. Trees should be planted with as early in the spring as possible to insure good tree establishment.

Trees should be spaced 5 to 6.5 feet between trees within the row and 15 to 18 feet between rows giving a tree density of approximately 375 to 580 trees per acre (Table 3). Use closer spacing for weaker, compact, or more upright growing trees or when planting on weak soils. For more vigorous cultivars, more spreading cultivars, or when planting on stronger soils use the wider spacing. Planting too close, although may provide some early increases in yield may result in hard-to-manage trees later in the orchard life and reduced yield and fruit quality due to inter-tree shading. If trees are planted to far apart, the advantage of high early production with the high density planting, and the tree size control caused by close spacing.

After planting, limbs should be allowed to develop along the leader from 24" upward. Allowing limbs to grow too low may cause management problems later in the orchard life, specifically difficulties with mechanical control for weed control. As the tree starts to vigorously grow during the first season, summer pruning should be used to head-back the leader at approximately 36 to 48" height to stimulate the lateral branching. At this time, it important to visualize the "V" or "Y" shape of the tree and begin to establish that shape. The 2 main laterals which are most perpendicular to the tree row and extending into the drive row should be selected and other limbs headed back. This process will further stimulate the growth of the new main scaffolds. The two scaffolds should be at a height of 24-36 inches above the soil and spaced 6 to 12 inches apart along the trunk of the tree. It is best not to have them develop directly on opposite sides of the trunk as this is somewhat architecturally weak and may cause problems when the tree is mature and carrying a full crop load. Limbs should not be started at heights greater than about 40 inches height on the trunk as the will result in a very tall tree or the production will be reduced to loss of canopy bearing surface.

During the dormant season following the first season of growth, trees should be pruned to remove the tree central leader and all side limbs and the two primary scaffolds selected. The grower should visualize the "V" or a "Y" shape of the trees now and prune and train to accomplish that shape.

The two scaffold limbs should be pruned as you would normally prune scaffold limbs in peaches to extend their growth. We have not had any experience whether heading the scaffold (bench-cuts) or not-heading the scaffold is best; this probably depends on the vigor of the growth, the nature of the cultivar, and whether or not the scaffold limb is growing too vertically

and needs to be encouraged to grow more angled outwardly. Strong side shoots along the scaffold should be removed as well as all upright shoots on the inward side of the "V". During the second summer season trees should not be cropped but allowed grow vegetatively. Summer pruning in late June or early July to continue encourage of the scaffold growth and removing all in-ward growth is important annually. During the dormant season following the second growing season, tree require good pruning. All side shoots along the trunk other than the scaffold limbs should be removed. All side shoots on the underside or top/in-ward side of the scaffold should be removed. All strong shoots along the scaffold limbs, those which are greater than 1/4 to 1/3 the diameter of the scaffold should be removed. Ideally, only horizontal (or nearly horizontal) shoots extending laterally from the scaffold between adjacent trees which are pencil diameter up to 3/8" diameter and 18 to 24" long should remain. The side shoots along the scaffold limbs should be spaced 4" to 10" apart. These shoots provide fruiting wood the following growing season.

Year 3-5

As the trees grow, scaffold limbs should be angled 60° to 80° apart (or 30° to 40° from the vertical plane). Growing trees too upright will result in very vigorous, tall trees and result in shading; the trees will not be as productive as needed. Growing trees with too flat of a limb angle will result in non-vigorous trees and trees which are structurally weak. To achieve the proper angel, limbs may need to be spread or tied down to increase limb angles or tied together to reduce limb angles. It may be necessary to band scaffolds together if their angle is too wide and to support the fruit crop load. It should be noted that the scaffold limbs will spread more horizontally as a result of age and carrying a heavy crop load.

If trees have reached a height of 6 to 8 feet by the third growing season, they should be allowed to fruit. Trees should have been pruned to leave side fruiting shoots along the two opposite sides of each scaffold spaced approximately 4-8 inches apart; that is approximately 18-20 shoots on each side of the scaffold limb. Fruiting wood of pencil diameter and approximately one to two foot length are desired and each side shoot should be able to carry 1-3 fruits per shoot.

A target yield in the first cropping season should be 250-350 bushels of fruit (Table 4). To achieve this yield, each tree must have 90-130 fruit per tree or 45 to 65 fruits per scaffold limb. Fruit should not be allowed to develop on the terminal 12 to 24" of the scaffolds so that they will continue to grow. Fruit should be spaced appropriately after thinning as in traditional training systems to encourage good size. In the second harvest season or fourth year growers should strive for a target yield of 300 to 400 bushel fruit - approaching the maximum for the system. Maximum yields of 450 bu/acre or more should be targeted for the 3 harvest season. Another advantage of the perpendicular V system is thinning and crop prediction. Yield can be both relatively accurately managed by thinning to specific fruit number targets along the limb, and then predicted by counting maturing fruit on sample trees.

Maturity

By year 5 or 6 the trees should reach a mature height of 10 to 14 feet and the gap between the scaffold limb tips of adjacent rows above the tractor drive row should be 6 to 8 feet.

Trees need both dormant and summer pruning. At both pruning times, in-ward growing limbs in the center of the "V" should be removed. Summer pruning should be done 2-3 weeks prior to harvest. After summer pruning, the grower should be able to look down the row and clearly see a "V" shape. During dormant pruning, limbs which are growing downward along the underside of the scaffold should also be removed. No permanent laterals along the scaffold should be allowed to remain and strong side shoots must be annually removed. Only "fruiting wood" of pencil diameter up to 3/8" diameter and 24-36" length which are extending horizontally from the scaffold between adjacent trees should be allowed to remain. However, we have found sometimes short stubs of 6 to 8" length at the bottom of the scaffold may be needed to encourage annual shoot re-growth. Pruning should encourage new fruiting wood to grow annually and be used to balance current fruiting wood with re-growth wood. After dormant pruning, the scaffold should have a "fishbone" or fish skeleton look as you would look down along the scaffold into the center of the tree, and there should be a 2 to 3 foot gap between limbs of adjacent trees so that a person could walk between trees through the row.

At maturity, the 2-scaffold perpendicular V system will not necessarily yield more than other systems. The main production advantage of the system is the early production. It is our experience, and that of others, that the perpendicular V system achieves mature production early; at least by the third or fourth harvest season, compared to traditional systems which may take six to eight years to achieve their maximum potential. At maturity, each tree should produce one to 1.5 bushels of fruit per tree or 160-190 fruit.

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Table 1. Tree systems, planting distance, and densities, of 'Redhaven'/Lovell peach grown in six training systems, Clarksville, AR.

System	In-Row Spacing (ft)	Between-Row Spacing (ft)	Tree Density (trees/Acre)
Open Center -- Traditional	15	18	161
Untrained, minimally pruned	15	18	161
4-Scaffold V	10	18	245
2-Scaffold Perpendicular -V	6.5	18	375
Leaning-V	6.5	18	375
Central Leader	8	18	300

Table 2. Tree Growth of 'Redhaven'/Lovell peach grown in six training systems, Clarksville, AR, 2001.

Training System	Average Tree Height (ft)	Average Tree Width (ft)	TCSA[x] (cm^2)	TCSA (cm^2) increase from 2000 (%)
Open Center	11.8	16.1 b	169 a	24.2 (17%)
Untrained	13.1	18.0 a	166 ab	28.1 (20%)
4-Scaffold V	12.1	16.5 b	143 b	23.1 (19%)
2-Scaffold V	13.8	13.1 c	118 c	10.4 (9%)
Leaning V	12.1	13.6 c	98 cd	11.1 (13%)
Central Leader	13.8	13.2 c	83 d	10.9 (15%)
	ns			

[z] Letters following numbers indicate mean separation among training system treatments , using LSMEANS; numbers with different letters are significantly different. ns = no significant difference. The absence of letters indicates calculated number for which means were not analyzed.
[x] TCSA = trunk cross-sectional area, measured at 6-10 inches above the soil-line; an indication of total above ground vegetative growth of the tree.

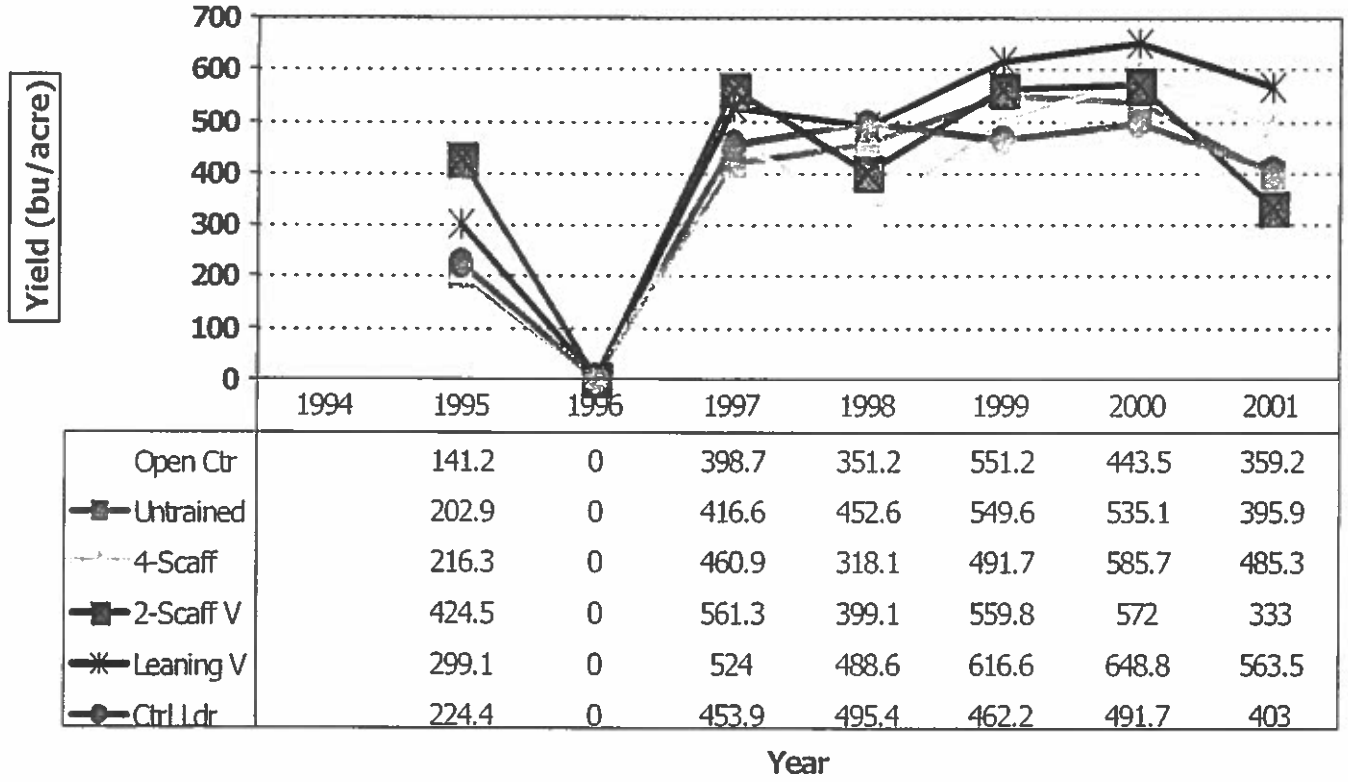
Table 3. Suggested planting distances and densities for using the 2-scaffold perpendicular V training system for peaches and nectarines in the Arkansas-Oklahoma region.

In-Row Spacing / Between-Row Spacing	5.0 ft	6.0 ft	6.5 ft
15 ft	**580 trees/acre** -Use for weak cultivars or stocks -Use on weak soils	**485 trees/acre**	
16 ft	**545 trees/acre**	**454 trees/acre**	**419 trees/acre**
18 ft	**484 trees/acre** -Use this row spacing for weak trees or soils only if there are equipment limitations	**405 trees/acre** -Use for average vigor trees -Use for average to strong soils *This is the average spacing for this system*	**375 trees/acre** -Use for strong cultivars or stocks -Use for strong, fertile soils

Table 4. Fruit cropping targets for the 2-scaffold perpendicular V training system based upon 405 trees planted per acre (6 ft x 18 ft spacing).

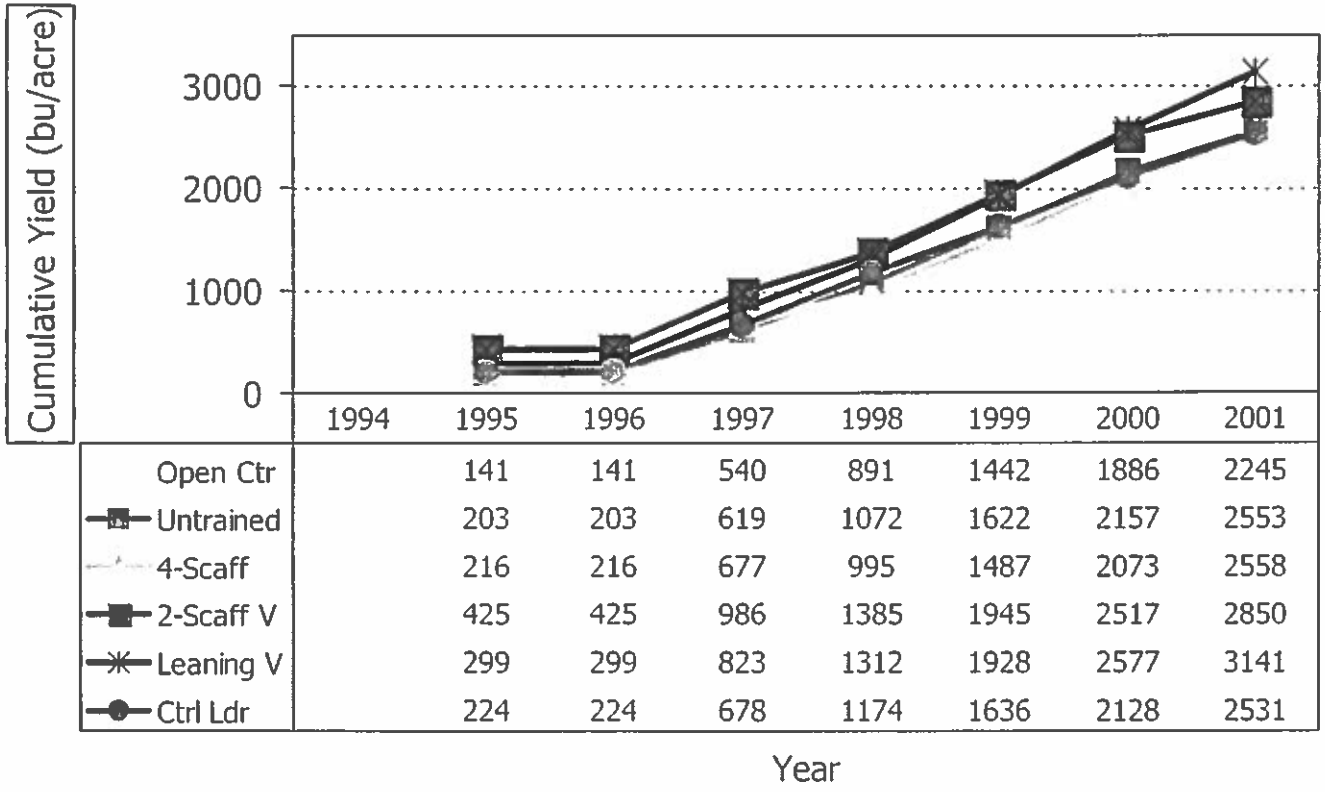
Tree Age	No. of Fruit/Scaffold Limb	No. Fruit/Tree	Estimated bu/acre
3 yrs	45 - 65	90 - 130	250 - 350
4-yrs	55 - 75	110 - 150	300 - 400
5-yrs	65-80	130-160	350 - 450
6-yrs and on	80-90	160-185	450 - 500

Figure 1. Annual yield (bushels/acre) of 'Redhaven'/Lovell peach grown in six training systems, Clarksville, AR.



	1994	1995	1996	1997	1998	1999	2000	2001
Open Ctr		141.2	0	398.7	351.2	551.2	443.5	359.2
Untrained		202.9	0	416.6	452.6	549.6	535.1	395.9
4-Scaff		216.3	0	460.9	318.1	491.7	585.7	485.3
2-Scaff V		424.5	0	561.3	399.1	559.8	572	333
Leaning V		299.1	0	524	488.6	616.6	648.8	563.5
Ctrl Ldr		224.4	0	453.9	495.4	462.2	491.7	403

Figure 2. Cumulative yield (bushels/acre) of 'Redhaven'/Lovell peach grown in six training systems, Clarksville, AR.



	1994	1995	1996	1997	1998	1999	2000	2001
Open Ctr		141	141	540	891	1442	1886	2245
Untrained		203	203	619	1072	1622	2157	2553
4-Scaff		216	216	677	995	1487	2073	2558
2-Scaff V		425	425	986	1385	1945	2517	2850
Leaning V		299	299	823	1312	1928	2577	3141
Ctrl Ldr		224	224	678	1174	1636	2128	2531

Unusual Fruits With Oklahoma Market Potential

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Look at the history of what we grow or eat and change is evident. In the early 1900's broccoli was not on our dinner plates in Oklahoma. Likewise, everyone thought blueberries were just a minor fruit harvested from the wild. As Italian immigrants arrived they brought with them a taste for broccoli and the seed to grow it. As the second half of the twentieth century arrived, blueberries became a cultivated crop and are now a staple part of our diets.

Recently, the "Maryland Orchardist" reported nationwide reductions in apple acreage. The reason? Low prices and a rise in apple acreage in China. In the Mid-Atlantic they are starting to grow more small fruits that command a higher per pound price and are too perishable for a "slow boat from China".

Today I would like to review five areas of fruit growing that might be put to use by local growers: ***Unique/ethnic fruits, out of season fruits, native fruits, specialty nursery crops and value-added products.***

Unique/Ethnic Fruits

Many growers sometimes wish for a new crop that might command a high price and is easy to grow. Several mail order fruit nurseries list many unusual temperate zone fruits. They may be native to places as far away as Chile or Siberia, but do they have real "potential" in the U.S.?

The North American Fruit Explorers, an association who has exhibited at HIS in the past, has kept alive an interest in unique fruits. In many of their home gardens one will find temperate zone fruit from all over the globe. While little has been done to exploit this commercially, their success with growing these plants does indicate that they can be grown in Oklahoma.

As eating fads come and go, we sometimes look for trends in the industry. For example, Aronia (Aronia melanocarpa) juice is being sold in supermarkets as a health food drink. While this small tree grows and fruits well in Oklahoma, is it something we can competitively grow? This photo is commonly called chokeberry, a cousin of the juice making Aronia melanocarpa. In either case, it wouldn't market well as chokeberry juice. Besides, is drinking Aronia juice a true trend? Or is it just a fad for now?

Experts who watch for industry trends know that it has a catch: Before recommending a new crop to growers, markets must be established. It's hard to establish a market, with no goods to back it up.

Both market and supply have to develop over time. The URL listed below has a well documented article titled "Temperate Berry Crops". Dr. Chad Finn, Research Geneticist at the Northwest Center for Small Fruit Research, has studied various small fruits that show potential and gives an honest appraisal of their worth: http://www.purdue.edu/newcrop/proceedings1999/v4-324.html.

The host website for this article is the Purdue University Center for New Crops and Plant Products. This serves as a clearinghouse for unexploited crops that we might grow in the U.S.

Several fruits mentioned might grow well in our region. Hardy kiwi, for example is grown on a small commercial planting in southeast Oklahoma. It is expensive to establish, takes three years to bear a crop, but has very few pests. Grocers in the East are packaging the fruit in trays, like grape tomatoes. Their claim to fame? High vitamin C content. Here's a case where marketing helps sell the product.

Recently, I have visited several local ethnic markets to see what they have for sale that might grow here. In Tulsa, over twenty ethnic markets cater to people from Asia, Russia, South America, Southeast Asia, the Middle East and even England! Their produce sections have many vegetables and fruits that could be grown here: Bitter melons, husk tomato or tomatillo, prickly pear pads, kiwano, eggplant, lychee, etc. Some of these vendors indicated that they would be interested in buying locally grown fruits and vegetables that originate in their homelands.

Two years ago at HIS, Steve Salt, from Yarrow, Missouri gave great program titled: "Around the World at the Farmers Market". His advice is to learn a bit about each culture. People who may not look ethnic, may have had a grandmother from, say the Balkans, who loved a certain type of fruit. Learn also, what they like to eat at certain holidays. A market could be targeted for these occasions. An example closer to home is that we eat cranberries around Thanksgiving and Christmas, thus an empire named "Ocean Spray" was born out of a holiday tradition.

One fruit, the Kiwano, or African Horned Melon, sells for $3.99 for each piece at local markets. It is eaten fresh, or the juice is used to flavor beverages. New Zealand growers patented the name "Kiwano" and have marketed it very well. It also keeps a long time, so shipping is no problem. However, it ALSO grows really well in Oklahoma. A member of the cucumber family, it readily self sows each year and has few pests.

Ginkgo nuts, (Ginkgo biloba) an Asian treat, also grow well in this area. Homeowners who want a ginkgo tree in their yards are advised to buy a male tree. When the females bear their fruit, gardeners notice an odor similar to dirty socks.

Some other ideas are to grow jujube (Zizyphus jujuba). The chinese false date may serve as a date substitute for Middle Eastern families. Or, try growing figs....we can't compete with those grown in other climates, but it's a local market treat for those making fig preserves.

Another idea is crabapples. They add a bittersweet component to batches of homemade hard cider. Tap into local beer and winemakers to see if there is interest. Some other easy fruits for here are trifoliate orange....I've see this sold as Oklahoma lemons. And, the red mulberry and it's cousins offers a fruit alternative to blackberries.

At last summer's Cherry Street Farmers Market in Tulsa, Laura Shanks, of Bixby, sold garden huckleberries. This was in August and September and they were being sold as a late summer replacement for blueberries.....to be used in baked products only. This is not to be confused with fruits of the Gaylussacia species found in the Ozarks. This plant is a cousin to tomatoes, belonging to the Solanaceae or Nightshade family.

Out of Season Fruits

Right now a quart of strawberries is $2.99. A half pint of red raspberries, blackberries or blueberries is also $2.99 and they come from California, Mexico and Chile, respectively.

If we could capture some of that out of season market, then the economics look very good. Some growers in Oklahoma are harvesting strawberries several weeks early by plasticulture. This takes greater initial inputs, and a lot knowledge, but yields are high and so is berry quality. The U. of Arkansas has led the way in this area as well as the Noble Foundation in Ardmore. And now, Dr. Lynn Brandenberger, OSU Dept. of Hort. and LA, has a demonstration/research trial in Bixby at our Experiment Station. A few growers are trying this method here with success.

In the Great Lakes States, considerable effort is being made to grow early season raspberries in greenhouses. Plants are containerized and kept outside until December to meet their dormancy requirement. Then, they are brought into greenhouses kept below 65 degrees F. This is warm enough to force plants into bloom allowing them to harvest berries in March, April and May in Michigan and Minnesota, commanding premium prices.

In our area it would be hard to meet their chill requirement in our warm falls. However, several primocane bearing varieties could have their season extended in a hoop house. Imagine being able to sell red raspberries during Thanksgiving and Christmas!

Native Fruits

Our ancestors foraged for wild fruits. People who visit farmers markets are sometimes seeking something unusual, that is also local. Such fruits are particularly marketable is a local history and recipes are provided. "Billy Joe Tatum's Wild Foods

Field Guide and Cookbook" is a great local reference for Ozark native fruits and vegetables.

Here are some ideas: **Passion Flower** (Passiflora incarnata) sold as maypop fruits; **Osage Orange** (Maclura pomifera), inedible, but sold as a fall decorative and natural insect repellant; **Elderberry** (Sambucus canadensis), for jam, juice or wine; **Serviceberry** (Amelanchier spp.), jams and jellies (on this one tell of how the Methodist Circuit Riders could not travel on roads until Spring, when the *Service*berry was in bloom, another name being shadblow.

Pawpaw (Asimina triloba), our most northern species of tropical fruit! **Wild Goose Plum** (Prunus munsoniana) so-named because the fruit was found in wild goose, make delicious jelly. Or how about the **Sand plum, a.k.a. Chickasaw Plum** (P. angustifolia).

Persimmons (Diospyros virginiana) might take a hard sell to those remembering eating an unripe fruit. But, try some of the Asian persimmons (D. kaki). Their the size of a tomato and a beautiful pumpkin color.

Rose Hips (Rosa spp.) are high in vitamin C and can be made into jelly. Try some cultivars with unusual shapes. **Rusty Black Haw** (Viburnum rudifolium) was eaten by our ancestors and is another native fruit that has been long forgotten.

Nursery Crops

How can a fruit grower turn a $2.00 tree into $20.00? By potting it, sticking in a label and growing it a bit larger. Specialty nurseries cater to gardeners with an interest in growing their own unusual fruits. Many such nurseries are scattered about the U.S., but none (that I know of) are in this region. These nurseries have very informative catalogs to generate interest among gardeners. This type of consumer education has paid off as they now produce color glossy catalogs and easy-to-navigate web sites.

Our office receives many calls a year from gardeners seeking unusual kinds of fruit or nut trees to grow as a hobby. While some are available at local nurseries, we sometimes refer people to nurseries as far away as Oregon or Virginia. With gardening as the nation's number one hobby, I think there is room for more specialty nurseries around here.

Here are some ideas: Ornamental blueberries, bananas, citrus, grapes with red fall color for arbors, nut trees, containerized apricots, and espaliered fruit trees.

Value Added Fruit

O.S.U.'s Food and Ag Products Research Center is dedicated to helping Oklahomans add value to their agricultural products. They offer two-day short courses in how to get into food processing. They will consult with you and help develop a workable commercial recipe. In the fruit realm this might include fruit leathers, jams, jellies, pie filling, fruit butters, etc

Herb Session

Better Crops
Through Soil
Conservation

Healthy Soils, Healthy Plants

Presented by Debbie Pleu,
Earthly Goods Farm & Garden Supply

The Nitrogen (N) cycle constitutes soil, plants, animals, and the atmosphere. All interact with one another in one or more ways. N sources include crop residues, cover crops, animal manures, ammonium and nitrate salts carried down in rain, nitrogen fixing soil microorganisms, and commercial fertilizers.

Plants use N to synthesize amino acids that form proteins. N is required for chlorophyll, nucleic acids, enzymes and the assimilation of sugars, starches, and carbohydrates. N levels in the soil can be carefully managed using soil tests, split applications of N, selecting the right N source for your site and crop, matching N inputs with the growth of the crop and rotational cropping with green manures and N fixing crops. These protect land, water, and your bottom line.

Phosphorus (P) "The Power Broker"

P handles all of the energy captured during photosynthesis and stores it in sugars, then re-distributes the energy given up by sugars and starches. P is essential to every metabolic process that includes protein synthesis, and N fixation in legumes. P is essential to seed development and size. Larger seeds can germinate deeper in soil thus has more drought resistance. P is a stimulant to root development. Roots branch out and root hairs form in the vicinity of a source of P. Therefore early growth of a plant is affected by P and will determine its' vigor throughout the season.

N and P compete for take-up by the plant roots but N is more mobile in the soil, and an excess of N can overwhelm P even when P levels are adequate or high. A P deficiency may delay the growth of new shoots and the development of flowers. A P deficiency like N produces stunted growth; the difference is the purplish color on the underside of leaves. This color is due to the accumulation of sugar whose energy is not utilized.

There are many factors that cause a P deficiency. Soil organisms or the mineral elements aluminum and calcium in clay can bind it up. Cool weather further slows P mobility due to low biological activity. Soil pH will affect the availability of P. Acid soils have higher available aluminum, which ties up P and reduces biological activity inhibiting soil organism's ability to function. Alkaline soils reduce P availability because insoluble calcium phosphate forms. Fortunately, a range in pH from 6.5 to 6.8 exists where neither aluminum nor calcium can bind with P. Interestingly this is the optimal range where trace elements are available, where biological activity is good, and plant growth is optimum.

To some degree the soil itself through biological activity, acts to reduce alkalinity. Biological activity is acid forming and causes the pH around plant roots to be lower than

in the surrounding soil. Organic matter and the activity of soil organisms have a strong influence on the availability of P. P released by decaying residues is highly available, and any P trapped by soil organisms eventually becomes available upon their death and decay. The microscopic threads of fungi, called mycelia, found in decaying organic matter distribute P to roots. Thus P spread on soil where biological activity is high will soon become available to the plants.

In summary, soil P is best managed with near neutral pH, sufficient water, and high biological activity with organic residues of cover crops, animal manures, compost, and supplemental additions of rock phosphate or bone meal as needed.

Potassium (K) "The Great Communicator"

K carries the message that triggers protein production, activates enzymes and regulates water movement. A K deficiency causes tomatoes to be tasteless, corn kernels don't swell, and potatoes are puny. When K is adequate yields are heavy, quality is high, stress resistance and winter hardiness result. Next to N, K is the one plant nutrient our gardens or fields are likely to lack.

Plant meals such as alfalfa, cottonseed and kelp are high quality potassium sources because they return to the soil what was taken from it in much the same form. K floats freely in the cell sap so most of it is water-soluble and will produce immediate growth response. When a soil test calls for many pounds of K plant meals may be too expensive. A combination of plant meals and the rock minerals greensand or granite dust would be a good choice. Rock minerals are all in insoluble form and it takes a while for them to become available. While you may see this as a disadvantage it can be turned to an advantage. Like plant meals, greensand and granite dust causes K to cling in soil to build your K reservoir over time. They all contain abundant cation exchange sites. Cations are positively charged particles. Potassium is one. Exchange sites are locations- mineral and clay particles, organic matter- where cations are temporarily held. When a root withdraws a K ion from an exchange site, K released by weathering clays or minerals nearby fills the gap. Managing your K input on your soil is vital. Soils severely depleted of K will use a large portion of the first fertilizer application to fill the empty exchange sites before feeding your plants.

In summary, yearly additions of cover crops, compost, plant-based fertilizers, and rock minerals all build up the biological activity, soil organisms, cation exchange sites, plant proteins, fungi, and contribute nutrients of their own as well. Increasing soil life is a good way to increase the N-P-K potential.

The Geometry of Hillside Gardening

Sharon Owen
Gardener: Moonshadow Gardens & Labyrinths
Artist,Dowser
Labyrinth Enthusiast
Certified Reiki Master (energy therapy)
Certified Dept. of Corrections Trainer specializing in Meditation & Stress Management

I grew up around gardens. My appreciation for gardens came from my childhood experiences in my parents' & grandparents' gardens. I was a tomboy & loved the "Great Outdoors", so it was natural for me to have an interest in gardening – I liked to feel the fresh soil between my toes & feel the sticky earthworms – still do.

Gardening is good for the soul. I like to think of myself as a steward of the Earth, so to me, gardening is an act of loving-kindness. Running a rake through fresh tilled soil is like combing the hair your beloved.

Years passed & I became a middle-aged gardener. It was at this point in my life that I began to realize that there is an extraordinary intelligence inherent in all forms of nature - within the seen & unseen - & that contained within this intelligence are the answers to any questions we could possibly have about nature & its rhythms & balances. So I began to work with nature on a co-creative basis instead of a purely manipulative one. And this is how my method of soil conservation works:

Conservation in my own "back yard"

- Observed the natural area beforehand, keeping in mind the natural habitat.
- Designated a "nature sanctuary" in a ravine & spring bog & left it in its natural state.
- Maintain a large brush pile near to ravine for a wildlife habitat.

- Incorporate **native plants** into the garden area & other plants that can exist on available rain/less water.
- Native plants provide best food sources for wildlife
- Plants native to the soil & climate require less fertilizer & less effort in controlling pests.
- Since native plantings can reduce the need for water & chemicals & can maintain or enhance biological diversity, conservationists should try to incorporate native plantings as much as possible.
- Usually planted at the <u>upper</u> end of the hillside bed. These plants are known as **xeriscape plants**. (Greek = xeros, meaning dry).
- Plant companion herbs around them – less watering = less downhill erosion.

- I work with natural elements as much as possible (rocks, driftwood, timbers, stumps, gravel & sand).

- If needed, I will use recyclable items.
- I work with archetypal designs found in Nature to form earthworks such as mazes & labyrinths.

Let's talk about what exactly earthwork designs are before going any further:

Geometry + Earthworks = Unique Gardens

What I'm going to talk about is similar to knot gardens, except for one very big difference:

- You walk around & look at a knot garden.
- Spirals, mazes, & meander patterns are interactive art pieces. They are walkable, allowing the person to be inside the pattern, where you get a new & more complete experience of it, as compared to just viewing it from the outside.
- The experience is both visual & kinesthetic. And to me, the experience is the key.

So, let's look at some examples, beginning with the simple SPIRAL: The SPIRAL is one of the most ancient symbols, appearing in all cultures. It is a symbol of eternity; a timeless geometric form, perhaps because of its never-ending quality that intrigues & draws us. Studies have shown that the repetitive form of a spiral also evokes deep relaxation & calmness. Therefore, it is an ideal pattern for walking meditations, as well as a dynamic energy pattern and soil conserver. Spirals can be seen in every aspect of nature: in plants, shells, horns, water, hurricanes – even the hair on our heads grows in a spiral. So, a spiral was the perfect geometric form.

Whenever I changed the rows for the main garden from straight lines running perpendicular to the hillside, into one long spiraling row on the hillside, there was a dramatic energy shift in the garden environment. I had also solved my erosion problems.

Spiral earth sculpture on hill

This is an earth sculpture – a double spiral on a hillside.

- They are based on archetypal patterns of Nature
- Earth sculptures have sunken paths & elevated earth mounds.
- They are walk-able, interactive art pieces.

An earth sculpture makes a good garden for practical reasons:

- All beds are readily accessible by the design of the paths. The elevated mound is easier to reach & easier on the back.
- They are made from the earth from the site, with simple drainage system, a rocked path (if desired).
- The mounds can be seeded with flowers, herbs, or vegetables.
- They are low maintenance.
- They can be simple geometric designs or meander & maze patterns.
- They create the maximum amount of path possible in a given area. Practically, this means you get to see every single part of an area allowing the discovery of microenvironments.

- AND they are one solution to the hillside gardening dilemma – wonderful way to help conserve the soil.

In the late 1980's & early 1990's I had a backyard garden out of which I grew & propagated herbs for sale at local festivals. I called it Moonshadow Herbs & Everlastings. In 1995, we sold that house & moved onto 5 acres. The back of the property was open meadow that poured into 3 hills sloping down into a hollow. It was basically a horse lot – trodden down – never cultivated. All prospective garden locations were on hillsides. I had a LOT of work to do to reestablish my herb gardens! Although herbs don't require (even dislike) rich soil, I had to figure out a plan for conserving the existing soil & preventing everything from washing downhill.

I now had 5 acres to be creative with, & got to work tilling gardens spaces. Working with nature & dowsing the area I also created two (2) labyrinths, which are used for walking meditations. Some gardens were to be experiential, too, with interactive designs

In the long downhill fence-line herb/flower beds

Working with the natural elements provided by Nature & using some basic geometric patterns found within Nature, I did the following:

- Dug out & created a small block retaining wall on end of bed to prevent soil erosion.
- Used native stone & added a large old terra cotta pot for a 'cornerstone' – I like the curious & unexpected in a garden.
- Planted perennial herbs & flowers every few feet to help stabilize, with annuals added as desired.
- Observed the water's run-off pattern & brought in native stone/rocks, driftwood & brick for terracing and/or creating & confined area to prevent downhill washing. Example: the brick were slightly inlaid into the soil in a geometric design & were used as seed bed barriers....& their design was interesting to look at.
- Mulched – used soil amendments
- This garden area is still a work in progress FOR THIS REASON:

Greek Key & Meander designs

This is a take-off of the Greek Key pattern called the 'Four Directions.' A meander pattern.

- It is a small space 14 x 20 feet, yet there is 70 feet of path.
- There are three distinct areas that have their own flavor.
- Since the view one way differs from the view the other way, you get a 140 foot walk with a constantly changing view of the symbol & of the garden
- It is an interesting walk in a small space.
- It can be as formal or informal as you wish.

Fence line garden (3 views)

Future plans for this garden could include adding a meander path design similar to the Greek Key.

***Now I'll explain how I applied these techniques to the MAIN HERB/VEGETABLE GARDEN:

In the main vegetable/herb garden:

- Gathered soil samples, per instructions by O.S.U. Extension Agent & had it analyzed.
- Made appropriate soil amendments -- sustainable agriculture helps in this project
- Tried straight row gardening, to include wide raised beds
- Mediocre results – good enough, but the feel wasn't right; no creative energy going on.
- Couldn't actually terrace the hillside (timbers or rock) – I'm the only worker & it's beyond my capabilities....Needed something simple—something cheap -- & preferably, something recyclable: TIRES
- Meditated on not only how to conserve the soil & solve the washing problem, but also how to improve the energy dynamics of the garden: Solution: combine tires with geometry!

Solution for the main garden:

- No straight rows – create a spiral & incorporate the tires, timbers, gravel & rocks along the way – specific to needs & aesthetically pleasing.
- I had already been working with labyrinth designs, so the garden spiral was perfect.

The main herb/vegetable garden is on a hillside facing Northeast, running downhill. (From asparagus row to the far end, the area measures 60' x 35')

- There are a few straight rows coming off the top of the hill (blackberries & asparagus) comfrey, chives, lavender & sage transition into the spiral.
- It is an earth sculpture: mounding the soil along the spiral row for seed beds, and/or mounding the soil around perennials (e.g., sage row) to hold in the water & prevent it from rolling downhill. The path may actually be sunken in some places.
- Wherever needed, the row is lined with timbers, rocks, or tires.
- Center = focal point; herbs & cottage garden flowers, with stump & rock. Sitting area.
- Tiller can be navigated down the paths & around the turns with enough room in the focal point to turn around & till your way out.

The main garden is accessible to family, friends, & the public for cutting & harvesting fresh herbs.

In a photo of a new spiral garden I'm working on at Moonshadow. It spirals out from a native cedar tree (anchor) on the side of a hill. It will be a child's meander theme garden.

I will use black rubber edging to keep the grass out & will plants low growing herbs & flowers. Rocks & mulch will also be used. It should be very low maintenance.

Meander patterns I am considering for herb gardens:

- First is what is called the 'spinning meander cross.' The top pattern could accommodate a sundial, birdbath, statuary, etc. A good example of this pattern is at the Huntingon Art & Botanical Gardens in San Marino, CA.
- Next is 'Vesica Triangle.' You have seen it in many Celtic designs. This design integrates body, mind & spirit. Its energy is relaxing, peaceful, & spiritual.
- Both of these patterns are based on sacred geometry principles, which (in part) deals with phi ratio. This is why these patterns are proven to be soothing to the human psyche -- because the human body is also based on phi ratio.

Summary

- Observe the ley of the land in its natural state & plan the garden design working in partnership with nature.
- Use standard methods of soil amendments & mulching, along with natural elements to form borders, barriers, berms.
- Choose an interesting garden design that will help to conserve the soil & retain the soil.
- Be creative! Don't stand outside of the Looking Glass – create an interactive garden that you can walk through & directly experience – step through the Looking Glass into your own space & time – your own sacred space – working in partnership with nature to preserve & conserve the soil & environment.

Quote from Lewis Carroll's Alice Through the Looking Glass:

"Oh Kitty! How nice it would be if we could only get through into the Looking-glass (House)! I'm sure it's got such beautiful things in it!"

Soil Biology: Compost, Humus Management, and The Living Soil

Steve Diver
Appropriate Technology Transfer for Rural Areas (ATTRA)
Fayetteville, Arkansas

Farmers like to talk about soil and describe its characteristics: tilth, texture, fertility, porosity, water holding capacity, organic matter content, and so on. The capacity of a soil to support plant growth and buffer the flow of water, nutrients, and energy through an ecosystem—understood through an evaluation of these soil characteristics—is known as soil quality.

In Maryland, soil scientists with the Extension Service and NRCS asked farmers to describe soil quality characteristics in their own words. The *Maryland Soil Quality Assessment Book*, a pocket guide used to record field observations, was published as a result. I like the way it makes soil quality feel more tangible. Here are two examples:

> Regarding **Water Holding Capacity**, farmers rated soils poor if plants stress two days after a good rain. They said good soils hold water for a long period of time without puddling.
>
> Regarding **Soil Tilth**, farmers used terms like "mellowness" and "friability" to describe good soils. They said good soils crumble well, can be sliced through like cutting butter, and are spongy to walk on. Farmers said poor soils look dead and seem cloddy like bricks or concrete, and are hard to pull a drill through.

Another good indicator of soil quality is root growth. In 1989 I attended a sustainable agriculture field day at the farm of Del Akerlund, one of the oldest practicing organic farmers in the state of Nebraska. Akerlund pulled corn plants out of the ground to examine the root balls and compare management practices employed on different fields. One corn plant had a nice, big root ball. The second root ball was noticeably smaller. These plants were grown in adjacent fields on the same soil type. The observed difference was due to organic farming management on Del Akerlund's farm and conventional farming management on his neighbor's farm.

Comparison of Farming Practices in Relation to Appearance of Corn Roots	
Organic	**Conventional**
• Rotation	• Monoculture
• Cultivation for weed control	• NPK-lime
• Cover crops	• Herbicides
• Green manures	• Insecticides
• Composted paunch manure	

Upon digging through the root balls we found crop residues present from two and three previous growing seasons under the stalk of the conventionally raised corn. This is a sure sign of poor soil biological activity. The biggest difference between these two farming systems was attention to soil organic matter and associated soil life.

Dr. Fred Magdoff, soil scientist at University of Vermont as well as author of *Building Soils for Better Crops*, refers to organic matter as the living, the dead, and the very dead. The living portion, or the soil biomass, includes bacteria, fungi, actinomycetes, nematodes, insects, earthworms and plant roots. The dead portion, comprising crop residues and the byproducts of soil biota, is the active organic matter or particulate organic matter that decomposes fairly easily, thus supplying food and nutrients to soil organisms. The very dead portion is well decomposed organic matter, or humus, which is fairly resistant to further decay. Typically, organic matter comprises from 1 to 6% of agricultural soils, and 60 to 80% of that is humus; 10 to 20% is active; and 10 to 20% is living biomass. Some farmers refer to the active components of soil organic matter as their "checking account," and soil humus as their "savings account."

Humus is the sponge-like form of soil organic matter that plays a critical role in soil structure, water holding capacity, and cation exchange capacity, or CEC. Selman Waksman, the famous soil microbiologist who discovered that actinomycetes produces antibiotics like streptomycin, said that "among the important aspects of humus in the soil, the most significant is its interaction with the clay constituents, which give rise to clay-humus." Under a microscope, clay-humus can be seen as the crumb structure of soils full of "nooks and crannies." Most importantly, clay-humus crumb provides food and shelter for soil microbes. Clay-humus is critical in plant nutrition because this organo-mineral complex is negatively charged and holds soil minerals like calcium, magnesium, and potassium.

Humus Management

- **Biological Farming Practices:**
  Cover crops, rotations, compost, tillage system, manures, microbials
- **Purpose:**
  Food and Home for soil creatures
  Clay-humus crumb
- **Applied Principle:**
  Soil Foodweb

Humus management is a term that refers to biological farming practices such as crop rotations, cover cropping, green manuring, composting—in combination with proper tillage—intended to maintain soil organic matter, provide food and shelter for soil creatures, and build the clay-humus crumb structure in soils. The applied principle of humus management is the *soil foodweb*. The clay-humus crumb is an architectural masterpiece of Nature, built by soil microbial engineers like bacteria and fungi. You cannot have clay-humus crumb without the soil foodweb, and you cannot have a decent home for soil creatures without humus management.

Crop rotations are commonly practiced by farmers as a mechanism to interrupt disease, insect, and weed life cycles. Yet, old USDA bulletins refer to "soil building" and "soil depleting" crop rotations. Row crops, on wide row spacings, tend to deplete the soil. Rotating the land to

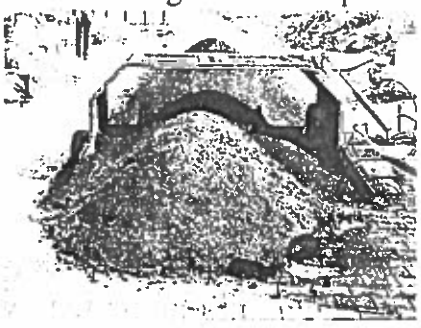
Crop Rotation Effects on Soil

Soil Depleting
Row crops
Soil Neutral
Cereal crops
Soil Building
Sod crops
Grasses
Forage Legumes

pastures for grazing and haying is a soil-building process because grasses and forage legumes form a tightly knit sod that protects the soil. Grass family roots are also known to "slough" off and deposit organic matter directly into the soil, a major reason native prairie soils are so high in organic matter.

Compost—rich in organic matter, microbial life, and humic substances—is *the* premier soil amendment. However, compost and especially high quality, premium grade compost is often in short supply. That is why farm-grown green manures are such an important source of organic matter on many farms.

When fresh, undecomposed organic matter (green manures, animal manures, crop residues) is added to soil or to a compost pile, an extremely rapid multiplication of soil microorganisms takes place. Certain microbes (bacteria, fungi, and actinomycetes) break this raw organic matter down into particles (gums, waxes, lignins) resistant to further decay and simple organic compounds (sugars, amino acids) that are water soluble. Using these simple compounds as building blocks, a second group of microbes binds these materials together, especially lignins and microbial biomass, into stable humic substances (fulvic acid, humic acid, humins). Humification is the process whereby raw organic matter undergoes a decomposition or *break down* phase, and through biological transformation, undergoes a repolymerization or *build up* phase, ultimately complexed as humic substances.



Improvements to compost quality are obtained primarily through proper management of moisture, temperature, and aeration. A compost turner is essential for larger farms and compost facilities. Amending the compost windrow with clay, at 10% by volume, is a practice Austrian farmers employ in a system known as Controlled Microbial Composting. In addition, they use compost covers or compost fleece, a polywoven fabric material. In many European countries farmers are required by law to cover compost windrows and manure piles to prevent leaching of nutrients and to promote good quality compost. A compost fleece sheds rainfall and modifies the compost environment in favor of microbial engineering. Compost inoculants are not used to "start" a compost pile, they are used to promote humification, enhance disease suppression, and moderate temperatures swings.

Composts and compost teas are a rich source of beneficial microbes that farmers use to inoculate the rhizosphere (root surface) and phyllosphere (leaf surface). Compost tea production is an aerobic brewing process that extracts microorganisms from compost followed by microbial growth and multiplication. When compost teas are sprayed onto the leaf surface, these *beneficial organisms* occupy *spatial niches* on the leaf surface and gobble up *leaf exudates* that pathogenic organisms would otherwise feed on to prosper; other microbes directly interfere with *pathogenic organisms* through *antagonism.*

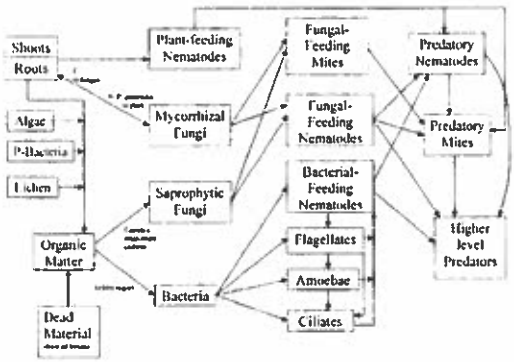
The edaphon is the living soil. Soil creatures either "stay put," swim, crawl, or burrow. Typical habitats include crevices, channels and pores left from old roots, the rhizosphere, and micro-aggregates and biofilms.

Two resources on soil life that have received wide acclaim from organic farmers around the country include:

1. *Life in the Soil*, a 30-minute video from Mokichi Okada Association in Japan.
   See: Nature Farming and Effective Microorganisms
   http://ncatark.uark.edu/~steved/Nature-Farm-EM.html

2. *Soil Biology Primer*, a 50-page booklet from USDA-NRCS
   http://www.statlab.iastate.edu/survey/SQI/

The soil food web is the community of organisms that live in the soil and feed on organic matter residues, and since it is akin to a food chain, they also feed on each other. A food web diagram shows a series of conversions of energy and nutrients as one organism eats another organism. Looking at all the functions of soil organisms and their collective impact provides increased understanding of the vital role a healthy, complex soil foodweb plays in agriculture: shredders, graziers, decomposers, mutualists, fungal-feeders, bacterial-feeders, predators, ecosystem engineers.



Soil foodweb diagram by Elaine Ingham, www.soilfoodweb.com

In organic farming there is a focus on feeding the soil to enhance soil quality and produce good crop yields. Attention is paid to organic matter additions as well as mineral supplementation in the form of rock mineral fertilizers to produce abundant crop yields. A goal of soil and fertility management is a healthy plant that possesses the inherent capacity to ward off disease and insect pests and produce nutritious, flavorful produce.

One of the easiest ways farmers can grasp food quality is to use a refractometer, also known as a Brix meter, to measure soluble solids (sugars and amino acids). Rex Harrill, an eco-farmer raising blueberries in Maryland, maintains a website on Brix and refractometers. It provides a wealth of information on the refractometer : How to use it; Brix charts for fruits and vegetables; Brix as an indicator of food quality.

Using a Refractometer to Measure the Quality of Fruits & Vegetables
http://www.crossroads.ws/brixbook/BBook.htm.

My home page, Rhizosphere II, contains documentation and resources on a range of topics relating to composting, compost teas, humus management, and soil biology:

Rhizosphere II: Publications, Resource Lists, and Web Links from Steve Diver
http://ncatark.uark.edu/~steved/index.html

Appropriate Technology Transfer for Rural Areas (ATTRA)
http://www.attra.ncat.org

Why Plant a Cover Crop?

Bill Farris
Prairie Wind Growers Inc., Noble, Oklahoma

Erosion Control

Farmland is most susceptible to erosion when there is no vegetative cover or plant residue on the soil surface. A cover crop will provide a vegetative cover during periods when a crop is not present to deflect raindrops, which can disturb soil and make it more prone to erosion. It will also slow the rate of run off, which not only helps prevent washing but improves moisture infiltration into the topsoil. A cover crop will also prevent the wind from drying out and picking up surface soil particles.

Organic Matter

Cover crops and green manures add organic material to the soil. Organic matter is an important component of topsoil. The stable broken down form of organic material is known as humus. When green manure crops are incorporated into the soil, organic matter is one of the products of their decomposition. Maintaining a high level of organic matter is critical to maintaining long-term productivity.

Improved Soil Structure and Tilth

Organic matter can act as a cement to bond some soil aggregates and can loosen tight clay soils. This will make soils more permeable and increases aeration, which in turn, makes crop emergence easier and promotes root growth.

Nitrogen Fixing

Any legume (a plant such as a bean or pea) has the ability to fix nitrogen from the air. This nitrogen remains in all parts of the plant. The longer a legume is grown the more nitrogen it can store. Many perennial legumes can be harvested for hay or forage and then be allowed to grow back before being plowed down. Also, some perennial legumes have very deep root systems, which help to break up hard pans and allow more water and air into the sub soils.

Recycling of Unused Nutrients/Catch Crops

Nitrogen is a very mobile nutrient and tends to leach with heavy rains in fall, winter and early spring. Some of this nitrogen can be taken up by a winter cover crop and recycled by a cash crop after the cover crop is turned under and begins to decompose.

Weed Suppression

Fast growing cover crops and green manures will outgrow many weed competitors. Weed seeds can lie dormant for many years until the proper conditions for germination are present. If the cover crop is faster growing than the weeds, the cover crop will suppress and/or shade out the weeds.

Soil Testing

Sherman Grubb
Creek County Extension Educator,
Agriculture/4-H Youth Development

The following fact sheet was discussed on how to test your soil.

OSU Extension Facts - F-2207 - How to Get a Good Soil Sample

Hailin Zhang
Director
Soil, Water and Forage Analytical Laboratory

Gordon Johnson
Nutrient Management Specialist

Soil tests provide a scientific basis for evaluating available plant nutrients in cropland, pastures, lawns, and gardens. Analyses of soil samples can help farmers and homeowners fine-tune nutrient applications from fertilizers, biosolids, and animal manure. Properly managing the amount of nutrients added to the soil can save money and protect the environment.

Soil nutrients vary by location, slope, soil depth, soil texture, organic matter content, and past management practices, so getting a good soil sample stands out as a major factor affecting the accuracy and usefulness of soil testing. This fact sheet outlines some specific considerations which should be taken into account to get the greatest benefit from soil testing.

Sample Soil at the Right Time

Fields used for production of cultivated crops may be sampled any time after harvest or before planting. Generally, two weeks should be allowed for mailing, analysis, and reporting of results. Additional time may need to be allotted for ordering and application of fertilizers, manure, or lime materials. Noncultivated fields should be sampled during the dormant season. In either case, do not sample immediately after lime, fertilizer, or manure applications because those samples do not represent the true soil fertility.

Fields should be tested annually to measure the available nitrogen pool or as frequently as necessary to gain an understanding of how soil properties may be changing in relation to cultural practices and crop production.

Collect a Representative Sample

Getting a representative sample is simple, but not easy. Research at OSU and other universities has clearly shown that a minimum of 20 cores or small samples taken randomly from the field or area of interest are necessary to obtain a sample which will represent an average of the soil in the field (Figure 1). These cores should be collected in a clean plastic bucket (to avoid metal contamination) and mixed thoroughly by hand. The

sample bag should be filled from the mixture. A one pint (OSU soil sample bag full) sample is usually adequate for all tests which might be required. If the sample is too wet to mix, it should be spread out to dry some and then mixed, or sampling should be delayed until the field is drier.

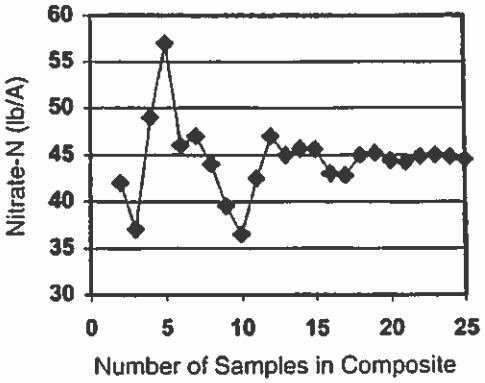


Figure 1. The minimum number of core samples needed to make a representative composite sample is about 20.

It is important to remember that the sample obtained by the above procedure will be an average of the area sampled. If the area sampled is extremely variable in the soil properties which are going to be tested, then it may be better to separate the field into smaller areas, and get a representative (20 cores) sample from each of these areas in order to determine how variable the field is (Figure 2). In this way, it may be possible to treat some areas of the field differently from others and remove variability so that the field can be sampled and treated as a unit in the future. Variability in a field can often be noted by differences in surface soil color and crop growth or yield.

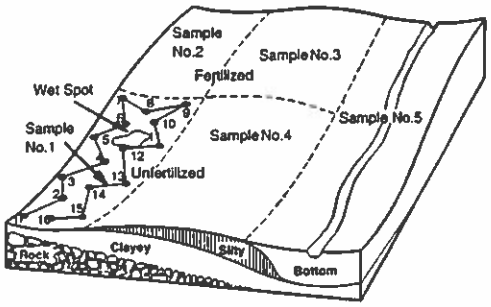


Figure 2. Divide field into uniform sampling areas and follow a random pattern when sampling. Avoid unusual spots and try to obtain a representative sample.

Using only one sample for a large variable field can be very costly. Since the sample represents an average of the soil in that field, recommendations based on the soil test will likely cause the field to be overfertilized on some parts and underfertilized on other parts. Failure to obtain uniform response to treatments based on a soil test is frequently a result of one sample being used to represent a large variable field.

An example of field variability is shown in Table 1. The range of test values was obtained by testing 40 individual cores taken at random from an "apparently uniform " 80-acre field. The variation is great enough so that for some analyses the average is not a good representation of the field. Areas of the field with the lowest pH, phosphorus, and potassium values will not receive adequate lime or fertilizer if recommendations are based on the average test values.

Table 1. Variability of an 80 Acre Field Based on Soil Tests of 40 Individual Soil Cores .

	Soil Test Values	
Analysis	*Range*	*Average*
pH	4.9-6.3	5.6
BufferIndex	7.1-7.4	7.3
Nitrogen	1-34	11
Phosphorus	23-114	36
Potassium	149-770	306

A single core sample, or spadeful, is extremely risky because it may test anywhere in the range shown for each of the analyses. For example, deficiencies for wheat could range from zero to 37 pounds of P_2O_5 and zero to 34 pounds of K_2O. For alfalfa, which has much greater nutrient requirements, deficiencies could range from zero to 94 pounds of P_2O_5 and zero to 120 pounds of K_2O. This would also affect the amount of nitrogen and lime required. Obviously, unless the 80 acres is divided into less variable units for testing, some areas of the field will receive either too much or too little fertilizer and lime.

In deciding how large an area can be represented by one composite sample (20 cores), the determining factor is not the number of acres involved, but rather, the variability of the area. Some large, uniform fields can be represented well by a single 20-core sample, while some highly variable fields need to be split into two or more smaller areas for testing. Regardless of the field size or main area being sampled, unusual spots in the field (salty or wet spots) should be avoided during the initial random sampling. When unusual spots make up a significant area, they should be sampled separately.

Sample at Proper Depth

Cultivated Fields

For most soil tests the sampling depth is the tillage depth. The reason for this is because most crops have their greatest root activity in the tillage depth. Obtaining a representative sample with regard to depth means that each of the 20 cores taken from an area should be from similar depth, tillage, or six inches. Soil tests are generally calibrated

on the basis of an acre furrow slice, approximately two million pounds of soil in the top six inches.

For deep-rooted nonlegumes such as wheat, bermudagrass, sorghum, and cotton, a separate sample representative of the subsoil should be taken in addition to the tillage depth or six-inch sample. This subsoil sample should represent the layer of soil from 7 to 24 inches below the surface. Because nitrate-nitrogen is mobile in the soil, a test of available nitrogen (and/or chloride and sulfate) in the subsoil sample will provide a more complete picture of available mobile nutrients for these crops (Figure 3) and can save fertilizer expenses.

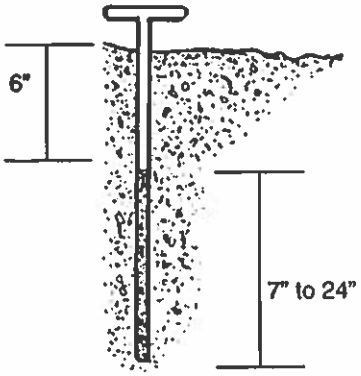


Figure 3. A soil probe is a good tool for obtaining soil samples. Push the tube to the six-inch depth and remove the core. Then take the seven to 24-inch core through the same hole for the subsoil test.

No-till Fields

Noncultivated fields should be sampled to a depth of six inches, again because this is the effective depth of most treatments and the depth of most root activity. Nutrients from fertilizer, animal manure, and lime can be accumulated on the surface if they are surface applied without incorporation. A set of samples from the top two inches will help identify stratification of nutrients and is especially important for pH determination for no-till fields. If nutrient loss in runoff is the main concern, the two-inch sample is better than a six-inch sample because only the surface inch or two is in direct contact with surface runoff.

Salinity Diagnosis

When salt accumulation is suspected as a cause of poor stand establishment and the sample is being taken after planting, then the depth of sampling should approximate the seeding depth (one to three inches). This is especially important when conditions have been favorable for soluble salts to move upward and accumulate near the surface after planting. Since excess salts are most harmful to germination and seedling vigor, it is this shallow depth which should be tested. At other times during the year, a sample of the entire tillage depth may be most useful to test for salt accumulation.

Send Samples for Analysis

Soil sample bags are available at local county Extension offices. Extension offices will mail your samples to the OSU Soil, Water and Forage Analytical Laboratory and assist you to interpret test results.

Herbs and Soil Conservation

Richard Frost,
Frost farms,
Noble, Oklahoma

Whether caused by rain, wind, or man, the soils of Oklahoma are on the move and if we don't protect it the loss could be astounding. The USDA estimates that unprotected farmland in central and western Oklahoma could lose 4 tons or more of soil per acre per year, northeast Oklahoma, including the Tulsa area, could lose 2 to 4 tons per acre per year. The estimated loss for the rest of eastern Oklahoma and western Arkansas is less than one ton per acre per year[i]. I know this is unprotected land, which none of us have, right, but it is an indicator of just how mobile our soil can be.

Rain causes many types of erosion, but, for our purposes today we will discus splash and sheet erosion [ii]. Splash erosion occurs when large raindrops hit the soil and knock the soil particals apart. To fight this type of erosion we just need to cover the soil. This can be done with landscape cloth, mulches, crop residue, or ground covers. Many herbs make great ground covers. Here are just a few:

Common name	Botanical name
▪ Crown Vetch	*Coronilla varia*
▪ Creeping thymes	*Thymus ssp.*
▪ Lady's Bedstraw	*Gallum verum*
▪ Red Clover	*Trifolium pratense*
▪ Germander	*Teucrium chamaedrys*
▪ Sweet Grass	*Hierochlie odorata*

There are many more, almost any creeping herb will make a good ground cover.

Sheet erosion occurs when the soil becomes saturated and the water runs off, carrying soil with it. To fight this type of erosion we need a plant with thick fibrous roots to hold the soil together. Most ground covers have this type of root as well as the following herbs:

Common name	Botanical name
▪ Alfalfa	*Medicago sativa*
▪ Oats	*Avena sativa*
▪ The Monardas	*Monarda ssp.*
▪ Most Sages	*Salvia ssp.*
▪ Sandbar Willow*	Salix *exigua*
▪ Chaste Tree	*Vitex agnus-castus*
▪ Kentucky Coffeetree*	*Gymnocladus dioicus*

Note: * denotes plants which can help fill in gullies. Again this is just a few herbs that will help with soil erosion.

We have all heard stories about the Dust Bowl but most of us are too young to have experienced it. But, anyone who has put up a fence and watched it get shorter each year has experienced wind erosion. Like water erosion the wind affects bare soil the most, so covering the soil will help us fight wind erosion. Another defence against wind erosion is to plant a barrier to the wind, which will reduce its speed downwind; these barriers are called windbreaks. The taller the windbreak the larger the area of protection is.[iii] Here are a few herbs that can be used to plant windbreaks:

Common name	Botanical name
▪ Junipers	*Juniperus ssp.*
▪ Rosemary	*Rosemarinus ssp.*
▪ Sunflowers	*Helianthus annus*

Sunflowers or even oats can be used as a temporary windbreak. Normally two rows of evergreens are planted to give the windbreak more density.

Man causes erosion by altering the land and leaving bare soil exposed to rain and wind, and by poor use of paths, roadways, and chemicals material. I'm afraid herbs wont stop men from these bad habits, but, one will help de-tox our soil, Dandelion (*Taraxacum officiale*), this herb will grow in soil that is toxic to other plants and over time it will cleanse the soil.

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[i] "Estimated Average Annual Rate of Soil Erosion if Farmers Used No Conservation Systems, 1992" USDA NRCS Map ID 2123

[ii] "Soil Erosion By Water" USDA Soil Conservation Service, Agriculture Information Bulletin No. 513

[iii] "Soil Erosion By Wind" USDA Soil Conservation Service, Agriculture Information Bulletin No. 555

Farmer's Market/Sustainable Agriculture Session

Better Crops Through Soil Conservation

Cover Crops and Their Many Uses

Doug Walton

My thanks to Sharon Messner and the members of the Oklahoma Herb Growers and Marketers Association for inviting me to talk with you today about one of my favorite topics. First, I'll just give a little background about myself, and where I'm coming from. Then, we can begin by considering exactly what cover crops are, and look in some detail at many of the benefits of using cover crops. Next will be a listing of some possible downsides of cover crops, then I hope to spend the remainder of our time discussing the use of various cover crops within the garden and market farm setting.

My family and I have an 8 acre farm just south of Muskogee, with less than a half acre in vegetable and herb production. We've been selling produce at the Muskogee Farmers' Market for the past three years, as well as selling fresh herbs to a local restaurant. Between home gardening, working on other farms and on my on farm, I've been playing with cover crops for about eight years. One thing I'll be telling you a little about is a research project that I've undertaken on our farm. We're currently in the midst of year 2 of a 3 year producer grant from the Kerr Center for Sustainable Agriculture. I've been fortunate to have collaboration with researchers from USDA-ARS and OSU to evaluate sixteen different cover crops and their suitability for use in limited tillage vegetable (and herb) production.

To start off, let's ask ourselves just what are cover crops anyway? One could say that a cover crop is essentially any crop that is grown in order to provide cover and protection of the soil. Many people use the term "green manure" interchangeably with that of "cover crops." But perhaps more technically, a cover crop becomes a green manure when the purpose of the cover crop shifts from merely protection of the soil to some other function(s) such as the provision of nutrients and/or organic matter. This would usually occur through the incorporation, or turning under, of the green manure but not necessarily. These purposes could also be achieved from a reduced tillage cropping system. In any case, the practice of using plant material, whether alive or dead, for providing cover and improving soil conditions is not a new one. Written accounts from ancient Chinese text indicate the use of green manures as long as 3000 years ago.

In defining cover crops, we've already mentioned some characteristics that bring about the many **benefits of cover cropping**. Some benefits are fairly straightforward and obvious, while others are quite interrelated and rather complex. By simply covering the soil, the following two benefits can be gained:

1. Reduction of erosion from wind and water.

2. Protection of surface soil structure from crusting caused by rain and sun.

These other benefits can be realized from the below ground activity during the growth or decomposition of the cover crop:

3. Addition of organic matter – This doesn't necessarily mean there will be an overall increase in the percentage of organic matter in the soil. This depends on variables such as the carbon to nitrogen ratio (C:N) of the cover crop, the amount of tillage, soil moisture, and the air and soil temperature following the termination of the cover crop. Concerning the C:N ratio, a mature cereal cover crop such as sorghum-sudangrass or winter rye can produce a significant volume of organic matter and will be more likely to contribute to soil organic content than would most leguminous species of cover crops. Although, a few summer annual legumes such as lablab and crotolaria, as well as some of the vining forage varieties of soybeans can cowpeas can also put on notable growth, given adequate conditions.

4. Improvement of soil structure – The rooting action of cover crops can create channels to help aerate and loosen hard, shallow soils. The decomposition of plant and root material can cause the formation of compounds in the soil that help to bind, or glue, soil particles into aggregates. These aggregates show up in what we often call a friable or crumbly soil. Soils of this nature tend to have a relatively high capacity to hold water internally.

5. Providing nutrients for soil life and for future crops – Nutrients from cover crops become available to soil and plants through mechanisms such as the decomposition of plant tissue, fixation of nitrogen by leguminous plants, and the accumulation of other nutrients by certain deep-rooted legumes and other cover crop species.

6. Weed suppression – Many cover crops can out compete weeds through smothering and shading out or by hoarding soil moisture. One good example is the use of sorghum-sudangrass to eradicate bermuda prior to bringing new ground into garden production. The tall growing sudangrass puts on huge growth and uses moisture at the same time that the bermuda needs the sunshine and water for its summer growth, thus greatly hindering the life cycle of the bermuda. Another weed suppressing mechanism that certain cover crops utilize is that of allelopathy, whereby chemical compounds are released by plants such as rye and oats that can inhibit the germination of certain weed seeds.

7. Pest control – Many cover crops provide natural habitat for beneficial, predatory insects, such as ladybugs, lacewings, mantids and parasitic wasps. If allowed to thrive, many of these creatures will seek out their food sources, most of which are common garden pests, within areas adjacent to their habitat.

Some of the **possible downsides of using cover crops** include the following:

1. Extra work as compared to doing nothing.
2. Consumption of soil moisture needed for later crop production.
3. Tying up of soil nitrogen due to excess carbon from fibrous cover crop residue.
4. Require proper soil conditions for incorporation prior to planing main crop.
5. Allelopathy with very small seeded crops such as carrots, lettuces and onions.
6. Weed problems from allowing certain cover crops to develop seed.
7. Attraction of some insect pests to particular cover crop species.

Now that we've covered many of the reasons for considering cover crops for use in the farm or garden, I'd like to open a discussion surrounding the topic of when and where to use which cover crops. A good place to begin is by asking yourself "what niches in place and time do I have available to be filled?" If your main window is in the winter, then it is likely you would want to consider the many winter annual cereals and legumes that grow well in our area. The cereals primarily include winter wheat, rye and barley and some hardy oat varieties. The legumes include vetches, clovers and winter peas. These are all plants that are best planted in mid September in northeast OK. They will establish and grow minimally in the fall and winter months and then put on significant top growth as the days lengthen and warm in the spring.

If your main window(s) comes during the late summer or early fall, then you might consider some of the summer annual cereals and legumes which perform well in Oklahoma. These cereals include sorghum-sudangrass and foxtail millet. The legumes are those such as cowpeas, soybeans, crotolaria, and a few other less common species. Another important candidate to consider is buchwheat, which is a non-leguminous broadleaf plant that grows very rapidly in warm conditions. All these summer annuals are usually planted during May and June in Oklahoma, but my research is studying how well some of these perform when planted in July and August. Perennials are another category of plants from which to select cover crops. Because they normally take more time and effort to establish, cover crops such as perennial clovers and alfalfa work best when an area is to be occupied for a year or more.

Cover Crop Resources

Books

Feed the Soil. 1982. Edwin McLeod. 8855 Kenberton, Oak Park, MI 48237.

*Green Manuring:Principles and Practice.*1927. Adrian J. Pieters. John Wiley & Sons, New York, NY.

Managing Cover Crops Profitably, 2nd Edition. 1998. USDA-SARE, Sustainable Agriculture Publications, Hills Building, Room 10, University of Vermont, Burlington, VT 05405. (www.sare.org)

Northeast Cover Crop Handbook. 1994. Marianne Sarrantonio. Rodale Institute, 222 Main St., Emmaus, PA 18049. (www.rodaleinstitute.org)

The Rodale Book of Composting: Easy Methods for Every Gardener. 1992. Deborah L. Martin and Grace Gershuny (eds.) Rodale Press, 33 Minor St., Emmaus, PA 18098.

Other

Cover Crops and Green Manures. ATTRA Information Packet. Appropriate Technology Transfer for Rural Areas, Fayetteville, AR. (1-800-346-9140)

Cover Crops for Soil Improvement in Horticultural Crops. Alan Ware. Publication H1100. The Kerr Center, PO Box 588, Poteau, OK 74953. (www.kerrcenter.com)

Green Manures: A Mini-Manual. Research Dept., Johnny's Selected Seeds, Foss Hill Rd., Albion, ME 04910. (www.johnnyseeds.com)

Seed Sources (Check local farm Co-op first)

Adams-Briscoe Seed Co., PO Box 19, Jackson, GA 30233. (770)775-7826, (abseed@juno.com)

Johnny's Selected Seeds, 305 Foss Hill Rd., Albion, ME 04910. (207)437-4395, (www.johnnyseeds.com)

Peaceful Valley Farm Supply, PO Box 2209, Grass Valley, CA 95945. (888)784-1722, (www.groworganic.com)

Onion Production and Variety Selection

Jim Shrefler
Oklahoma Cooperative Extension Service

Biography: Jim Shrefler joined Oklahoma State University in 1995 as Area Extension Horticulturist at the Lane Agriculture Center. He received a Ph.D. degree from the University of Florida in 1993, an MS degree at Louisiana State University, and BS degree at The Ohio State University. He resides with his wife, Carmen and son, Lawrence, in Durant, Okla.

Onion is not currently considered a major crop in Oklahoma. However, onion is often found in home and market gardens. Many agricultural producers are in search of viable crop alternatives and onion is one that has been considered by some growers in recent years. During the past several years efforts have been made to establish a production system for bulb onions that would be suitable for commercial purposes. One means of producing onions in Oklahoma is to set transplants in the field during February or March. Onion production methods and procedures have been sought that would produce a commercially acceptable crop and minimize pest losses and labor requirements.

Onions are being grown on a raised beds. A row spacing of about three feet is being used for several reasons. This makes it possible to cultivate the onions with standard row crop cultivation equipment such as sweeps and rolling cultivators. Mechanical transplanters are being used to set plants. Because of the spacing of the planter units, two rows can be planted simultaneously on a three foot spacing. Without major equipment modification, it is not possible to plant rows any closer. Two different bed sizes have been used. A five feet wide bed has been used with two onion rows on the same bed. Narrower beds on three foot wide spacing have been used with one onion row per bed. One important reason for the raised be it to aid in surface drainage. Heavy rainfall anytime during the crop cycle can be detrimental. Without drainage, ponded water could be damaging to the crop. Disease incidence has been greatest in areas of the field where drainage was poorest.

Weed control is important in onion production. Control measures have included the use of preemergence herbicides and cultivation. Generally there is not much new weed germination at the time of transplanting. For this reason preemergence herbicides have been applied several weeks after planting. Sometimes this is done after a cultivation if soil is crusted by rainfall. OSU Current Report 6008 Weed Control In Vegetables shows which herbicides are approved for use in onions in Oklahoma.

Soil fertility has been managed by using a soil test and fertilizing bases on OSU soil fertility recommendations provided in Fact Sheet F-6000, Fertilizing Commercial Vegetables. Phosphorus, potassium and part of the nitrogen are applied as a broadcast during soil preparation and mixed into the soil. The remainder of the nitrogen has been

applied at as a side-dress several weeks after planting. We do not have a good guide as to how much nitrogen to use. Since nitrogen is important for good bulb size it is important not to under fertilize. Nitrogen sidedress can be applied with a fertilizer wagon. If applied after cultivation fertilizer will not roll off of the beds.

Insects have not been a major problem so far. Small numbers of caterpillars and cucumber beetles have been observed at times but injury has been minimal and probably not of economic concern. Thrips are a major pest of onion in many production areas. Although not observed in great numbers so far, there have been some thrips and insecticide has been applied. Onion growers should watch for this insect and be prepared to take action to prevent possible outbreaks.

One source of transplants is plants that are field grown and sold bare rooted. These plants are produced at lower latitudes than Oklahoma, one major source being south Texas. Producers who use this plant source are dependent on the varieties that are marketed by transplant producers. There has not been much variety evaluation of transplanted onions for Oklahoma in recent years. Variety evaluations were conducted in 2001 to evaluate some onion varieties that are available as bare rooted transplants. The results of these trials are presented in the Oklahoma State University 2001 Vegetable Trial Report. As a brief summary follows. Two trial were conducted. At Calvin, OK, onions were planted March 21 and harvested June 24. At Lane trials were planted March 22 and harvested July 8. Plants were grown as discussed in this paper with plants spaced 6 inches apart in the row. At Calvin, where onions were harvested earliest, varieties that performed best were Yellow Granex, Walla Walla, White Granex, and 1015Y giving the top four yields. At Lane, the top yields were for Candy, Walla Walla, Big Daddy and Yellow Granex. Candy and Big Daddy are intermediate daylenth type varieties. It may be that these would have yield more at Calvin if given more growing time in the field.

'E'nnovative Marketing

Paul and Allison Wiediger

Everything you read these days is 'e' this and 'e' that. E-commerce is something most medium to large businesses will have to embrace to stay in business. As a market farmer, you may have decided that e-commerce is not important to your business. After all, you have a very perishable product, and you probably deal with your customers face-to-face at least once a week during the 'season'. However, some facets of e-marketing could increase your market share – maybe significantly.

We are market growers. We run a certified organic farm that includes year-round produce, cut flowers, potted perennials and herbs, and grass finished beef and lamb. We have always marketed our production direct to the consumer, mostly through a Farmers' Market. However, when we started marketing our winter produce a few years ago, we had to find a different way. Our Farmers' Market is open May through October, and our winter produce is best October through May.

We began with a small core group of customers in the same neighborhood in a nearby large town. One of our summer customers put the group together, and we delivered a bag of winter produce every Saturday morning to their neighborhood. These customers are people with very busy schedules, so we put together a standard bag – whatever was available, similar to a CSA. The orders averaged about $10 a bag. The problem that arose was that some people like more spinach, some like more leaf lettuce, some like more mesclun, some like greens, some don't, etc., etc.

Customers told friends about us, and they told more friends about the fresh, organic produce available locally. The list of customers continued to grow. We decided to give our customers a chance to order what they wanted, and began calling each week with a list of available items.

Remembering that these are mostly very busy people, there were some problems with our methods. The first is actually reaching them by phone. We also found that an answering machine is not a foolproof way to reach them, especially if there are children in the house. The second problem is the length of the list of available products. Just think about it. If I called you and said: "Hi, this is Paul. We have available for Saturday's delivery, mesclun in 1 and 1/2 lb packages, spinach, red and green Romaine lettuce, red and green leaf lettuce, red and green bibb lettuce, Deer Tongue lettuce, red and green mustard, Red and White Russian Kale, turnip greens, beet greens, arugula, bunching onions and carrots." Along with prices. Whew!! Most people bought 2 or 3 items, whatever they could remember at the end of the list. The average order was $8.00-$10.00.

Obviously, there had to be a better way to reach our customers. Now, Alison has 22 years experience working in the computer field, and we didn't even own a computer. But, she uses one at work every day and knew the possibilities. So, we started asking who had email access. Turns out, all of our customers did, and were very positive about being

contacted that way. We mulled it over, decided the business was demanding that we purchase one, and in late November 2000, we bought one and contracted for Internet access. We immediately put together an email distribution list of all our customers and started sending out email for our weekly orders. The response was amazing! We got orders from more people, and the average order increased over 50%! What a rush! And, the customers loved it. Rather than waiting on a call, they can look at their email at their leisure, see the whole list rather than trying to remember it, and reply to it after thinking about it. So how does it work?

Well, first you have to get email addresses for interested people. We do a lot of that during the summer. When someone tells us how much he or she loves our produce at the Market, we explain our winter growing and ask if they have email. No one has yet said 'no'!

Second, we set them up in a distribution list in our email application. That will vary depending upon what email you use, but most have a way to do it. Right now our distribution list is over 60 addresses.

Then, each Tuesday, we compose an email with that week's offerings, including prices, and ask that they reply back by Thursday evening. All they have to do is click 'reply' and type their order (or delete the lines they don't want to order). Friday, the orders are harvested, washed and packed, and Saturday morning we deliver them.

So, you don't have produce to deliver in the winter? Can this method still apply? Absolutely! During the summer, we sell at a local Farmers' Market. It starts at 6:00 AM – really early for most people! But, the customer who isn't there early frequently has a lot less to choose from. So, we started a summer email list too. That list also is sent on Tuesday evening and they have until Thursday evening to reply. The only difference is that they pick up their orders at the Farmers' Market prior to 10:00. It allows them to get first choice of our produce without having to be at the market at 6:00.

Both methods have expanded our customer base considerably. It is not unusual to get an email order from someone we didn't send an email to – one of our folks forwarded it! 'Course the next week we include them! It also allows us, in winter, to harvest only what is sold, and in summer, to go to the market with much of our harvest pre-sold. The customer list is currently a great vehicle for marketing our beef, and whatever products our farm might produce in the future. It's easier for us and easier for our customers.

Will we expand our ordering to our website? Probably not. Our customer base is mostly local and the email is working great. However, we won't rule it out. Although our website doesn't "bring" us customers, the fact that we have one is good for our image with the customer base we have. And, we have recently added a page where interested folks can look at what is available in a given week. Website? You've just gotten used to the idea of email? Well, maybe in the next 'e'nnovative marketing story.....

Salads in the Snow

Paul and Allison Wiediger

When most market farmers think about production, they think spring-summer-fall. Unless, that is, they live in the few frost-free sections of the country. We have found that one of the most productive and enjoyable times to grow crops is in the winter. Yes, I said winter, as in November through February. And, it doesn't require an expensive heated greenhouse. We produce leaf lettuces, spinach, mesclun mix, red russian kale, mustards, mizuna, arugula, beet greens, etc, all winter in an unheated coldframe, and we are into our 7th season with this technique.

First, the structure. We now have four. All are greenhouse frames with double layers of poly, separated by a bubble of air. The first was picked up at auction when a large discount store built a "superstore" and auctioned all items at the old store. It is a 21'x60' steel structure and we paid $750.00 for it. Serendipity ! You may be able to pick up the same type of bargain. In many parts of the US, the same auction company will be handling all the stores within a region, and may put you on a mailing list. The second and third were built in1999 and 2000 and are what many greenhouse manufacturers sell as 'coldframes' . Current price is $885 for a 20x96 foot frame. You have to add site preparation, endwalls, door, irrigation, poly and an inflation fan to that price. We spent just under $2000 or about $1 per sqft. We would recommend budgeting about $2500 for a frame this size. And the fourth, like the first, was picked up as WalMart surplus in 2000.

We think the double poly layer makes the system work. The inner layer is 6 mil IR (infrared). The outer layer is standard 6 mil 4 year poly. It provides several degrees of protection for the plants inside. Even in cloudy weather, we often have a gain of 10-15 degrees. In sunny weather, the interior temperatures will soar above 80 degrees, even when the temperature outside is below 20 degrees. The soil temperature rarely falls below 50 degrees and we have earthworm activity all winter. At night, the air temperature will hold as much as ten degrees above the outside temperature at a height of 5 feet, and at plant level, temperatures are even warmer.

The inside of the coldframe is divided into 5 raised beds with 15" pathways between them. The beds on the outside walls are 30", which allows us to reach all the way across them. The center bed is 48" and the other two beds are 36" across. We have chosen 15" aisles because a narrower aisle doesn't allow us to work and harvest without damaging plants. The bed sizes are chosen to maximize the growing area in this particular width of frame. For a different size, you may need to work out the most effective sizes for your growing beds. By keeping permanent beds and paths, we no longer need anything other than hand tools to get the beds prepared for the next crop. These beds, because they are used intensively, are amended intensively. After each cropping season, we add compost, about 1" deep, composted chicken manure, and, if needed , colloidal phosphate and lime. That is spread on the top and worked in with a spading fork or wheel hoe with scuffle hoe attachments. Beds are smoothed with a rake and ready to plant.

Aside from fertility, we think that moisture control is the most important part of the equation. We keep the plants on the 'dry' side when it comes to water. No, we don't let them wilt, but we don't keep them really turgid either. If you think about it, it makes sense. When the temperature goes below freezing (and it does regularly), if the plant cell is turgid with water, the cell walls burst with the pressure of the expanding water. If the cell is a **little** on the 'low' side, it is less likely to burst. We can go in the cold frame on a sub freezing morning (say below 20 degrees F) and all the plants look dead --laying on the ground, you know that frozen look! But, by 10:00 or so, especially if the sun is out, they are all upright and beautiful again. It breaks your heart the first time you see it, but it invokes wonder 2-3 hours later. Most years we have the soil at a good moisture level in mid-November and we don't need to do much watering until February. However, some years are sunnier than others, or the summer was drier, and we need to water more to keep adequate moisture. When we need to water, we watch the weather forecast for a window of several days and nights above freezing. We water on the first day of that window, so that by the time the freezing temperatures return, the plants have adjusted to the extra water.

We have found that we get the best continued production if we transplant "plugs" into the beds rather than trying to seed. The plug transplants are raised outside for the first few fall plantings, then in our small heated transplant greenhouse for later plantings. We usually use 96 cell inserts so we have a robust transplant and plan on about 5 weeks from seeding to transplant, although true plug trays, say 288 cell, would work very well if you have the time to manage them (keep them moist). We space our lettuce transplants at about 1 foot apart each way to allow the plants room for nice head development. At this spacing, the transplants make a canopy over the soil quickly, which slows weed growth. We transplant enough lettuce plants every 3-4 weeks during the season to supply our current market for a 3-4 week sales window. This requires seeding those flats every 3-4 weeks as well. Although we use our small heated greenhouse for this task, we think it could also be done on a small scale with grow lights. A five week transplant usually gives us a saleable head of lettuce in four to six weeks from date of transplant, depending upon the month. We get a significant growth slowdown for about 6 weeks around the solstice.

We direct seed mesclun mix throughout the winter. In November, it will be ready to cut in about 3 weeks, but in January takes a little longer to get to a cutting stage (mid-February). It also takes longer to re-grow after cutting – as long as 3 weeks. So in production planning, we sow 2-3 times the mesclun row footage in early December as we would in October – just to have enough for January harvests. We have grown as many as 17 varieties of lettuces in a season to determine the best varieties for this type of growing. We have found that the Grand Rapids and oak leaf types are the best producers for the entire winter. We also get nice heads from green bibbs until early December, and again in mid-February. The red lettuces don't keep their color well and don't grow as well in the low-light conditions of winter. The romaines are very susceptible to tip burn when the temperatures got below 20 degrees. They are great until about the end of December and again after February.

The varieties of lettuce that produce best for us are : Black Seeded Simpson, Simpson Elite, Waldmann's Dark Green, Red Sails, Royal Oak, Cocarde, Kalura,Rouge D'Hiver, buttercrunch, Freckles and Deer Tongue. Red Sails is very brittle, and care has to be taken washing and packing. We continue to experiment with red lettuces in an attempt to find some that hold their red color during the low light of December, January and early February. We have noticed that Cocarde will totally lose its color, but if you get a few sunny days, the color comes back quickly. The best red we have found is Merlot. It is a dark wine-red Grand Rapids type, keeps its color nicely, but grows slowly. It still gets good sales, however, because of its rich and unusual color.

We grow spinach from direct seeding. We use Space, a smooth leafed variety. It handles the temperatures really well, is easy to wash, and makes a large plant. We grow beet greens from direct seeding. They are a beautiful addition to salads, but get a little burned in the lowest temperatures. However, they will outgrow that damage when the temperatures moderate. We seed Arugula, Red and White Russian Kale, Red Bor Kale, Endive, Green and Red Mustard, Mizuna and a leaf lettuce mix (reds and greens) for mesclun. Through early December, we can cut once every 5-7 days, depending upon light levels - it takes a little longer when it is overcast.

Many other types of "greens" do well in the cold frame. Some that we have grown are Chinese Cabbage, shungiku, mibuna, claytonia, and minutina. Chinese Cabbage does really well, and there are no flea beetles in winter to make it look ragged. Some of the others don't have great sales in our market. We are always trying something new.

About the third week in February, the greens start to bolt. At that time, we harvest the remaining spinach and freeze it for summer quiches, cut the rest of the greens and feed them to the cattle (they LOVE that late winter shot of vitamins!) and prepare the planting beds. About the 15th of March, we set tomato transplants into the beds. Yes, the coldframe is still unheated and we are lower USDA zone 6 with a last frost date of May 5th. In 1998 we had a 10-degree freeze on the 10th of March and we set out tomatoes in the coldframe on the 16th, in 1999 we had snow and ice on the 13th and set on the 16th. We usually have lengths of remay cut to cover them, just in case, but we have only had to use the remay once, in 2001. These transplants are grown in 36 cell, deep cell inserts and are about 8 weeks old when we set them. The tomatoes are set 2 feet apart, down the center of each inside bed. Sometimes, we also set lettuce transplants between the tomatoes. They are harvested before the tomatoes need the space. We use trickle tape for irrigation, one down the middle of each bed and use black paper mulch for weed control. Steel fence posts in the center of each bed are used for an Indian Weave to hold the plants upright. Insect problems are very minimal, mostly consisting of tomato hornworms which we hand pick. We discovered this past year, that if we close the frames before dusk, the Sphinx moth can't get into the frame to lay eggs, and we almost totally control the hornworm damage.

We use Bush Early Girl for earliness, taste, fruit size and determinate habit. We want an 8-10 oz tomato for Farmers' Market, and this plant gives us that, and some fruits

much larger. After using indeterminate types for several years, we have chosen a determinate as easiest to manage in this environment, and by the time it is finished, our field tomatoes are ripening. We are now also using Bush Celebrity. It is a little slower to ripen (7-10 days), but the tomatoes are deeper bodied, heavier, and have a heavier set on the plant. We plant a few yellow tomatoes for market appeal – it really draws the customers in. We usually have ripe tomatoes to sell by the third or fourth week in May – about 5 weeks earlier than field planted in this area. That gives us a great price at the market, and a great market share. We also devote some space to peppers, cucumbers, and summer squash. They all work. Tomatoes seem to be the most profitable use of the space, but the other items really give us an early customer boost at the Farmers' Market.

By July, the tomatoes have seen their best and the field tomatoes are bearing, so the tomatoes come out and go to the compost heap. The beds are amended and reshaped. We believe that this would be a great time to transplant melon plants. Melons do well here outdoors, but they do love heat, and the coldframe, in the summer, is HOT. This would give us melons for the late summer/fall market, after the melons planted outdoors are gone. However, with the pressure of harvesting our market garden, we have not yet tried this technique. Of course, once the melons are done, it's time to prepare the beds for the salad crop. Here, we can put the earliest transplants in about the middle of September, although we are often late because of the pressure of harvest time. If we get them in late (in 1999 it was November 1), they still grow and we still have our 'salads in the snow'.

This is a planting technique well worth trying. The structure can literally be used 12 months of the year in much of the temperate area of this country. We know of a man in Massachusetts who is doing this and marketing to white tablecloth restaurants in Boston. Elliott Coleman in Maine also uses this technique, although that area probably won't show the regrowth we can because of being so much farther north. It's not hard – the hardest part is getting some sort of a structure in place. And, it is so healthy, both physically and emotionally. There is nothing better than bundling up on a cold morning, walking up to the coldframe, walking inside to 70+ degrees and picking a salad for your meal, or $100+ worth of produce for delivery. It picks up our spirits to the point we don't dread winter anymore. We can always walk to 'spring' and it doesn't cost a plane ticket!

Try it! You'll never make a better investment.

For additional reading, ATTRA has available two excellent publications, "Season Extension Techniques For Market Gardeners" and "Organic Greenhouse Vegetable Production". ATTRA can be contacted at 1-800-346-9140 and most of their publications are available on the Web at www.attra.org.

Vegetable Session

Better Crops
Through Soil
Conservation

Dry Bean Yields: Weed Control and Soil Moisture

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Chuck Webber, Research Agronomist, received his B.S. (Soil Science) and M.S. (Agriculture) degrees from California Polytechnic State University, San Luis Obispo, CA, and his Ph.D. (Agronomy/Weed Science) from the University of Missouri, Columbia, MO. He has been an employee of the USDA, Agricultural Research Service since 1976. His current research assignment is the development of integrated weed control systems for horticultural crops.

Introduction

Dry bean (*Phaseolus vulgaris* L.) production is an alternative cropping option within the Southern Plains region with increasing production and market potential. Three of the primary decisions facing producers interested in diversifying their agriculture production to include dry beans include: 1) which type of dry bean to produce; 2) what pest control practices to use; and 3) will the dry beans need to be irrigated. Dry bean production systems research is needed to investigate combinations of these factors, and answer the producer's questions. This research was conducted to determine the effect of weed control and plant water stress on yield components of four dry bean varieties.

Materials and Methods

The first year of a two-year field study was conducted at Lane, Oklahoma, on a Bernow fine sandy loam, 0 - 3% slope, (fine-loamy, siliceous, thermic Glossic Paleudalf). The research design was a randomized complete block with four dry bean varieties, two weed control levels, two moisture levels, and four replications.

Planting and Bean Varieties

Eighteen days prior to planting, the land was plowed and disked. Fertilizer was applied and incorporated with a disk on April 24, just prior to planting, at a rate of 45-49-124 lb/a N-P-K to all plots. The four dry bean varieties included black bean cv. 'Black Knight', navy bean cv. 'Gryphon', pink bean cv. 'ISB 462', and pinto bean cv. 'Apache'. Each bean variety was planted on April 24, 2001, with a four-row planter set on 36-in row spacing using a 30-hole planting plate which delivers 4.4 seeds/ft (63,888 seeds/a). Individual plots were 12 ft wide and 20 ft long, oriented in an east-west direction.

Weed Control (Weed-Free & Weedy-Check)

The two weed control treatments included a "weed-free" and "weedy-check" treatment. In the weedy-check treatment, the weeds were allowed to grow throughout the 90-day growing season, April 24 to July 23. Weeds in the weed-free treatment were removed by hand-weeding during the growing season.

Soil Moisture (Irrigated & Non-Irrigated)

The soil moisture treatments included an "irrigated" and "non-irrigated" (dryland) treatment. Water was applied to the irrigated plots through a drip irrigation system consisting of a 0.6-in. diameter drip line for each row with in-line emitters spaced every 12 inches. The emitters had an application rate of 0.6 gallons/hour.

Harvest

At harvest, 90 days after planting, a 6-ft length of plant row was harvested from each of the center two rows of the 4-row plots (36 ft^2), and the seed yield (lb/a), number of pods/plant, seeds/pod, seed weight (g/100 seeds), and plant populations (plants/a) were determined. When the F-test indicated statistical significance at the P = 0.05 level, the least significant difference (LSD) test was used to separate means.

Results and Discussions

Rainfall and Irrigation

Rainfall during the 2001 growing season, April 24 to July 23, was 10.2 inches - halfway between the 8-yr (1994-2001) average rainfall of 7.8 inches for Lane, OK, and the 30-yr (1961-1990) average rainfall of 13.1 inches for Atoka county (Table 1). The 7.6 inches of irrigation and the 10.2 inches of rainfall during the growing season provided 17.8 inches of water for the irrigated plots. This was 10.0 inches greater than the 8-yr average rainfall, 4.7 inches greater than the 30-yr average rainfall, and 75% greater than the non-irrigated plots.

Table 1. Inches of rainfall and irrigation received during the growing season (April 24 – July 23) for the year 2001 and the 8 and 30-year average rainfall for Lane and Atoka county, OK, respectively.

Month	Rainfall	Irrigation	Rainfall & Irrigation	8-Yr Avg.[a]	30-Yr Avg.[b]
	inches	inches	inches	inches	inches
April 24 –30	0	0.2	0.2	0.5	0.9
May	5.8	1.0	6.8	3.5	5.9
June	3.6	4.0	7.6	2.5	4.2
July 1-23	0.8	2.4	3.2	1.3	2.1
Total	10.2	7.6	17.8	7.8	13.1

[a]8-Yr (1994-2001) average rainfall for the Lane Agricultural Center, Atoka county, OK.
[b]30-Yr (1961-1990) average rainfall for Atoka county, OK.

Bean Varieties

When averaged across weed control and soil moisture treatments, the black beans had significantly greater yields than the other three bean varieties (Table 2). The greater seed yields for black beans were the result of differences in yield components, including significantly greater seeds/pod and plants/acre (Table 2). Although seed size (weight/100 seeds), pods/plant, seeds/pod, and plant/a were significantly different among the three

lower yielding bean varieties (navy, pink, and pinto), the seed yield was not significantly different among these varieties (Table 2).

Table 2. Effect of dry bean variety on yield components averaged across weed control and soil moisture treatments for the year 2001.

Dry Bean Variety	Seed Yield	Pod Number	Seed Number	Seed Weight	Plant Populations
	lb/a	pods/plant	seeds/pod	g/100 seeds	plants/a
Black	1,227 a	12.68 b	4.86 a	16.68 c	53,240 a
Navy	917 b	15.01 a	4.08 b	13.95 d	48,249 b
Pink	934 b	12.69 b	3.52 c	25.39 b	37,586 c
Pinto	941 b	12.73 b	3.38 c	27.24 a	36,678 c
LSD (0.05)	151	1.67	0.31	1.82	4,141

Means in a column followed by the same letter are not significantly different based on a Least Significant Difference (LSD) test, P=0.05.

Weed Control

When averaged across bean varieties and soil moisture treatments, weed competition significantly reduced seed yields by 320 lb/a (27%)(Table 3). Weed competition reduced seed yields by adversely affecting three of the four yield components: pods/plant, weight per 100 seeds, and plant populations (Table 3).

Table 3. Effect of weed control system on dry bean yield components averaged across varieties and soil moisture treatments for the year 2001.

Weed Control	Seed Yield	Pod Number	Seed Number	Seed Weight	Plant Populations
	lb/a	pods/plant	seeds/pod	g/100 seeds	plants/a
Weed-Free	1,165 a	14.23 a	3.96 a	21.70 a	46,434 a
Weedy-Check	845 b	12.32 b	3.96 a	19.93 b	41,443 b
LSD (0.05)	107	1.18	0.22	1.29	2,929

Means in a column followed by the same letter are not significantly different based on a Least Significant Difference (LSD) test, P=0.05.

Soil Moisture

The seed yield for the irrigated plants, when averaged across bean varieties and weed control treatments, was greater than for the non-irrigated plants (Table 4). It is interesting to note that seed yield differences between soil moisture treatments were smaller than the differences between weed control treatments (Table 3 & 4). The yield components contributing to the seed yield differences for the soil moisture treatments were slightly different from those contributing to yield depression by weed competition (Table 3 & 4). Unlike the weed control treatments, there was not a significant difference between the number of pods/plant or plants/a for the irrigated treatments; but there was a difference for the number of seeds/pod. In addition, weed competition and lower soil moisture had a similar effect by reducing seed size (weight/100 seeds).

Table 4. Effect of soil moisture on dry bean yield components averaged across varieties and weed control treatments for the year 2001.

Soil Moisture	Seed Yield	Pod Number	Seed Number	Seed Weight	Plant Populations
	lb/a	pods/plant	seeds/pod	g/100 seeds	plants/a
Irrigated	1089 a	13.46 a	4.09 a	21.59 a	43,258 a
Non-Irrigated	920 b	13.10 a	3.83 b	20.04 b	44,619 a
LSD (0.05)	107	1.18	0.22	1.29	2,929

Means in a column followed by the same letter are not significantly different based on a Least Significant Difference (LSD) test, P=0.05.

Summary

This manuscript reports the results of the first year of a 2-yr study to determine the effects of weed control and soil moisture on dry bean yield components. Black beans (cv. 'Black Knight') produced the greatest seed yields compared to navy (cv. 'Gryphon'), pink (cv. 'ISB 462'), and pinto (cv. 'Apache') beans across weed control and soil moisture levels. Although weed competition and soil moisture both significantly affected the dry bean yield components, and therefore the final seed yield, the influence of these treatments was different. The field research on dry bean production will be used to gain a greater understanding of the mode of action of seed yield depression in dry beans and possible methods for adapting the cultural practices for this region to maximize dry bean seed yields.

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Strawberry Plasticulture: Varieties and Planting Dates. Trials at the Vegetable Sub-Station, Kibler AR

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In Arkansas there has been an expansion of the strawberry industry for the last ten years. The trend has been to grow day neutral strawberry cultivars through the use of plasticulture. The plants are grown as an annual crop, being planted in the fall and harvested the next spring. At the end of the harvest period the plants are discarded and another crop can be planted.

The attraction of annual culture of strawberries is that the plants are produced quickly resulting in fewer long-term weed and disease problems. The berries produced are large, attractive, and of high quality. The equipment and irrigation techniques used to prepare and grow the plants are the same as the vegetable industry uses for plasticulture tomato, pepper, melon, and squash production. Growers have been able to adapt to this type of production with out making major investments in new equipment. The plants are grown on raised plastic covered beds leading to easily picked clean fruit. At the end of the harvest period the plants are discarded. You do not have to worry about renovation of the beds and the long-term problems of disease and weed control.

This technique of growing strawberries is not without risks and problems. The greatest risk is the weather. Growing conditions in the fall determine how rapidly the plants develop, the low temperatures during the winter determine the survival of the plants, and spring freezes and frosts determine the survival of the flowers and berry quality. The level of management required to grow this crop is quite high. Considerable attention needs to given to the details of irrigation, fertilization, disease and frost control. In order to minimize these risks we started a trial in 1994 with Dr. W. Keith Patterson to examine planting dates and cultivar evaluation for the industry.

Strawberry tip cuttings were rooted in a greenhouse mist bed for three weeks. Plants were kept in cold storage until they were planted. The plants were transplanted to plastic covered raised beds at the Kibler Substation. Plots were 10 feet long with plants at 12 inch spacing and two rows of plants to each bed. Plantings were done at intervals from Sept 28 through November 5. The results were as follows for 1994-1995 harvest season.

Influence of planting date on yield and growth of strawberries. Kibler, AR 1995 season.

Planting date	Branch crowns/plant	Yield (lbs/Ac)
Sept 28	3.8	14422
Oct. 7	3.5	9440
Oct 26	2.5	1457
Nov 5	1.9	993

The results of the trial indicated that the earlier the planting date, the greater the number of crowns and yield per acre. The greater the number of crowns is an advantage to a point where the berry size starts to decrease. The recommended planting dates were from September 15th in northern Arkansas to October 15th in southern Arkansas. Planting too early results in excessive growth, more winter damage, and smaller berry size.

Subsequent trials were conducted with Dr. Keith Streigler. The objectives of these trials were to:

1. Evaluate the performance of new cultivars
2. Demonstrate the effects of late plantings
3. Demonstrate plasticulture production systems

The Strawberry Yield Results of the 2000 harvest season at Kibler are as follows.

Variety	Yield (lbs/Ac)	Berry Weight (g)	Crown #
Camarosa	23481 a*	16.5 a	4.9 a
Chandler	26350 a	13.6 c	4.8 ab
Gaviota	15616 b	14.7 b	3.5 b
Sweet Charlie	11636 b	10.6 d	3.8 ab

Means followed by the same letter, within a column, are not significantly different at the 0.05 level.

The harvest period started on April 17 and ended on June 1. Average berry weights were greatest at the beginning of the season (15 to 20 gms per berry) and smallest at the end of the season (8 to 13 gms per berry).

Plasticulture annual strawberry production can be accomplished in Arkansas. The risks of production can be reduced by planting at the proper time and be choosing adapted cultivars.

Processing and Marketing of Washed and Bagged Fresh Leafy Greens

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Oklahoma has proven to be a very good location for the production of spinach and fresh greens. The market for fresh spinach and leafy greens is expanding. Sales of packaged and baby spinach have been growing rapidly over the last few years (about 36 per cent a year for packaged spinach, and 44 per cent a year for baby spinach), according to A.C. Nielsen scan data (Harvey, 2000). The market for cut, washed and ready to use packaged leafy greens appears to be growing. The top growing segments of the market are the small sizes of packaged spinach (6 and 10-ounce bags). However, Oklahoma's producers are not benefiting from the fresh market growth. Production is primarily marketed to food processors and very little fresh marketing of the product is currently done. In order to seize the opportunities offered by the growing market for packaged leafy greens, producers would have to invest in washing and packing facilities.
Some producers are not producing fresh greens, because:
1- Packing labor is a problem;
2- More profitable alternatives were identified and pursued; and
3- The equipment investment is high and the harvest season is short.

The objective of this paper is to explore the possibility of developing a producer owned processing and marketing facility relative to fresh greens and spinach in Oklahoma and Arkansas. Producers may recognize the possible advantages of having a fresh outlet for their products but may not individually have the financial capacity, land resources or marketing expertise to operate an independent fresh greens packing and marketing facility. To achieve this objective, a business plan for a fresh greens packing facility needs to be completed. The business plan would include the mission and objectives of the new entity, the production and operation plan, the marketing plan, the financial plan, the staffing and organization plan, and a contingency plan.

Production and Operation Plan

To complete the production and operations plan, it will be important to address these questions:
- How many producers are interested in growing spinach/greens for the fresh market?
- How much are they willing to grow?
- Can we achieve a consistent quality across producers?
- How much can be profitably marketed during the time period when Oklahoma/Arkansas are in production?

Production Facilities

The magnitude of the production facility depends on the volume and the type of the activity being undertaken. The following factors are important:

- Packaged vs. product to be repackaged;
- Degree of automation of the production facility; and
- Seasonal facility utilization.

Description of Packing System Product Flow Reference: Trim Line with hand packing (Figure 1).

The raw product is received in totes or bins and placed close to the workers at the 2 station prep line. The workers inspect, trim and make longitudinal cuts before placing the produce on the feed conveyor of the belt cutter.

- The 6 station preparation table (1) can produce up to about 2000 pounds per hour of greens. The 6 station prep table has provision for waste receptacles under the trim area to receive the trimmed material from the trim line's waste chutes.
- The belt cutter (2) makes the cross cuts to the greens. The cut product is fed from the GS-25 belt cutter onto a transfer conveyor (3), which elevates the product up, and into the helical wash system (4).
- The helical wash system shown is sized to handle the volume from the cutter. The helical wash action aggressively cleans the product without damaging the more delicate items such as greens. The wash system includes the dewatering shaker, pumps, the electrical control panel, adjustable water jets, and large tank drains for water changes in 5 minutes.
- The dewatering shaker shown is a single deck type but a double deck option is available to remove fines and protect the water chiller if required. The shakers are designed with changeable screens for different size cuts and products and for easy cleaning.
- The product will leave the wash system at the shaker and move into a spin-dryer basket on a dolly. A second dryer is shown to handle the volume.

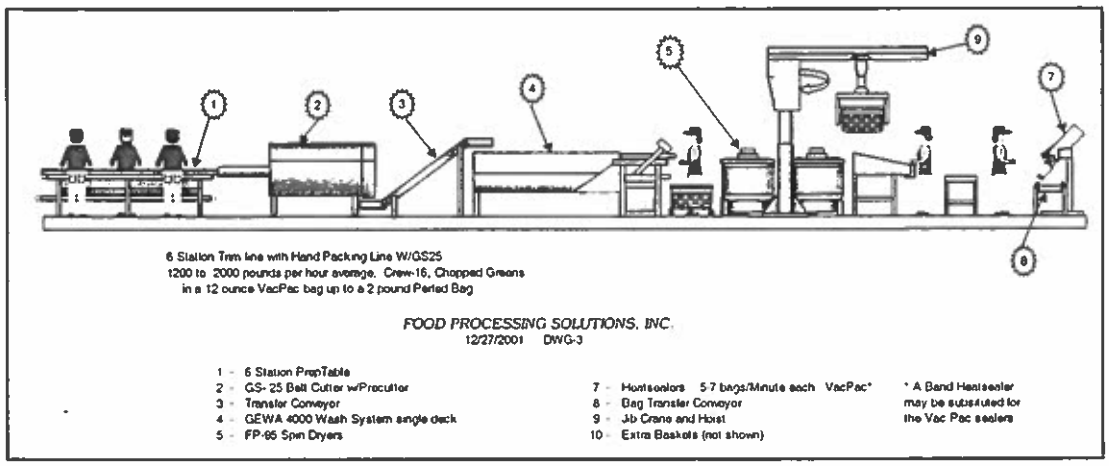

Figure1: 6 Station Trim Line With Hand Packing

The above figures present a simple hand packing facility that would be adjusted from two to six people, depending on the volume of spinach or greens to be processed. The facility could be automated to some degree, if needed.

Marketing Plan

A marketing plan for fresh vegetable packing facility includes a statement of the intended target market, distribution tactics to deliver the product to the target market, packaging the product in the form desired by the customers, pricing strategies, and promotion of the product. Good marketing plans generally require knowledge of competitors' marketing tactics as well. Organizations that have access to people with experience with the fresh greens market and the relevant customers are more likely to be successful. Among the alternatives are hiring brokers and setting up a company's own sales staff. There are possibilities of partnerships with other producers with a complementary production and marketing season.

Financial Plan

A financial plan would clearly outline the source of and the use of the funds, the equipment needed and its utilization, as well as the cash flow implication and profitability of the activity. To avoid having to support an opportunity cost due to the non use of the facility during off season, packing for others may be an alternative, and will be considered in the financial plan. State incentive programs will be integrated in such a way that producer profitability can be easily determined.

The State of Oklahoma offers tax incentives to Oklahoma agricultural producers who invest in Oklahoma-owned agricultural processing cooperatives, ventures or marketing associations (Oklahoma Statutes, Title 68; Section 2357.25 and Rule 710:50-15-85). Thirty per cent of qualified investment in a qualified agricultural processing facility may be used as a credit against any Oklahoma income tax due. In case the tax credit is unused, a 6-year carryover is currently allowed.

Organization and Staffing Plan

To insure a smooth operation of the facility, all modern structures have organization and staffing plans. It includes management, accountability job-descriptions, personnel policies, potential problems, and contingency plans. Labor availability, recruitment and training must be considered as well. A knowledgeable manager is critical, and acquiring the necessary marketing expertise is a must. Staffing and training people for a packing facility is challenging, and the seasonality of the crops involved might bring additional problems. Organization and staffing plans will vary depending on the type of organization. The various potential type of organization include:

- Individual proprietorship
- Partnership
- Corporation
- Closed cooperative
- Traditional cooperative.

Most of these organizational form are familiar, but closed cooperative is relatively new. Closed cooperatives have been used for agricultural processing activities, since equity capital is involved. Membership is closed, and only members can do business with the cooperative. Members have specific delivery responsibilities tied to their level of equity investment. Delivery rights are transferable and their value can appreciate or depreciate.

Conclusion

Arkansas and Oklahoma have proven to be good locations for the production of spinach and fresh greens. Farmers in these locations may take advantage of the growing fresh market as well as various tax incentives to invest in fresh cuts processing facilities. Several organizational forms are available to choose from, a closed cooperative being the latest form of cooperative especially tailored for this kind of activity.

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Sprayer Technology Options and a Review of Calibration

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Calibration

A properly maintained and adjusted sprayer is a key component for the application of pesticides. When spray equipment is worn or poorly calibrated, application effectiveness suffers and can result in wasted material and poor control of the target pest.

Prior to calibrating, equipment should be serviced and all nozzles checked for uniform output and pattern and to be sure that they are all the same type of nozzle. To service the sprayer, all hoses and connections should be inspected for aging, damage, and leaks, and the pump should be inspected for output and leaks. Following this, each nozzle, screen, and strainer should be cleaned and inspected, at which time the sprayer is ready for calibration and use. After the sprayer has been used, be certain to rinse out the spray tank with clean water and follow that with partially filling the tank and running the sprayer to clean nozzle tips and screens.

Selection of nozzles should be based upon the type and volume of material that will be sprayed. Nozzles come in a large array of designs and materials as shown in the table below, but the producer should be acquainted with newer innovations in nozzle technology. Select nozzles that will spray the pesticide with the least amount of off-target drift. Generally speaking, nozzles with higher spray angles, i.e., 110° angle vs. 80° angle, can be operated at a lower boom height, thus reducing the potential for drift to occur. Other recent innovations include nozzles that create a larger droplet size, etc., which will reduce the potential for drift.

Spray Nozzle Material Qualities			
Material	Corrosion	Abrasion	Cost
Brass	Moderate	Susceptible	Low
Nylon	Resistant	Susceptible	Low
Stainless	Resistant	Resistant	Moderate
Tungsten	Resistant	Resistant	High
Ceramic	Resistant	Resistant	High

Distance required to travel with different nozzle spacings.			
Row width or nozzle space in inches	Distance to drive in feet	Row width or nozzle spacing in inches	Distance to drive in feet
80	51	26	157
60	68	24	170
40	102	22	185
38	107	20	204
36	113	18	227
34	120	16	255
32	127	14	291
30	136	12	340
28	146	10	408

There are many effective ways to calibrate a sprayer. When getting started, it may be best to calibrate using more than one method. If the same calibration is completed with two different methods then the operator has a good indication that calibration is correct. The following steps provide one method of calibration, but other methods can be found in the OCES Publication E-832, Extension Agents' Handbook of Insect, Plant Disease, and Weed Control.

5 Step Calibration Process

1 Use the table above to determine the distance to drive the tractor and sprayer in the field. Use the nozzle spacing on the boom or for directed and banding sprays that utilize more than one nozzle over a given row, use the row spacing. Mark off this distance in the field.

2 Attach all equipment to the tractor that will be used for spraying and fill the spray tank ½ full with water. Next, select the desired gear and throttle settings and drive the course in the field that was measured off in Step 1. Be certain to provide a starting line for the course that will allow the tractor and spray rig ample time to come up to operating speed prior to starting the timing. Using a stopwatch, determine the amount of time required to drive the marked off distance. Timed drives should be repeated, recorded and those recorded times used to calculate the average time to drive the measured distance.

3 Using the average time determined in Step 2 the calibrator can then capture the sprayer discharge for that amount of time in a container graduated in ounces. For broadcast

sprayers that have even nozzle spacing, capture the discharge from one nozzle. For directed sprayers that use multiple nozzles over a given row, capture the discharge from all nozzles for a given row and combine.

4 The total amount of discharge collected given in ounces from Step 3 is equal to the gallons per acre that will be applied.

5 Check each nozzle on the spray boom by repeating Steps 3 and 4. If nozzle discharge amounts vary more than 10 % from the average for the entire boom, then replace the nozzle. Spray volume can be adjusted several ways including changing the speed of the spray rig, changing nozzle size or increasing or decreasing pressure with the pressure regulator. Be aware that increasing pressure will result in smaller spray droplet size and that drift potential will likewise increase. Increasing pressure to increase a spray rate should be used only when alteration of speed or nozzle type have already been used to make coarse adjustments. Nozzle manufacturers can provide information about the flow rates and approximate pressures that a given nozzle is designed to operate. Be informed of this information and calibrate your sprayer to operate within the suggested ranges.

Technology considerations and developments

Progress made in pesticide application technology has sought to increase operator safety, reduce possibilities for undesirable effects on the environment and improve application efficiency. Improvements in operator safety result from the use of modern personal protection equipment such as respirators, chemical resistant clothing and gloves. The pesticide label for a product is the operator's guide to the selection of proper safety equipment for the application of that product.

Choosing a sprayer that is well suited to the specific needs of a farm is the first step in achieving optimum pesticide application with minimum environmental impact. Sprayer technology needs for pesticide application in vegetable production are determined by first considering which crops are to be grown, the farm location, the farm size and application needs. A boom sprayer is probably the most common and most versatile type of sprayer in a vegetable production situation. Knowledge of the crops that are to be grown is important for determining needs such as clearance above of the crop by the boom, tractor and sprayer. Boom length is another consideration for a vine crop like watermelon. Location and farm size are additional considerations. If crops will be grown near populated areas it is important to choose equipment that will enable maximum control of spray drift. For locations of uneven terrain or where small plots will be cropped, a sprayer with a short boom might be most convenient.

Proper nozzle selection is an important step in sprayer set up for several reasons. It is important so that the desired nozzle output can be obtained using the desired operating pressure. A properly selected nozzle will also maximize the amount of spray solution that reaches the intended target. At the same time, a properly selected nozzle will minimize the amount of spray that remains in the air in the form of small droplets. Small droplets are susceptible to being carried by moving air (drifting) and falling on non-target surfaces. Under hot and dry conditions, small droplets may also dry before

reaching the target, which also interferes with the chemical doing the intended job. An improperly selected nozzle may result in excessive small droplets and the consequential losses to drift and drying. There have been some developments in nozzle design in recent years that make it possible to reduce problems associated with small droplets.

Traditional nozzle types include flat-fan, cone and flood nozzles. Cone nozzles are designed for the production of numerous small droplets that are useful for obtaining thorough spray coverage of dense foliage. These, by nature, are very susceptible to drift. Flood nozzles do not produce as many small, drift prone droplets but they also do not provide the uniform application needed with many pesticide applications. Flat-fan nozzles provide a uniform spray pattern for controlled application. However, these produce a spray pattern that includes small droplets that are susceptible to drift. Developments that have made it possible to obtain spray patterns with reduced production of drift prone droplets include extended range nozzles and, more recently, air induction nozzles and pre-orifice low-drift nozzles. A discussion on nozzle technology development can be found in the Ohio State University Fact Sheet titled "New Nozzles for Spray Drift Reduction" (http://ohioline.osu.edu/aex-fact/0523.html).

Nozzle selection

Nozzle selection information must be in-hand in order for a sprayer to be fitted with the correct nozzles. Nozzle selection in sprayer calibration is a two-step process. The first step is to select the type of nozzle to be used. In addition to the discussion already presented on nozzle technology, the Oklahoma Cooperative Extension Service Fact Sheet F-1215 also provides guidelines for nozzle selection. Determination of nozzle size, or output, is the next step after nozzle type has been selected. This is a characteristic of a nozzle's design and is usually expressed as the gallons per minute rating (gpm) of the nozzle. To select nozzle size you need to know 1. the spray volume per acre that will be used (in gallons per acre), 2. the sprayer ground speed, and 3. the effective spray width of a nozzle.

1. Spray volume is determined by the needs of a particular application job. Pesticide labels often give a range of spray volumes that should be used for the application of the product for each acre that is to be treated. This is usually given in gallons per minute (gpm).

2. Measurement of ground speed is done as explained in step 2 of the "5 Step Calibration Process" section and the results are converted to miles per hour. To convert results, first divide the distance driven (in feet) by the time (in seconds) needed to drive it. Next multiply the results by 0.68 to get miles per hour.

3. The effective spray width (W) is the distance, in inches, between nozzles on a boom for a broadcast application or the width of a band for a band application. For other nozzle configurations refer to OSU Fact Sheet F-1215.

Once this information is obtained, nozzle gpm is determined by multiplying gpa x mph x W and dividing the result by 5,940. Nozzle manufacturer catalogs often include

tables that are useful for selecting nozzle sizes. The information in 1, 2, and 3 above is needed to use the tables. Following these nozzle selection and calibration guidelines should result in more effective pesticide application. For additional questions, contact your local County Extension Office.

Vegetable Insect Pest Management: Effects of Squash Bug Feeding on Watermelon Productivity & Controlling Insect Pests on Commercial Vegetable Crops

By Jonathan Edelson, Professor of Entomology

Jonathan Edelson is a Professor of Entomology in the Department of Entomology and Plant Pathology, Oklahoma State University. He is located at the Wes Watkins Agricultural Research and Extension Center, Lane, OK. He has conducted research and developed IPM education programs for managing insect pests on commercially grown vegetable crops over the past 20 years. Prior to his arrival at OSU he served as Assistant and Associate Professor of Entomology at Texas A&M University and conducted similar work in the Lower Rio Grande Valley of Texas on vegetable and cotton crops. He has developed and implemented successful pest management programs for carrots, onions, cabbage, leafy greens and cucurbit crops throughout the south central region of the U.S. and in central Mexico. He has published over 100 scientific and technical journal articles and consulted and presented results of his work throughout the U.S., Canada, Trinidad/Tobago, England, China, Mexico, Israel and Turkey.

Introduction

The key vegetable crops grown in significant quantities in Oklahoma and that are also of significance in the south central U.S. are leafy greens (kale, collards, mustard, turnip, spinach) grown for various processors and cucurbit crops (watermelon, squash, cantaloupe, pumpkin) grown for the fresh market. Therefore, most of the research conducted by our research team is focused on the pests of these crops. Results of our research on the impact of squash bug feeding on watermelon growth and productivity and controlling pests of cucurbit crops and leafy greens crops are reported in the following.

Effects Of Squash Bug Feeding On Watermelon Productivity

The squash bug has been reported as a key pest of concern to cucurbit crop producers in the region. Little research has previously been reported regarding the impact of squash bug on growth and productivity of watermelon.

Research was conducted at the Center in Lane, OK to determine effects of squash bug feeding on watermelon growth and production. The following results are from individual trials conducted in 1998, 1999 and two trials conducted in 2000. Watermelon seedlings were transplanted into pots or bags of soils. Cages were placed over plants and set numbers of adult squash bugs were released into the cages to feed on the plants. Four different growth stages of plants were treated with the differing numbers of squash bugs. Plants were infested at the seedling, vining, flowering or fruiting stage of growth. Seedling plants were treated with 0, 1, 2, or 4 bugs per plant and plants were harvested when they reached the 5-true leaf stage and weighed. Plants at the vining, flowering and fruiting stages of growth were treated with 0, 1, 2 or 4 bugs in 1998 and with 0, 2, 8 or 32 bugs per plant in 1999 and 2000. Plant foliage and roots and all fruit were harvested when plants died or when the first fruit matured and all were weighed. Regression analysis was used to determine relationships between the number of squash bugs per

plant and the impact on plant growth (foliage and root weight), fruit weight or plant mortality.

Seedling plant growth was significantly impacted by squash bug feeding with reductions in plant foliage and root weight. 100% of the seedlings with 4 bugs per plant were killed by squash bugs prior to reaching the vining or 5-true leaf stage.

Vining and flowering stage of plant growth. Squash bug feeding had a significant impact on plant growth with large reductions in plant foliage and root weights. Additionally, fruit weight was reduced.

Fruiting stage of plant growth. There was little to no effect of squash bugs on plant foliage or fruit production when plants were not infested until the plants had set at least one fruit.

Conclusions

Squash bugs have a significant negative effect on plants by causing early plant mortality, foliage and root reduction and fruit reduction. There is less impact on plant growth when plants are infested at the fruit-set stage of growth. Pest management strategies should be focused on squash bug populations early in the growing season and especially so at the seedling to vining plant growth stage.

Controlling Insect Pests On Commercial Vegetable Crops

We have continued our evaluations of new and currently registered insecticides and of insecticides in review by EPA. These results are reported in the following research trial summaries. Many of the organophosphate and carbamate insecticides that are currently being used may not be available for all crops or all uses as in current registrations. However, a number of new insecticides with novel modes of activity have been registered and should be included in the IPM programs. Additionally, other novel insecticides are in the process of being registered for use on vegetable crops and will be extremely useful in the short term. In general, our results indicate that the newer insecticides are very active, many are very specific in activity and these will end up replacing many uses of the organophosphate and carbamate insecticides.

Results of insecticide efficacy trials to compare various of the registered and new insecticides follow. We have conducted multiple field trials of most of the insecticides over the past three years. Rather than listing results of each trial we have summarized the results by averaging the percentage control achieved by each of the insecticides across trials in reference to similar insect pests. Percentage control was calculated based on numbers of pest insects present in research plots treated with insecticides as compared to numbers of pest insects present in plots not treated with insecticides. The results are variable and the information is provided as a reference only and not a recommendation for specific uses of the insecticides. This information should be used in combination with consultation with a specialist in making application decisions in your crops and against specific pests.

This work is supported primarily by Oklahoma State University, Agricultural Experiment Station and/or Cooperative Extension Service funds. Other financial contributors included USDA/CSREES through funds from the Pest Management Alternatives Program, IR4, Crops at Risk program and various agricultural support industries Gowan, Syngenta and Bayer.

I. Percentage Control of Aphids on Leafy Greens- Soil Applications at Planting (results indicate control at end of growing season – approx. 60 days), 1999 - 2001.

REGISTERED NAME	CLASS OF COMPOUND	% CONTROL
Admire	Neonicotinoid	65
Platinum	Neonicotinoid	73

II. Percentage Control of Aphids on Leafy Greens - Foliar Applications 7 days prior to results, 1999 - 2001.

REGISTERED NAME	CLASS OF COMPOUND	% CONTROL
Acetameprid	Neonicotinoid	99
Aphistar	carbamate	97
Provado	Neonicotinoid	97
Pirimicarb	Carbamate	95
Spintor	Macrocyclic lactone	89
Proclaim	Avermectin analogue	82
warrior	Pyrethroid	80
Fulfill	Pyridine azomethene	75
Confirm	diacylhydrazine	73
actara	neonicotinoid	68
m-pede	Insecticidal soap	62
Neemix	Botanical extract	18

III. Percentage Control of Caterpillars on Leafy Greens – Foliar Applications 7 days prior to results, 1999 - 2001.

REGISTERED NAME	CLASS OF COMPOUND	% CONTROL
Dipel	Bacillus thuringiensis	95
Spintor	Macrocyclic lactone	91
Capture	Pyrethroid	88
Intrepid	Diacylhydrazine IGR	81
Fury	Pyrethroid	79
Avaunt	oxadiazine	76
Proclaim	Avermectin analogue	74
Regent	phenylpyrazole	72
Novaluron	Benzoylphenyl urea IGR	68
Warrior	Pyrethroid	63
Lepinox	Bacillus thuringiensis	60

IV. Percentage Control of Squash Bugs on Watermelon and Squash – Foliar Applications of Insecticides, 1999 - 2001.

REGISTERED NAME	CLASS OF COMPOUND	% CONTROL
Capture	Pyrethroid	100
Warrior	Pyrethroid	98
Neemix	Botanical extract	94
Metasystox R	Organophosphate	93
Diazinon	Organophosphate	82
Lannate	Carbamate	70
Endosulfan	Cyclodiene	66
Provado	Neonicotinoid	57
Spintor	Macrocyclic lactone	21

V. Percentage Control of Squash Bugs on Watermelon and Squash – At-planting soil applications of insecticides and control evaluated 14 days after seedling emergence, 1999 - 2001.

REGISTERED NAME	CLASS OF COMPOUND	% CONTROL
Furadan	carbamate	90
Platinum	Neonicotinoid	31

Summary

The application of insecticides remains a primary and viable method of controlling insect pests on vegetable crops. The proper use of insecticides as dictated by the label results in safe production and safe produce free of insects, contaminants and damage. Specific insecticides and methods of use are changing rapidly and radically and producers must stay informed to remain competitive. Results of research at OSU indicate that new insecticides can be used as replacements for many of those lost through actions taken by EPA under FQPA.

Regional Southern Pea Cooperative Trial 2001

Larry Martin, Stephen Eaton
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Department of Horticulture
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Larry Martin is a native of Arkansas. He holds a B.A. degree in chemistry and a B.S. degree in secondary education from the University of Arkansas. He has worked as a Research Associate at the University of Arkansas Vegetable Substation since March 1989.

Introduction

The Southern Pea Cooperative Trial is an annual trial for southern pea breeders to have selected breeding lines evaluated in different soil types under varying environmental conditions. The breeding lines are evaluated using named commercial varieties as controls.

The U. S. Vegetable Laboratory in Charleston, South Carolina rates the lines for nematode resistance in a greenhouse study.

The Department of Food Science, University of Arkansas, Fayetteville, Arkansas processes the dried peas for a sensory evaluation of canned southern peas. The canned peas are evaluated for pea color, liquor color, wholeness, texture, flavor, and general appearance.

Plant Breeders

The plant breeders in the southern region are: Dr. Blair Buckley, Louisiana State University, Calhoun, Louisiana; Dr. R. L. Fery, U. S. Vegetable Laboratory, Charleston, South Carolina; Dr. J. Creighton Miller Jr., Texas A&M University, College Station, Texas; and Dr. T. E. Morelock, University of Arkansas, Fayetteville, Arkansas.

Locations

There were a total of ten trial locations planted in the southern states with three in Arkansas and one each in Missouri, Oklahoma, Texas, Louisiana, Mississippi, Tennessee, and Alabama.

Research Description

Only the trial planted at the Vegetable Substation near Kibler, Arkansas will be discussed.

The trial is divided into two parts: REPLICATED (advanced lines), OBSERVATION (screening lines). The difference between the two is that the replicated is planted four times in the plot whereas the observation is planted two times in the plot.

The trial was planted in a Roxana Silt Loam soil. Pre-plant fertilizer of 15-30-15 was incorporated. A herbicide treatment consisting of pursuit 2AS at the rate of four ounce per acre and trifluralin 4EC at the rate of one pint per acre was applied in a tank mix pre-plant incorporated. The trial had a row spacing of three feet with four seed per foot in the row. Planting date was June 13, 2001. The plot received 5.07 inches of rainfall with an additional 5.1 inches of irrigation from an overhead linear system. The trial was cultivated twice and harvested on August 29, 2001 with a plot combine after the seedpods were dry. After harvest the peas were mechanically cleaned and bagged.

Findings

Early Acre (cream type), Coronet (pinkeye type) and Arkansas Blackeye #1 (blackeye type) were used as controls in both portions of the trial.

1. Blackeye-replicated: All four of the breeding lines produced as well as the control.
2. Cream-replicated: Two of the three breeding lines produced as well as the control.
3. Pinkeye-replicated: Two of the four breeding lines produced as well or better than the control.
4. Blackeye-observation: None of the three breeding lines produced as well as the control.
5. Cream-observation: All seven breeding lines produced as well as the control, however, four of the breeding lines have the potential to produce better than the control.
6. Pinkeye-observation: All four of the breeding lines produced as well as the control.

Summary

The data indicates that the southern pea breeders have breeding lines that have the potential to match the production of the controls and some will surpass the control.

This information is very important for the breeders to evaluate their breeding lines. This annual test only indicates the potential of a breeding line.

REPLICATED PORTION

EYE TYPE	VARIETY	YIELD LB/ACRE
Blackeye	AR Blackeye #1 – control	1051 A
Blackeye	TX 159 BE	1024 A
Blackeye	TX 128 BE	1010 A
Blackeye	US 1033	758 A
Blackeye	AR 92-574	742 A
Cream	Early Acre – control	756 A
Cream	TX 139 CM	735 A
Cream	LA 92-180	674 AB
Cream	AR 96-918	617 B
Pinkeye	Coronet – control	620 AB
Pinkeye	LA 96-21	962 A
Pinkeye	TX 164 PE	620 AB
Pinkeye	TX 149 PE	486 B
Pinkeye	TX 148 PE	354 B

The same eye type with the same letter are not significantly different.

OBSERVATION PORTION

EYE TYPE	VARIETY	YIELD LB/ACRE
Blackeye	AR Blackeye # 1 – control	1051 A
Blackeye	TX 123 BE	768 B
Blackeye	TX 158 BE	446 C
Blackeye	TX 160 BE	421 C
Cream	Early Acre – control	756 ABC
Cream	LA 95-62	873 A
Cream	US 1031	784 AB
Cream	LA 96-7	632 ABC
Cream	US 1070	574 ABC
Cream	US 1032	542 BC
Cream	US 1069	499 BC
Cream	US 1068	466 C
Pinkeye	Coronet – control	620 A
Pinkeye	TX 162 PE	896 A
Pinkeye	LA 92-86	810 A
Pinkeye	AR 96-1022	808 A
Pinkeye	TX 158 PE	742 A

The same eye type with the same letter are not significantly different.

Southern Pea Variety and Advanced Breeding Line Trials

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Impact Statement

A three-year study was to evaluate Arkansas breeding lines with the commercial varieties to compare yield, maturity date, and plant type. The data from this study indicates that some of the Arkansas breeding lines had equal or higher yields than the varieties that are currently bring grown in commercial production. Some of these breeding lines will continue to be evaluated with the potential of becoming a variety.

Background

Southern pea is an important commodity for home gardeners and commercial processors in the southern region of the United States. The University of Arkansas has an extensive breeding program on southern peas. This program creates advanced lines that need to be evaluated for their potential use as new commercial or home garden varieties. Until the past few years, the main commercial and garden varieties grown were California Blackeye #5 and #46, Coronet and BVR (pinkeye), Mississippi Silver (brown crowder), and White Acre (cream). Presently, the main commercial varieties have switched to Early Scarlet (pinkeye), Early Acre (cream), and Arkansas Blackeye # 1. Breeding lines with the best potential are then entered in the Southern Regional Pea Cooperative Trial and evaluated in the different regions of the southern United States. If they continue to do well, they may be released as a variety.

Research Description

All three years (1999, 2000, and 2001), the trials were planted in a Roxana silt loam soil type in the Arkansas river valley near Kibler, Arkansas. The plots were fertilized with a complete fertilizer 15-30-15. Herbicide treatment was Treflan (trifluralin) and Pursuit (imazethapyr) at the recommended rates pre-plant incorporated. Planting dates all three years were near the optimum planting date for southern peas in this region, June 10-24. The plots were thirty feet (9.14 meters) long with four rows, thirty-six inches apart and a seeding rate of three to four seed per foot in the row. The plots were cultivated twice, once when the plants were six to eight inches tall and again just before flower pods were initiated. Irrigation was used to supplement rainfall to insure the plots received at least one inch of water every seven days, especially at the critical times of bloom and the week after bloom for pod fill. Each plot was harvested with a combine, and the peas were dried and weighed.

Results
Days to maturity were taken from the 2001 planting.

BLACKEYE

No significant difference was found between Arkansas Blackeye # 1 and the top blackeye breeding lines. However, Arkansas Blackeye # 1 and 95-648 did have significantly higher yields than California Blackeye #46. Arkansas Blackeye # 1 and the remaining blackeye breeding lines matured on an average of twenty to twenty-five days earlier than California Blackeye #46.

Table 1: Yield of Blackeye Type

ENTRY	3-YR. AVG. LBS. PER ACRE	PLANT TYPE	DAYS TO MATURITY
95-648	773 A	Erect	54
AR BE #1	770 A	Erect	59
91-308	706 AB	Erect	55
91-298	683 AB	Erect	59
92-574	661 AB	Erect	54
CAL BE #46	586 B	Vining	80

Averages followed by the same letter are not significantly different.

PINKEYE

Twenty-four pinkeye varieties and breeding lines were evaluated in this trial. The top five yielding pinkeye entries were (1) 96-854; (2) 96-868; (3) Early Scarlet; (4) 96-1022, and (5) 92-552. The five lowest yielding pinkeye entries were Excel, 87-435-68, Coronet, C.T. Pinkeye, and BVR.

Table 2: Yield of Pinkeye Type

ENTRY	3-YR. AVG. LBS. PER ACRE	PLANT TYPE	DAYS TO MATURITY
96-854	973 A	Erect	59
96-868	810 AB	Erect	58
Early Scarlet	756 BC	Erect	56
96-1022	750 BCD	Erect	56
92-552	686 BCDE	Erect	65
Excel	505 EFGH	Erect	61
87-435-68	500 EFGH	Erect	62
Coronet	412 FGH	Vining	63
C.T. Pinkeye	364 GH	Vining	63
BVR	323 H	Vining	63

Averages followed by the same letter are not significantly different.

Brown Crowder

The Arkansas brown crowder breeding line of 92-674 had a higher yield than Mississippi Silver. Both Arkansas brown crowder lines matured five to seven days ahead of Mississippi Silver.

Table 3: Yield of Brown Crowder Type

ENTRY	3 YR. AVG. LBS. PER ACRE	PLANT TYPE	DAYS TO MATURITY
92-674	718 A	Erect	63
95-306	660 AB	Erect	61
Mississippi Silver	555 B	Vining	68

Averages followed by the same letter are not significantly different.

Cream

Breeding line 96-918 yielded significantly lower than all other cream types.

Table 4: Yield of Cream Type

ENTRY	3 YR. AVG. LBS. PER ACRE	PLANT TYPE	DAYS TO MATURITY
95-105	811 A	Erect	61
95-104	801 A	Erect	61
Early Acre	770 A	Erect	61
Erect Set	706 A	Erect	63
96-918	466 B	Erect	63

Averages followed by the same letter are not significantly different.

Discussion

The data from this three-year study indicates that some of the Arkansas breeding lines had equal or higher yields than the varieties that are currently being grown in commercial production. Some of these breeding lines will continue to be evaluated with the potential of becoming a variety.

Summary

1. Forty southern pea varieties and breeding lines were evaluated for a period of three years at the University of Arkansas Vegetable Substation.

2. Arkansas Blackeye #1 and the breeding line 95-648 had higher yields than California Blackeye #46.

3. Two of Arkansas' pinkeye breeding lines, 96-854 and 96-868, had higher yields than any other pinkeye type.

4. An Arkansas brown crowder breeding line, 92-674, had higher yields than Mississippi Silver.

5. The cream southern pea breeding lines of 95-105 and 95-104 yielded the same as Early Acre and Erect Set.

Watermelon Survey Findings for Oklahoma

Warren Roberts, Maciej Biernacki, Jonathan Edelson
Jim Duthie, Jim Shrefler, Merritt Taylor, Wenhua Lu

A survey was conducted for two years, in1998 and 1999, on commercial watermelon fields in Oklahoma. The purpose of the survey was to document and categorize production systems in use by watermelon producers in Oklahoma. All aspects of production, including field selection, fertility, cultivar, planting date, cultural practices, pest control, harvest, and yield were recorded. Parts of the results of this survey are described here.

During the two years of this survey, 106 watermelon fields were surveyed throughout Oklahoma. The surveyed fields represented 63 growers, and over 4000 acres, in 19 counties. Thus, the survey represented a substantial part of the total watermelon acreage in Oklahoma. The surveyed counties were primarily in the southern two-thirds of the state, where most of the watermelon production occurs.

We attempted to survey at least one field in every county with substantial watermelon acreage. Fields to be surveyed were selected from lists of previous grower cooperators, and from contacts with Oklahoma Cooperative Extension personnel. Certain restrictions were placed on fields to be surveyed. Because of limited time and funds, attempts were made to survey as many fields as possible within a given time period. This requirement encouraged us to sample fields within a reasonable distance of a highway, for quick access. We also attempted to locate fields that had a reasonably short travel time from one field to another. Technicians were hired to collect the data from each site, and each site was visited approximately once a week from planting time until harvest time.

The fields were categorized by size, and divided into 25 acre categories. Of all the fields surveyed, about half were 25 acres or smaller. About one-fourth of the surveyed fields were from 25 to 50 acres in size, and the remainder of the fields were distributed over the range of 50 to more than 200 acres. One field was over 200 acres, and two fields were in the 150-175 acre category.

The average soil fertility was in accordance with OSU fertility recommendations. The average pH was 5.9 in 1998 and 6.0 in 1999, which is slightly below recommended levels. Nitrogen averaged 93 lbs per acre in 1998, and 124 pounds per acre in 1999. Phosphorus averaged 43 lbs per acre in 1998 and 76 pounds per acre in 1999. Potassium averaged 136 lbs per acre in 1998 and 163 lbs per acre in 1999. Soil samples were collected at or near planting time, and often reflected fertilizers that had been recently applied. There was a wide range of all nutrients tested, with some fields being deficient in one or more nutrients, and other fields showing excessive levels of nutrients. However, the average values were typical of fields that were fertilized according to soil test recommendations.

Of the fields surveyed, approximately one-third of the acreage was planted with seedless watermelons. Several of the large fields were planted with seedless melons, which tended to indicate a high percentage of seedless melons being grown. This does

not indicate that one third of the number of fields were planted with seedless melons, but rather that one third of the total acreage was planted with seedless melons. Most of the smaller fields were planted with conventional, seeded melons.

The time of planting was monitored for each field, and was categorized into two-week intervals. In 1998, approximately one-half of all plantings were completed during the last two weeks of April, with an additional one-third of the plantings being completed during the first two weeks of May. In 1999, the most common planting dates were during the first two weeks of May. About 20% of the fields were planted during the first half of April, about 30% of the fields were planted during the second half of April, and about 35% of the fields were planted during the first half of May.

At planting time, the average soil temperature was 64 degrees in 1998 and 67 degrees in 1999. The range of planting temperatures was 58-85 in 1998, and 61-82 in 1999. These temperatures are satisfactory for planting, with the cooler temperatures of 58 to 61 being somewhat low for good germination and growth, but the average temperatures of 64 and 67 being adequate, if not ideal.

Several fields were abandoned because of un-satisfactory stand establishment. Stand establishment within a field was considered satisfactory if the field was maintained until harvest, rather than being abandoned or plowed under prior to harvest. Stand establishment was more satisfactory with transplanted fields than with direct-seeded fields. Over the two year period, from 82 to 85 % of the fields that were direct-seeded had satisfactory stand establishment, while 94 to 95% of the transplanted fields were satisfactory.

In 1998, harvest occurred an average of 78 days after planting for direct-seeded fields, and 71 days after planting for transplanted fields. In 1999, harvest occurred an average of 76 days after direct-seeding, or 69 days after transplanting. Thus, in both years the time from planting to harvest was 7 days less for transplanted fields than for direct-seeded fields. In 1998, the average field produced 1.0 marketable fruit per plant, while in 1999 a similar value of 1.1 marketable fruits per plant was obtained.

Vine decline diseases accounted for significant losses throughout the season. Over the two year period, only 5 to 6 percent of the direct-seeded plants displayed vine decline symptoms, while 26 to 28 percent of the transplanted watermelons over the two years displayed symptoms of vine decline. Over the two year period, the symptoms of vine declines first appeared an average of 63 to 68 days after planting.

The timing of vine decline appearances and fruit harvests indicates that most of the vine declines were first apparent about one to two weeks before harvest. The causal agent for the vine declines may have been present well before this time, but visual symptoms were not apparent until just before harvest.

Much additional data was collected from these surveys, and will be presented in later publications.

Lycopene Development in Watermelons

Zhimin Shen, Warren Roberts
Jim Duthie
Jonathan Edelson, Penny Perkins-Veazie

This report is based on research conducted by Zhimin Shen as part of the requirements for a Master's Degree Program at Oklahoma State University. The work was done under the advisement of the remaining co-authors, who served as committee members. The research was conducted during the summers of 2001 and 2002 at the Wes Watkins Agricultural Research and Extension Center at Lane, Oklahoma.

Lycopene is a carotenoid that is responsible for the dark red color that is present in fruits such as tomato, grapefruit, and watermelon. Lycopene is an anti-oxidant associated with positive human health benefits. It is chemically similar to carotene. Anti-oxidants such as lycopene have been shown to lessen the risk of cancer in humans. Research now underway suggests that regular consumption of fruits or vegetables containing lycopene may have many positive health benefits.

For some time, lycopene has been known to occur in tomatoes. Tomato products, such as catsup and tomato sauce, have been marketed for their high lycopene content. However, research now indicates that watermelon may have even higher concentrations of lycopene than tomatoes. It is not uncommon to find about 50ug of lycopene per gram of watermelon, while most fresh market tomatoes contain about 30 or 40 ug/g.

Fresh watermelon could provide substantial amounts of lycopene to consumers. There is great potential to capitalize on the health benefits associated with eating watermelon. Increased awareness of lycopene benefits could lead to increased sales of watermelon, and thus increased farm revenues. Fresh watermelon could be seen not just as a flavorful food, or a picnic treat, but also as a healthy amendment to the diet. Americans are becoming more aware of the positive benefits obtained by consuming a healthy, nutritional diet, and such an awareness should lead to continued increases of sales in healthy foods such as watermelons.

If lycopene can be successfully and economically extracted and stored from watermelon fruit, it is possible that watermelon might be grown just for its lycopene content. Although watermelon today is marketed almost exclusively as a fresh market food item, it is conceivable that it could be grown as a processing vegetable, and could be harvested solely for its lycopene content. Since watermelon has one of the highest lycopene concentrations of any fruit or vegetable, it is logical that watermelons would be examined as a potential lycopene source. If this should occur, it would be imperative that an accurate estimate of the lycopene content of a watermelon be obtained. Before a 'crop' of lycopene could be sold, the buyer and seller would have to agree upon the lycopene concentration within a given watermelon or a given field of watermelons. Presently, we do not know the range of lycopene within a given fruit, or the variation in lycopene from one portion of the fruit to another portion.

A large percentage of all watermelons grown in Oklahoma are not marketed. Perhaps as many as one-half of all watermelons that are produced are left in the field, rather than being sold. Watermelons that are over-sized, under-sized, or mis-shapen may never be sold, even though they are physiologically and nutritionally sound. Market conditions will fluctuate throughout the year, and at times prices for fresh-market melons may be too low to warrant harvest. Watermelons that remain un-harvested contribute nothing to farm revenues, and markets are needed for melons that cannot be sold in the fresh market arena.

Melons that are not harvested for fresh markets may still be suitable for lycopene extraction. Such a harvest would increase the amount of revenue per acre, without adding to production costs. For such harvests to be practical, it is important to understand more about lycopene occurrence in watermelon fruits. We do not know the rate of development of lycopene within a fruit, we do not know the time when maximum lycopene concentrations are reached, and we do not know how long the maximum levels of lycopene are maintained. Likewise, we do not know whether lycopene is uniformly distributed within a fruit, and whether or not there are areas of the fruit in which the lycopene is concentrated. Such information must be gathered before lycopene harvest of watermelons becomes practical.

Sweetness (sugar concentration or soluble solids) is a routine method for gauging watermelon flavor and ripeness. Most fresh market watermelons are sold based on a baseline sugar content, but at present lycopene is not a factor in determining ripeness. We do not know if sugar concentration and lycopene concentration increase at similar rates, or whether one may reach a peak level prior to the other. Likewise, we do not know if sugar content can be used to predict lycopene concentrations.

We conducted a study to determine the concentration of lycopene at different locations within watermelon fruit. We also designed the study to determine the rate of lycopene development, and the time at which a maximum concentration was obtained.

Sangria watermelons were grown at the Wes Watkins Agricultural Research and Extension Center at Lane, Oklahoma in 2001 and 2002. Standard fertility, cultural, and disease control techniques were used. Fruits were collected and sampled over the growing season. The first fruits were sampled soon after fruit set occurred, and sampling continued until the fruits were determined ripe by sugar content standards. Samples were taken at various specific locations within a fruit, including the stem end, the blossom end, the center of the fruit, and the side of the fruit near the rind. Other sampling locations were dispersed among the fruit, adjacent to and between the previously mentioned locations.

In general, the highest concentration of lycopene was found at or near the location of the seeds and/or seed cavities. Lycopene was usually detected near the seed cavities even before it was detected in the heart of the fruit. The location of the sample relative to the length of the fruit also affected lycopene concentration. There was a tendency for

more lycopene to be found on the end closer to the blossom end of the fruit than on the end closest to the stem end, although the difference in lycopene at the two ends of the fruit was minimal.

Lycopene formation tended to occur gradually. Lycopene was measurable two months after planting, but continued to increase with time. The rate of increase per day was faster when the fruits were young, and tended to increase slowly or even level off at about 80-90 days after planting. Thus, it appears that lycopene does exist long before the fruits are considered ripe, but lycopene continues to increase up until the time of harvest. Since lycopene production tended to level off near the time of harvest, it does not appear that fruits left on the vine after a normal harvest time would continue to increase in lycopene content.

Over the two years of the study, lycopene and sugar content were measured. There was a correlation between the two measurements, but sugar content was not always a good indicator of lycopene. There was a very strong correlation between the two measurements in the year 2000, indicating that sugar content might be a useful predictor of lycopene content. However, in the year 2001, the correlation was not as strong, indicating that measurements of sugar content should not necessarily be used as an indicator of lycopene content. Both lycopene and sugar content tend to increase with time, but apparently there is enough variation between the two that a measurement of one will not necessarily give an accurate prediction of the other.

This research was conducted only with Sangria, and different cultivars might respond in a different manner. Also, there are indications that environmental or cultural variables will also affect lycopene concentrations within a watermelon fruit.

Food Safety Issues in the Packing Shed and Field

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Field Sources

Vegetables may become contaminated in the field by animal manure, irrigation water, and so on. If this field-contamination is heavy and uncontrolled, it can lead to chronic contamination of packing facilities with illness-causing microorganisms. Therefore, field-contamination control measures are a vital part of any overall food safety program. Prevention of field contamination should begin with proper growing site selection and maintenance. Potential production fields should be investigated regarding their use history including past crops, grazing, and checked to make certain that the soil has not been treated with improperly composted organic matter within the last year, materials such as un-composted animal manure are what producers should be concerned about. Property surrounding the site should be checked to determine if runoff onto production fields may contain fecal contamination from wastewater treatment sites, feedlots, or confinement facilities for poultry or swine. Last, production fields should not be close to or downstream from packing shed cull piles or refuse disposal sites. Fertilization practices for production fields should consider soil and crop needs and the potential of different materials to harbor microbial contamination. Inorganic fertilizers generally originate from synthetic chemicals and have little potential for contamination. Un-composted and improperly composted manures have a much higher potential for contamination with pathogenic microbes. Even with the best in-field sanitation practices, soil carried from the field on transport equipment, workers, and containers can become a source of contamination. For this reason, it is best whenever possible to clean materials, including produce, coming into the packing shed. Consider using a sanitizing agent as described below as part of the cleaning process. Damaged or diseased fruit should be culled in the field if possible, to avoid contaminating good fruit during packing. If this is not possible, fruit culling should take place as early in the packing process as possible.

Water

Water is the number one source of microbial contamination for fresh produce. It can act as a carrier for many types of food-borne pathogens including; *Escherichia coli* (E-Coli), *Salmonella* spp., *Vibrio cholerae*, *Shigella* spp, *Cryptosporidium parvum*, *Giardia lamblia*, *Cyclospora cayetanensis*, *Toxisplasma gondii*, the Norwalk virus, and hepatitis A. Both irrigation water and water used in the packing shed should be tested for microbial contamination and if found, water should be treated to remedy the problem. Irrigation methods vary considerably regarding their potential for contaminating produce. Application of water to fields utilizing drip or furrow irrigation is less likely to spread contamination onto produce than overhead watering with sprinklers which wets both leaves and fruit with water and soil.

Workers

Workers are another possible source of microbial contamination in the field and packing shed. Proper worker hygiene is critical for maintaining food safety. Adequate restroom and hand-washing facilities must be provided and workers must be regularly trained in food safety basics such as proper hand-washing before beginning work and after breaks and restroom use in both the field and packing shed. Workers directly handling produce should wear properly sanitized gloves. Workers with wounds that might come into contact with the produce should not handle product during harvest or packing operations, even if gloves are worn. Gloves are useful, but are not a substitute for proper hand-washing and sanitizing. Teach workers to be aware of food safety issues. With the right training, workers can become the first line in ensuring the success of any food safety program.

Pests

Many types of pests can contaminate packing sheds, equipment, and produce. These include birds, insects, and rodents or other mammals. In this context, pests may include domestic animals such as dogs and cats. It may not be feasible to completely exclude these pests, but simple steps such as traps for rodents or screens over exposed rafters to keep birds from landing can help. Animal waste should never be allowed to accumulate. Dead animals, fruit waste, and other items that may attract pests should be promptly removed. Any pest control measures employed should be documented and monitored to support the grower and shipper in case of a food borne disease outbreak.

Equipment and Facilities

Produce handling equipment and the facilities themselves may become a source of contamination once harmful microorganisms have been introduced by any of the vectors mentioned above. A regular, documented cleaning routine is essential to any food safety program. The proper use of cleaners and sanitizers is also vital, especially to prevent the formation of hard-to-kill buildups of microorganisms called bio-films.

HACCP

HACCP is an acronym that stands for Hazard Analysis Critical Control Point. It is a plan and a process that food processors have used for several decades to ensure the safety of processed foodstuffs. HACCP-like programs can be developed for producers and shippers in the fresh produce industry. Recently the Food and Drug Administration and the United States Department of Agriculture came together to help develop guidelines to ensure the safety of fresh produce on the farm and in the packing shed. These guidelines are outlined in two publications, "Food Safety Begins on the Farm: A Grower's Guide" and "Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables". These publications are an excellent source of information for producers and shippers and are available at (607) 254-5383 for the grower's guide and at Food Safety Initiative Staff (HFS-32) U.S. Food and Drug Administration Center for Food safety and Applied Nutrition 200 C Street SW Washington, DC 20204 or on the Internet at: http://vm.cfsan.fda.gov/~dms/prodguid.html, respectively for the other guide.

Scheduling for Food Safety Things to do Several Times a Day

Test strength of any chlorinated dump or wash water and change as needed. Inspect handling/packing lines and remove any dirt and fruit debris. These may become reservoirs of microorganisms spreading contamination to other produce. Remove culled fruit and other trash from packing area.

Things to do Once a Day

Change and re-chlorinate or otherwise sanitize water in dump or wash tanks. When disposing of chlorinated water be sure to check local regulations. Clean and sanitize handling and packing line equipment, floors, drains, waste receptacles, and bathrooms.

Things to do Once a Month or Between Operations

Clean and sanitize cold rooms, including ceiling, floors, walls, condenser coils, and doors or curtains.

Other Things to Keep in Mind

Maintaining a proper "cold-chain" is critical to controlling microbial growth. Produce should always be cooled as quickly as practical and kept cool to the extent possible during storage and transportation. This will also help to maximize quality.

Proper layout of the facility and equipment can help prevent contamination. Try to segregate "clean" and "dirty" areas so that equipment, products, and people do not move through "dirty" areas once cleaned. Also, be aware of storage of possible chemical contaminants such as sanitizers. These should always be stored away from produce handling and storage areas.

Promptly correct flaws in handling equipment that result in mechanical injury to the fruit. Damaged fruit can become an incubator for illness causing microorganisms. Prepare boxes and cartons only as needed for packing. Pre-assembled containers can become harbors for pests or other contaminants. Produce should always be kept off the floor. Any product that falls on the floor should be discarded. Periodically inspect fruit in storage and promptly remove any fruit that develops signs of injury or disease. These fruit can spread contamination to healthy fruit nearby.

Common Types of Sanitizers and Their Use

Chlorine Based Sanitizers

Chlorine based sanitizers are commonly used for treating wash water as well as equipment cleaning. Dilute mixtures of sodium hypochlorite, the chlorinating agent found in household bleach, are frequently used. Systems employing chlorine gas or chlorine dioxide are also available. The use of hypochlorite as a sanitizer offers several advantages including low cost, easy availability, and rapid effectiveness against a wide range of microorganisms. Disadvantages include corrosiveness, irritating fumes, and rapid loss of killing power in the presence of organic compounds such as soil and plant

material debris. The corrosiveness of hypochlorite makes it generally unsuitable for use on iron, galvanized-iron and mild steel equipment. Concentrations of up to 200 parts per million (ppm) active chlorine (21 CFR Part 178) may be used on food contact surfaces with adequate draining without a potable water rinse afterward. Concentrations of up to 2000 ppm hypochlorite (21 CFR Part 173) may be used in produce wash water provided there is a subsequent potable water rinse. One tablespoon of household bleach (5.25% hypochlorite) per gallon of water gives about a 200 ppm solution. Contact times of 1 to 5 minutes at 200 ppm are usually sufficient to achieve a thorough kill, depending on chlorine concentration and organic load. Hypochlorite solutions should be checked frequently for strength, as the chlorine is lost due to interaction with organic compounds as well as evaporation.

Quaternary Ammonia Compounds

Quaternary ammonia compounds, or quats, are also commonly used as sanitizing agents. These have the advantage of being non-corrosive and non-irritating. As a result, they are often employed to clean aluminum, non-stainless steel, or iron equipment for which a chlorine-based solution may be too corrosive. They also have good residual activity and are stable in the presence of organic matter. One disadvantage of quats is that they are less effective than other types of sanitizers against gram-negative microorganisms such as *E. coli*. Therefore, a stronger solution, in the range of 500 or greater ppm with a longer contact time of 20 minutes or more may be recommended for equipment cleaning. As with hypochlorite, a potable water rinse is required when concentrations greater than 200 ppm active quaternary compound are used on food contact surfaces.

Iodophors

Iodophors are iodine-containing sanitizers. They have several advantages as sanitizing agents. Iodophors are effective against a very wide range of microorganisms and are generally non-irritating. They have good penetrating power and work well to prevent biofilm formation. In addition, unlike many other sanitizers, they maintain their killing power over a wide pH range and work well in hard water. They are, however, expensive compared to many other sanitizers. And while iodophors are less corrosive than hypochlorite solutions, they may still be unsuitable for sanitizing iron or galvanized-iron equipment. These compounds may also be slower acting at typical concentrations than either quats or hypochlorites. A potable water rinse is required when concentrations greater than 25 ppm iodine are used on food contact surfaces.

General Cleaning Tips

Pre-rinsing with water will often help in overall cleaning. The use of an acid-detergent cleanser may also help clean certain types of soil such as mineral deposits. Cleaning supply vendors are a good resource for specific information on cleaning needs. Cleaning, sanitizing, and rinsing should always be done from the top down, to avoid re-contaminating cleaned areas. Also, cleanser should not be allowed to dry on surfaces as this may lead to incomplete cleanser removal and product contamination.

Recommendations for Documentation

Documentation is an absolutely key step for any food safety program and is the only way to establish due diligence in case of suspected problems or food borne illness outbreaks. The basic elements of a food safety plan should be written down and records of compliance should be kept. These need not be elaborate but should include basic information on what was done, who did it, when it was done, and the results of any tests performed, for example chlorine strength in wash water. Records should also be dated and signed. Such records are typically kept for 3 years. It is useful to periodically review these records in order to identify and fix any consistent problem areas that may turn up. These practices form the basis of a Hazard Analysis Critical Control Point (HACCP) plan and such a plan can be formalized if needed or desired.

Conclusions

Above all, a useful food safety program for packing shed facilities is based on common sense. Keep things clean, keep things sanitary, and look for possible problems before they become food safety issues. On-going training and awareness of food safety issues from the workers on up can help protect producers, processors, retailers, and the public alike. Safer, more wholesome food is in everyone's interest.

Spring 2001 Spinach Variety Trials

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Cooperators Merlin Schantz & Dean Smith

Introduction and Objectives

Spinach is an important vegetable crop for producers in Oklahoma, primarily for the processing market. Producers have been growing spinach commercially during the past few years for fall and over-winter processing markets, but recently the opportunity to produce spring spinach was made possible. Evaluation of spring planted spinach varieties regarding seedling vigor, resistance to bolting, yield potential and color intensity will provide producers with better information when making cultivar selections in the future.

Materials and methods

Three separate variety trials were planted in March 2001. Locations were the Oklahoma Vegetable research station near Bixby, Custer County at Merlin Schantz farm east of Weatherford, Oklahoma and Caddo County at Dean Smith's farm west of Hinton. The trial included nine different spinach varieties replicated four times in a randomized block design. Each variety was direct seeded at a rate of approximately 558,000 seeds per acre. Trials ranged from 10-15 inch centers per plot and 20 to 30 feet long plots with two rows per plot. The producers and station manager conducted all other practices including irrigation, fertilization, weed, disease and insect control.

The trials were rated for seedling emergence approximately three weeks after planting, vigor and color intensity approximately six weeks after planting, color intensity, yield and bolting nine weeks after planting. Color and vigor ratings were recorded utilizing a scale of 1 to 5 where 1=lowest and 5=the highest level.

Results

Emergence ratings varied significantly in all trials with the highest being Samish, Bolero, and XP 278. Vigor was significantly higher for Bolero in all trials, Catalina was on the low end in the trials. Color ratings were averaged over two dates and varied significantly between several of the cultivars. Catalina, Olympia and XP 278 had the highest average color ratings. The lowest color ratings were recorded for Baker and Bolero. Bolero being significantly lower in all trials. Yield results varied between trials; however there was little significance within each trial. Bolting varied significantly between cultivars in all trials. Baker, Bolero, Catalina, Olympia and XP 278 had little or no bolting at harvest, compared to Cypress, F-380, F91-415, and Samish that averaged 21.7, 75.9, 39.2, 88.8 percent bolting, respectively.

Conclusions

Although spinach cultivars in the trial varied significantly for differences in emergence and in vigor, these differences resulted in very few yield differences at harvest time. High levels of color intensity are thought to be related to higher nutritional value in

spinach and did vary considerably in this study, with Catalina, Olympia and XP 278 having the highest levels of color in the trial. Bolting was the most clear-cut characteristic that was measured in the trial and is vital for spinach cultivars that will be grown during the spring season. Five cultivars including Baker, Bolero, Catalina, Olympia and XP 278 recorded little or no bolting at harvest time.

Acknowledgements

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Table 1. Spring 2001 Spinach Variety Trials, averages for all trials. Study results.

Variety	Seed Source	Emerge[z]	Vigor[y]	Color[x]	Yield[w]	Bolting[v]
Baker	Alf Christianson	50.9	2.4	3.1	29.1	0.4
Bolero	Petoseed	74.6	4.0	2.4	29.3	0.0
Catalina	Seminis	54.2	1.8	4.2	24.8	1.3
Cypress	Asgrow	45.0	2.2	3.3	23.0	21.7
F-380	U of A release	60.4	3.3	3.1	26.9	75.9
F91-415	U of A release	59.2	3.0	3.2	28.1	39.2
Olympia	Alf Christianson	51.7	2.5	3.7	24.4	0.0
Samish	Alf Christianson	72.9	3.4	3.3	29.2	88.8
XP 278	Asgrow	66.3	3.2	3.5	28.3	0.0

[z]Emerge=Estimated percent of crop emerging.
[y]Vigor=Rating 1-5, 5 best.
[x]Color=Rating 1-5, 5 best mean of two ratings.
[w]Yield=pounds per plot.
[v]Bolting=Estimated percent of plants bolting.

Spinach Breeding in Arkansas

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The Spinach Breeding Program at the University of Arkansas was started in 1970 to address the need for a public sector breeding program to deal with the need white rust and fusarium resistant varieties for Arkansas and the surrounding states. The first varieties released from the program were Ozarka and Greenvalley both of which provided a useful level of white rust resistance in adapted semi-savoy varieties. Since that time Fallgreen (semi-savory) and F380 (flat) have provided higher levels of white rust resistance and have been widely grown in the region. The varieties developed by the University of Arkansas have also provided the basis of resistance for the seed company hybrids or it could be said the all commercially available white rust resistance has some 'Arkansas blood'.

Spinach breeding nurseries are presently being grown at the University of Arkansas Vegetable Substation located at Kibler, Arkansas, the Del Monte research farm at Crystal City, Texas and the Texas A & M Research and extension center at Uvalde, Texas. The University of Arkansas Vegetable Substation site has used the same nursery location for the past 25 years and has good disease presence for most diseases on the area but is particularly good for the soul borne diseases especially fusarium. Both Texas sites provide excellent white rust presence but recently the Del Monte site has been more consistent than Uvalde.

Plants are selected for disease response and horticultural characteristics. The plants are dug, placed in pots and transported to the spinach seed production greenhouse at Fayetteville, Arkansas. The greenhouse has 80 isolation compartments when the controlled crosses are made.

As for the future 88-310 (wintergreen) is a slow growing semi-savoy that shows promise for certain fresh market uses. It has good white rust resistance and has excellent dark green color and high quality. Another new line that well probably be released is 91-415. It is a flat leaf that is similar to F380 but has a more upright plant habit and slightly better color with a similar level of white rust resistance.

Pumpkin Production on the Texas High Plains

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Introduction

Texas High Plains pumpkin growers also produce cotton, grain sorghum, peanuts, soybeans, wheat and other grains. Our markets include supermarket chains, garden centers, retail outlets, and mail order in U.S.A., Canada and Mexico. Farm retailing is profitable for some growers.

Our pumpkins are grown in clay loam, sandy loam, and loamy sands in Floyd, Hale, Castro, Lubbock and Yoakum counties. Pumpkin roots grow 18 to 36 inches deep and absorb available water from depths of two to four feet. High Plains growers harvest 3,000 to 4,000 acres of pumpkins yearly. Yields range from 20,000 to >40,000 lb./acre.

Varieties Planted

Today, the word "pumpkin" can refer to many horticultural varieties of three distinct species: *Cucurbita pepo, Cucurbita maxima, and Cucurbita moschata.* Some winter squash varieties are included. Varieties: Prizewinner, Big Max, and Cinderella are closely related to Hubbard, Delicious, and Sweet Meat winter squashes, all of which are *C. maxima.* The Mexican Candy pumpkin, Fairytale, Waltham Butternut winter squash and Neck Pumpkin are members of *C. moschata.* Varieties: Howden, Munchkin, Lumina, and Magic Lantern are *C. pepo* along with Spaghetti Squash, Sweet Dumpling squash, some small ornamental gourds, and the highly colorful Carnival hybrid squash. Perhaps only *Cucurbita* breeders, horticulturists and seed growers need to know which variety belongs to which species. My point is this. If a pumpkin or squash has appealing color and/or shape, it will appeal to many people. So, grow them and market them to creative people who appreciate their artistic value. As more varieties are thought of as being pumpkin-like, a greater the number of varieties will be planted, and the volume of pumpkins sold and profit realized by growers will increase.

Let's take a look at varieties grown here. Very small (up to 2 lb.) varieties include: Jack-Be-Little (4oz.), Munchkin (4 oz.), Lil' Goblin (2lb.), Baby Boo, Carnival (F1) and Lil' Pump-Ke-Mon (F1). Small (2 to 8 lb.) varieties: Small Sugar, Spookie, Snackjack (F1), Bushkin (F1), Oz (F1), Mystic (F1), and Lil' Goblin (F1). Mystic Plus is a new powdery mildew tolerant F1 hybrid. Medium (10 to 15 lb.) varieties: Autumn Gold (F1), Jackpot (F1), Wizard (F1), and Lumina. Large (15 to 25 lb.) varieties: Howden, Ghost Rider, Mexican Candy Pumpkin, ProGold #510, Pankow's Field, Fairytale, Cinderella, plus Merlin (F1) and Magic Lantern (F1) which are powdery mildew (*Sphaerotheca fuliginea)* tolerant. Enormous (30 to > 300 lb.) varieties: Howden Biggie, Big Max, Prizewinner (F1), and Atlantic Giant top the list.

Pollination

All pumpkins require cross pollination. Plants are monoecious. Both male and female flowers develop on the same plant. Pollen is taken from anthers of male flowers and deposited on stigma of female flowers. Bees are indispensable in this process. Growers assumed that native, wild honey bees would take care of pollination. Native bees are extinct, killed by disease and a tiny parasitic mite. By mid to late 90s entire 60-acre fields were fruitless, resulting in extreme loss to growers. Every successful grower owns or rents bees. One strong hive or two average hives/acre are placed so bees do not have to fly more than 100 yards from hive to reach all flowers in the field. Floyd County growers found Bumblebees were excellent pollinators. But cost was $150 to $200 per acre, and supply was unreliable.

Soil Fertility Management

Our soils range in pH from 7.3 to 8.0. Growers strive to begin growing season with high levels of N, P, and K. If levels are low to medium, 60 lb. N, 80 lb. P, and 100 lb. K are applied. Our soils mineralize 25 to 30 lb. N/acre/year. Band all phosphorus under seed if soil pH > 7.5. Most loams, sandy loams and loamy sands have very high K. Organic matter rarely exceeds 1.5% and addition of compost is beneficial. Composting rates range from 2,000 to 4,000 lb./year. Never apply feed lot manure the year pumpkins are planted. Apply 20 to 30 lb. of N and all P and K preplant. Side dress 60 to 70 lb. N at three to four true leaf stage. Band N for semi-vine and semi-bush varieties. Broadcast N for vining varieties which develop roots at each leaf node.

Rotation

Successful growers allow four years between vine crops: pumpkin, squash, cucumber, cantaloupe and watermelon. Do not plant pumpkins the year after triazine herbicide use. Choose pumpkin herbicides in relation to crops following in the rotation. Crops grown in typical rotations: watermelon, onion, chile, cotton, grain sorghum, soybean, peanut, wheat, and other grains.

Planting Patterns

Most Howden growers no longer plant on raised beds with 40-inch centers because in clay loams, enlarging fruits come to rest in irrigation middles where they become infected with anthracnose. An alternative is to plant flat and install center pivot LEPA irrigation. Vining varieties are usually spaced on 80-inch centers with plants averaging 30 to 40 inches apart. Space semi-vine and semi-bush varieties in rows 36 to 48 inches apart and plants 18 to 24 inches apart.

Soil Fumigants

Pumpkins are very susceptible to root knot nematode injury. The season before planting pumpkins, while the crop is still growing in the field, sample soil and have it assayed for kind and numbers of nematodes. Telone nematicide soil fumigant applied the fall before year of planting pumpkin while soil temperature is still above 60 degrees F. An alternative is Vorlex soil fumigant which kills nematodes and some weeds. Spring or fall application is acceptable when fumigants are applied according to label instructions.

Windbreaks

Pumpkins and winter squash are not wind tolerant plants. Growers with high yield goals of 30,000 to >40,000 lb./acre plant windbreaks to ensure good stands of vigorous seedlings. Some growers plant into overwintered wheat or Elbon rye which has been sprayed with glyphosate. Escape grasses are controlled with sethoxydim applied postemergence to crop. Giant Grey Stripe, Giant Russian, or Skyscraper sunflower -- young plants are cold tolerant -- make excellent windbreaks when planted in single rows 30 to 40 feet apart in March. Tall-growing headless sorghum G1990 (Northrup King) can be planted in April, but plants will not be as large as sunflower when pumpkins are planted.

Seed and Seeding

Growers plant fungicide-treated seed 3/4 to one inch deep in clay loams, one to 11/2 inches deep in sandy loams and about two inches in loamy sands. Pumpkin seed size varies widely from variety to variety. Howden has 2550 seeds/lb., whereas Small Sugar has 3,500 and Munchkin 7,200. A rule of thumb, which takes germinate and emergence rate into consideration, is to plant twice the number of seeds/acre as the number of plants calculated by spacing. A single plant spacing of 80" x 40" for Howden would require about 2,000 plants/acre and a seeding rate of about 4,000 seeds/acre or at least 1.5 to 2 lb./acre. To have to thin plants out is better than being stuck with a poor stand.

Planting Dates

Days from seeding to harvest is about 90 to 95 for semibush varieties up to 140 for Mexican Candy Pumpkin. Seed catalog varietydescriptions usually estimate growing time. Optimum soil temperature for seed germination is 85 to 90F. Try to sow seed when soil temp is at least 65F at the 4-inch depth to stimulate rapid germination and strong emergence.

Growers start seeding Howden in late May to early June. Some growers plant again in late June or early July to ensure crop success even if earlier crop suffers weather damage. Mexican Candy Pumpkin takes a long time to reach full maturity, even longer than Waltham Butternut Squash.

Irrigation

Pumpkins require 20 and 30 inches assuming soil profile to be full at planting. In-season rainfall, soil type and variety impact soil moisture use. Growers should maintain soil moisture tension between 10 cb. (near field capacity) and 30 cb. (stress threshold). Critical growth stages when soil moisture deficit can hurt yield and quality are: germination/emergence, rapid vine growth, flower formation, pollination/fruit set, fruit development/enlargement, and fruit ripening. Pumpkin roots penetrate our soils to a depth of two to three feet.

Growth Stages

There are six stages. Emerged Seedling: 7 to 10 days from seeding in warm soil; Vegetative Growth: 10 to 40 days from seeding; Flowering: 40 to 60 days from seeding;

Fruit Set: 50 to 60 days from seeding; Fruit Enlargement: 50 to 90 days from seeding; and Fruit Maturation: 70 to 120 days from seeding.

Disease Management

The objective of disease management is to keep plant foliage disease free until fruit are fully mature. Powdery mildew (*Sphaerotheca fuliginea)*, a major fungus disease can consume leaves in a week left unsprayed. Recently released hybrids Merlin, Magic Lantern and Mystic Plus are powdery mildew tolerant. When you notice morning dew for the first time, spray susceptible varieties for powdery mildew with sufficient volume and force to cover both leaf surfaces. This will require 20 to 30 gallons/acre at least. Skillfully operated air blast sprayers cover foliage very well by causing the leaves to present their lower surface much as an umbrella does when caught by a strong wind. Apply Bravo to prevent anthracnose when first fruit are golf ball size. Applied before plants are infected, Bravo 720 @ three pt./acre or Bravo Ultrex, or Bravo Weather Stick @ one qt./acre if field is irrigated by center pivot or if rain is expected will be effective. The cost is about $14.00/qt. plus $4.25 for aerial application for a total of about $18.25/acre.

Disease Management

Growers, pathologists, and consultants have observed that fungi which are controlled by Bravo are not building up tolerance of Bravo. If a grower is not satisfied with performance of Bravo or wants to provide extra protection for very susceptible, high cost hybrids, or wishes to alternate fungicides to lower chances of fungi building tolerant generations, there are three relatively new, effective fungicides which have Section 18 labels for Texas. Quadris, Nova and Flint can be alternated with Bravo or with each other in a spray program during intense disease pressure. Quadris @ 12.5 oz. costs about $28 +4.25/app. Nova @ 2.5 oz. costs about $10.33 + 4.25/app. Flint @ 2.0 oz. costs about $34.74 +4.25/app. They are alternated in sequence with a 10 to 14-day spray interval. The total cost is about $85 to $90/acre for the program consisting of one spray of each fungicide.

Viruses

Insect transmitted viruses often infect individual plants but rarely take the entire field. There are exceptions. This year curly top virus, brought to us by beet leafhoppers, destroyed up to 30 to 50% of some fields of squash and pumpkins. Poty viruses, zucchini yellows, and watermelon mosaic virus are vectored by aphids. Insects feed on weeds and early season perennials in wild areas and fly into fields of young pumpkin and squash plants where they inject viruses by penetrating leaf cells with their piercing-sucking mouth parts.

Insect Management

Growers and professionals scout fields of newly emerged pumpkin seedlings to see incoming squash bug adults which are elusive, even hiding in spaces between surface soil crust and plant stem. Be certain to apply only labeled insecticides according to label directions. Growers use mostly Asana and Thiodan to control squash bug and striped or spotted cucumber beetle. Asana and pyrethrins are applied to control leafhopper. Phaser and Asana are effective controls for squash vine borer which is rarely a problem. Aphids

rarely reach economic thresholds but are easily controlled with Phaser if they reach damaging populations.

Weed Management

Weed control is a challenge because pumpkin varieties vary in sensitivity to labeled herbicides and the time lapse required before planting other crops in rotation. Labeled preplant-applied herbicides include Command, Gramoxone Extra, Prefar, and Roundup. Command, Curbit, and Prefar can be applied postplanting before weeds and crop emerge. Glyphosate is cleared for application preemergence to the crop, but growers are not advised to plant into stale seedbeds or when soil is so cool that pumpkin seed doesn't germinate rapidly. Poast is applied to kill grasses after crop emergence. Consult with your Extension herbicide person on a program which will work on your farm.

Harvest, Handling, Storage

Mature pumpkins with hard skin and stem are harvested by cutting the vine away at its attachment to the stem. This method often results in cutting part of the stem away or cracking the stem-fruit attachment which often results in the stem falling off during shipping and fruit rot. A better method is to use a sharp shear pruner to make the cut. There is less chance of cracking the stem-fruit attachment. Pumpkins left in the field after leaves die often rot and suffer damage from soil insects. Our intense sunlight bleaches skin of exposed fruit.

Ideally, high quality pumpkins would be hauled from field to barn storage as soon as they are fully mature even though it means double handling. Fruit are piled not more than three to four deep on pallets, wagons, or wood floors to dry and await shipment. Never pile fruit on concrete floor. Fan-dry barn air to prevent moisture from condensing on fruit. Storage life is two to three months at 50 to 55F at 65 to 70% relative humidity. Actually, most of our pumpkins are harvested, hauled from field on trailers, and conveyed onto waiting 18-wheelers at the highway. Rains during harvest cause delays in harvest and shipping schedules.

Powdery Mildew Resistance in Watermelon

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Anthracnose, gummy stem blight, and downy mildew have historically been the predominant foliar diseases encountered by U.S. watermelon (*Citrullus lanatus* (Thunb.) Matsum. &Nakai) growers (Zitter et. al., 1996); however, in the last few years, powdery mildew has emerged as an important disease problem of watermelon in the major U.S. production areas. Powdery mildew symptoms on cucurbits typically appear as white powdery spots of mycelia and conidia on both sides of the leaves, but may appear on petioles and stems. Symptoms first develop on older leaves reducing plant canopy, and subsequent yield due to decreased fruit size and number of fruit per plant (McGrath and Thomas, 1996). The reduced canopy may result in sunscald of the fruits making them unmarketable. The presence of the pathogen is more readily apparent on pumpkin and squash than on watermelon, which can obscure visual detection until after plants are severely damaged by the disease. For example, watermelon leaves often begin deteriorating prior to obvious appearance of mycelia and conidia, which makes early diagnosis and control on watermelon more difficult. There are at least two types of symptoms on watermelon. One is a yellow blotching (chlorotic spots) that occurs on leaves accompanied by little or no sporulation and only a small amount of mycelial development. The other symptom is powdery mycelial and conidial development on either leaf surface without the associated chlorotic spots. Often, the disease first appears as a slight yellowing of crown leaves in low areas of a field associated with higher relative humidity. However, an entire field should be scouted for early powdery mildew detection, since low areas are not always the first to be affected. Because of the short disease cycle, control measures must be implemented soon after disease onset to be effective.

Two genera are considered the predominant fungi causing powdery mildew in cucurbits, *Sphaerotheca fuliginea* (Schlechtend.:Fr.) Pollacci and *Erysiphe cichoracearum* DC. Within S. *fuliginea*, there are as many as seven pathogenically distinct races based on melon differentials (Pitrat et. al., 1998). Correct identification of the causal organism is important since *E. cichoracearum* and *S. fuliginea* are known to differ in virulence as well as sensitivity to fungicides (Bertrand, 1991; Epinat et al., 1993). Control of powdery mildew on pumpkin has been accomplished in the past by planting resistant cultivars and fungicide applications (Keinath, 2001). Unfortunately, powdery mildew resistance to fungicides has been detected and application of fungicides to the undersides of leaves is difficult unless a systemic product is used (McGrath and Thomas, 1996).

To manage powdery mildew on watermelon, it is suggested that a broad-spectrum fungicide, such as Bravo, benomyl and mancozeb, or a tank mixture of thiophanate-methyl be applied at flowering (Damicone, 2001)[1]. This regimen can be continued at 14 day intervals. However, once powdery mildew is detected, application of Flint or Nova is most effective at controlling the disease(Damicone, 2001)[1]. One application is normally sufficient for excellent control of powdery mildew. However, no more then two applications of Flint or Nova should be used in a season and alternating applications of Flint and Nova are suggested.[1]

Since powdery mildew has been rare on watermelon in the U.S. (Robinson and Provvidenti, 1975) there was little incentive to study powdery mildew resistance in watermelon until recently. However, in the last few years, powdery mildew has caused moderate to severe damage to watermelon crops in South Carolina, Georgia, Florida, Oklahoma, Texas, and California. As a result, we have undertaken studies to evaluate powdery mildew resistance in PI lines from the Griffins, GA germplasm collection. We screened watermelon for resistance to powdery mildew in the summer of 2000 (Davis et. al., 2001), and found a continuum of disease severity suggesting multigenic control. In that study we found several potential resistant lines. Two of the lines showing high resistance in the 2000 field study were crossed to 'Black Diamond' (a susceptible open-pollinated cultivar) to determine the inheritance of the powdery mildew resistance. The original parents and their progeny were evaluated in a growth chamber in which plants were inoculated with the powdery mildew fungus collected from field grown watermelon plants. We determined that the powdery mildew resistance in PI525088 held up in the growth chamber experiment but PI225557 did not. By studying the parental and F1 seedlings from our cross between PI525088 and Black Diamond, we concluded that the powdery mildew resistance is dominant in these crosses however, it is likely a multigenic trait within the watermelon gene pool. Further crosses are being tested to continue to delineate the inheritance of this resistance. Concurrently we studied cantaloupe differentials for powdery mildew and the results suggest we are working with race 0 or race 1.

In the United States, Robinson and Provvidenti (1975) studied 590 *Citrullus lanatus* accessions for resistance to an unknown race of powdery mildew. All but one of the accessions were resistant. Robinson et.al. (1975) used the susceptible accession from Belize (PI 269677) to study the inheritance of powdery mildew resistance to what appeared to be race 2 of *S. fuliginea*. Using PI 269677 X 'Sugar Baby' F1, F2 and backcross generations, they determined that resistance was due to a single recessive gene. This is contrary to our findings, which suggest that resistance is controlled by multiple genes. Our study showed a continuum of disease severity ratings from 1.5 to 5.0 among the watermelon population screened in the 2000 field study and quantitative inheritance in our growth chamber study supported those findings. This preliminary data suggests that genetic resistance to race 0 or 1 of *S. fuliginea* is controlled by multiple genes that are expressed as degrees of tolerance. Since we are screening for resistance to a different race of *S. fuliginea* than Robinson et. al. (1975), it is not surprising that a different array of genes may be involved in the observed resistance.

Without resistant cultivars and with limited fungicide availability, U.S. watermelon growers could experience severe crop losses in years with optimal conditions for powdery mildew development. Currently, fungicide application and planting resistant varieties remain the best controls for powdery mildew outbreaks on cucurbits. However, there is no published

information available on relative resistance or susceptibility in U.S. watermelon cultivars against the new strain of *S. fuliginea*. Because of the capacity of this fungus to develop resistance to fungicides (McGrath, 2001), alternating fungicides with different modes of action should be integrated into the disease management program.

[1]Mention of trade names or commercial products in this article is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture. All programs and services of the U.S. Department of Agriculture are offered on a nondiscriminatory basis without regard to race, color, national origin, religion, sex, age, marital status, or handicap. The article cited was prepared by a USDA employee as part of his/her official duties. Copyright protection under U.S. copyright law is not available for such works. Accordingly, there is no copyright to transfer. The fact that the private publication in which the article appears is itself copyrighted does not affect the material of the U.S. Government, which can be freely reproduced by the public.

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Cultural Methods for Non-pungent Jalapeños

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Vince Russo has been Research Plant Physiologist at the South Central Agricultural Research Laboratory since 1988. His research interests include the development of planting systems designed to diversify agricultural production in the Southern Plains.

Tomato based products with varying levels of pungency are becoming popular in the American diet. The pungency in these products is supplied by capsaicin, a naturally occurring product, produced in jalapeño pepper fruit. To obtain the desired level of pungency the industry uses a dilution process during product processing. Pungency in pepper fruit can be affected by the conditions under which they are grown. Pungency can vary in peppers produced on different fields, and from different production regions. Recently peppers have been bred that retain the jalapeño flavor, but do not have any pungency. Industry can add known amounts of capsaicin to products that will have the desired consistency and pungency for various consumer tastes.

There is little information about the cultural methods that are beneficial to the production of the highest yields of these peppers. The Southern Plains may have advantages in climate and in proximity to a major processor that could make production of these specialty peppers a viable alternative crop for the region. Affects of cultivar, planting date, and number of plants at a site on yield were examined.

Materials and Methods

The experiments were conducted on a Bernow fine-loamy, siliceous, thermic Glossic Paleudalf soil at Lane, OK. Fertilizer and herbicides were applied preplant and beds were formed on three foot centers. Six-week old transplants were transferred to the beds comprised of bare soil on 15 and 20 July 1999, 15 April and 17 June 2000, and 16 April and 8 June 2001. The plantings in 1999 were for an expected early fall harvest. In the other years the harvests were expected in mid- and late-summer. Irrigation was with overhead sprinklers and at least of two inches of water per week was delivered. No fungicides or insecticides were needed or applied.

In 1999 the cvs. Pace103, Pace105, Pace108, TAM Sweet were used. These same cultivars along with the cv. Dulce were used in 2000 and 2001. In 1999 there was one plant per site in plots. In 2000 and 2001 there was either one or two plants at a site. To have two plants at a site cells in seedling trays were over seeded and thinned to two plants per cell at three weeks after sowing. The fruit of 'TAM Sweet' and 'Dulce' look like slightly larger typical jalapeño fruit, while those of the Pace cultivars are longer, wider, have thicker walls and are heavier. All plants were harvested once when 5% of fruit were red. The processor requires that fruit have the pedicel and calyx removed in the field and that the fruit be washed, cooled and packed in 1,000 lb bulk bins to be accepted at the dock. Even if the fruit were mechanically harvested, removal of stems requires hand labor

since no machine currently exists to perform this function. Removal of the stems is easiest with the Pace cultivars, and less so with the other cultivars.

Results

Plants from April plantings were harvested by mid-July. Plants from June planting were harvested by late-August to early-September, and plants from the July plantings were harvested by mid-October. Yields for the April 2000 and 2001 and June 2000 and 2001 plantings were averaged. The yield from plants from the April planting were higher than for the other plantings (Table 1). Also, yields produced by the Pace cultivars generally exceeded the average.

Table 1. Effect of planting date on yield (T/acre) of non-pungent jalapeño peppers.

	Planting date		
Cultivar	April	June	July
Pace103	5.3	3.6	4.0
Pace105	4.9	3.9	4.1
Pace106	4.8	3.3	3.2
TAM Sweet	3.9	2.8	2.1
Dulce	3.7	3.5	2.0
Average	4.5	3.5	3.1

The average yield from sites that had two plants were higher than for those that had one plant (Table 2). The Pace cultivars generally exceed the average yield. Only the yield for 'Dulce', when there were two plants at a site, was equal to the average.

Table 2. Effect of number of plants at a site on yield (T/acre) of non-pungent jalapeño peppers.

	Number of Plants	
Cultivar	One	Two
Pace103	3.9	5.0
Pace105	4.0	4.8
Pace106	3.4	4.7
TAM Sweet	3.3	3.4
Dulce	2.9	4.3
Average	3.5	4.3

The price at the dock for a product that meets the processor's specifications is $0.30/lb ($600/ton), which is a higher price than for most non-vegetable crops produced in the region. However, more manual labor is required in the harvesting and preparation of the product for transportation. The opportunity exists for two crops in a year using the same ground with the second crop producing at 75% the level of the first crop. Since the processing plant is close to potential production fields in the Southern Plains, transportation costs will be reduced and the quality of the delivered product will be improved.

Grape Session

Better Crops
Through Soil
Conservation

Demonstration of Grape IPM

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There are tremendous economic benefits from production and tourism associated with wine and bunch grapes in the Southern United States. The grape industry is thriving in Arkansas, Tennessee and North Carolina, and other southern states. Attendance at the 2001 Oklahoma Grape Workshop in Perkins, OK indicates a great interest in increasing wine vineyard acreage in Oklahoma. There is potential for more grape acreage because this area could fill a niche market in the eastern United States and Canada with table grapes with unique flavors like Labrusca ('Concord'). Fruit from this region also hits the market earlier than fruit from production areas further north, thus achieving a better price. Presently, grape growers appear more receptive to implementing various grape management practices that will increase profitability, curb rising pesticide costs and prolong pesticide efficacy.

This project demonstrating grape IPM is planned to occur from 2001 through 2003 in a bunch grape vineyard in Searcy, AR. The major insect pests and diseases include grape berry moth, grape root borer, black rot, downy and powdery mildew, bunch rot and anthracnose. There are other occasional pests like grape scale, green June beetle and grape leafhopper and virus diseases. One problem is that fungicides and insecticides are applied at fixed intervals to protect the vines and fruit. This project promotes pesticide use determined by scouting, weather reports and management practices that are integrated to improve and sustain yields and fruit quality. In 1993, the Environmental Protection Agency banned methyl parathion that gave excellent control of grape berry moth (infests fruit) and grape scale (kills canes and vines). Now, the grape industry has less effective insecticides for control of grape scale and grape berry moth resulting in more damage reports since the ban. The EPA also restricted chlorpyrifos (Lorsban 4E) to one application to soil under vines per year against the grape root borer (larval root feeding causes loss of vine vigor, yield and kill vines). This gives only partial control of grape root borer because soil toxicity persists only 4 of the 8-to16 weeks of egg laying (determined by pheromone trapping). Alternative prevention tactics for grape berry moth, grape scale and grape root borer must be studied and implemented. Researchers state that fruit damage from the grape berry moth can be kept below the 1% acceptance level by insecticide applications timed by degree-day (DD) models. The grape berry moth and grape root borer can also be controlled by pheromone permeation of the air in and around vineyards. Mating disruption results in reduced mating, laying of fertile eggs and nearly zero berry damage.

This study demonstrates viticultural practices that enhance and sustain vine vigor, yield, fruit quality, and pest and disease management including mating disruption. County agents and growers learn how to scout and use weather forecasting to improve

timing of pesticide applications for pest and disease management. This information is used to derive management recommendations that are made available as scouting reports to the grower and timely updates of the Fruit IPM web page (http://comp.uark.edu/~dtjohnso/) and on a toll-free call-in message phone.

Materials and Methods

Scouting and forecasting of pests began at bud break. White County Agent, Sherri Wesson, inspected pheromone traps on a weekly basis. At bud break, the grower inspected for cutworm hot spots by looking for hollowed-out buds. Spot sprays of insecticide were recommended for hot spots. On April 1, two grape berry moth pheromone traps were hung from trees in woods adjacent to the edge of a 26-acre vineyard in Searcy, AR and one trap was placed in the woods of a 4 acre vineyard 1 mile west. Traps in both vineyards were inspected for moths weekly. The date of the first consistent trap catch of moths was called the biofix, after which DD were accumulated daily [(DD = (Daily Maximum °F + Daily Minimum °F) / 2) - 50]. During egg laying period in May (500 to 700 DD), 100 grape clusters were inspected for presence of grape berry moth larvae (10 clusters on each of 10 vines in the edge row). In mid-May, these three pheromone traps were moved to the center of each vineyard and monitored weekly thereafter through harvest. On 21 June (1500 DD) and 18 July (2330 DD), 100 clusters were inspected for presence of grape berry moth larvae in edge rows 1 and 49, and interior rows 3, 25 (center) and 47 (Table 1). Jeff Smith sprayed the edge rows on 11 May (400 DD) and again on the 22 June (1500 DD). It is recommended that insecticide sprays be applied to the edge rows between 450 and 700 DD (mid May after bloom) and again between 1250 and 1700 DD (mid to late June). These applications were applied to minimize the grape berry moth population in preparation for use of mating disruption. The Isomate-GBM dispensers were tied to the top wire every 11 ft to achieve at least 400 dispensers per acre (Source: Great Lakes IPM, 10220 Church Rd., NE, Vestaburg, MI 48891, 517-268-5693, http://www.greatlakesipm.com). Three grape root borer pheromone traps were set in the vineyard on 8 August.

The mating disruption tactic will be evaluated for both the grape very moth and grape root borer. The purpose of mating disruption is to prevent mating and the laying of fertile eggs of both pest species. This tactic is expected to reduce the percentage fruit damage by grape berry moth larvae without the use of insecticides after mid-May and reduced root infestation by grape root borer without applying Lorsban 4E to the soil under the vines in July. At the end of first flight in mid-May, grape berry moth mating disruption dispensers will be placed within the 30-acre vineyard. Grape root borer pheromone traps should be set out by June 1 and monitored weekly through August.

In late March, a Hobo Pro® temperature and RH logger was set inside a weather box in a 4-acre vineyard in Searcy, AR. Degree-days (base 50°F) were calculated daily through August and used to predict grape berry moth hatch (Table 1).

Grape disease, pest, and production information were disseminated weekly. Sherri Wesson collaborated with Donn Johnson to make weekly pest and disease control recommendations. Sherri Wesson made this information available weekly on a toll free

call in message phone and Donn updated the Fruit IPM web site. County offices in all grape-producing areas of Arkansas were kept updated as needed about grape pest recommendations via Email.

Results and Discussion

In 2001, Keith Striegler, Donn Johnson, Dean McCraw and Sharon Von Broembsen contributed chapters to a Grape Workbook and gave several presentations on viticultural practices and pest management at the Oklahoma Grape Workshop in Perkins, AR. Over 80 people attended this workshop. The workshop included tours of the new grape planting at Perkins and a tour of an established wine grape vineyard.

A grower in Searcy, AR collaborated on the pilot grape IPM project supported by the University of Arkansas Cooperative Extension Service Diversified IPM Program. On 9 April, three grape berry moth pheromone traps were hung from tree limbs at the edge of woods adjacent to the vineyard. These traps were moved into the center of the vineyard on 22 May. First trap catch occurred on 18 April (Table 1). Degree-days (base 50°F) were accumulated daily from that date of first catch. Trap catch remained below 3 moths/trap/week through May. The trap catch was the highest in early June. Mating disruption dispensers were set out by 9 June and trap catch remained low the rest of the season. On 21 June, most of the damage was restricted to the vineyard edge at rows 1, 3, 47 and 49 (Table 2). By 18 July, the IPM vineyard using mating disruption had no damage compared to 24% at the edge of the traditional vineyard.

Grape root borer larvae infest the roots of grapevines and reduce vine vigor and health over time. In 2001, the grape root borer pheromone traps averaged 32 and 6.3 moths/trap between 8 and 18 August and between 18 August and 19 September, respectively. Grape root borer traps should be set out by 15 June (Johnson reported that the earliest adult emergence in AR was 17 June). In late July and again in late August, records should be made of the number of grape root borer pupal skins at the soil surface around each of 100 grape trunks. This is the best way to assess the number of grape root borers per vine.

Table 1. Grape berry moth pheromone cumulative degree-day, pheromone trap catch data and management practices followed in a table grape vineyard in Searcy, AR (2001)

Date	Σ DD	Moths per trap	Management Activities
4/09	0		Set pheromone traps
4/18	0	1	
5/4	250	1	
5/11	400	1.3	Sprayed perimeter
5/14	590	1.3	
5/22	771	3.0	Moved traps to vineyard center on 31 May
6/4	1016	16.5	Hatch began by 14 June
6/9	1206	6.3	Mating disruption put out by 9 June
6/22	1500	1.3	Sprayed 3 perimeter rows of vines
6/26	1706	0	
8/8	3069	1.3	
8/17	3300	0	

Table 2. Percent of table grape clusters damaged by grape berry moth larvae in a traditional vineyard where only insecticides were applied compared to an IPM vineyard was sprayed with insecticide through early June plus placement of 100 Isomate-GBM dispensers/A (Searcy, AR, 2001)

Row	June 21		July 18	
	Mating Disruption		Mating Disruption (Isomate-GBM)	Traditional (Insecticides only)
	Middle Block	East Block		
49 (north edge)	11	3	0	
47	2	5	0	
40	0	0	0	
20	1	1	0	
10	1	1	0	1
3	4	15	0	2
1 (south edge)	28	38	0	24

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Performance of New Wine Grape Cultivars

Jon Held

Jon Held is part-owner and General Manager of Stone Hill Winery in Hermann, Missouri. Jon's parents re-opened the famous pre-Prohibition winery in 1965. His youth was spent working in the vineyards and winery. In 1980 he graduated with a B.S. in Enology from California State University, Fresno. This was followed by an apprenticeship in a Swiss winery and a stint as Asst. Winemaker for Andres Wines Ltd. in Ontario, Canada. In 1983 he returned to work in his family winery and vineyards. He has served multiple terms on the Missouri Wine and Grape Advisory Board, MWGAB Research Committee and currently serves on the Eastern Viticulture Research Consortium Regional Guidance Committee. In 1994 he was named Wine Grower of the Year by Wineries Unlimited.

I would like to open with a little background on my family business, the Stone Hill Winery in Hermann, Missouri. Prior to Prohibition the town of Hermann was the center of Missouri wine production with approximately 60 wineries. Stone Hill Winery was by far the largest in the town and one of the largest in the nation with a production reaching 1.25 million gallons. The Winery achieved tremendous international acclaim with their wines and received nine separate gold medals at Worlds Fair Wine competitions. The most awarded wine at that time was made from the Norton grape. While famous for its wide range of table wines, the winery also achieved renown for its Champagnes, dessert wines, brandies and Eau de vie. In addition to Norton, some of the other grapes grown at that time included Concord, Catawba, Ives, Delaware, Missouri Riesling, Elvira, Goethe, Taylor, Martha, and Herbamont.

With the advent of Prohibition, the underground wine cellars were converted to mushroom cultivation until 1965 when my parents Jim and Betty Held re-opened the winery. That year they made 1500 gallons of Catawba and Norton wine with granddad's old hand-cranked grape crusher and press and 30 used whiskey barrels. Since then we have steadily grown and modernized the facility. Today we are again Missouri's largest winery with a storage capacity of 300,000 gallons and annual production of approximately 200,000 gallons. In 2001 we purchased grapes from eight independent Missouri growers in addition to what we raise on our 106 acres of vineyards. The cultivars grown in Stone Hill's vineyards, in order of descending acreage, are Norton, Vignoles, Vidal, Chambourcin, Cayuga, Vivant, Vincent, and Seyval. Additionally, we purchase Catawba, Concord, Chardonel and St. Vincent. From this mix of cultivars, plus a very limited amount of out-state juice, we produce 19 highly awarded wines, which cover the style spectrum from our flagship Norton and barrel-fermented, sur-lie aged Chardonel, to sweet carbonated Spumantes, plus Port, Sherry and bottle-fermented Champagne.

At Stone Hill we have always listened to our consumers and made wines to satisfy their broad range of taste preferences rather than arrogantly assuming they want just

another dry white and dry red. Make what they want not what you want. With this guiding philosophy and a deep commitment to quality in both the vineyards and winery, we have been very successful with our "alternative" wine grape varieties. In spite of this, I firmly believe our No. 1 Viticultural priority in the mid-west is the need for more grape cultivars capable of producing high quality wines that can be economically grown under our harsh climatic conditions and disease pressure.

You will notice that I have not mentioned any Vitis vinifera cultivars. We do not grow any vinifera at Stone Hill Winery simply because they lack adequate cold hardiness for our climate. In Missouri we typically have low temperatures below 0 degrees Fahrenheit. In addition, we have multiple periods of fluctuating warm and cold weather during the winter months. These conditions are devastating to most cultivars with a lot of vinifera in their parentage. Combined with excessively low temperatures we also have high summer humidity and frequent rains that favor every conceivable grape fungus disease known to man and some not yet identified. In addition we have the issues of crown gall, phylloxera in both root and aerial forms, spring frost and as you get farther south in the mid-west, Pierce's Disease.

While I take a dim view of the prospects of growing Vitis vinifera under Missouri or mid-western climatic conditions, I have not ruled it out. It may be feasible, on a limited basis on very exceptional sites with excellent management. To succeed will require a site with a temperature- moderating large body of water, the most cold hardy cultivars on a well-matched rootstock, a perfectly balanced soil with good soil biology, ideal soil drainage, consistent crop to canopy balancing, excellent disease management, a strong personal constitution and a lot of luck. If you are serious about making your vineyard a successful business of any size, I would humbly suggest that you stick with the hybrid and native American cultivars proven to consistently tolerate this climate.

The old guard of native American cultivars in Missouri is Norton (Cynthiana), Catawba, and Concord. Norton is a Vitis aestivalis cultivar while Catawba and Concord are primarily Vitis labrusca. Previously we also grew the labrusca cultivars Missouri Riesling and Niagara, but both have been eliminated from our vineyards. We have traditionally processed more Catawba at Stone Hill Winery then any other cultivar. It is a very important grape for Stone Hill's product mix and ripens better in Missouri than anywhere else in the East. It is easy to grow, relatively cold hardy, disease resistant and a lot of folks love the flavor. I love what it does for the bottom line. The same applies to Concord. Unfortunately the wine critics of the world will not take these cultivars serious. And I admit I much prefer Norton.

Norton is causing quite a stir in the wine world. It has blessed us with some tremendous accolades from the wine press and has developed quite a consumer following. Two years ago I sent Norton wood to Australia and Japan for test planting. While not the perfect grape, it is the most suited cultivar to our climate, and it has recently become the most widely planted grape cultivar in Missouri. Norton is very cold hardy and extremely disease resistant. We have grown one test vineyard without any fungicides for five years straight without any disease problems. On the negative side

Norton tends toward high juice pH levels, it's fickle about nutritional needs, is inconsistent in yield levels, particularly if the canopy is poorly managed, is sensitive to some fungicides, requires a long sunny growing season, is difficult to harvest and tends to be excessively vigorous. But, I would not plant a vineyard in this part of the country without it.

Of the old-line hybrids, Vidal is my favorite. It is the work horse of our blending program and makes crisp-tasting, spicy, fruited wine somewhat similar to Pinot Gris. Vidal is relatively easy to grow, yields great (6.5-9 tons/acre) and has easily manageable disease problems. The cultivar is a bit cold tender, but good soil balancing and canopy management will help in this regard. Periodic trunk renewal is needed due to crown gall. Most folks recommend grafted vines for any new planting. I would like to get this cultivar grafted and virus free for our future planting.

Seyval has good name recognition but several problems that I think will limit its future. While we have traditionally used many tons of this grape at our winery, I think it is on the way out. Some of the problems include cold tenderness, brittle canes, poor trunk and cordon life, a tendency to second crop, the need for crop thinning and poor machine harvesting. The best Seyval wine always has a little bit of something else blended in to improve the character.

Vignoles is our most famous hybrid wine, it can be truly wonderful. In selected years we let some Vignoles hang until we reach sugar levels of 30 Brix. These late harvest wines can be stellar. Unfortunately, this cultivar is very difficult to grow, primarily due to its susceptibility to late season rots. An open canopy and diligent spray program are mandatory. Last summer we began mechanical leaf pulling to maximize air movement in the canopy. While the results are encouraging, we need to do a little more playing around with timing, machine adjustment, spur orientation, and shoot positioning. Vignoles is also a very shy-bearing cultivar.

We also have some new-to-Missouri hybrids in our vineyards and future planting. The most promising from a wine quality standpoint are Chardonel, Chambourcin and Vivant. We planted six acres of Vivant in 1999, 11 acres of Chambourcin in 2000 and will plant 5 acres of Chardonel and 4 more acres of Vivant in 2002.

The cultivar Chardonel was created by crossing Chardonnay and Seyval. A recent survey of the Missouri grape industry shows Chardonel to be the second most widely planted cultivar in the state with roughly 150 acres in the ground. Most of these are new planting and not yet in production. I have a slight fear that we may be over planted in this cultivar for the short-term future. With the name similarity to Chardonnay, many growers feel this wine will be easy to market. In the vineyard Chardonel appears superior to Seyval, but in some test vineyards it has a history of poor trunk and vine survival. The wine is clearly superior to Seyval with better body, structure, flavor and aroma. Ripening must be closely monitored since Chardonel can develop high sugars levels and appears to have a higher then normal conversion of sugar to ethanol.

While not a new hybrid, I predict that Chambourcin will steadily increase in acreage in our part of the country. Growers love this grape. High yields, easy to grow and good wine. While originally reported to be moderately tender, some growers whom I respect report it is hardier than they anticipated. We have not harvested any Chambourcin from our recent planting, but wines from other Missouri wineries have been very encouraging.

Vivant along with Vincent are hybrids form the old breeding program at Vineland, Ontario, Canada. Vivant makes a pleasant, fruity-style wine somewhat similar to Vignoles but much lighter in aroma. To date there has been only one acre of commercially producing Vivant in Missouri. The wine produced from this vineyard and wines produced at the Mountain Grove Research Campus have been consistently promising. We will have six acres in production this coming harvest. The variety appears to be very hardy and relatively easy to grow. I don't have enough experience to comment at length on it, but from what I have seen I am confident enough that I am increasing our acreage this year.

Vincent is a teinturier (pigmented pulp) cultivar and has value as a blend component for increasing red or pink wine color. I would not recommend planting it unless you need a grape for this purpose. While the wine is ok by itself, it is coal black. It grows well but tends to not get very high sugars before the pH starts to rise and the fruit quality goes south.

St. Vincent started out as a rogue vine in a Missouri vineyard. It has since been spread around the state and has a certain level of popularity. It is a cold hardy, high yielding variety that requires some fruit thinning to get good quality. The wines from this cultivar can be quite light in color and character if over cropped. St. Vincent is fairly susceptible to downy mildew but is easily controlled with a good spray program. It has been a valuable blend component at Stone Hill Winery for several years and makes a nice blush wine if cold pressed.

At Stone Hill Winery we are deeply committed to the long term future of the mid-western grape and wine industry. To this end we have a continually expanding observational vineyard for newly available grape cultivars. To date we have planted 44 cultivars for observation and evaluation. All of these have been legally obtained, but most are under non-distribution agreements so please do not ask me for propagation wood. Most of these cultivars came from Eastern Europe through the Missouri Importation Program begun by my dear friend, the late Dr. Robert Goodman. In addition we have planted new hybrid cultivars from the Geneva, N.Y. program and some from Germany. It is too early to draw any meaningful conclusion about the Eastern-European Hybrids from this planting or its companion planting in Mountain Grove and elsewhere. Some of the cultivars break bud too early, some are too cold tender but some look very promising. Wines produced at the Mountain Grove Research Campus have shown real promise particularly from some of the red cultivars.

In selecting new cultivars for this part of the world be extremely careful and cautious. Vineyard establishment and yearly management have become extremely expensive. To be successful you must minimize your production losses and maximize your efficiency of production. Cold tender, disease susceptible cultivars will never be cost effective regardless of the wine quality. Likewise you will never sell multiple cases of wine from a very hardy cultivar that lacks any positive wine characteristics. When I select a new cultivar, first and foremost, it must make wine that is exceptional as a varietal or have positive attributes as a blend component. Second, it must have adequate cold hardiness to maintain a suitable vine structure that can be mechanically managed to some degree. Third, it must be free of severe disease pressure. Other things to consider are the ease of machine harvesting and whether a cultivar requires crop thinning. Once you have satisfied these questions, you have a chance of competing in this highly competitive industry.

Freeze Damage In The Vineyard

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That day in October is one I won't soon forget. It had been a warm September with adequate rainfall and the vineyard was showing new growth and very little signs of going into dormancy. It had reached 70 degrees and then this blue northern came flying down, and the temperature plummeted to 26 degrees. The next day showed a brown vineyard and I was very concerned. Instead of checking for bud damage I just inspected the canes in January and found green when I cut into the canes. I was to learn later that is when you can make a crucial pruning decision. Bud inspection would have saved a huge amount of labor. With minimal bud damage one could minimal prune and still get a crop but with major bud damage as I experienced a crop would not be forthcoming this season. Since I pruned in the conventional method in Feb., I not only didn't get a crop but I put stress on damaged vines to try and regrow some new canes. The old trunks I left had cracks and splits which made them vulnerable to crown gall. Some of the plants showed excellent vigor but overall the vineyard lacked energy. In retrospect and after discussion with other growers, I feel it is best to cut the vines off at ground level after such damage as we had. I toured another vineyard nearby which suffered the same damaging freeze and this is the method he used. After cutting the vines at ground level the roots sent up vigorous growth of which he selected two of the healthiest shoots and placed a grow tube over them and removed the others. His vineyard has recovered tremendously and has shown excellent growth with no crown gall or split trunks to deal with later. He lost his crop that year but it appears he will make up for it this year. With minimal pruning after freeze damage you can still get a small crop but I have found it is not nearly worth it as my vineyard is still struggling. I plan on cutting off all the weak vines at ground level early spring and hope to establish a new trunk. Where there aren't any shoots coming up I can only assume that I had root damage also and will replant. The question remains as to my varietal selection as to cold hardiness but I had damage to my hybrids as well. I am reminded many times over as to the number one advice given to me when I started. Site selection, site selection, site selection. With frost pockets in your vineyard you seem to be wasting a lot of effort you have put into establishing your vineyard. Hopefully we won't have another drastic change in the temperature so early as that broke a hundred year record for the earliest freeze, but if we do then check for bud and trunk damage and if it is extensive then I would recommend reestablishing the trunk. There is some research in a system that will freeze your root zone to send the plants into early dormancy and maybe harden the buds earlier. I am not sure what a system like this would cost but it may be an answer to saving your crop. Contact me for any more information if I can be of assistance.

Vineyard Site Selection & Development Planning in California

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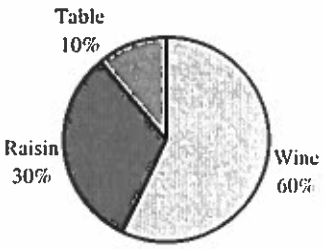
Horticulture Industry Show, January 2002
Tulsa, Okalahoma

Why spend time and money on selecting a site and doing the planning work for a vineyard development? It all has to do with economics. The land for a vineyard site in California will cost $2,000 to $20,000 per acre to purchase, and another $5,000 to $25,000 per acre will be spent on establishment and getting the vineyard into production. Because of these high development costs, one simply cannot afford to make mistakes. With these thoughts in mind, we will review the three major components which affect site selection and vineyard development planning – ***the climate, soil, and water resources***.

Grape Growing in California

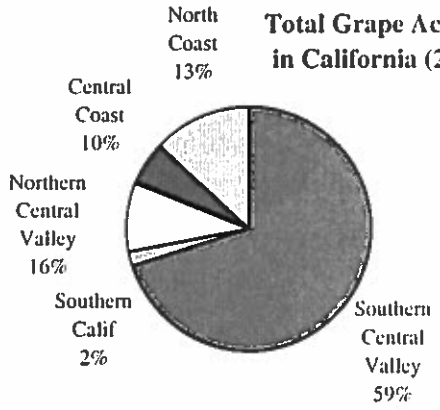
Before we discuss specifics, we need to gain some perspective on grape growing in California. California vineyards produce grapes for use in wine and fruit juice concentrate, raisins, and for the fresh market. A total of 955,000 acres of grapes were planted in California in 2000. The primary use of these grapes is for wine and fruit juice concentrate production (60% of the acreage). Raisin production is the next largest use (30%), and fresh market table grapes account for the remaining (10%).

Destination for 955,000 acres of California Grapes (2000)



The largest grape growing area in California is in the Southern Central Valley, which accounts for 59% of the total acreage. Grapes from the Southern Central Valley are used for wine, raisins, and fresh market. Grapes grown in the North Coast, Northern Central Valley and along the Central Coast are used almost exclusively for wine production. These three areas account for 39% of the total grape acreage. Grapes from the Southern California area are primarily sold in the table grape market.

Total Grape Acreage in California (2000)



Currently in California, we have an over supply problem that will probably last for a few more years. Of the 568,000 total acres of wine grapes, some 110,000 acres (or 19%) are non-bearing as of 2000.

Climate Resources Assessment

There is a wide range of climates available in California for grape growers. The climates in the grape growing areas are unique because of their temperatures and the chances of rain during the growing season. Grapes require a temperate climate consisting of mild winters, plus long, dry, and warm growing seasons of about 200 frost-free days, or about seven months. Long, dry summers are needed for fruit ripening and to facilitate harvesting, since the fruit is highly susceptible to damage from rains. Statistically, the chances of rain start around September 1 and increase through October.

As far as our temperatures are concerned, there is a wide range of choices in California. All five of the traditional classifications of grape growing regions can be found in California. The North Coast area offers primarily Regions I, II and III; and Central Coast, Regions III and IV. The North Central Valley has Regions II, III, and IV. The Southern Central Valley and the Southern California areas are Regions IV and V.

Grape Growing Regions Based on Degree-Day Accumulation

Category	Total Degree-Days (°F)
Region I	Less than 2,500
Region II	2,501 to 3,000
Region III	3,001 to 3,500
Region IV	3,501 to 4,000
Region V	More than 4,001

Also of importance are cool winter temperatures from which the grapevines can acquire enough chilling hours during dormancy. Grapevines require about 100 hours below 45°F during dormancy. We almost always achieve this in California's grape growing areas. Fortunately, we rarely get temperatures below about 25°F, which can cause injury to vines during dormancy.

Effects of Minimum Temperatures During Dormancy

Minimum Temperatures	Damage To
Below 20°F	Fruit Buds
15 to 20°F	Canes & Spurs
10 to 15°F	Trunks & Cordons
Less than 10°F	All Vine Parts

The weather is not always so benign and does cause problems at times. In the early spring, frosts of below 31°F after growth begins can result in significant damage to shoots and a reduction in crop yields. Early spring rains can also spread fungi such as phomopsis, which will affect cane development. In late spring, high wind velocities of over 20 miles per hour can cause cane breakage and trellis damage. In the summer, sudden high temperatures in June and July can result in heat-damaged fruit. Also, grapes are highly susceptible to air pollution damage, and yield reductions can be expected in areas where air quality is poor. In the fall, we want moderate temperatures with no rain. Rain in the fall increases the chances of bunch rot in tighter varietal clustered clones.

Soil Resources Assessment

California offers a wide range of soil environments for grapevines. The soil environment for vineyards can be viewed from three different perspectives. One is the ***physical characteristics*** of the soils, the second concerns the ***chemistry*** of the soil, and the third is the potential for ***soil pests and diseases***.

Soil Types & Depths

Grapes are adaptable to a wide range of soil textures from sandy loams to loams and clay loams. The advent of drip irrigation provided much more flexibility in soil selection, we do have some limits. We are usually looking for moderately deep soil profiles, but not too deep. The ideal soil depth for grapes depends on the texture of the soil and its associated water holding capacity. Individuals who are involved with water management of grapes will have different philosophies concerning the ideal root zone depths. Expressed below are my personal preferences based on 20 years of experience with grapes.

For lighter textured soils like sandy loams, we need a minimum depth of 5 feet and a maximum of 7 feet. For a loam soil texture, we can use a minimum depth of 4 feet and a maximum of about 6 feet, and for clay loams 3 to 5 feet. We can use shallower soil depths than these and compensate with more frequent irrigations using a drip system, but this increases the management attention required and the opportunity for mistakes. Also, we do not want a soil that is too deep. If we have an unrestricted rooting depth, then we have no control over vine growth through irrigation. Control of vine vigor is important if we want to manipulate the characteristics of the grape.

Available Water Holding Capacities

In looking at soil depth and texture, what we are really doing is targeting to have a certain total available water holding capacity (AWHC) in our vine root zone. A total of 7 to 10 inches of AWHC will accommodate furrow, sprinkler, or drip irrigation. Root zones with less than 7 inches of AWHC will require very frequent irrigations. Deeper soils with AWHC's of greater than 10 inches reduces the flexibility and control one has as a vineyard manager. Deeper soils can be managed but they require different strategies.

	Rooting Depth		Total AWHC	
	Min	Max	Min	Max
Sandy Loam	5 feet	7 feet	7 inches	10 inches
Loam	4 feet	6 feet	7 inches	10 inches
Clay Loam	3 feet	5 feet	7 inches	10 inches

Even more important from a management standpoint is the uniformity of soil water holding capacities. If the soils within a vineyard block have uniform water holding capacities, it makes irrigation decisions fairly easy. The more non-uniform the water holding capacities, the more irrigation decisions become compromised. A sand streak through the middle of a vineyard is almost impossible to manage correctly without compromising the rest of the block.

We can create uniformity in water holding capacities by carefully laying out vineyard blocks. In this way, individual blocks have a built-in uniformity. Also, we can be innovative in our pre plant deep tillage (ripping or slip plowing before planting) by tilling at different depths to create uniformity. For instance, the loam soil in one part of a vineyard block may be ripped at 4 feet, and the sandy loam area at 5 feet.

Chemical Characteristics

While grapes can be grown in many areas in California from the standpoint of climate and types of soil, they are quite sensitive to soil salinity and specifically sensitive to high levels of sodium, chlorides and boron. Grapes also have difficulties with very low or high soil pH levels. Grapes are even more sensitive to these problems than some vegetable crops. If one plants grapes in an adverse soil chemistry situation (i.e. high salinity, lime, or magnesium), they will not only experience growth problems, but will also suffer yield losses. Through careful selection of rootstocks, the effects of some adverse soil chemistry can be minimized.

Grapes start to experience yield losses when the soil salinity in the root zone is above 1.5 to 2.5 mmhos/cm, when the soil boron level is greater than 1.0 ppm, or chlorides are above 10 meq/l. The degree to which grapes are sensitive to individual ions is shown in this table taken from UC Leaflet 21056, "Salinity Appraisal of Soil and Water for Successful Production of Grapes".

Guidelines for Interpreting Soil Chemistry Data

		No Problem (less than 10% yield loss expected)	Increasing Problem (10% to 25% yield loss expected)	Severe Problems (25% to 50% yield loss expected)
Salinity - ECe	(mmhos/cm)	1.5 to 2.5	2.5 to 4.0	4.0 to 7.0
Permeability	SAR/ESP	Below 10	10 to 15	Above 15
Toxicities	Sodium (meq/l)	----	Above 30	----
	Chloride (meq/l)	Below 10	10 to 30	Above 30
	Boron (ppm)	Below 1.0	1.0 to 3.0	Above 3.0
Balance	pH	6.5 to 7.5	5.5 to 8.5	<5.5 or >8.5

Nutritionally, the soils in California are reasonably well suited to grapes. Our soil pH levels are usually between 6.5 and 7.5, which gives us a well-balanced uptake of nutrients. Of the macro-nutrients (nitrogen, phosphorous and potassium), we normally supply nitrogen on an annual basis. Phosphorous is not a problem, however, we frequently do have problems with potassium. Soil levels of potassium in most areas range from adequate to marginal. In some areas, potassium is low, and we see nutritional deficiencies that require fertilization. Red varieties in general are more sensitive to potassium deficiencies than whites, except for Chardonnay, which is sensitive to potassium deficiencies. For soil chemical analysis, commonly used standards for interpretation of nutrient levels are shown below.

Guidelines for Interpreting Soil Nutrient Levels

Nutrient (ppm)	No Problem	Increasing Problem	Severe Problem
Nitrogen	(supplied annually)	----	----
Phosphorous	> 5	2 to 4	< 2
Potassium	> 125	125 to 100	< 100
Zinc	> 0.7	0.7 to 0.5	< 0.5
Boron	1.0 to 0.5	0.5 to 0.3	< 0.3

Within the micronutrients, the only nutrients we are usually concerned with are zinc and boron. These two nutrients are important in fruit set at bloom time and early fruit development. Deficiencies in zinc are quite common in California vineyards and boron deficiencies are not too difficult to find.

Other Soil Factors

Nematode and phylloxera are soil pests that are of concern in the operation of the vineyard. If they are identified prior to vineyard planting, then soil pre-plant fumigation

is needed and/or the use of a resistant rootstock. Even if no nematode or phylloxera are found during a site evaluation, one should almost certainly anticipate the use of a resistant rootstock. If one chooses to forego a resistant rootstock and plant own-rooted vines, then a drip irrigation system is essential. This is because a drip system is the only effective way to deliver chemicals to treat for these soil pests.

The last soil related factors that are of concern for grapevines are viruses, fungi, and bacteria. The two most common in California are Grapevine Fanleaf virus and Pierce's disease. Grapevine Fanleaf virus is transmitted from one vine to another by a nematode (xiphinema index), which can be identified in the soil prior to planting. Also of concern is Oak Root Fungus, which can be present in some situations. The presence of x. index or Oak Root Fungus frequently dictates the need to fumigate and use a resistant rootstock. In California, Pierce's disease has traditionally been transmitted to vines by the sharpshooter leafhopper. Also, a new vector for Pierce's disease, the Glassy Winged Sharpshooter, has been identified in California vineyards and is spreading the disease quite rapidly. We have to watch vineyard sites located near habitats for these sharpshooters to minimize potential infections.

Water Resources Assessment

Many of the grape growing areas of California are basically deserts during the summer and therefore we need to provide supplemental water to crops. Winter rainfall is low in these areas. The Southern Central Valley, Central Coast, and Southern California areas receive less than 15 inches of winter rain. The Northern Central Valley receives more rain, about 20 inches, and the North Coast receives a normal of 30 inches per year. When we consider irrigation water sources we have two things to consider – one is the ***quality*** of the water and the other is the ***quantity***.

Quality Considerations

Water quality, in turn, has two aspects – the ***chemical characteristics*** and the ***physical characteristics***. Evaluating water chemistry can become quite complex because it can impact so many things we do in vineyard site selection, development, and operation.

Chemical Characteristics

Because grapevines are sensitive to salinity and certain specific ions, we need to look at the chemistry of the irrigation water. Generally accepted interpretation standards for the quality of water used to irrigate grapevines are shown below (from UC Leaflet 21056):

Guidelines for Interpreting Water Chemistry Data

		No Problem	Increasing Problems	Severe Problems
Salinity ECw	(mmhos/cm)	< 1.0	1.0 to 2.7	> 2.7
Infiltration				
ECw	(mmhos/cm)	> 0.5	0.5 to 0.2	< 0.2
SAR	(mmhos/cm)	< 6	6 to 9	> 9
Toxicities				
Sodium	(meq/l)	< 20	----	----
Chloride	(meq/l)	< 4	4 to 15	> 15
Boron	(ppm)	< 1	1 to 3	> 3
Miscellaneous				
Bicarbonates	(meq/l)	< 1.5	1.5 to 7.5	> 7.5
Nitrate-nitrogen	(ppm)	< 5	5 to 30	> 30

These guidelines to interpret water quality are important because most of the potentially toxic elements included with irrigation water are left behind, and can accumulate in the soil as the vines use the water. As they build up in the soil, the vines then start to absorb them, and we see the negative effects in growth and yield.

The chemical quality of most of the irrigation waters in California is very good. In some areas, we have problems with total salinity (ECw) and boron. Water quality can also affect irrigation system selection and we need to be aware of high sodium, chlorides and bicarbonates in the water. High sodium or bicarbonates can affect water infiltration into the soil in flood and sprinkler systems. High sodium, chloride or bicarbonates can cause leaf burn with sprinkler systems. In drip systems, high bicarbonates or high levels of iron or manganese can cause emitter clogging.

From a nutrient standpoint, the only element of concern in irrigation water is nitrogen. While it is good to get some nitrogen from the irrigation water, too much of a good thing can cause a problem. For every 1.0 ppm of NO_3-N in the irrigation water, 2.7 lbs of nitrogen is applied per acre-foot. If we apply 3.0 feet of 6 ppm NO_3-N water per year, we are applying 50 lbs of nitrogen per acre. And this meets our annual need of 40 to 60 lbs/acre of nitrogen for grapevines.

Physical Particulate

All irrigation water contains some solid particles. Well water normally has some level of sand and reservoir water has organic matter. In a flood irrigation system, neither of these is usually of concern. In a sprinkler system, we need sand filters for well water. Both the size and quantity of sand and the presence of organic matter impact the selection of filters for drip systems. Ignoring the solid particle content of irrigation water sources will invariably lead to problems with system maintenance.

Quantity Considerations

The total water need for grapevines during a season is driven by two factors. First is the evapotranspiration (ET) in the area. The same vineyard planted in the North Coast area (Regions I to III) will use less water than one in the Central Valley (Regions IV to V). Also, vineyards with wider canopies and/or narrower row spacing will use more water.

The grape-growing objective of the manager is the second major factor in determining the amount of water needed. If the goal is maximum production, then we need to meet almost the full ET for the crop as we do in the Southern Central Valley. In the North Coast, Central Coast, and Northern Central Valley, we are striving for a higher quality fruit and are willing to accept lower production levels; therefore, we withhold water from the vines during certain periods of growth.

Withholding water at selected times during the season is called Regulated Deficit Irrigation (RDI). RDI managed vines are frequently allowed to use only 50 to 60% of the normal crop ET. While there are other factors which can influence total water requirements, some typical normal vine ET's, allowed ET's (with RDI), and irrigation application amounts which can be used for planning are:

Typical Vine Water Use & Applied Water Amounts

	Normal Vine ET	Allowed Vine ET (RDI) *	Irrigation Amounts
North Coast	23 in	11 in	6 in
Central Coast	29 in	16 in	11 in
North Central Valley	30 in	20 in	16 in
South Central Valley	31 in	25 in	21 in
Southern California	33 in	26 in	22 in

* Water not supplied by irrigations is obtained from stored winter rainfall.

Vineyard Site Evaluation & Development Planning

The evaluation of a site for a potential vineyard planting is the first step in the development process. As discussed above, this is basically an integrated, three step process involving an assessment of ***the climate, the soil environment, and the water resources***. The implementation of each step is discussed below.

Climate Evaluation

The first step is to evaluate the climate to determine that grapevines will grow and the fruit will reach maturity. A part of the climate evaluation is to assess the potential for frost, since we know that this can have a major impact on the water resource requirements. Fortunately in California, we have climate studies done as a part of the California Irrigation Management Information System (CIMIS). From the work done in

this project and that from the National Weather Service, we can make our assessments of climate data.

Soil Evaluation

The next step is to assess the physical and chemical characteristics of the soil. This can be done initially by looking at published soil surveys. The next step is to go into the field and dig a series of backhoe pits to see how well the soils actually match the published mapping and to collect soil samples for chemical analysis.

During the last several years, two technologies have become available to help us organize and view information. These technologies are Global Positioning Systems (GPS) and Geographic Information Systems (GIS). GPS and GIS can be used for a number of applications in agriculture, including categorizing soil characteristic information. As we move into the field, we use GPS to identify the locations of our backhoe pits. We can get the actual location of each pit within a few feet. This will allow us to map all of the data associated from each pit using GIS software. This means that we can easily draw maps of soil texture, soil chemistry, land topography, or any other parameter. These maps will all be to the same scale. Also, 10 years later if we want to go back to a backhoe pit location, we can find it.

The number of backhoe pits needed for a pre-plant evaluation depends on the variability of the soils and whether we are conducting ***a feasibility study*** or ***a development study***. For a first look at a property (a feasibility study), one backhoe per 10 to 20 acres is usually adequate. For more detailed development work, one pit per 2 to 5 acres is needed. If GPS and GIS are used in a feasibility study, then the more detailed, additional backhoe work done as part of a development study can be easily integrated. From the backhoe work, we can determine how deep to pre plant till the land, and whether simple ripping is adequate or if slip plowing needs to be done. From the backhoe pits, one can also lay out vineyard blocks to match the variations in soil textures, and have uniform available water holding capacities within each block.

Soil samples should be collected from each of the backhoe pits, but chemical analysis only needs to be run on a portion of the samples. For instance, if you do backhoe pits at the rate of one per 5 acres, you may chemically analyze samples at the rate of one per 10 acres. Collecting and saving all of the samples allows you to run additional analysis if anything unusual shows up in the initial analysis. The results of the chemical analysis should be evaluated for soil pH, total salinity and it's components, cation balance, and nutrients. From this evaluation of soil chemistry, you can identify any problems, determine if soil amendments are needed, and be forewarned of any nutrient deficiencies.

Samples for soil pests (nematode and phylloxera) can be obtained at the same time as the backhoe work is done if the past cropping history of the property indicates a need.

Water Resources Evaluation

The third step is to assess the quality and quantity of water for the property. The chemistry of the water often dictates the choices in irrigation systems. The quantity of water needed is really dictated by the peak summer crop demand and the grape growing objectives.

If we have shallow root zones with lighter textured soils (sandy loams) and our objective is high production, then we need the full water delivery rate for the area to meet maximum crop ET. With deeper root zones and soils that have higher water holding capacity (loams and clay loams) we can slightly reduce our total water need. If our grape-growing objective is focused on higher quality and not high production, our peak delivery need can be significantly reduced using Regulated Deficit Irrigation.

Summary

Vineyard siting and development planning can be a straightforward process. The use of GPS and GIS technologies makes the process more accurate, useful, and economical than has been possible in the past. The typical cost for a feasibility level study can range from $20 to $40 per acre. For a detailed development study, the cost will be $50 to $100 per acre with one backhoe pit per 5 acres. These costs include all fieldwork and reporting and are actually pretty low when compared to a total investment of $7,000 to $50,000 per acre. Using an integrated and structured process in vineyard site selection and development planning will insure that the mature vineyard will meet the original objectives.

California AgQuest Consulting, Inc. is a full service agricultural consulting company headquartered in Fresno, California. AgQuest has been in business for 20 years providing irrigation, nutrition and pest management services for vineyards. Based on their experience in production, AgQuest regularly performs vineyard site development studies.

Monitoring and Interpreting Vine Mineral Nutrition Status

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Horticulture Industry Show, January 2002
Tulsa, Okalahoma

Monitoring vineyard mineral nutrition has become increasingly important and complex as we plant vineyards into more diverse sites using differing scion-rootstock combinations. Tissue analysis is the most common laboratory technique used for monitoring nutrition in California. However the interpretation of tissue analysis data should include the integration of information on soil chemical and physical characteristics, irrigation water analysis, known rootstock and variety requirements, fertilizer history, and observations of vine growth.

The intent of this summary is to provide information on the approach used in monitoring and interpreting vine mineral nutrition in California viticulture.

Use of Soil Analysis

Soil analysis is primarily used to determine soil chemical problems or nutrient imbalances. This includes problems related to pH, salts, permeability (excess sodium or very acidic pH), toxic ions (chloride and boron), and imbalances of magnesium, calcium and potassium. Growers should have soil chemical analysis run to establish baseline levels or to anticipate potential mineral nutrition problems in new plantings. However, nutrient analysis of soil should not be used to guide routine fertilizer practices.

Basically, it has not been possible to establish critical soil mineral nutrient values for grapevines. This is due to the many soil and plant factors that influence vine nutrient uptake and utilization. Soil analysis does not take into consideration the influence of rootstock, cultivar, soil depth, root distribution, soil water status through the season, crop load, soil pests, and rate of nutrient availability.

Using Tissue Analysis

Tissue analysis is a direct measure of the nutrient status for grapevines based on their ability to absorb, accumulate, and utilize mineral nutrients. Therefore, its determination involves all of the above soil and plant factors and avoids the limitations of soil analysis. It is also easy to perform and is repeatable, making it easy to track changes during the season and from year to year.

Methods of tissue analysis have been studied since laboratory analysis began. Pioneers in vine tissue analysis research found leaf petioles to be generally preferable over other tissues, including leaf blades. Petiole surfaces tend to have less surface contamination than blades. Other reasons include ease of sampling, handling, washing and drying petiole tissues. Petiole samples also represent more individual shoots and vines as compared to blades. This is because it takes 2 to 3 times more petioles to make

up the same amount of dry tissue as compared to blades. Most importantly, we have more experience and data on which to base petiole critical values, and petioles show a greater range in values for nitrate-nitrogen (NO_3-N), phosphorus (P), potassium (K), magnesium (Mg), and zinc (Zn). Therefore, fertilizer response and deficient and excess values of these elements and other nutrients are more easily defined with petioles.

Sampling Grapevines

The method of sampling and the time that the sample is taken are dependent on the objectives. These can be categorized as: (1) ***a general survey of nutrient status***, (2) ***follow-up sampling for specific nutrients***, and (3) ***diagnosing visual symptoms and disorders***.

Survey of Nutrient Status

This approach is used when surveying a vineyard for general nutrient status and evaluating fertilizer needs or practices. Most of the data and experiences in California are based on leaf petioles sampled at bloom time. The petioles are taken from opposite flower clusters near the base of the shoot. This provides a clean, easily sampled, repeatable tissue that tends to accumulate nutrients more than other plant parts. The samples should be taken during bloom, the nearer to full bloom the better ("full bloom" is when approximately two-thirds of the caps have loosened or fallen from the flowers). The full bloom sample assures that the tissue will be at the same physiological stage regardless of district and seasonal differences.

Samples should be taken from a single block or management unit and should represent a single variety and rootstock. Areas of distinctly different soil, vine appearance, or other condition should be sampled separately. Each sample should consist of 60-80 petioles collected from representative vines uniformly distributed over the area. Samples should be obtained from non-shaded, normally growing shoots on both sides of the vine canopy.

Foliage contamination from a nutrient spray will give erroneous laboratory results. Growers should not sample after a nutrient spray unless they: 1) are not analyzing for any nutrient element contained in the spray; 2) thoroughly wash the samples; or 3) are sampling uncontaminated tissue later in the season.

Follow-up Nutrient Sampling

Certain nutrients, which are in a questionable range at bloom, can be re-checked later in the season to determine if a deficiency has developed, or to confirm a questionable level from bloom time analysis. This is particularly useful with K, which declines in the vegetative parts and can become deficient during fruit ripening. Sampling is best performed at veraison (berry softening at beginning of ripening) as it represents another physiological stage with supportive data, and when leaf tissue is still healthy and functioning. Petioles should be selected from recently matured leaves. This would be the second fully expanded leaf, usually the 6th to 7th leaf from the tip, on an actively growing shoot. The sampled leaves should have the color and texture of the other

mature leaves rather than the lighter and more shiny, tender appearance of young, expanding leaves.

The smaller petioles at this time may require a higher number in the sample as compared to bloom. Each sample should contain 75 to 100 petioles if more than one elemental determination is needed. When assessing nutrients that accumulate in leaf blades, 25 to 35 blades are sufficient, due to their greater mass as compared to petioles.

Diagnosing Visual Symptoms and Disorders

Visual deficiency or toxicity symptoms more commonly appear during mid-summer to harvest time. Thus, sampling at this time is useful in diagnosing vine disorders or verifying a deficiency or toxicity. For such situations, sample the affected leaves regardless of location on the shoot and at any time when abnormal appearance is noted. When there are no reasonable clues, take both the petioles and blades but analyze them separately. If Na and/or Cl toxicity are suspected, analyze only the petioles (these elements accumulate in the petioles, even though the blades may show the symptoms). For excess B, use the blades where much greater levels will be found.

Monitoring Nutrients & Interpreting Laboratory Data

After a tissue sample has been obtained and analyzed, the next step is to interpret the results. Critical levels for the interpretation of individual nutrients have been fairly well established for varieties grown in California. Most of the research work has been done for the Thompson Seedless variety grown on its own roots. During the past 10 to 20 years, research work has been expanded to other varieties and various rootstocks.

Critical nutrients levels are established primarily for sampling at bloom time using the petiole opposite the first/basal cluster on a cane. Critical levels for some nutrients are also documented for sampling later in the season.

Nitrate-nitrogen ($N0_3$-N)

It is well known that grape varieties have inherently different $N0_3$-N levels. This is, at least, partly attributed to differences in nitrogen metabolism (reduction of NO_3-N in the foliage). For example, Merlot, a high NO_3 variety, shows lower nitrate reduction activity than Zinfandel, a moderate NO_3 variety. Petiole NO_3-N is also known to be affected by climatic conditions prior to and during bloom. Thus, critical levels need to be developed for each variety in various regions. This has only been accomplished with own-rooted Thompson Seedless in the California's San Joaquin Valley, and research work is in progress for other varieties.

A number of varieties grown in California have been grouped according to their typical differences in $N0_3$-N levels. This data shows Thompson Seedless to be of medium NO_3-N status, while some of the other important varieties are in comparatively higher or lower categories.

Nitrate-nitrogen status can also be strongly influenced by rootstock. Higher petiole values are commonly experienced with Freedom, Ramsey, St. George, and 3309.

Lower values are more common with 5C, 5BB, 420A, and Harmony. The interaction of rootstock and fruiting variety is not well understood, although NO_3-N status of some varieties are known to be strongly influenced by rootstocks.

Seasonal changes in NO_3-N levels can be rapid, especially with extreme weather changes before bloom. Increases are associated with cool temperatures and low light intensity, while sunny, warm weather favors decreased levels. They are typically highest 5 to 10 days before bloom, decline through the bloom period, and reach a relatively stable, lower level by 2 to 3 weeks after bloom.

Phosphorus (P)

Confirmed deficiencies have been rare in California; tissue analysis has been useful in separating them from similar-appearing problems such as Leafroll Virus and Willamette Mite injury. Petiole P levels tend to decline through the bloom period and level off through midsummer; hence, critical levels change somewhat during the season. Differences among mature leaf petioles along the shoot are minor. There are wide differences among grape varieties and rootstocks. Levels in the same vineyard can fluctuate as much as 100% from year to year.

Potassium (K)

Tissue analysis will confirm deficiency symptoms and is particularly useful in identifying isolated areas that warrant treatment. Vines in questionable range at bloom should be rechecked 6-10 weeks later at veraison by sampling recently mature leaf petioles. This will determine if a deficiency is developing at fruit ripening, a more common occurrence.

Petiole levels usually decline most rapidly from before bloom until 2 to 4 weeks afterwards. Thereafter they decline gradually or level off through midsummer. Heavy crop loads can lower petiole K levels dramatically during fruit ripening.

Potassium levels are highest in the youngest mature leaf petioles where they peak at bloom and then decline with time and leaf age. Potassium levels can vary widely (30-50%) from year to year in the same vineyard and are strongly affected by variety, rootstock, and irrigation practice.

Magnesium (Mg)

Petiole levels increase as the growing season progresses and tend to be higher in older petioles. Critical levels are probably higher later in the season, but they have not been established.

Mg tends to be reciprocal to K in tissue concentration, a relationship that is strongly influenced by variety and rootstock, as well as soil levels. Ratios of K:Mg under deficiency situations vary too widely to be diagnostic. However, they can be indicative of extremes where antagonism may contribute to either Mg or K deficiency. On occasion these ratios may be useful, however, the absolute levels of Mg and K, rather than their ratios, are the most definitive indication of deficiency.

Calcium (Ca)

Critical tissue levels are not well established since Ca deficiencies have not been documented in California. The benefits of Ca in amending sodic (high Na) or acid soils are well known, but this practice is based on soil analysis. Direct vine response to Ca has only been demonstrated under extremely high Mg conditions, presumably due to Mg antagonism to Ca and K.

Zinc (Zn)

Grape varieties and rootstocks vary widely in susceptibility to Zn deficiency. Most varieties fit within similar critical levels, although there are varieties that are more sensitive to zinc deficiencies and should always be maintained above the adequate threshold level.

Differences in petiole levels along the shoot and changes during the growing season are minor. Bloom time levels are most critical because of possible fruit set and "shot berry" effects.

Manganese (Mn)

Experience in California with deficiencies is limited due to the small number of occurrences. High levels of Mn usually indicate a low pH or acid soil. This is due to increased Mn availability in acid soils. High Mn is probably not a problem until 1,200 ppm or higher is reached. The toxic level is not well defined due to a lack of experience in California; it is based on European literature where toxic levels range up to 5,000 ppm.

Boron (B)

Both deficiency and toxicity of B are found in California vineyards. Deficiencies are found in the Coastal highlands and the granitic alluvial soils along the east side of the San Joaquin Valley. Toxicities are mostly associated with soils derived from the sedimentary coastal mountain ranges, especially where well waters contain B in excess of 1.0 ppm.

Petiole levels normally do not vary markedly along the shoot or during the growing season. However, in soils with high B, the petiole levels increase gradually throughout the season.

Boron accumulates more in the blades. Thus, in high-B areas, the levels increase markedly during the season and are higher in the older leaves. Samples of affected blades will readily confirm toxicity.

Iron (Fe)

Critical levels have not been established, because there is no correlation between Fe deficiency and tissue levels. Deficiencies are related more to Fe mobility within the plant rather than the total Fe levels. Iron contamination of the sample from dust, equipment, etc. is a common analytical problem.

Chlorides (Cl)

Varieties and rootstocks differ widely in tolerance. Chlorides continues to accumulate during the growing season and does so predominately in the petiole, although the symptoms of excess appear in the blades. Leaf injury from Cl sometimes occurs at petiole levels down to 0.8% in sensitive varieties and when Na is high. Blade analysis may help to confirm toxicity.

Sodium (Na)

Effects of excess Na have not been clearly defined, because they are usually associated with high Cl. Sodium may aggravate a Cl problem. Petiole levels of over 0.5% Na at bloom suggests problems, especially if K is relatively low.

Factors That Effect Nutrient Levels

There are several factors that can influence the expected levels of various nutrients for grapevines. These can be summarized as:

Time of Sampling

Obtaining and analyzing samples at bloom time has been the primary basis of California nutritional monitoring. Physiologically, this is a well-defined time during the season and most nutrient levels are reasonably stable. When sampling at other times during the season, it must be recognized that critical nutrient levels will change.

Plant Part and Position

The petiole opposite the cluster nearest the base of the cane was selected for analysis in California at bloom time. The primary reason for this selection is that it is identifiable and repeatable for all sampling. At later physiological stages (i.e. veraison or pre-harvest), different petiole positions are utilized, depending on the objective of the analysis. It is important to recognize that the levels of individual nutrients will vary depending on the position on the cane of a petiole or leaf blade sample.

Weather

The primary effect of weather is on nitrogen levels. Sunny days with warmer temperatures tend to result in lower nitrogen levels at bloom, while low light intensities and cooler temperatures produce higher nitrogen levels.

Soil Acidity / Alkalinity

The pH of the soil can significantly influence the uptake of nutrients. Under neutral soil pH levels (6.5 to 7.5), nutrient uptake is well balanced. Soils that are more acidic (pHs less than 6.5) tend to increase the uptake of micro nutrient and decrease the uptake of macro nutrients. Soils that are alkaline (pH's greater than 7.5) tend to depress micro nutrient uptake and increase uptake of specific macro nutrients.

Grape Varieties

One of the greatest influences of variety is on the expected level of nitrogen at bloom time. Some varieties reduce nitrates more slowly and bloom time nitrogen levels can be expected to be higher, while other varieties reduce nitrates more rapidly and

bloom time nitrogen levels are lower. Some varieties also have higher or lower critical levels of specific nutrients.

Rootstocks

The extensive use of rootstocks in California has added a new dimension to the interpretation of tissue analysis. Rootstocks are known to significantly influence the uptake of nitrogen, phosphorous, potassium and zinc. It is likely that specific rootstocks also influence the levels of other nutrients.

Summary

The critical levels of individual nutrients can vary depending on a number of factors. The time of sampling and the plant part used for analysis is one of the most important standardizations in developing critical nutrient levels.

Because of the variations that can exist from one vineyard situation to another, it is important for individual vineyard operators to develop and continue an annual program of tissues sampling and analysis. This analysis history, combined with visual observations and records of fertilizers applied, can be effectively used to make better fertilization decisions.

Growers should utilize an analytical laboratory that has experience in interpreting grape tissue analysis. Almost any agricultural laboratory can provide the data, however, the value is not in the data but in the interpretation of the results.

Research work to establish critical nutrient levels is essential to the interpretation of laboratory data and the development of comprehensive nutrient management programs. Efforts by growers to standardize sample timing and plant parts and develop historical information are enhanced when information concerning critical nutrient levels exists.

Much of the information included in this summary was obtained from publications by Peter Christensen, Extension Viticulturist, Emeritus, Department of Viticulture and Enology, University of California, Davis and Kearney Agricultural Center, Parlier.

The Glassy-winged Sharpshooter & Pierce's Disease in California

Ronald J. Brase
California AgQuest Consulting, Inc.
Horticulture Industry Show, January 2002
Tulsa, Okalahoma

California's vineyards are facing a serious threat due to the combination of a plant disease with no cure (Pierce's disease) and a half-inch-long leafhopper called a glassy-winged sharpshooter.

Pierce's disease has existed for more than 100 years in California. Until recently there was no carrier that was effective in transmitting the bacteria that causes Pierce's disease more than a few feet. However, a new carrier, the glassy-winged sharpshooter is a very effective transporter of the bacteria, and this insect has spread throughout Southern California. This insect is now moving northward in the state.

Pierce's Disease

Pierce's disease (PD) is caused by a bacterium, *Xylella fastidiosa*. The bacterium blocks the xylem, the water- and nutrient-conducting vessels of plants. The typical symptom is when leaves on a plant begin to dry or scorch. Infected plants can die in as little as one to two years.

In some species of grapevines, *X. fastidiosa* causes Pierce's disease. It also causes almond leaf scorch, phoney peach disease, alfalfa dwarf, oleander leaf scorch, and citrus variegated chlorosis.

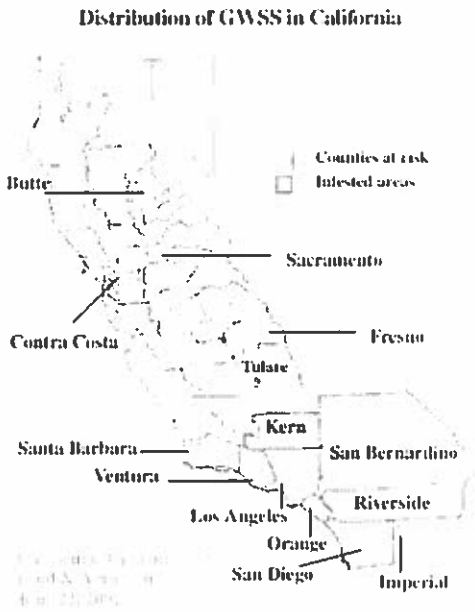
In the late 19th century, Pierce's disease decimated 40,000 acres of grapes in the Los Angles basin. It was dubbed Anaheim disease, but the name was later changed because of Newton Pierce, who studied the infection. This incurable plant disease has appeared on and off ever since, but its spread was limited. The principal carrier, or vector, in 1890 was the blue-green sharpshooter, a weak, small insect not able to fly much further than three feet.

The Glassy-winged Sharpshooter

The glassy-winged sharpshooter (GWSS) is native to the southeastern United States and has a long association with Pierce's disease of grapes in the southeastern US as a vector of the *X. fastidiosa* bacterium. The GWSS was first found in California in 1990. It is a large insect, almost a half-inch in length, and it is dark brown to black in color. Its head and back are stippled with either ivory or yellowish spots and it receives its name from its transparent wings.

The glassy-winged sharpshooter can fly up to one-quarter of a mile, and it frequently appears in high numbers. The insect is able to survive winter temperatures dipping as low as 20°F.

The insect over-winters as an adult. It begins laying egg masses from late February through May. The year's first generation matures as adults from May through August. The year's second generation begins as egg masses laid from June through September. It is this generation that produces the next year's offspring.



How the GWSS Spreads Pierce's Disease

The glassy-winged sharpshooter is a voracious eater. It can consume 10 times its body weight in liquids per hour.

Sharpshooters can acquire the bacterium from infected plants and transmit it to healthy plants while feeding. If the adult stage of the insect has acquired the bacterium that causes Pierce's disease, the bacterium remains in its mouthparts throughout its life, which can last over 6 months.

GWSS has an extensive host range, attacking at least 73 species of plants in 35 different families. In some host plants, such as grapes, the bacteria can spread systemically and cause disease. Once in the plant, the bacteria multiply and block the xylem, or water-conducting vessels of the plants. Plants eventually develop symptoms of dry or scorched leaves, particularly in mid-summer

Once a plant is contaminated with Pierce's disease, the plant can act as a reservoir of the bacterium. Any sharpshooter that feeds on the plant can pass the infection to other plants. Once an adult sharpshooter acquires the bacterium, it may transmit the disease throughout the rest of its life.

Research, Treatment and Management

There has been excellent cooperation among agencies and growers in California to control the spread of GWSS and PD. The USDA is administering pilot projects and performing research; the University of California is conducting both basic and applied research; the California Department of Food and Agriculture in cooperation with local County Ag Commissioners are running monitoring, trapping, inspection and reporting programs; and local county Task Forces are bringing growers together as part of educational outreach programs.

The primary means for long distance movement of GWSS has generally been through the transport of nursery stock and the bulk shipment of harvested citrus. In order to prevent the spread of GWSS from infested to non-infested areas, all nursery stock and certain bulk Ag product shippers are required to enter into compliance agreements. These agreements require that nurseries and growers perform monitoring, trapping,

inspections, and certain chemical treatments. Also, inspections are made of all shipments.

With the full support of broad bi-partisan coalition of members of congress and state legislators, significant funding has been directed to this problem. Federal, State, and local governments as well as the grape industry have committed a total of nearly $50 million.

USDA Pilot Projects

The United States Department of Agriculture is coordinating a number of pilot projects. One of these is located in a GWSS infested area in the southern San Joaquin Valley and is known as the General Beal Road Pilot Project. A second study location is called the Bena Road Area.

General Beal Road Project

This pilot project consists of 13,000 acres of grapevines, citrus, and field crops. It surrounds the site of the original GWSS infestations in Kern County. The project is a cooperative effort among growers and government agencies. The project area is heavily monitored and various approaches to control and treatment for GWSS are being tested and evaluated. The project area is being handled as an "area wide" Pest Management Program". Chemical treatments are coordinated among the crops and growers and with the lifecycle of the GWSS. To encourage participation, citrus growers within the pilot project area are actually reimbursed for chemical treatments.

Bena Road Study Area

This area is located on the northern edge of the General Beal Road Project. The area includes citrus and grapes that are infested with GWSS. GWSS populations are monitored with traps and field checks. Crops within the Bena Road area are being treated for GWSS, but these treatments are not necessarily being done as part of an "area wide" Pest Management Program. GWSS populations are significantly higher in the Bena Road Area than in the Beale Road Project.

Study Area Conclusions

The project teams have made very good progress in acquiring information concerning GWSS lifecycles, appropriate treatment timing (chemicals & predatory insects), and chemical control measures. Two important conclusions have been reached so far in this work:

- The control of GWSS (and controlling the spread of Pierce's Disease) must be addressed as an "area wide" Pest Management Program. GWSS control programs can only be successful when there is an integration of the insect lifecycles, plant physiology, cropping patterns, and control materials/approaches.
- Integrated Pest Management (IPM) programs have not been as effective as conventional chemical treatments. IPM will likely become a more viable option when the lifecycle of the insect is better understood, and more preventative measures become available.

Organizing a Cooperative

James Nickell
Belleview Hollow Vineyard
Nelo, Illinois

Why A Cooperative

- Increases purchasing power of the growers
- Improves marketing ability & the price received for the grapes
- Becomes an educational tool for growers
- Can be a problem solving clearing house for growers
- A psychological crutch for members

How To Organize A Cooperative

- There are many ways & structures to use
- Identify growers who are in "like" situations
- Establish a plan of action

Assistance Needed

- ATTORNEY
- USDA – has specialist in coop development
- Conduct a "simple" feasibility study
- Conduct an analysis of the feasibility study & decide if a coop is beneficial

Steps in Legal Formation

- Contact Attorney
- Write easy to understand bylaws
- Establish goals & objectives for cooperative
- Attorney & cooperative write legal and binding contracts with members and wineries

Establish Internal Structure

- Board of Directors
- Officers
- Committees
  - Bylaws
  - Nominating
  - Purchasing
  - Marketing
  - Tourism & Education
  - Public Relations
  - Cooperative Business Planning

Selection Criteria for Grape Varieties

- Adaptable
  - To the geographical location
  - To the Vineyard Soil & Topography
- Winter Hardiness
  - Cold low temp
  - High – low fluctuation
  - Soil structure & moisture levels
  - Survival vs. survival & production
  - Borderline varieties

Old Varieties - Tried and True

- Concord, Niagara, Catawba, etc.
- Standard: Chambourcin, Fosh, Cab. Sav. Chardonnay, Merlot

New Varieties – French Hybrids

- Chardonel
- Traminette
- Edelweiss
- LaCross
- LaCresent
- MY 76.0844.24 (Traminette x Ravat 34)

New Varieties – French Hybrids

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Christmas Tree Session

Better Crops
Through Soil
Conservation

Oklahoma-Grown Christmas Tree Sales in 2001

Bill Ross, OSU Extension Forestry Specialist

Introduction

We contacted a total of 55 Oklahoma Christmas tree growers by mail, telephone or email before and immediately after the Christmas tree sales season. We asked growers to list sales by sales method: choose and cut, wholesale and retail. Live tree sales were listed as those sold at the farm, wholesale and retail. Growers also were asked about imported tree sales and other holiday and alternative products.

Total Sales

Of the growers contacted, 33 submitted sales reports. Two of the 33 had no tree sales because they hadn't been in business long enough to have marketable trees. Three growers reported that they were no longer in business, and the remainder did not respond in time for inclusion in this report, could not be located or declined to be interviewed. Wholesale Oklahoma-grown figures could not be ascertained in time for inclusion in this article. Total reported choose-and-cut (CC) sales were down from the previous year (Tables 1 and 2), but average choose-and-cut sales per grower were the highest since data collection began (Table 1)

Table 1. Oklahoma-grown tree sales (live trees included), 1989 - 2001.

Year	Number of Growers	Total Sales	Sales per grower Total (CC only)
1989	NA	8,769	NA
1990	42	11,527	274 (197)
1991	48	11,989	250 (186)
1992	54	14,145	262 (185)
1993	55	18,002	327 (230)
1994	63	20,102	319 (223)
1995	64	21,071	329 (234)
1996	59	20,795	352 (248)
1997	55	18,982	344 (224)
1998	34	13,131	386 (237)
1999	41	14,564	355 (242)
2000	44*	15,699	356 (226)
2001	28*	7590**	NA (271)

*Does not include growers who responded, but had no sales because they hadn't been growers long enough to have marketable trees, or who did not market trees.
**Choose-and-cut (CC) only-other years are all methods.

Sales Methods

The primary sales method used for Oklahoma-grown trees is choose and cut (Table 2) As stated earlier, wholesale tree sales could not be verified by publication deadline, but indications are that the same trend occurred this year. No growers reported retailing cut trees grown on their farm this year. Only one grower reported wholesale

sales of live trees, all others who sold live trees did so on their farms. Virginia pine was the dominant species in the Oklahoma-grown Christmas tree market for 2001, constituting over two-thirds of trees sold. Substantial numbers of Scotch pines were sold also, followed by a small number of Austrian pines, eastern white pines, and Leyland cypress.

Table 2. Oklahoma-grown tree sales by sales method 1989 – 2001.

Year	Choose and Cut	Wholesale	Retail	Total
1989	6,662	1,625	482	8,769
1990	8,111	2,641	775	11,527
1991	8,762	1,969	1,228	11,989
1992	9,852	3,294	999	14,145
1993	12,459	4,586	957	18,002
1994	13,848	5,460	796	20,104
1995	14,766	4,893	1,432	21,071
1996	14,394	4,270	2,131	20,795
1997	12,103	5,483	1,342	18,928
1998*	7,833	3,383	193	11,409
1999*	9,697	3,080	521	13,298
2000*	9,736	4,931	None reported**	14,667
2001*	7590	Not Available	None reported**	Not Available

*Only cut trees

** Does not include retail sales of imported trees at growers farm.

Live Trees and Other Sales

Live trees sales declined as a percentage of total tree sales for the fifth consecutive year (Table 3). Approximately 30% of growers sell imported trees (fir species mostly) from other states at their choose-and-cut farms. Those growers sold 2296 imported trees, which was 36% of their combined total tree sales.

Table 3. Live trees sold from 1990 – 2001.

Year	Live Trees Sold	Percent of Total
1990	1,177	10.2
1991	2,030	16.9
1992	1,825	12.9
1993	2.810	15.6
1994	2,247	11.2
1995	1,251	13.2
1996	4,038	19.4
1997	3,001	15.9
1998	1,722	13.1
1999	1,266	8.7
2000	1,184	7.6
2001	541	NA

Sixty-one percent of the growers reported sales of wreaths, memorial blankets and other greenery products, both from Oklahoma and imported materials. Estimated sales of these products were valued at $16,735. Twenty-one percent reported sales of other holiday items such as ornaments, toys and tree stands. Sales reported totaled $47295. Twenty-seven percent of growers have other non-Christmas crops such as you-pick berries, corn and pumpkins.

Prices

Tree prices reported in 2000 were slightly higher than in 2001. Choose and cut prices ranged from $3.50 per foot to $6.00 per foot, with $5.10 being the average. The majority of growers who price by the foot charge $ 5.00 to $6.00 per foot. Those who sell on a per tree basis charge $25 to $40.00, with $28.50 being the average price per tree. Virginia pines tend to occupy the lower end of the price range, with Scotch and eastern white pines usually selling for higher prices. Live trees ranged from $10.00 to $15.00 per foot (almost all were $10.00), or up to $60.00 per tree. Highest prices were fetched by imported trees, ranging from $35.00 to $83.00 per tree, with the average being $56.70.

Sales by Region

Regions of Oklahoma were defined by using Interstate 35 as a north-south line and Interstate 40 as an east-west line. The northeastern part of the state led in sales, with forty-two percent of choose-and-cut sales coming from that region. These results have been the general trend since these data have been compiled, and indicate plenty of room in Oklahoma for additional Christmas tree growers.

Discussion

Most growers responding to the survey characterized the sales years as very good to their best ever. Several reported selling out early in the season. Highest ever choose-and-cut sales per grower would tend to support this assessment.

Last year 78% of responding growers reported a total of $724,280 in losses, mostly due to drought and adverse weather. This year, quantified damages were less than $10,000, although 39% reported losses from drought, disease and animal herbivory. Pine wilt disease caused by the pine wood nematode *Bursaphelenchus xylophilus* was cited as a major problem for Scotch and Austrian pines.

Most growers continue to be optimistic about the future of Oklahoma's Christmas tree industry. Research is currently being conducted by Oklahoma State University Department of Forestry faculty to identify alternative species for Christmas tree growers. Trials using heat and drought tolerant varieties of spruces, firs and other species began last spring, with ten growers from various parts of the state cooperating. Survival was mostly poor for the first year, but more species trials are planned. As has been the case in previous surveys, results indicate a market that needs more Oklahoma growers, particularly with retirements among many longtime growers.

Acknowledgements

Results from 1989-1997 were compiled by Dr. Steven Anderson, Extension Forestry Specialist, and Champe Greene, Renewable Resources Extension Specialist. Clark Perry, Senior Secretary at OSU Extension Forestry and Wildlife, provided much needed assistance with data collection 1998-2001. Thanks also to the Oklahoma Christmas Tree Association and all growers who take part in this survey.

Chemical Updates for Christmas Tree Production

Lonnie Smith
Agriculture and Ornamental Sales Representative
Estes Inc.
Tulsa, Oklahoma

Changes in chemical use are ongoing and plentiful. The EPA started with the ban of DDT, and continued to work with the Food Quality Protection Act. The function of the Food Quality Protection Act is to test for environmental risks and ban insecticides they feel are harmful. DDT has no confirmed human fatalities and saved millions of lives by killing insects that were vectors of disease. Chlorodane was banned due to its longevity. The focus is now on insecticides in the organophosphate class of insecticides. Some have been discontinued, some are being phased out by the manufacturer, and others will undergo label changes. The ones affected the most in our industry are:

- Lindane—Discontinued; used for borers.
- Dursban—Label change; for borers and bark beetles
- Orthene—Passed the risk assessment of F.Q.P.A.

Lindane was best on borers but the addition of a silicone surfactant (thoroughbred) will increase the efficacy of Dursban.

Dow is pulling Dursban voluntarily to keep uses in agriculture and nursery markets. It will have no residential use and may be a restricted use pesticide.

Pine tip moth control insecticides include:

- Merit—systemic control
- Orthene—a systemic spray best used early season
- Tempo—a synthetic pyrethroid that is both economical and a good knock down
- Dimilin 4L—an insect growth regulator

Tempo and other pyrethroids used early can kill beneficial insects that will allow for an aphid, scale, or mite explosion. The use of Pheremone traps to time insecticide applications, and using insecticides like Merit or Dimilin 4L that do not harm beneficial insects will help. Dimilin 4L is an insect growth regulator; use on early second-generation instars, or when 75% of the first generation pupal cases are empty. To control scale use Diazinon or Orthene at crawler stage tank mixed with Precision IGR. Diazinon may become a restricted use Pesticide as well.

Merit has activity on scale, aphids, and pine tip moths. Talstar flowable is labeled for crawler stage scale, and mixed with thoroughbred does well on mites.

Herbicides

A new Pre-emerge herbicide coming to the market soon by Valent Corporation will be very broad spectrum and safe.

Barricade pre-emerge is safe and comes in a smaller package size. With a three (3) pound bag use 1.2# per acre.

Goal 2 XL is used to establish seedbeds and on transplanted conifers (before bud break or after they have hardened off). Use Surf King with Goal 2XL to get post-emerge activity as well as pre-emerge.

Roundup Pro is the most widely used post-emerge chemical for Christmas trees. It is a nonselective herbicide that is best on grasses. Tank mixed with Barricade it will provide longer control. Roundup now has a generic that will save about 20%. Glyphos is the generic Estes sold this year. The difference in the two products is surfactants. Add Surfking Plus with Glyphos, they are both 40% glyphosate. Roundup Pro has a surfactant that has rainfast capabilities in 1 hour. Glyphos and Surfking Plus will need about 4 hours before a rain.

Always read and follow label instructions.

New Markets! New Products! New Problems?

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Craig McKinley is a native of Elmore City Oklahoma. He received his B. S. degree in Forestry from OSU in 1968 and his advanced degrees from Texas A&M University. His professional experience includes six years in industry, 14 years with the Texas Forest Service/Texas A&M University and five years at North Carolina State University. While at N. C. State he served as extension specialist for Christmas trees with emphasis on production and marketing. He has been in his current position for two years.

Activities related to the production of Christmas trees (shearing, pest control, coloring etc.) sometimes lead growers to experience a certain level of frustration. One hope to eliminate these problems is that maybe there are Christmas tree species, which don't have pests, or don't need to be sheared or that stay sufficiently green all year. While no species is perfect, some are better than others. The use of exotics for Christmas trees is certainly a viable alternative to be explored, evaluated and implemented where feasible.

There have been a number of successes in the use of exotics. There have also been failures. By reviewing some general considerations we can obtain a better understanding of how exotics fit into the overall production scheme.

What are Exotics?

A great deal of confusion often arises in the use of the term exotic. To many, an exotic is a species, which is imported from a different country. The most-recognized example for Christmas trees is Scotch pine, which was imported from Europe and Asia for use in the United States. Likewise, Nordmann fir and Afghan pine, currently being tested in this country, are imported. These species are properly called exotics. Several western species are commonly utilized in the northeastern United States as Christmas trees. Are they also exotics? They are not from a foreign country, yet they are not native to the eastern U.S. Other examples deal with less distinct differences. Fraser fir is planted in areas that are lower in elevation than where it naturally occurs, although the planted areas are still within the same geographical region. Is Fraser fir an exotic there? In response to these and other similar questions, an exotic is usually considered as "a plant grown outside its native range". Thus, the term is applied not only to species, but also to all plants being grown in non-native locations.

Why Use Exotics?

Exotics have long been used throughout the world as a method of introducing new and different types of trees into an area. They have been most beneficial to areas where only a limited number of suitable indigenous species exist. Examples from the forestry arena include the introduction of Monterey pine to New Zealand and Australia and the use of loblolly pine in southern Brazil. Success stories for Christmas trees in the U.S.

include Scotch pine, Monterey pine in southern California, Douglas-fir and white fir in the Northeast and Virginia pine in the Southeast.

The underlying objective for exotics has been to introduce material that was better than what was grown locally. The intent is to meet one or more of the following needs:

1) To provide a merchantable product that was not locally available. For example, many Christmas tree species do not store well after being harvested. By introducing new species, the local demand can be met without having to handle unsuitable trees from other areas. Growing non-native trees can also provide a greater variety of choices for the consumers.

2) To provide species which are resistant to native pests. White pine is sometimes used in the southeastern United States as an alternative to Virginia pine. Virginia pine is susceptible to tip moth, and white pine is not attacked by this pest. However, introduced trees provide no guarantees. In this case, white pine is susceptible to blister rust and pine bark adelgids, which do not infest Virginia pine. A trade-off of accepting one set of pests for another is often the result of introducing exotics.

3) To improve the quality of the product produced. Most exotics are introduced to meet this third objective. Through introduced species, growers may have the opportunity to offer trees which are better shaped, have a more pleasant fragrance, hold needles longer, etc. and which are more efficient to produce.

It is interesting to note that while commercial forestry in the United States has made minimal use of exotics, it is exotic species on which the majority of the Christmas tree industry is based. That dependence demands that significant efforts be placed on the selection and deployment of the material to be grown.

Selecting Exotic Material for Use

In selecting potential species for Christmas tree production, it should be noted that a great deal of variation exists within all species. That variation is due to: 1) the genetic makeup of the individuals within the species and 2) the environment to which those individuals are exposed. The environment is a non-genetic (non-heritable) component that cannot be transferred. Conversely, a portion of the genetic makeup of each plant is passed to its offspring. This genetic component is due to a number of factors all resulting from the environmental adaptation of that tree's ancestors. Over time, trees that were adapted produced the most offspring, and those less adapted produced either fewer or no offspring. The genetic compositions of today's plants are a result of the environment of many years ago. This adaptation and reproduction sequence has led to some genetic differences within species that are attributable to geographic location (or provenance). Those differences are important in the selection of material for planting.

Why should provenance be considered?

Just as species differ in their ability to survive, grow and produce a quality product, so do plants from different provenances. One example is in Douglas-fir. Testing of sources from various regions has identified material from southern New Mexico as more desirable for planting in the northeastern United States. In eastern white pine, sources from western North Carolina tend to have a needle color that is more blue than other sources - a trait desired by some growers. In the selection of exotics, particular attention must be given to both the species and the provenance of the material being imported. Use of material from the wrong provenance can result in significant losses even though the appropriate species is selected.

No firm rules can be established in selecting material for introduction. However, some broad guidelines are generally applicable: \

1) Material from continental climates can be moved to maritime areas but movement in the other direction is not recommended.

2) Material should not be moved from areas with uniform climates that have small fluctuations in temperature and rainfall to areas having large fluctuations.

3) Higher elevation sources should generally not be moved to low elevations, and low elevation material should not be moved to higher elevations. This rule is not true for all species, as elevational differences may not always be observed.

4) Material should not be moved to areas with vastly different soil characteristics such as pH, soil structure and nutrient composition.

Whether or not the above rules apply to specific instances, it is important to remember that the potential for failure exists whenever non-native material is introduced. Only extensive testing in the proposed area prior to widespread planting can decrease the risk of such failures.

In Christmas trees, a number of species have been successfully introduced into non-native regions. An excellent example is Scotch pine. Scotch pine occurs naturally in Europe and Asia. In 1938, the International Union of Forestry Research Organizations sponsored the planting of replicated provenance tests in several locations worldwide, including two in the United States. A number of additional plantings were later established throughout the eastern part of the United States. The combined result of these plantings is that Scotch pine now has the largest database for any species from the standpoint of provenance information. This information has been used by both foresters and Christmas tree growers to formulate guidelines for movement of material for commercial timber and Christmas tree production.

Testing in other species has not been as exhaustive as with Scotch pine, but seed movement recommendations are published for several Christmas tree species. For example, grand fir from the Inland Empire region is often recommended for planting

through the Northwest. In Virginia pine, sources from the western Piedmont in North Carolina are being used throughout the south. White fir from the Rocky Mountain region is used in the Northeast. These examples illustrate the type of information available to growers to assist in their planting decisions.

Pitfalls and Cautions

Not all introduced species perform as hoped. In many cases the results are less than spectacular, or even worse can only be classified as disasters. A major reason for many of these failures is that the introduced material was not adapted to the conditions at the planting site. The underlying philosophy is best stated as "If the trees did not grow there naturally, there must be a reason". Obviously, such a statement is rather simplistic but does give food for thought. No trees are totally immune to insects, diseases or weather related stress. By definition, exotics are being planted in conditions where they do not occur naturally and often will be exposed to conditions not previously encountered.

Many failures of exotics are immediate in that planted trees fail to live through the first year. These results are probably more common than acknowledged, as most people do not report their failures. Unfortunately, the same mistake may then be repeated in later years.

Failures of exotic species are often more subtle than simply the lack of survival. Many times, exotics survive and grow but not to an extent acceptable for continued use as Christmas trees. Several years ago, Momi fir was attempted in several locations in the southeastern United States. Many of these plantings still exist, but the growth has been less than desired. The species is now considered as not economically feasible for planting in that region. Fraser fir will survive outside its native range of the Appalachian Mountains, but becomes much more susceptible to root rot and other maladies as environmental stress increases. The result is often delayed mortality occurring prior to harvest. Difficulties have been observed in Scotch pine in the Northwest where both insects and diseases result in increased management costs as well as less-than-desired product quality. In the introduction of new species, a certain amount of risk must be taken, and the possibility of complete or partial failure considered.

It is possible that a species not suited in one area might be successful in other environments. Decisions for use must be based on performance in the area to be planted. It is also important to determine if failures were due to a non-adaptation of the genetic material or whether poor management practices were to blame.

What Does the Future Hold?

What are the opportunities for exotics as Christmas trees in the United States? Certainly, a great number of species have not been evaluated. As new material is established and tested, more choices should become available to Christmas tree producers.

The most important use of exotics may not be the species themselves, but rather the genetic material that they can provide. New laboratory techniques are being developed which allow for specific segments of the genetic material (DNA) of one individual to be removed and inserted into the genetic material of totally unrelated individuals. The result of this type of biotechnology has resulted in the development of genetically modified organisms, often called GMOs. The selection and testing of GMOs is expected to follow a protocol not unlike that used for exotics, simply because of the similarity of the information required to make sound decisions.

Some concern has been expressed, primarily in Europe but also in the U. S., regarding these molecular techniques. It is important to realize that new gene combinations have also been developed throughout the years from selective breeding, only a slower rate and with fewer potential genetic combinations. As with any technology, the value of GMOs should be judged on the results and not simply the process.

In using this new technology, imagine the number of new gene combinations that might become available. Given proper testing of these new combinations, it is feasible that plants with greatly improved resistance to insects, diseases and other environmental stresses can be rapidly developed.

Summary

In summary, exotics have been extremely important in the Christmas tree industry. Certainly, risks are present when new material is introduced. However, in Christmas trees the past successes have far outweighed the failures, and with new technologies, both exotics and genetically modified organisms may play an even larger role as our industry moves to the future.

Basic Design Steps

Monty Savage
Doc Savage Supply Co., Oklahoma City, Oklahoma

Monty was President of Doc Savage Supply Company of Amarillo, Texas from 1974 to 1987. He established Doc Savage Supply of Oklahoma in 1981. He moved to the great state of Oklahoma in 1987 when that store was offered for sale. It was an opportunity to be involved in irrigation exclusively for the first time and it was just what his family had been looking for. Commercial and residential turf irrigation have been a main stay over the years, but drip and micro irrigation are expanding on a rapid basis. In Oklahoma we see a growing demand (no pun intended) for agriculture drip application.

Site Survey

1. Obtain or draw a scaled plan of the area.
2. Identify soil types.
3. Determine plant material to be irrigated.

Point of Connection

1. Type of water, potable, well pump, effluent, etc.
2. Pressure and volume available.
3. Determine location and size of filtration equipment.

Basic Layout

1. Determine location and size of main lines.
2. Determine location and size of supply headers.
3. Determine if exhaust headers are to be used, and determine their size and location.
4. Determine type of drip and length of runs.
    a. Drip tape 15 PSI or less non PSI compensated. Inexpensive but labor intensive.
    b. Drip line 7 to 60 PSI, pressure or non pressure compensated. Labor friendly and long life.
    c. P/E tube or blank poly tube, 7 to 60 PSI and can accept any emitter you want at any spacing.

Note, on long runs make sure the tube you have chosen can handle the volume of water for the distance ran. Make any adjustments now.

Begin your installation, you can feel secure knowing that you have done your homework, and it works on paper so it will work as well in the field.

Growing Christmas Trees

Harold McAlpine, Christmas Tree Grower

Both my wife Bobbie and I grew up on Iowa crop and livestock farms. We both graduated from Iowa State University with her degree in math and mine in forestry. We moved to Arkansas in 1970 where Bobbie taught math and I worked for Weyerhaeuser Company in a number of Forestry positions until 1981. When I left Weyerhaeuser we started our Christmas tree operation which has kept us and our two sons, John & Burt busy for the last 20 years. As our sons are now pursuing their own careers we are scaling down our operation from the 60+ acres of Christmas trees we have gown for most of this time. I am also a consulting forester and do small custom logging operations.

Introduction

We started the McAlpine Christmas Tree Farm in 1981. Though we are scaling back our operation, we are still the largest (that we know of) and one of the oldest farms in Arkansas. Since we are involved in both choose and cut sale and wholesale tree production we have a broader Christmas tree marketing experience than most growers in our area. Today I would like to share some information on the history of our farm and some of the lessons we have learned (both easy and hard). Most of our experience has been with Virginia Pine with very limited experience with Leyland Cypress and Eastern White Pine. I will give you a fast trip from site selection to marketing, a slide field tour and history of our farm with plenty of time for questions afterwards.

So your want to grow Christmas Trees?

ACTGA (Arkansas Christmas Tree Growers Association) had nearly 140 members 20 years ago- now less than 30. Many never sold a tree! Some key questions before starting are:

1. Are adequate markets available?
2. Can you make the time commitment needed?
3. Do you have adequate capital and/or equipment?
4. What is your level of experience in related areas?
5. Are you physically able to take this on?

Site and species selection go together. Another consideration in site selection is having ground conditions which will allow you to handle field work, especially harvesting, under all weather conditions.

Laying out fields, roads and tree spacing requires planning to match available equipment and make your work easier.

The Basics of Christmas tree production with Virginia Pine are:

1. "Good" seedlings from a proven genetic base.
2. Proper tree planting techniques.
3. Weed control

4. Insect control (tip moth, aphids, Pales weevils, scale etc.)
5. Needle disease control (fungus)
6. Pruning - shearing and basal
7. Staking

Growing Christmas trees is a lot of work and requires sizable expenditures but it gives a great deal of satisfaction to see a good field of trees ready for market. Marketing is the test to see if it was all worth it and also to see if you can continue to grow trees. Certain hassles are inherent with live Christmas trees. We need to make them as "user friendly" as possible. A cleanup spray to get rid of unwanted "wildlife" before the tree goes inside is essential. For Virginia pines and many other species a good shaking to remove loose dead needles and other debris is also essential.

A good quality, fresh tree at a reasonable price gives you a marketing edge. Locally grown trees can provide a fresher product and a better level of service to retail lots than "imported" trees. Split deliveries, handling small accounts and innovative financing can be important in local wholesale marketing. Retail sales (choose and cut) are the major sales for most growers in Arkansas. Repeat customers and "word-of mouth" advertising are essential to success.

We started our farm with the purchase of 80 acres in 1981. The land had a history of cultivation for agriculture in some areas with resulting soil loss on this rolling land. When we purchased it the current use was as rough, semi-wooded pasture land. Each year we clearing enough land to plant 10 thousand trees on a 6' x8' spacing. In the last few years we have scaled back to about 40% of this level. We are shifting from primarily wholesale production to about 50% wholesale and 50% choose and cut. The following slides give a feel for the land, trees and equipment we use. As they say "There are more than one way to skin a cat." Hopefully some of the things we do may be helpful or interesting to you but they may not be the only way to produce a good tree.

Public Gardens/Master Gardeners Session

Hypertufa Garden Containers

Bob Constien
Horticulturist & Artificer
Perkins Township, Oklahoma

The story of hypertufa garden containers actually begins with the rise of settled agriculture in England. No, those pre-Roman rustics did not grow exotic plants in pot-culture outside their huts, but they did begin to carve stone troughs for their livestock and stone sinks for themselves. They continued making these until the industrial revolution and the Acts of Enclosure began the depopulation of rural areas and the growth of cities. The discarded stone containers waited patiently.

At about the same time, the children of the gentry began making the Grand Tour of Europe to accumulate culture. On their way, these travelers discovered the Alps and (as you might expect) alpine plants. Gardeners among them took the plants home and started resurrecting the old stone troughs to house their new collections. As this practice spread with time, the original stone containers became scarce and very expensive. To remedy this problem, hypertufa containers were created to mimic them.

A few explanations are in order. Tufa is a soft, porous mineral deposited by springs. It was not used to make the original troughs and sinks. Neither is it used to make hypertufa. But, because alpine and other plants grew well in recesses cut in tufa, it was used as a model for the construction of even more lightweight and porous containers. Hence: Hypertufa (or supertufa...or extreme tufa...). The new hypertufa also had the advantage of acquiring the patina of antiquity without centuries of time and livestock noses.

Hypertufa containers are easily made in a variety of shapes. The basic necessity is a form against which the mix may be pressed to give shape to either the inside or the outside of the new container.

Recipe:
2 parts portland cement
3 parts peat moss
3 parts vermiculite
water

Variations:
1/20 part fibermesh for large castings
mortar color as desired
sand substituted for vermiculite increases strength and weight

Safety considerations:
Wet portland cement is very alkaline. Skin exposed to it will become chapped. Permanent scarring may result if portland cement enters breaks in the skin. Use waterproof gloves.
Sporotrichosis is a fungal disease sometimes present in sphagnum moss and rarely in sphagnum peat moss. It enters the body through breaks in the skin. Use waterproof gloves.
Dry portland cement and peat moss dust are lung irritants. Wear a dust mask.

Procedure:
Mix dry ingredients well. Add water a little at a time, blending the mixture thoroughly after each addition. Keep adding water until the mixture is the consistency of cottage cheese. Press mixture into the mold tightly to exclude air bubbles. Cover with plastic for a couple of days. Then un-mold, wire-brush sides for desired texture and round off edges using a broken piece of concrete block. Drill drainage holes with a screwdriver. Recover with plastic for another five days. At this point, the container will have about 90% of its eventual strength. The surface, however, will be very alkaline. Wash the container thoroughly with a garden hose. Place the container in a plastic bag for another two weeks. It is important not to let the container dry out during the curing period. If fibermesh was used, burn off the protruding fibers with a propane torch. Wash the container again before use.

How to Make Your Flowers Say Cheese

Charles S. Lewallen
Amateur photographer with 6 years
experience with digital cameras.
Author of the web site:
Oklahoma Wildflowers; www.biosurvey.ou.edu/okwild/

There are at least 5 things that are needed to take a good photo. First you must be comfortable. If you have positioned yourself in a cramped or painful position your chances of getting a good shot are much less than if you are relaxed. An example of this is that when I started taking pictures I did not want to lay down on the ground, after all what would people think? Well the alternative, at least if your subjects are low to the ground, is to squat down, try to balance, all the time trying to hold the camera steady. It can be done, but your chances of getting a good picture are not very good.

This is where a tripod comes in. For years I would not use a tripod. I did not want to take the time to set one up, much less carry it around. I have come to believe now that a tripod is indispensable, and I use one 95% of the time. The tripod holds the camera steady and lets you relax while composing the shot. Combine this with a cable release and you have a much better chance of not moving the camera while taking a picture. I shoot for depth of field and this sometimes means very slow shutter speeds so a steady camera is essential. A good tripod for this kind of work is one where the center post can be removed and placed in a horizontal position and the legs can be laid out flat.

Bracket your photos, This will give you one under exposed, one over exposed and one "normal" exposure. I often find that I can get a better picture out of the under exposed shot than the "normal" one.

Take more than one shot of your subject, take several. I have, on many occasions taken as many as 40 pictures of a flower only to throw all of them away and go back and take 40 more. As a rule I throw away 95% of the pictures I take. This is of course easier with digital photography than with film.

List Of Slides:
ecoregions.jpg
Male Collard lizard
American Columbo flower
American Lotus Cherokee Co.
Arogos Skipper
arrowhead with beetle
bee fly
Bladderwort Okmulgee Co.
blue eyed grass
bractless mentzelia
bur cucumber flower
buttonbush
Carolina Anemone Okmulgee Co.
Catulpa Okmulgee Co.
chatterbox Orchid2
chickory
Clematis pitcher
crestpetal clammyweed
Dion Skipper
dovesfoot cranesbill
dutchmans pipe.
giant robber fly
Great Blue Skimmer

green lynx spider
ground nut
henbit
Hover beauty
Jonny Jump-up
killdeer chick
leavenworth eryngo
Meadow Flax
melonette
mouse-eared chickweed
nodding lady's tresses& spider
Okla. Grass Pink
paw paw
Plains Coreopsis Okmulgee Co.
plains prickly pear
Prairie Dog & Pup
Prairie Iris
Prairie Sabatia Okmulgee Co
Purple Coneflower McCurtain Co
Purple Pleatleaf S. E. Okla.
rain lily
Red Bud Okmulgee Co.
red penstemon.
Royal Catchfly Cherokee Co.
Sand Verbena Jackson Co.
shooting star
silver-spotted skipper
Snake-Mouth
soapwort
speckled kingsnake
Spring Ladies Tresses Okm.
Standing Cypress Comanche C.
star violet
swamp rose mallow
water lily
water smartweed
western wood rose Cimarron Co.
white trout lily.jpg
yellow fringed orchid
yellow lady's slipper
yellow star grass.
Zebra Butterfly

Oklahoma's Remarkable Diversity of Native Plants

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Botanically, Oklahoma is quite exciting! Its vascular flora comprises 173 families, 868 genera, and 2,540 species, and is a complex assemblage of plants representative of different phytogeographic regions. Species characteristic of the eastern deciduous forests and central grasslands are the most common, however, taxa characteristic of the forests of New England, the swamps of the Gulf Coast states, the deserts of the Southwest, the mountains of the West, and the prairies of Canada also are present within the state's borders.

The diversity of plant vegetation types present reflects this diversity of species. Fourteen, described in 1943 by Duck and Fletcher, are traditionally recognized. The six forest types are: oak-hickory, oak-pine, post oak-blackjack oak, loblolly pine, cypress bottoms, and bottomland (flood plain). The three grassland types are: tallgrass prairie, shortgrass prairie-high plains, and mixedgrass-eroded plains. The five shrubland types are: sandsage grassland, mesquite grassland, shinnery oak-grassland, stabilized dune, and pinon-juniper mesa.

The tremendous diversity of plant species and communities in Oklahoma reflects the considerable variation in the state's climatic, physiographic, geological, and edaphic features. A plethora of different habitats for plants is present.

With respect to abundance, the five largest families in Oklahoma are the Asteraceae (sunflowers) with 105 genera and 351 species, the Poaceae (grasses) with 96 and 305, the Fabaceae (legumes) with 40 and 154, and the Cyperaceae (sedges) with 14 and 155. Fourteen percent of the state's flora is naturalized. Familiar introductions include: *Taraxcum officinale* (dandelion), *Sorghum halepense* (Johnsongrass), *Digitaria sanguinalis* (crabgrass), and *Paspalum dilatatum* (dallisgrass). Introductions that are becoming abundant and potential threats to native species and communities are: *Lespedeza cuneata* (sericea lespedeza), *Bothriochloa ischaemum* (yellow bluestem), *Ligustrum sinense* (privet), and *Lonicera japonica* (Japanese honeysuckle).

Oklahoma's large and complex flora constitutes a valuable, natural resource. Consequently, its plants are harvested, manipulated, conserved, and studied by many individuals – farmers, ranchers, foresters, sportsmen, gardeners, extension agents, conservationists, agronomists, range scientists, wildlife biologists, horticulturalists, soil scientists, ecologists, and botanists. Many others simply enjoy the beauty of the state's plants. Individuals needing to or simply interested in identifying Oklahoma's plants have four references available. The first and most comprehensive is *Identification of Oklahoma Plants* authored by seven state taxonomists. It is a traditional taxonomic

manual and comprises keys to families, genera, and species; family descriptions; and an illustrated glossary. It differs in several ways from its predecessor *Keys to the Flora of Oklahoma* by U.T. Waterfall. All couplets leads are absolutely parallel and mutually exclusive; each couplet includes vegetative, floral, and fruit characters whenever possible; and terminology is uniform throughout the keys and descriptions. *Identification* is a work in progress. The authors meet monthly to write keys and descriptions and publish a revised version each semester as new material is added. The book is used in high school and college classes. To obtain a copy, contact Flora Oklahoma Incorporated, 15100 Etowah Road, Noble, OK 73068 (Tel: 405-744-9558).

The second reference that will be published in the summer of 2002 is *Field Guide to Oklahoma Plants – Commonly Encountered Prairie, Shrubland, and Forest Species.* Written by a taxonomist, range scientist and wildlife biologist at Oklahoma State University, it is designed, as its title implies, to facilitate identification of commonly encountered, ecologically distinctive, or biologically/economically important plants of the state. One-page synopses of 203 species are provided. Each synopsis comprises: a brief morphological description; a list of diagnostic features; and brief summaries of the species' taxonomy, nomenclature, distribution, ecology, and economic or wildlife significance. The information presented in each element of the synopsis is a compilation of the authors' observations of the species in the field, examination of herbarium specimens, and information appearing in the literature. Accompanying each synopsis is a detailed illustration of the species' features prepared by noted botanical artist Bellamy Parks Jansen. To facilitate fieldwork, the species are organized into four categories: graminoids (true grasses and grass-like taxa), legumes, forbs, and woody taxa. To obtain a copy, contact Ronald J. Tyrl (Tel: 405-744-9558) or Terrence G. Bidwell (Tel: 405-744-6421) at OSU.

The third reference – quite familiar to wildflower enthusiasts – is *Roadside Flowers of Oklahoma* by Doyle McCoy, formerly a taxonomist at Cameron University. Published in 1976, this treatise consists of plates of color, close-up photographs of the state's showy wildflowers. Accompanying the plates are short narratives about each species. Sequels include: *Roadside Flowers of Oklahoma, Volume II* published in 1978, *Roadside Wild Fruits of Oklahoma* in 1980, and *Oklahoma Wildflowers* in 1987. These books can be purchased in commercial bookstores.

Contrary to its title, *Shinners and Mahler's Illustrated Flora of North Central Texas* is a useful reference for the identification of state plants. Plant species pay no attention to political boundaries and many of the taxa treated in this book also occur in Oklahoma. Like *Identification of Oklahoma Plants*, it is a formal taxonomic manual and comprises keys, descriptions, and illustrations. Written by Texas taxonomists, it is available from the Botanical Research Institute of Texas in Fort Worth (Tel: 817-332-4441).

Dry and Wild

Steve Owens
Associate Extension Specialist
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The presented plants are mostly natives of Oklahoma that are adapted to the normal amount of rainfall received in the state. The species from the western part of the state are accustomed to even drier conditions because of the lower amount of rainfall. These are best grown in a raised bed with an unamended soil, especially when growing them in eastern Oklahoma. The western species do not have a mechanism to combat the organisms present in soil that is high in organic matter. This makes them more challenging to grow commercially because of the organic peat moss used in most commercial mixes. For this reason few are offered in the trade.

Home gardeners and other plant enthusiasts can try growing these plants from seed collected from well represented wild populations. The closer to home the seed is collected, the better the performance that can be expected. After the plants are established in the garden, a few stems or portions of the faded flowers should be left on the plant each year and not dead-headed. This will ensure that enough seed will be produced to germinate and continue the plants' presence in the garden if the parent plants die.

A collection of native plants in the home garden is a great way to increase the diversity of the landscape. Some of the best butterfly, hummingbird, and other pollinator attracting plants are members of Oklahoma's native flora.

Native Plants

Steve Owens
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1. Wild plant	
2. *Cercis canadensis*	Eastern Redbud
3. *Cercis Canadensis* 'Forest Pansey'	Redbud
4. *Gleditsia triacanthos* 'Ruby Lace'	Purple Honeylocust
5. *Cornus florida*	Flowering Dogwood
6. *Cornus florida* 'Rubrum'	Pink Flowering Dogwood
7. *Ilex vomitoria*	Yaupon Holly
8. *Solidago sphacelata* 'Golden Fleece'	Goldenrod
9. *Artemisia ludoviciana* 'Silver King'	White sage
10. *Eupatorium fistulosum* 'Selection'	Joe Pye weed
11. *Gaura lindheimeri* 'Corrie's Gold'	Gaura
12. *Gaura lindheimeri* 'Crimson Butterflies'	Gaura
13. *Gaura lindheimeri*	Gaura
14. *Zinnia grandiflora*	Plains Zinnia
15. *Senecio plattensis*	Prairie Groundsel
16. *Melampodium leucanthemum*	Blackfoot Daisy
17. *Ruellia humils*	Hairy Wild Petunia
18. *Delphinium carolinianum*	Carolina Larkspur
19. *Rudbeckia maxima*	Giant Coneflower
20. *Engelmannia pinnatifida*	Engelmann Daisy

21. *Verbena bipinnatifida*	Prairie Verbena/Dakota Vervain
22. *Ipomoea leptophylla*	Bush Morning Glory
23. *Oxytropis lambertii* var. *articulata*	Purple Loco Weed
24. *Astragalus crassicarpus* var. *trichocalyx*	Ground Plum
25. *Machaeranthra pinnatifida*	Yellow Spiny Aster
26. *Scutellaria resinosa*	Resinous Skullcap
27. *Marshallia caespitosa*	Barbara's Buttons
28. *Helianthus salicifolius*	Willow-Leaved Sunflower
29. *Passiflora incarnata*	Passion Flower
30. *Lithospermum incisum*	Fringed Puccon
31. *Lesquerella ovalifolia* var. *alba*	White Badderpod
32. *Arenaria patula*	Sandwort
33. *Hymenoxys scaposa*	Perky Sue
34. *Polygonella americana*	Jointweed
35. Same	
36. *Astragalus racemosus*	Milk Vetch
37. *Veronicastrum virginicum*	Culver's Root
38. *Smilacina racemosa*	False Soloman's Seal
39. *Salvia azurea*	Blue Sage
40. *Baptisia australis*	Blue False Indigo
41. *Baptisia sphaerocarpa*	Golden False Indigo
42. *Oenothera missouriensis*	Missouri Primrose
43. *Calylophus serrulatus*	Plains Yellow Evening Primrose

44. *Toxicodendron radicans*	Poison Ivy
45. *Panicum virgatum* 'Heavy Metal'	Switch Grass
46. *Sorghastrum nutans*	Indian Grass
47. *Chasmanthium latifolium*	Fish-on-a-fishing-pole
48. *Penstemon buckleyi*	Buckley's Penstemon
49. same	
50. *Penstemon cobea*	Purple Beard Tongue
51. same	
52. *Penstemon oklahomensis*	Oklahoma Penstemon
53. same	
54. *Pesnstemon arkansanus*	Arkansas Penstemon
55. *Penstemon digitalis* 'Husker Red'	Husker Red Penstemon
56. *Penstemon grandiflorus*	Large-flowered Penstemon
57. same	
58. *Euphorbia marginata*	Snow-on-the-Mountain
59. same	
60. *Helianthus argophyllus*	Silver Sunflower
61. *Stylophorum diphyllum*	Celandine Poppy
62. *Campsis radicans* & *C. grandiflora*	Trumpet Creepers
63. Campsis grandiflora	
64. Native Oklahoma Iceplants	
65. My Native Collection	

Plant Identification for the Beginner

Pat Folley

In Oklahoma, there are about 172 families of vascular plants, out of about 300 worldwide. There are about 850 genera (the first name of a plant or animal) and about 2,549 species (the second name of a plant or animal). I say "about" because experts sometimes do not agree on the separation of two varieties into separate species, and also on where the genera should be split. And because, in nature, nothing is ever "always" or "never", and all life is one process, caught by the necessities of human thought at a snapshot of time and artificially forced into the categories so necessary to the way we know.

The first thing you need to know about plant names is how many you already know, or can figure out with just a few clues. For example:
Slides: Some of the kinds of plants in Oklahoma include: **Liverwort:** ***Asterella tenella*, (not vascular), ferns:** ***Cheilanthes tomentosa* (wooly lipfern) *& Osmunda regalis*, fern-ally:** ***Equisetum hyemale*, monocot: corn seedling, dicot: morning-glory seedling.** Not shown: mosses, algae, and gymnosperms.

1) The largest plant family in Oklahoma is the Asteraceae (351 species), **slides:** *Helianthus maximliani, Echinacea angustifolia, Ambrosia trifida, Cirsium altissimum, Gnaphalium purpureum, Haplopappus ciliatus* fruit. The composites, or Sunflower family: Flowers contained in heads, or compact clusters, resembling flowers themselves. Individual flowers may be tubular (called disk florets), or all joined together except for one seam, and unrolled to be flat, (called ray florets or ligules). The seeds (one per floret) are formed below the base of the corolla. The calyx is often turned into a fluffy pappus which helps to disperse the seed.

2) Poaceae (308 species),**slides:** *Sorghastrum nutans, Andropogon gerardii, Schizachyrium scoparium, Panicum virgatum, Buchloe dactyloides.*
The grass family are monocots, have the typical monocot leaf, which is long and thin. The stems are usually round, and the leaves are wrapped around the stem at their bases, but not sealed into a tube. The stem leaves are two-ranked and alternate. Except for bamboos, all Oklahoma grasses are herbaceous, and most native grasses are perennials. The grasses have small flowers, mostly wind-pollinated so they need not be showy. The spikes are almost always at the top of the stem (the better to catch the breeze), and contain many tiny flowers that have no calyx or corolla, but are supported by 3 –6 small papery bracts. If you learn to recognize the unique grasses, you will already know 1/3 to ½ of the grass species in Oklahoma.

3) Cyperaceae (155 species) **slides:** *Cyperus setigerus, Dichromena nivea, Eleocharis montevidensis, Scirpus cyperinus, Scleria ciliata. The s*edge family. The other large group of monocots, sedges usually have triangular stems with the stem leaves arranged in whorls of 3. Sheathing leaf-bases are sealed into a tube, called a sheath. The flowers resemble grass flowers in being wind-pollinated, but are more varied in style and shape.

"Grasses are round; sedges have edges" refers to the sharply triangular-sided stems. Most sedges grow in moist habitats.

4. Fabaceae (154 species) **slides:** *Baptisia australis, Dalea purpurea, Clitoria mariana, Pueraria lobata, Robinia pseudoacacia.* The bean family. The familiar garden plants, peas and beans, are in this family, as well as trees like black locust. All bean-family plants have the bonnet-shaped flowers, and most are insect-pollinated, so they are also colorful, showy and fragrant. If you meet a plant with pea-like flowers and the fruit in pods, you can be sure it is a Fab.

Total, first four families: 968 species. 38% of all species, including many of the most common. Another 12 families have more than 30 species each:

5. Brassicaceae (69 species) **slides:** *Dithrya wislizenii, Capsella bursa-pastoris, Erysimium capitatum, Lesquerella gracilis, Streptanthus hyacinthoides.* The mustard family. Yes, the farmer's mustard, and also cabbage, turnips and many more. The flowers are simple, four-petalled, with the petals not joined, and usually white or yellow or lavender. There are 2, 4, or 6 stamens and one pistil. The fruit is a long or short pod.

6. Rosaceae (67 species) **slides:** *Crataetus crus-galli, Fragaria virginica, Geum canadense, Rosa foliolosa.* The rose family. Includes not only roses, but also many fruit trees, such as plum, peach, pear and apples. Flowers have five separate petals, 1 to many stamens, 1 to many pistils. Fruits of many kinds, from strawberry to rose-hips to Agrimonia's little burrs. The simple 5-petalled flower in a saucer shape is the best indicator of the roses.

7. Scrophulariaceae (65 species) **slides:** *Penstemon cobaea, Castilleja indivisa, Collinsia violacea, Mimulus ringens.* The figwort family, named for a European herb. Our most recognizable member is probably Penstemon. The family is very diverse, but most members have tubular, bilaterally symmetrical flowers, and fruits that are capsules. The fused petals have 4 or 5 lobes, 2, 4 or 5 stamens, 1 pistil with 2 carpels.

8. Lamiaceae (60 species) **slides:***Cunila oreganoides, Hedeoma drummondii, Lamium amplexicaule, Monarda citriodora, Salvia azurea.* The mint family. Familiar to us from the fragrant herbs, mints resemble the scrophs in having tubular, bilaterally symmetrical flowers. Usually there are two upper lobes and 3 lower lobes. Stamens 2 or 4, pistils of 2 divided carpels forming 4 seeds, but only one style. While it is true that mints have 4-sided stems, so do many other plants in other families.

9. Apiaceae (56 species) **slides:** *Conium maculatum, Erigenia bulbosa, Eryngium leavenworthii, Polytaenia nuttallii.* The carrot family. Herbs, usually with hollow stems and leaves that clasp them at the base. Flowers are in distinctive umbellate heads. Petals 5, not joined at the base, usually very small, radially symmetrical. Stamens 5, pistils 1, compound, with 2 carpels and 2 stigmas. Fruits small capsules splitting into 5 one-seeded segments.

10. Euphorbiaceae (51 species) **slides:** *Acalypha virginica, Cnidoscolus texanus, Croton capitatus, Euphorbia marginata, Stillingia sylvatica.* The spurge family. Usually with milky sap, including bull nettle, poinsettia, and snow-on-the-mountain. Often weeds. Flowers imperfect but stamens and pistils held in clusters called cyathia, which resemble flowers themselves. The one pistil has usually 3, sometimes 2 carpels, forming distinctive dry capsules that split into 3-6 segments.

11. Onagraceae (43 species) **slides:** *Gaura filiformis, Ludwigia peploides, Oenothera macrocarpa, Oenothera speciosa, Stenosiphon virgatum.* The evening primrose family. Herbs, with often showy flowers that may bloom at night, thus the name. Corollas radially symmetrical with usually 4 petals, white or pink or yellow. Stamens 2-10, longer than the petals, pistils 1, compound of 2-5 carpels. Stigmas 1, 4-lobed. Fruits capsules or nutlets.

12. Liliaceae (40 species) **slides:** *Allium canadense, Androstephium coeruleum, Camassia scilloides, Erythronium albidum, Nothoscordium bivalve.* The lily family. Includes the garden lilies and amaryllis, as well as asparagus and onions. Perennials from bulbs or rhizomes. Leaves usually grass-like but can be broader. Flowers of 3 or 6 tepals that may be free or fused, stamens 6, pistils 1, compound with 3 carpels. Fruits capsules or berries.

13. Polygonaceae (38 species) **slides:** *Eriogonum annuum, Polygonum amphibium, Polygonum scandens, Rumex altissimus.* The buckwheat family. Includes rhubarb, knotweeds, and vines. The stems are jointed, with swollen nodes that often bear a band of tissue around the node, called an ocrea. Flowers have no petals, but may have 3 showy, colored sepals. Stamens 2-9, pistils 1 with 2 or 3 carpels, each bearing one seed.

14. Ranunculaceae (37 species) **slides:** *Anemone caroliniana, Aquilegia canadense, Delphinium tricorne, Ranunculus hispidus.* The buttercup family. Includes the familiar garden flowers delphinium and columbine, and mostly known for its showy flowers, though many have medicinal values. The sepals are often petal-like, but the extremely variable flowers may also include showy petals. Petals none, 2, 5, or 10; stamens 5 to many, pistils many or 3, 7, or 1. Fruits achenes or berries.

15. Asclepiadaceae (33 species) **slides:** *Asclepias tuberosa, Cynanchum laeve, Matelia cynanchoides, Sarcostemma cynanchoides.* The milkweed family. Most have milky sap and showy, insect-pollinated, fragrant flowers. Flowers have 5 fused sepals, 5 fused petals, 5 stamens that are fused to the compound style. Fruits "pods" with many flat seeds bearing long silky hairs.

16. Orchidaceae (32 species) **slides:** *Calopogon oklahomensis, Platanthera ciliaris, Spiranthes magnicamporum, Triphora trianthophora.* The orchid family. Most Oklahoma orchids are not showy, and all are terrestrial perennials from bulbs or bulb-like roots. Leaves are similar to those of lilies. Flowers are usually borne on spikes. Sepals 3 and petals 3, bilaterally symmetrical, all petaloid. One petal usually enlarged. Stamens 1 or 2, fused to the style and stigma. Fruits capsules with several thousand tiny seeds.

The total of these 16 large families is 1559, or 61% of all species.

Serious about learning the wildflowers of Oklahoma? Log on to Charles Lewallen's display of pictures, with identification, on www.biosurvey.ou.edu/okwild/. ONPS's home page (www.telepath.com/chadcox/onps/index.html has links to other sources. The Biological Survey also has a whole book on-line with pictures, maps and descriptions of native woody plants at www.biosurvey.ou.edu/shrub/cover.htm.

The best books for a beginner are still Doyle McCoy's "Roadside Wildflowers of Oklahoma", in print in several versions. These have clear color photos and a short description of each of about 450 species. Ruth Boyd usually has some for sale and the hardbound edition is available through the OU Press.

If you need help translating the scientific names into the common (English) names and back again, try John and Connie Taylor's "An Annotated List of the Ferns, Fern Allies, Gymnosperms and Flowering Plants of Oklahoma", which is available through the ONPS.

Floras are wonderful books if you can use the keys, which takes determination and lots of practice. Some for the region include: Illustrated Flora of North Central Texas, published in 1999 by the Botanical Research Institute of Texas, drawings and photographs; Flora of the Great Plains, University Press of Kansas, Steyermark's Flora of Missouri, which is great because it is illustrated with detailed line drawings; or the Dover reprints of Britton & Brown's three-volume set of the flora of Eastern North America. You may find a few of these in public libraries.

The Flora of Oklahoma association is working on a similar work for Oklahoma. It is far from complete, but Xerox copies of the work to date are issued at the beginning of each semester. Temporary title: Identification of Oklahoma Plants. Contains a complete copy of Waterfall's Keys to the Flora of Oklahoma. Contact Ron Tyrl at the Botany Department, Oklahoma State University.

Native Trees and Shrubs for the Urban Landscape

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Below is a random and small sampling of native woody plants appropriate for most or all of Oklahoma as well neighboring states in many instances. For today=s purposes, a native woody plant has been defined as any tree or shrub found wild in at least one of the lower 48 (contiguous) states.

SHRUBS

Holly (Ilex) - both deciduous and evergreen, tree and shrub forms to choose from - check with your local garden center personnel for appropriate pollinator when desirable - pictured today are possumhaw (Ilex decidua) and American holly (Ilex opaca)- many others such as Yaupon (I. vomitoria) found in this area of the U.S.

Southern bush honeysuckle (Diervilla spp.) - yellow-green flowers - many cultivars 'Copper'- copper colored new foliage, Summer Stars™ - dwarf 2-3' - yellow trumpet flowers use Diervilla in tough climates, difficult soils, hot wind-swept areas, etc. - good for butterflies - however, if you want Magnolia-type take your breath away flowers, this is not your shrub

Viburnum (Viburnum spp.) - deciduous, semi-evergreen and evergreen types available- whether native or exotic choose from wide variety for fragrance, fall color and showy fruits- use viburnums en masse in the shrub border or occasionally as single specimens- come in all heights. If you try only one new shrub this spring, make it a viburnum. There are nearly 40 different types of viburnums at OSU, Stillwater to review/study.

Clove currant (Ribes odoratum) - not a perfect plant but the scented flowers are exquisite- and putting one in your yard is not going to wipe out our white pines despite the hysteria in popular press. Clove currants are also edible (black fruits with yellow cv. available), make good screening plants and can tolerate some shade when necessary.

Fothergilla (Fothergilla gardenii and cultivars)- a beautiful witch hazel relative that deserves more attention- full sun to some shade actually beneficial - blue-green foliage, interesting bottlebrush flowers and very attractive fall color – 'Blue Mist' for blue foliage and many other types available

Purpleleaf ninebark (Physocarpus opulifolius Diablo) - ninebark thought to belong in the North while in reality can be grown well in OK - green or purple foliage (Diablo)

available - early white flowers, exfoliating bark, grows in difficult soils. With a little moisture and sometimes partial shade, leaf scorch will usually not occur in Oklahoma (based from ongoing OSU trials).

American bladdernut (Staphylea trifolia) - great OK native for three-leaved foliage, white flowers, interesting seed pods - use for natural, low-maintenance areas - can prune into small tree 8-10' if desired.

Buttonbush (Cephalanthus occidentalis) - easily found around OK lakes- but doesn't require being in or near a body of water - white flowers, extra glossy foliage, modest yellow fall color, showy button-like fruits all winter- a bit erratic in growth so personalities that need Bradford pears and other absolutely predicatable growth habits will not like this shrub - tolerates pruning well to keep in bounds and shape as desired. Steve Bieberich (Sunshine Nursery, Clinton), one of Oklahoma's top plantsmen, has found a selection for even larger flowers/fruits that he's named 'Sputnik'.

American beautyberry (Callicarpa americana) - so easy to grow yet many have never tried this genus for purple or white berries in the fall. Greenleaf Nursery has a fine strain/selection also in OBGA trials and can again be found throughout the OBGA affiliate garden network.

White fringetree (Chionanthus virginicus) - can be seen from the highway/turnpike while driving to Tulsa or further east in the spring - great shrub or small tree - also consider C. retusus although not native. This plant looks good in the back of a shrub border/bed- white flowers, blue drupes, yellow fall color.

Red and black chokeberry (Aronia arbutifolia and A. melanocarpa, respectively) - this shrub is finally getting respect - year round beauty - white early flowers, glossy foliage in the summer, exceptional fall color and persistent red or black fruits - many cultivars as well for even showier fall color and larger fruits such as 'Viking'. The Viking chokeberry is one of many OBGA test/display plants that can be seen around the state such as in the collections at Northern Oklahoma College, Tonkawa. Grow any of these shrubs for erosion control, wildscapes, informal hedges, edible landscapes, etc.

Oakleaf hydrangea (Hydrangea quercifolia)- a common but underutilized hydrangea. Again 12 months of beauty is had by white flowers, oak-like showy leaves, brilliant fall color, persistent fruiting structures (infrutescences) in the winter and exfoliating bark with age. This Oklahoma Proven shrub comes in a number of cultivars with variable ornamental characteristics. I believe the plant often does better with a little shade in our OK heat- some of the newer cvs. from tissue culture.

TREES

Deciduous conifers

Pond cypress (Taxodium distichum var. ascendens) - grows more narrow in habit than bald cypress - foliage is needle-like and perpendicular to twigs - otherwise similar to bald cypress

Bald cypress (Taxodium distichum) - common but still needs to be used more often in many landscapes and communities – doesn't have to be in or near water - knees normally not a problem in normally irrigated settings- give this plant room to grow up and out - many people cramp it only to prune it back later effectively ruining its ornamental appeal- weeper type, Cascade Falls, will become more readily available in the near future - weeps down to the ground - can be seen at OBGA, Stillwater.

Evergreen conifers

California incense cedar (Calocedrus decurrens) - grow to provide more diversity amongst current conifers - mature specimens do exist throughout OK but many more need to be planted - retains good green color in winter, showy brownish-orange bark, much variation in habit from almost fastigiate to very globose - not the toughest conifer so avoid wind swept areas, winter irrigate, don't prune up too high.

Arizona cypress (Cupressus arizonica) - showy gray, green or blue foliage, interesting cones, bark exfoliates with age and quite attractive - much cold hardier than often thought and will survive OK throughout Oklahoma.

Western red cedar (Thuja plicata) - all plants have problems, even natives to this country- although a great tree it can and will have bagworms on occasion although less than many other comparable evergreens - keeps a better green color in the winter - grows incredibly fast - and many cultivars and hybrids available to choose from for size, variegation and other needs - definitely a fine group of plants to grow. Mike Shoup, Botany Shop, Joplin, MO has done an excellent job in promoting this group of outstanding conifers- this species can be found up to Alaska but still does well with our heat - the key is to find the few selections, from the sea of cultivars that exist, that will thrive best in our heat and sometimes difficult soils. Many cultivars are being trialed at OSU.

Limber pine (Pinus flexilis) - an elegant five-needled pine, soft to the touch with blue or green needled types available- much easier to grow than many of the other 5-needled type for OK-LA's and landscapers are doing a good job getting these out throughout Oklahoma. Again, because it's a U.S. native, its chances for long term survival and avoiding PWN are good.

Deciduous trees

Buckeye (Aesculus spp.) - use as understory plants with full sun OK too if adequate moisture provided - grow for large showy flowers, persistent "buckeyes" in the winter

(toxic). It is much easier to stick with buckeyes over horse chestnuts this far south - pictures today are Ohio buckeye (A. glabra) and red buckeye (A. pavia) - TX buckeye (A. glabra var. arguta) good too

Carolina buckthorn (Rhamnus caroliniana) - a must have tree or large shrub in your landscape - beauty all of the time between showy green foliage, yellow-orange-purple fall color - persistent red changing to black fruits!

Oklahoma redbud (Cercis canadensis ssp. texensis 'Oklahoma') - Oklahoma redbud will be emphasized today - brought to us by Mr. Preston Warren, Warren and Sons Nursery, Oklahoma City, one of our most talented individuals in the Oklahoma ornamentals industry. Oklahoma redbud, shorter in stature than many redbuds, deeply colored flowers, extremely glossy leaves, etc. - should be used as a "utilitree" and in its white flowering form (Texas White) is far superior to many crabapples.

Cockspur and Washington hawthorn (Crataegus crus-galli and C. phaenopyrum, respectively) - these trees have been bashed by too many people with their problems exaggerated - do get cedar hawthorn rust sometimes - definitely have significant thorns - but still have a place in the landscape as a specimen tree or sheared into a hedge.

Kentucky coffeetree (Gymnocladus dioicus) - large shade tree with great success growing turf underneath the canopy - showy tropical looking leaves up to 3-4' long, white summer flowers, yellow fall color, persistent fruits on female although messy at times, shaggy bark with age - male cultivars are not easy to propagate but 'Espresso' available now in limited quantities - but it's a shame the number of people that shun the female trees.

River birch (Betula nigra)- most of us in Oklahoma take this native for granted and continue to struggle with European birches - it is s fine to have the European and Asian birches, but make the native birch the key species in any landscape - borer resistant, drought resistant, showy bark, etc. For a dwarf, try Tecumseh Compact discovered by Dr. Dale Maronek while working at Studebaker Nurseries, New Carlisle, Ohio. Researchers elsewhere are trying to develop a river birch with a pure white trunk to satisfy the European birch lovers. At OSU, Stillwater and other OBGA trial gardens also have exotic birch such as Betula ermanii and others.

Oak (Quercus spp.) - too broad to adequately cover in today's presentation - many good native as well as exotic oaks that need to be used more - if not already growing try Chinkapin, Swamp white and other U.S. natives.

Cedar elm (Ulmus crassifolia) - a great street tree being utilized well in Texas but not as much as we could here in Oklahoma- dark, thick green leaves, fairly pest resistant and most of all, tough. While its true that one must sacrifice a showy bark like that of lacebark elm, it is imperative that we break up the almost monoculture of lacebarks in some cities. Winged elm, another native similar to but not as large as cedar elm, has potential as well.

Our native elms are not weeds just because we are not obtaining them from China or Japan.

Western soapberry (Sapindus drummondii) - a great tree with two strikes against it - some people object to the fruits and also to the red shoulder bugs in the fall - these problems have been blown out of proportion the majority of the time - if they can be overlooked you get a tough as nails tree, clean summer foliage, showy white flowers, yellow fall color and bark that sometimes can be as striking as a lacebark elm. I know of no way to get around the fall bug invasion but no doubt there will be sterile or nearly sterile clones available in the future.

Black gum (Nyssa sylvatica) - gets trickier to grow as you head west of Tulsa - needs some moisture and acidic pH to grow well - large shade tree, attractive red to bluish-black fruits, brilliant red fall color, etc. - also looking at the Chinese relative, Nyssa sinensis in trials but am struggling with this exotic species.

Fruitless sweetgum (Liquidambar styraciflua 'Rotundiloba') - this cultivar is more narrow in habit, lighter green leaves, leaves with now smooth lobes and almost rubbery to the touch, somewhat less fall color, and sterile or nearly sterile - even with the problems inherent with all sweetgums they are still a fantastic tree.

Native plant material resources

Books:

Bir, Richard E. 1992. *Growing and Propagating Showy Native Plants.* University of North Carolina Press.

McCoy, Doyle. 1981. *Roadside Trees and Shrubs of Oklahoma.* University of Oklahoma Press.

McCoy, Doyle. 1980. *Roadside Wild Fruits of Oklahoma.* University of Oklahoma Press.

Societies:

Oklahoma Native Plant Society

Tulsa/Bixby Garden Centers/Nurseries/Contact people:

Southwood Nursery, Joe Schulte
Juniper Hill Farm, Dr. Cecil Wells, Jr.
Binding Stevens Garden Center, Scott Williams
(Many other fine nurseries and garden centers with examples listed above randomly selected)

Native Plant Materials for Western Oklahoma and beyond:

Sunshine Nursery, Steve and Sherry Bieberich, co-owners
Clinton, OK - 580-323-6259 / sunshine.farm@mailexcite.com www.sunshinenursery.com

Arboreta:
Oklahoma Botanical Garden and Arboretum, Stillwater
Washington Irving Memorial Park and Arboretum, 13900 S. Memorial Drive, Bixby

Tulsa Cooperative Extension Service Horticulturalists - 918-746-3707
Barry Fugatt
Sue Gray

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