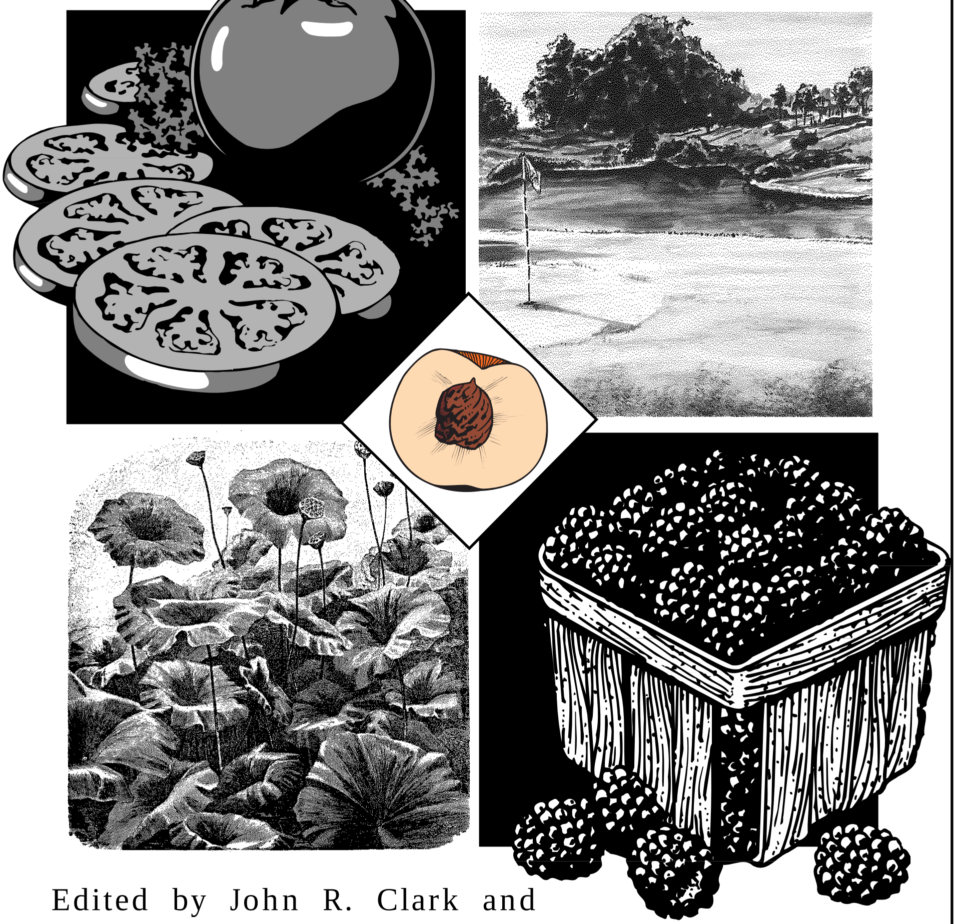
HORTICULTURAL STUDIES

• 1998 •



Edited by John R. Clark and
Michael D. Richardson

ARKANSAS AGRICULTURAL EXPERIMENT STATION
Division of Agriculture University of Arkansas
May 1999 Research Series 466

Editing and cover design by Karen Eskew

Arkansas Agricultural Experiment Station, University of Arkansas Division of Agriculture, Fayetteville. Milo J. Shult, Vice President for Agriculture and Director; Charles J. Scifres, Associate Vice President for Agriculture. PS1.20599PM65. The Arkansas Agricultural Experiment Station follows a nondiscriminatory policy in programs and employment.

ISSN:0099-5010 CODEN:AKAMA6

HORTICULTURAL STUDIES 1998

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PREFACE

This initial volume of *Horticultural Studies* reports results of numerous investigations on a range of horticultural crops in Arkansas. This publication is intended to give the reader increased information on current activities underway in the Division of Agriculture in the area of horticulture and its many related disciplines. Our goals with this publication include; 1) informing the citizens of Arkansas about ongoing investigations in the area of horticulture, and 2) providing recent findings of research that can be utilized in production or use of horticultural crops.

Our hope is that the information in *Horticultural Studies 1998* will be of value to all interested in horticultural crops in Arkansas. These reports, along with new and continuing research, teaching, and extension programs, are intended to serve the citizens of the state by improving quality of life, enhancing food supplies, and providing safe and enjoyable recreational areas. You may find this publication on the internet at the following web address: www.uark.edu/depts/agripub/Publications/researchseries/

John R. Clark and Michael D. Richardson, Editors

SPECIAL THANKS

Thanks are expressed to the donors listed below who contributed to Horticulture programs in 1998. External support of all programs is critical to the continuing enhancement of Horticulture industries in Arkansas.

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Winrock Grass Farm
Winter Garden Spinach Growers Assn.
Zeneca Inc.

FRUIT AND VEGETABLE HORTICULTURE 1998 HIGHLIGHTS

Horticulture connects with people in many ways including an enhanced awareness concerning the importance of fruits and vegetables in our diet. The health benefits of such a diet is gaining wide recognition throughout the public and will likely provide tremendous opportunities for research, education and business development. Significant faculty additions and programmatic efforts were made to the university's fruit and vegetable programs in 1998.

Keith Striegler joined the department as Extension Specialist -- commercial fruit crops. He has degrees from the University of Arkansas and Michigan State University. He was previously on faculty at Oklahoma State University. Most recently he was on faculty at Fresno State where he held the Julio Gallo Chair for Viticulture Research. He now assumes statewide leadership for extension fruit programs and will focus on development of the fruit industry.

Phytochemicals, naturally-occurring compounds found in a wide range of fruits and vegetables, are now being researched relative to their positive impact on human health. Researchers, in collaboration with UA-Medical Sciences faculty, are using conventional breeding, biochemical, and biotechnological methods to enhance the phytochemical characteristics of fruit and vegetable cultivars.

Fruit crop acreage has the potential to expand as the demand for fresh fruit continues to climb, particularly relative to direct marketing. Plasticulture strawberry trials were established at three locations across the state to better evaluate the system under Arkansas conditions. These locations were UA-Fayetteville, a commercial site in Searcy, and at the Southwest Research and Extension Center in Hope.

Fruit Breeding Program released 'Summit' southern highbush blueberry in 1998 which, along with 1996 release 'Ozarkblue', offers high-yielding cultivars that ripen later than midseason northern and southern highbush cultivars but earlier than rabbiteye cultivars. These new cultivars are adapted to areas similar to central Arkansas and southward with adaptability confirmed in trials at the Southwest Research and Extension Center, Hope. Additionally, two blackberry and two table grape cultivars were approved for release and are under propagation for public availability for 1999-2000. Advanced selections of nectarines are under final evaluation for release in the near future.

The *"Arkansas Fruit Green Newsletter"* was redesigned in a collaboration between horticulture faculty and staff in the Cooperative Extension's Communications Department. This newsletter disseminates timely information on a range of topics important to commercial fruit producers in the state.

Fresh-market vegetable crops include melons, squash, peppers, sweet corn, sweet potatoes, cabbage, greens, spinach and southern peas. The use of drip irrigation and black plastic has increased to near 100% for the tomato industry, and nearly 40% for the melon industry. The introduction of this technology was promoted extensively by extension specialists with a new Agricultural and Natural Resource Plasticulture Emphasis Program.

Multi-disciplinary collaboration with tomato growers, extension personnel, researchers, and students worked toward solving problems critical to the state's 1,100 acres of tomatoes in Bradley, Drew, and Ashley counties. An on-farm research project in collaboration with grower Roger Pace provided faculty a site maintained under industry conditions. The project was viewed during a **Tomato Study Day** in May. A tomato marketing newsletter from the Southeast Research and Extension Center, Monticello, was sent to growers in 11 counties from May through July.

The Spinach Program at the University of Arkansas is an example of multi-disciplinary and multi-state effort with participation of research and extension faculty. A formal agreement was signed between the University of Arkansas and Texas A&M University to facilitate collaboration between faculty relative to extension and research programs.

Collaborative research between the UA Division of Agriculture and UA-Pine Bluff was conducted at the Cotton Branch Station, Marianna. Trials involved new technology relative to use of transplants and drip irrigation to increase early okra production.

Vegetable Breeding Program releases in recent years include 'Excel', 'Early Scarlet', and 'Arkansas Blackeye #1' southernpeas. 'Excel' is a new pinkeye purple hull southernpea which has a compact bush plant and shells easily at the green mature stage. 'Early Scarlet' is a pinkeye purple hull type, medium sized plant that shells easily at the green mature stage. 'Arkansas Blackeye #1' produces a bush plant that shells easily at the green mature stage. All of these new varieties are more adapted to mechanical harvesting.

A Multi-state Educational Program between Arkansas (University of Arkansas, Arkansas State Horticultural Society) and Oklahoma (Oklahoma State University, Oklahoma Horticulture Industries Show) was initiated in 1998 as a result of faculty leadership in planning the regional meeting.

Retail marketing, include farmer's markets, retail produce markets, and pick-your-own operations, are becoming an important avenue for marketing. An Extension Agriculture and Natural Resource Emphasis Program, implemented by eight county agents in 1998 in cooperation with local municipalities, led to the development of new farmer's markets in Marshall and Paragould. The program, developed by extension faculty, is an example of a partnership between the business community, growers, and the U of A's programs.

Stephen Myers
Professor and Head, Department of Horticulture

TURF AND LANDSCAPE HORTICULTURE 1998 HIGHLIGHTS

During 1998, there was a concerted effort at the University of Arkansas to expand programs related to turf, ornamentals, and landscape horticulture. The development results from university recognition of the growing importance of the turf, ornamental, and landscape industry, collectively termed the "green industry", to the state economy as well as the potential for further economic development. Significant faculty / staff additions and programmatic efforts were made to the university's Green Industry Program in 1998.

Mike Richardson began duties as Assistant Professor, turfgrass management and physiology. A native of north Louisiana, he received degrees from Louisiana Tech, Louisiana State University, and the University of Georgia. He worked in the commercial turf industry in Oregon and most recently was on faculty at Rutgers University as a turfgrass physiologist. His work will focus on research related to golf and sports turf physiology and management.

Jon Lindstrom began duties as Assistant Professor, woody ornamental plant evaluation, improvement and introduction. A native of Pennsylvania, he received degrees from Cornell University, University of Maryland, and the University of Illinois at Urbana-Champaign. Most recently, he held a post-doctoral fellowship in the Department of Horticulture at Purdue University. He will focus on research related to woody ornamental plants.

Jim Robbins joined the department as Extension Specialist -- commercial ornamental crops. He has degrees from the University of Wisconsin, University of Georgia, and the University of California -- Davis. He was previously on faculty at Kansas State University and at Berry College. From 1990 to 1994, he was Manager of Research & Education for Briggs Nursery in Olympia, Washington. Most recently he was Director of Horticultural Research for IMC Vigoro in Winter Haven, Florida. Housed at the Extension Headquarters Building in Little Rock, his work focuses on development of the ornamental industry in the state.

Kevin Hensler joined the department as Research Specialist in turfgrass management. A native of Missouri, he has B.S. and M.S. degrees from Mississippi State University and was most recently at Pennsylvania State University.

Scott Starr joined the department as Research Specialist in ornamental horticulture. He has a B.S. degree from the University of Arkansas. Prior to joining the department, he owned and operated City Garden Service, a local landscape and maintenance service, for 22 years.

The **Arkansas Select Program** was initiated in the spring of 1998 by horticulture faculty, with cooperation and support from the Arkansas Greenhouse Growers as well as the Arkansas Nurseryman's Association, to identify superior ornamental plants for use in Arkansas landscapes. The program will select four to six superior plants each year to be highlighted in a Plant Promotion Program. During 1998, the program was a resounding success and created significant consumer demand for the retail horticulture industry.

In 1998, the sixth annual **Arkansas Flower and Garden Show** was held in Little Rock. The show, consisting of garden areas, trade show, flower show and educational meetings, has become the major educational and promotional event for Arkansas gardeners. Last year the three-day show drew over 10,000 participants. A similar event, called the **Arkansas River Valley Lawn and Garden Show**, was held in Fort Smith with approximately 8,000 participants.

A comprehensive **Turf Research and Extension Program** has been developed across the state. The program now has cooperative turf work being conducted at sites in the north, central, and southern parts of the state. Areas of emphasis include cultivar evaluation, weed control, establishment of sand-based putting greens, summer decline of creeping bentgrass, and cold tolerance of bermudagrass.

Division faculty participated in the **Razorback High School Football Coaching Clinic** in collaboration with the UofA Athletics Department. Survey information indicated that most high school coaches must maintain their own fields and that the Cooperative Extension Service is a major source of technical information. As a result, an **Extension Ag and Natural Resources Emphasis Program** was developed to train county agents in working with sports field managers.

A new **Horticulture Display Garden** was established on the UA-Fayetteville campus as part of the Department of Horticulture's Research, Extension, and Teaching Program in ornamentals. Ornamental plants, both woody and herbaceous, will be evaluated for their adaptability to Arkansas. Companion plantings to evaluate ornamental plants will be established at the Cammack Garden in Little Rock, as well as the Southwest Research and Extension Center at Hope in 1999.

The implementation of quarterly in-depth **Horticulture Workshops** was accomplished by horticulture extension specialists in 1998. These included a "Native Plant Workshop" and a "Landscape Construction Workshop" in Little Rock, and an "Herbal Workshop" in Fayetteville. The workshops had a total of 573 registered participants.

The growing participation in outdoor activities continues to create demand for golf courses, parks, sports fields as well as the infrastructure that serves that industry. Economic and environmental benefits of the landscape to property and business continues to drive the ornamental and landscape horticulture industry that is integral to an expanding and diverse economy.

Stephen Myers
Professor and Head, Department of Horticulture

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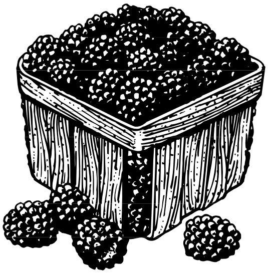

F R U I T S

MUSCADINE CULTIVAR TESTING, 1996-98 RESULTS

John R. Clark[1] *and Kenda R. Woodburn*[2]

IMPACT STATEMENT

Muscadine grapes are adapted to all areas of Arkansas except for the more northern counties, where vines can be killed by low winter temperatures. Muscadines are grown for both home and commercial use. Muscadine cultivar development has been conducted by several public and private organizations and these breeding programs have provided an array of cultivars. No breeding work is currently being conducted by the University of Arkansas, but there is an active cultivar evaluation program at the Fruit Substation, Clarksville. The goal is to discover which cultivars or selections from both public and private institutions are best suited for the Arkansas climate. Data collected from the replicated trial at Clarksville included yield, average berry weight, percent soluble solids, and other quality components. 'Fry', 'Carlos', 'Cowart', 'Sugargate', 'Summit', and 'Jumbo' are older cultivars (released prior to 1980) which have performed well in the current trial, and of those tested and released in the early to mid-1980s, 'Nesbitt', 'Sterling', 'Doreen' and 'Triumph' have provided positive results. Among the newer cultivars (1986 to 1994 released) 'Darlene', 'Tara', 'Black Beauty', and 'Southern Home' have shown one or more positive attributes.

BACKGROUND

In the early 1900s, public muscadine breeding programs were initiated at the University of Georgia and cooperatively between North Carolina State University and the USDA. The North Carolina program was phased out in the late 1980s but the University of Georgia program continues. Ison's Nursery of Brooks, Georgia, conducted a private muscadine breeding program and has released a number of cultivars in the last 25 years. The earliest cultivars released from either wild selections or public programs were all pistillate, meaning that they bore only female flowers; thus, for fruit set to

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[1] Department of Horticulture, Fayetteville.
[2] Fruit Substation, Clarksville.

occur, pollen was required from a male vine or perfect-flowered (self-fruitful) cultivar. The first muscadine grape cultivars were selected from the wild, and among these the most famous is ‘Scuppernong’. This is a bronze-fruited, pistillate (not self-fruitful) cultivar that was found in eastern North Carolina. Many perfect-flowered cultivars have now been released, among the more successful ‘Magnolia’ and ‘Carlos’ (1962 and 1970, respectively, both from North Carolina), ‘Cowart’ (1968 from Georgia) and ‘Noble’ (1973 from North Carolina). The largest-fruited cultivars have historically been pistillate, and among these ‘Fry’ (released in 1970 from Georgia), ‘Summit’ (1977 from Georgia) and ‘Sugargate’ (1974 from Ison’s Nursery) are among the more important commercially. The objective of our research was to evaluate new cultivars in comparison with established cultivars for adaptation to Arkansas, with an emphasis on determining cultivar heartiness.

RESEARCH DESCRIPTION

The cultivar evaluation planting was established in 1982 at the Fruit Substation, Clarksville, and initially included 25 entries of both named cultivars and breeding selections. Additionally, 16 cultivars or selections were added to the planting between 1990 and 1994. This planting was maintained through 1998, with unacceptable cultivars being discarded periodically. The planting consisted of three to six replications of each entry, arranged in a randomized block design. Data collected included total yield as measured by a once-over harvest at fruit maturity, average berry weight of 25 berries, percent soluble solids as determined by a hand-held refractometer, and ratings for evenness of ripening, fruit picking scar, flavor, and overall quality. Observations were made each year on vine hardiness and diseases. Only yield and berry weight data are presented in this discussion.

FINDINGS

Cultivars discarded from the planting due to one or more weaknesses (including but not limited to poor yield, lack of hardiness, poor quality or disease susceptibility) included ‘Dixie’, ‘Dixieland’, ‘Dixiered’, ‘Ison’, ‘Magnolia’, ‘Redgate’, ‘Regale’, ‘Senoia’, ‘Watergate’ and ‘Welder’ (data not shown). Older cultivars (released prior to 1980) that were maintained in the planting included ‘Carlos’, ‘Cowart’, ‘Fry’, ‘Jumbo’, ‘Sugargate’ and ‘Summit’. All of these cultivars continue to be recommended for planting with the exception of ‘Jumbo’, which has poor fruit quality and very thick skin. However, use of each (fresh market or processing) varies by cultivar. Among the early to mid-1980s-released cultivars, ‘Nesbitt’ consistently performed well, while ‘Doreen’, ‘Triumph’, and ‘Sterling’ have usually performed well and have been suggested for trial by growers. The newer cultivars which have shown the most promise include ‘Darlene’, ‘Black Beauty’, ‘Tara’, and ‘Southern Home’; however, ‘Black Beauty’ and ‘Southern Home’ suffered cold damage during 1996-98.

‘Fry’, ‘Doreen’, ‘Cowart’ and the two North Carolina selections (Table 1) were among the top 10 entries in yield for three years (1996-1998). Among those planted during or after 1990,'Darlene' and 'Black Fry' appeared in the top 10 for yield two of three years. 'Black Fry' had uneven berry size and uneven ripening in this trial and is not recommended.

Large-fruited cultivars are the most popular for fresh markets.'Darlene', Black Beauty','Jumbo', 'Sugargate', 'Summit' and two of the University of Georgia selections (Table 1) were in the top 10 for berry size all three years, with 'Darlene' having the largest average berry size. A new entry,'Supreme',which yielded its first crop in 1998 (data not shown), possessed very large, good-quality berries.

Table 1. Muscadine cultivar yields and berry weights from a trial established at the University of Arkansas Fruit Substation, Clarksville, 1996-98.

Cultivar/ year planted	Yield (lb/vine) 1996		1997		1998		Berry wt. (g) 1996		1997		1998	
Alachua/94	3.5	h[z]	17.0	c-e	32.0	a-f	8.7	e-1	6.7	f-j	5.0	h-j
Black Beauty/94	6.7	g h	9.3	fg	23.0	d-f	14.2	a	8.9	c-f	10.0	a-d
Black Fry/90	35.3	a-h	52.8	ab	44.7	a-e	9.5	d-g	8.7	c-g	7.6	d-h
Carlos/82	56.1	a-c	35.3	a-g	38.9	a-f	8.5	l-n	5.1	j-l	5.0	h-j
Cowart/82	41.7	a-g	48.1	a-d	39.1	a-f	4.6	mn	4.7	kl	4.4	j
Darlene/90	42.5	a-g	46.5	a-f	32.0	a-f	12.6	ab	12.8	a	12.3	a
Doreen/82	46.3	a-f	47.2	a-d	42.3	a-f	4.5	n	4.0	l	4.8	ij
Farrer/90	15.5	c-h	14.8	d-g	60.3	a	9.0	e-h	7.6	d-i	8.2	d-g
Fla. Fry/92	30.3	a-h	45.7	a-d	29.5	a-f	7.7	g-k	5.6	i-l	5.9	g-j
Fry/82	55.9	a-c	60.3	a	44.0	a-e	8.0	h-m	7.4	e-j	8.1	d-g
GA 15-172/94	6.6	gh	14.7	d-g	14.7	ef	7.4	h-k	5.1	h-l	4.9	ij
GA 15-6-2/94	9.7	f-h	16.3	d-g	25.6	c-f	11.3	b-d	8.4	c-g	8.8	c-f
GA 29-4-4/82	19.7	c-h	22.8	b-g	17.8	ef	11.7	bc	9.3	b-e	9.7	b-e
GA 33-2-1/94	-		10.5	e-g	16.4	ef	-		9.8	b-d	11.8	ab
GA 33-3-4/94	-		17.9	c-e	17.3	ef	-		6.5	g-j	6.3	f-j
Ison/90	19.0	c-h	-		-		6.7	j-l	-		-	
Jumbo/82	67.0	a	44.7	a-e	54.4	a-c	11.1	b-d	11.3	ab	10.9	a-c
Late Fry/94	10.8	d-h	30.7	a-g	12.8	f	8.7	e-i	5.8	h-l	7.2	e-i
Loomis/90	30.1	a-h	5.9	g	21.3	d-f	7.1	i-k	7.3	e-j	5.9	g-j
NC67A01517/82	63.2	ab	56.7	ab	57.0	ab	6.3	j-m	5.8	h-l	4.9	ij
NC67A01526/82	37.0	a-h	50.8	a-c	51.4	a-d	5.0	l-n	4.6	kl	4.2	j
Nesbitt/82	50.1	a-c	41.2	a-f	53.9	a-c	9.7	d-f	6.8	f-k	6.8	f-j
Southern Home/91	8.8	f-h	36.1	a-g	35.4	a-f	6.0	k-n	4.0	l	5.0	h-j
Sterling/82	47.6	a-e	40.0	a-g	37.8	a-f	7.0	ij	7.0	e-k	6.7	f-j
Sugargate/82	48.0	a-d	37.1	a-g	18.6	ef	11.0	b-d	10.6	bc	8.9	c-f
Summit/82	36.2	a-h	34.4	a-g	38.7	a-f	9.1	e-h	8.7	c-g	7.8	d-g
Tara/91	20.4	c-h	46.2	a-d	27.3	b-f	10.5	c-e	8.1	c-h	7.2	e-i
Triumph/82	29.2	a-h	54.3	ab	54.5	a-c	9.0	e-h	7.4	e-j	6.6	f-j

[z] Means within a column followed by a different letter are significantly different as determined by a *t test* ($P < 0.05$).

'OZARKBLUE' AND 'SUMMIT' SOUTHERN HIGHBUSH BLUEBERRIES

John R. Clark and James N. Moore[1]

IMPACT STATEMENT

In the 1980s and 1990s, blueberry production in Arkansas became an important enterprise. Standard or northern highbush blueberry cultivars made up the largest acreage and were produced mostly in northwest and north-central Arkansas. Production of blueberries in most other areas of Arkansas including central and southern areas of the state have been of rabbiteye cultivars. Rabbiteyes are more adapted to the hot, dry conditions of Arkansas but have the disadvantage of ripening later and suffering crop losses due to spring freezes near bloom. Two new southern highbush cultivars, 'Ozarkblue' and 'Summit', provide new options for blueberry growers in traditional rabbiteye production areas. These cultivars ripen 7 to 14 days earlier than rabbiteyes and have shown more reliable cropping when spring freezes have occurred. These new cultivars should enhance blueberry production in the rabbiteye-growing areas of Arkansas and provide more reliable, high-cropping capability for blueberry growers.

BACKGROUND

The blueberry is one of the newest fruit crops to be domesticated. Initial domestication research began in 1910 in New Jersey. Since that time, blueberry production has become a widespread enterprise. Research on adapting blueberries to Arkansas began in 1964. In the early 1970s the first commercial blueberry production in Arkansas began in northwest Arkansas. This production was of standard or northern highbush cultivars, the same species of blueberry that is grown commercially in New Jersey and

[1] Both authors are associated with the Department of Horticulture, Fayetteville.

Michigan. Research done in west-central and southwest Arkansas suggested that rabbiteye blueberry cultivars were adapted to these areas, while northern highbush were not. Since then, the southern highbush blueberry has been developed, which combines one or more southern-adapted, native blueberry species with the northern highbush species. Testing of southern highbush varieties began in the 1980s. At this same time, blueberry breeding was ongoing in Arkansas. One of the objectives was to develop southern highbush cultivars for non-northern highbush production areas. This effort has yielded two new southern highbush cultivars for Arkansas blueberry growers, 'Ozarkblue' and 'Summit'.

RESEARCH DESCRIPTION

'Ozarkblue' resulted from the cross of G-144 x FL 4-76 made in 1976 at Beltsville, Maryland. G-144 is a USDA northern highbush selection, and FL 4-76 is an interspecific hybrid of *V. corymbosum* (highbush blueberry), *V. darrowi* (evergreen blueberry from the deep South) and *V. ashei* (rabbiteye blueberry). In 1980, 'Ozarkblue' was selected by the Arkansas Agricultural Research and Extension Center, Fayetteville, and tested (as A-109) at locations in Clarksville, Fayetteville, and Hope. 'Ozarkblue' was released by the University of Arkansas in 1996.

'Summit' has the same parentage as 'Ozarkblue'and was selected in 1982 at Hammonton, New Jersey. It was tested as G-616. In 1988, G-616 was sent to Arkansas and first established at the Fruit Substation, Clarksville. In 1995, G-616 was tested at the Southwest Research and Extension Center, Hope. In 1998, G-616 was released as 'Summit' by the University of Arkansas, North Carolina State University, and the USDA.

Cultural practices in all testing of 'Ozarkblue' and 'Summit' included the addition of peat moss to the planting holes, mulching with sawdust or pine straw at 6-in. depth, and trickle irrigation. All entries, except for the initial trial of 'Summit' at Clarksville, were planted using a randomized complete block design with data analyzed by analysis of variance and means separated by Least Significant Difference (LSD).

FINDINGS

'Ozarkblue' plants are semi-upright and vigorous, but heavy crop loads can cause canes to often have a willow-like growth habit during the fruiting season. 'Ozarkblue' was more vigorous than other southern highbush cultivars in research plots at Clarksville and Hope, perhaps due to its multi-species parentage. At Clarksville 'Ozarkblue' ripened 7 to 14 days later than 'Bluecrop', 'Cooper', and 'Gulfcoast', but seven days earlier than 'Climax', an early-ripening rabbiteye (data not shown). 'Ozarkblue' produced consistently high yields in its original replicated trial at Clarksville, even when spring freezes reduced the crops of other southern highbush or rabbiteye cultivars (data not shown). 'Ozarkblue' bloomed later than most of these cultivars and no damage was noted on its flowers following spring freezes, and yields were not reduced. The avoidance of freeze damage and possible greater hardiness of flower tissues has allowed consistent full crops with 'Ozarkblue' throughout its evaluations. Berry weight averaged 2.1 g during evaluations at Clarksville (data not shown).

'Summit' produced high yields in its initial trial at Clarksville, usually slightly less than 'Ozarkblue' (data not shown). Berry weight averaged 1.4 g in this trial. 'Summit' ripened four to seven days earlier than 'Ozarkblue' at this location. Also, 'Summit' had earlier budbreak and bloom than 'Ozarkblue' and did experience some spring freeze damage in some years. Although spring freeze damage was noted, it was less than that observed on rabbiteye or most other southern highbush cultivars. Excellent plant vigor and health were observed on 'Summit' at this location.

Both cultivars were included in a trial at Hope, with 'Ozarkblue' and the other entries planted in 1994 and 'Summit' added in 1995 (plants of 'Summit' were not available in 1994). Among all entries for 1997, yields were highest for 'Ozarkblue' (Table 1). Several freezes occurred after budbreak and during bloom for this planting in 1997 which contributed to lower yields for many cultivars; however, 'Ozarkblue' avoided bud or flower damage due to its later time of bud and flower development. 'Summit' yield was less than 'Ozarkblue' but comparable to most other entries despite being its first year of fruiting. 'Ozarkblue' and 'Summit' were the largest-fruited cultivars in the planting (Table 1). Data for 1998 revealed these two cultivars were in the top three for yield, along with 'Legacy' the other high-yielding cultivar. 'Ozarkblue' and 'Summit' again were among the largest-fruited cultivars.

These two new cultivars are recommended for planting in areas of Arkansas where rabbiteye cultivars are adapted. Since they ripen later than most northern highbush cultivars grown in northwest or north-central Arkansas, it is not anticipated that these will be planted in these regions. It should be noted that these new cultivars were tested using cultural practices recommended for highbush blueberry production including peat moss additions at planting, mulching, and trickle irrigation. Similar cultural methods should be used in commercial plantings.

ACKNOWLEDGMENTS

We wish to thank Jack Young, Kelly Irvin, Paula Watson, and Gina Fernandez for assistance in the evaluations of 'Ozarkblue' and 'Summit'.

Table 1. Performance of 'Ozarkblue' and 'Summit' compared to nine other southern highbush and two rabbiteye blueberry cultivars at the Southwest Research and Extension Center, Hope, 1997 and 1998.

	1997				1998			
Cultivar	Yield[z]		Berry wt (g)		Yield		Berry wt (g)	
Ozarkblue	15,382	a[y]	1.4	a	13,350	a	1.3	ab
Summit[x]	3,241	b-d	1.3	a	9,033	ab	1.4	a
Bladen	3,747	b-d	0.7	d	3,822	bc	0.8	de
Blue Ridge	2,264	d	1.0	b-d	2,984	c	1.0	b-d
Brightwell (RE)	3,893	b-d	1.0	b-d	7,231	a-c	0.9	cd
Cape Fear	3,612	b-d	0.8	d	3,828	bc	1.1	a-c
Cooper	2,967	cd	0.9	d	4,060	bc	1.2	a-c
Georgiagem	2,890	cd	0.8	d	3,935	bc	1.0	b-d
Gulf Coast	4,620	b-d	0.8	d	4,579	bc	1.0	b-d
Legacy	7,719	b	0.9	d	13,997	a	1.2	a-c
O'Neal	3,821	b-d	1.2	a-c	4,887	bc	1.4	a
Premier(RE)	2,930	c-d	1.2	ab	3,660	bc	1.3	ab
Reveille	1,127	d	0.7	d	4,492	bc	0.6	e

[z] Yields in lb/acre based on 4 x 10 ft spacing for southern highbush and 6 x 12 ft spacing for rabbiteye (RE).

[y] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

[x] 'Summit' plants were planted in 1995, and were one year younger than other entries in the trial.

THE UNIVERSITY OF ARKANSAS FRUIT BREEDING PROGRAM: PROGRESS AND PROSPECTS

John R. Clark, James N. Moore, and Curt R. Rom[1]

IMPACT STATEMENT

Availability and choice of cultivars are the cornerstone of success in fruit crop production. Lack of adapted cultivars or poor choices at planting can greatly lessen the chances of profitability. Cultivars that are developed within a specific region or climate where a grower is located are usually the most adapted thereby producing the highest and most reliable yields. Fruit cultivars developed by the University of Arkansas have greatly increased the cultivar options available to Arkansas growers. These and future developments from this effort will ensure enhanced success of the fruit industries of the state.

BACKGROUND

Dr. Jim Moore began the Arkansas fruit breeding program in 1964, and led this effort for 33 years. Dr. Moore began endeavors in blackberry, grape (stressing table grapes), strawberry and peach breeding (stressing canning cling peaches in cooperation with Dr. Roy Rom). Apple breeding was added in the 1960s, again in cooperation with Dr. Rom. Blueberry breeding was begun in 1976. The majority of the fruit breeding efforts have been based at the Fruit Substation, Clarksville. From 1964 to 1997, the breeding program released eight blackberry, three strawberry, one blueberry, two processing peach, three ornamental peach, one ornamental nectarine and five grape varieties. These varieties have played a major role in the fruit industries of Arkansas. Also during this time, a wealth of breeding selections (unreleased material) were developed and these selections are currently serving as a source of new cultivars and as parents for further crossing.

[1] All authors are associated with the Department of Horticulture, Fayetteville.

RESEARCH DESCRIPTION

The program continues today with a number of areas of emphasis (described below). In addition, several new cultivars have been recently released and other selections are under final consideration for release. Most of the current work is done at the Fruit Substation, Clarksville, where Dan Chapman, Bryan Blackburn, and Kenda Woodburn carry out the program activities. It is at this location where the majority of the hybridizations are made, seedlings grown and evaluated, and selections tested. Selection testing is also conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville, under the supervision of Andy Allen, and at the Southwest Research and Extension Center in Hope, under the direction of Jack Young (through 1998) and Manjula Carter (beginning in 1999).

FINDINGS

Blackberry. The effort in blackberry breeding continues and current emphases are; 1) improved thornless cultivar development with increased yield, fruit size, and earliness in ripening over current cultivars, 2) improved thorny varieties with large fruit size, fruit firmness for expanded shelf life, and expanded choices for early-season ripening, 3) enhanced fruit firmness characteristics with near "crisp" blackberry fruit quality for incorporation into cultivars for shipping markets, and 4) primocane (late summer and fall) fruiting cultivars which upon release should provide the first commercially available late summer and fall fruiting cultivar options in existence for blackberry production.

Following the 1998 season, two new cultivars have been released from the program. 'Chickasaw' is a new thorny, large-fruited, productive cultivar. It ripens near the same season as 'Shawnee' but has larger size (11 g), firmer fruit and has shown higher productivity. 'Apache' is a new thornless cultivar which has large fruit (up to 10 g) and is more productive than the currently available 'Navaho' and 'Arapaho'. 'Apache' ripens near 'Navaho' season and both of these new cultivars should be available commercially in the winter and spring of 1999-2000.

Blueberry. Current emphases include; 1) southern highbush varieties for central and southern Arkansas with reliable cropping, high quality and broadened soil, and heat adaptation, 2) standard highbush-type cultivars with an expanded genetic base (including other blueberry species) for adaptation to traditional highbush growing areas in northern Arkansas.

In 1986, 'Ozarkblue' was the first cultivar released from the program. 'Ozarkblue' is a southern highbush cultivar and is intended to be grown in traditional rabbiteye blueberry production areas of the state. Compared to rabbiteyes, 'Ozarkblue' ripens earlier, has higher quality, is higher yielding, and has shown greater reliability of cropping. Also recently released is 'Summit', a joint release of the University of Arkansas, North Carolina State University, and the USDA. 'Summit' has many similar attributes to 'Ozarkblue', but ripens a few days earlier and has exceptional fruit flavor. Both of these new cultivars have performed well at Clarksville and Hope.

Grape. The major emphasis continues on seedless, hardy, non-slipskin, high quality table grape cultivars. A much smaller effort continues on wine and juice grape cultivar development. No new hybridizations are being done with wine or juice grapes, but processing evaluations continue by Drs. Justin Morris and Gary Main in the University of Arkansas Food Science Department.

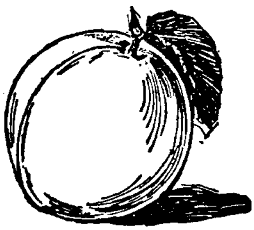
Following the 1998 season, two new seedless table grapes were released. 'Jupiter' is blue, has a mild muscat flavor, is non-slipskin, large-fruited, and has shown high productivity. 'Neptune' is the first white-fruited cultivar from the program. Attributes of 'Neptune' include a pleasing, fruity flavor, non-slipskin flesh, and large, attractive clusters. Both of these new cultivars should be available on a limited basis for purchase in winter and spring of 1999-2000.

Peach and Nectarine. The peach breeding program has undergone substantial change in the last two years. Processing cling peaches, long a central focus of the program, has been de-emphasized since processing peach planting in Arkansas has declined or ceased. The final processing peach seedlings and selections are still under evaluation, but no new hybridizations will be conducted. Major efforts in peach and nectarine breeding continues with emphasis on the following; fresh market peaches with a priority on white-fleshed types and specific objectives including large size, enhanced handling capability using non-melting flesh, bacterial spot resistance, and excellent quality; and nectarines with high quality, large fruit, attractive skin color, firm flesh and bacterial spot resistance.

Several nectarine selections and one early-ripening peach have been identified for potential release in 1999. These nectarines all have non-melting flesh, which is intended to enhance post-harvest handling capability. Several promising white-fleshed selections are in the final stages of testing; however, the decision to release these selections will probably be made after the 1999 growing season.

Apple. The apple breeding program is another effort that is going through changes. The original efforts of Drs. Rom and Moore focused on summer-ripening apples for processing. Over time the primary objectives have changed to late summer and fall ripening with an emphasis on increased disease resistance. Dr. Curt Rom has led the effort during this time of program change, and new cultivars should be forthcoming.

Strawberry. The strawberry program was greatly reduced when the Strawberry Substation at Bald Knob was closed. Since that time hybridizations on strawberries have ceased and only 13 selections remain for evaluation. These final selections will be evaluated and tested in matted-row culture. Any worthy selections will be released.



EVALUATION OF FUNGICIDES FOR CONTROL OF PHOMOPSIS FRUIT ROT ON RIPENING PEACHES

Patrick Fenn and Hanna Barczynska[1]

IMPACT STATEMENT

Five fungicides were evaluated in the laboratory for their efficacy in preventing infection and subsequent fruit rot by *Phomopsis* sp. Firm-mature 'Allgold' fruit were treated with fungicides at rates recommended for stone fruits or other fruit crops, and after 24 hours, inoculated with spores of the pathogen. The time to lesion appearance and the rate of growth of the rot lesions were recorded. Orbit (propiconazole) gave the best control. Ziram (zinc dimethyldithiocarbamate), Elite (tebuconazole) and Zeneca 5504 (azoxystrobin) were effective in delaying symptom development. Vanguard (cyprodinil) and Elite slowed the rate of rot development indicating systemic activity.

BACKGROUND

Phomopsis twig blight occurs in many peach growing areas of the Southeast and mid-South. Twig infections and subsequent blight kill fruiting wood and thereby limit fruit production. Phomopsis fruit rot has not been commonly reported in the United States, but has been a persistent problem on processing clingstone peaches in many orchards in the Crowley's Ridge area of eastern Arkansas for the past 20 years. Current fungicide programs, mainly to control brown rot and scab, have not effectively controlled Phomopsis fruit rot, and the ability of the fungus to latently infect fruit at all stages of development has made control problematic. Chemical control will most likely be attained with fungicides that have both protective and systemic (eradicative) activi-

[1] Both authors are associated with the Department of Plant Pathology, Fayetteville.

ties in fruit tissues. This research was a laboratory test of several new fungicides recently registered for use on fruit crops for their possible efficacy in controlling Phomopsis fruit rot.

RESEARCH DESCRIPTION

Firm mature fruit of 'Allgold' were obtained from the University of Arkansas Fruit Substation, Clarksville, on 6 July 1998. Fruit were washed in warm water with 0.02% Tween 20, rinsed, and dried for six hours. Fungicides were prepared at the rates given in Table 1. Latron B1956 spreader / sticker (3.0 oz / 100 gal equivalent) was used with all fungicides except Orbit. Fruit were submerged with agitation in the fungicide preparations for 10-15 seconds, then dried overnight. Each fruit was inoculated with 0.02 ml of water containing 50,000 *Phomopsis* sp. spores placed on the unwounded surface. Fruit were incubated in covered flats to maintain near 100 % relative humidity at 21-23 ^{o}C. Fruit were examined daily, and the time when lesions first appeared and the rates of lesion diameter growth were determined. Three replicates of six fruit were use for each fungicide treatment and replicates were randomized among the flats during incubation. Statistical analysis was by ANOVA with mean separation by Least Significant Difference (LSD) ($P < 0.05$).

FINDINGS

Orbit was clearly superior to the other fungicides tested in preventing infection and fruit rot by *Phomopsis* sp. (Table 1). This confirms previous results (Fenn and Barczynska, 1993) which showed that Obit had both protective and systemic activity in limiting rot development in firm-mature fruit. Ziram, Elite, and Zeneca 5504 also delayed infection compared to the control, whereas Vangard was ineffective. Vangard and Elite showed statistically significant decreases in the rate of rot development; however, the effect (about 0.25 cm / day) is probably not of practical significance. Ziram, a protectant fungicide, showed no systemic activity as expected.

Arkansas growers have used Orbit in pre-harvest sprays to control brown rot, but have not had success in controlling Phomopsis fruit rot at harvest with this compound. While Orbit has protectant activity against Phomopsis infection, fruit rot at harvest most likely develops from latent infections established earlier in the season. Orbit sprays were not effective in eradicating latent Phomopsis infections in developing peach fruit in the field. (Fenn *et al.*, 1998). Breakdown of the compound in fruit, dilution below effective concentrations during final fruit swell, and weathering are factors that may account for the lack of control of Phomopsis fruit rot by Orbit in the field.

During incubation, brown rot developed from latent infections on 56% of the control fruit compared to 0-11% of fruit treated with Orbit, Vangard, Elite, and Zeneca 5504, indicating that these compounds have systemic activity in ripening peaches and are effective against the brown rot pathogen.

LITERATURE CITED

Fenn, P. and H. Barczynska. 1993. Preliminary studies on fungicidal control of Phomopsis fruit rot of peaches. Proc. 114th Ann. Mtg. Arkansas State Hort. Soc., Ft. Smith, Arkansas. pp. 87-89.

Fenn, P., H. Barczynska, and P. Miller. 1998. Evaluation of benomyl and propiconazole for control of Phomopsis fruit rot of peach. Phytopathology 88:S28.

ACKNOWLEDGMENTS

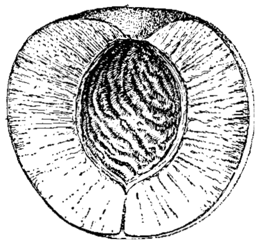
The authors thank the staff of the Fruit Substation and Gerber Products Company for their support.

Table 1. Effect of fungicides on time to lesion appearance and rot development on firm-mature 'Allgold' peaches inoculated with *Phomopsis* sp., 1998.

Fungicide	Rate (per 100 gal)	Days to lesions	Lesion growth (cm/day)
Orbit[z]	1.4 oz	-[z]	-[z]
Ziram	2.0 lb	7.9 a[y]	1.51 a
Elite	2.0 oz	6.9 ab	1.25 cd
Zeneca 5504 (80 %)	3.3 oz	6.8 ab	1.40 abc
Zeneca 5504 (80 %)	2.0 oz	6.1 bc	1.35 abc
Vangard	1.8 oz	4.8 cd	1.24 cd
Vangard	3.6 oz	4.6 cd	1.24 cd
Control (Latron B1956)	3.0 oz	3.7 d	1.41 ab

[z] No lesions developed on fruit treated with Orbit after 14 days incubation at 22-24 °C.

[y] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$). Orbit data were not included in the statistical analysis.



FIELD EVALUATION OF BENLATE AND ORBIT FOR CONTROL OF LATENT PHOMOPSIS INFECTION OF DEVELOPING PEACH FRUIT

Patrick Fenn, Hanna Barczynska, and Pamela Miller[1]

IMPACT STATEMENT

Benlate (benomyl) and Orbit (propiconazole) were tested in an orchard for efficacy in eradicating latent infections of *Phomopsis* sp. from developing peach fruit. Applications of these fungicides were superimposed on a standard fungicide spray program that served as a control. Sprays were applied three times during the season. Five to six days after each spray, fruit were collected and the percent fruit latently infected by *Phomopsis* sp. was assessed in the laboratory. After each Benlate spray, fruit infection was decreased to about half that of the control; however, there was no difference between the Benlate treatment and the control in percent Phomopsis infection at harvest. Orbit was not effective at any time.

BACKGROUND

Phomopsis fruit rot has been a problem in orchards of processing clingstone peaches in the Crowley's Ridge area of eastern Arkansas for many years. Fungicide schedules used to control scab and brown rot have not controlled Phomopsis fruit rot. Studies of the disease cycle have shown that, like most species of Phomopsis, the species from peach can latently (asymptomatically) infect its host. Developing fruit become latently infected from shuck split until the time of harvest, but rot symptoms develop only as the fruits ripen. Because of latent infections, chemical control would benefit from compounds with systemic (eradicative) activity. Laboratory tests have shown that Benlate

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[1] All authors are associated with the Department of Plant Pathology, Fayetteville.

and Orbit were effective in eradicating latent infections from green fruit collected from the field. The objective of this research was to test whether Benlate and Orbit applied three times as orchard cover sprays could control the levels of latent infection of fruit and the final incidence of Phomopsis fruit rot in a commercial orchard.

RESEARCH DESCRIPTION

The test was done in an 11-year-old 'Babygold 5' block that had sustained serious losses from Phomopsis fruit rot in years prior to our study. All trees in the block received a standard season-long spray program to control other diseases (see footnote in Table 1). On 28 February, half the block was sprayed with Benlate (50WP, 0.75 lb / acre) in dormant oil to determine if this might suppress the levels of inoculum from twig cankers and buds. Three Benlate and Orbit cover sprays applied on 29 April, 21 May, and 11 June were superimposed on the standard and standard plus Benlate in dormant oil treatments. Benlate 50WP was applied at 0.75 lb / acre and Orbit at 4.0 oz / acre on these three dates. From 35 to 50 trees were included in each treatment. Spraying was done with an air blast sprayer applying 200 gal / acre of water. Five to six days after each spray, and at harvest, 25 fruit were collected from eight randomly selected trees in each treatment. Fruit were surface disinfested and plated on potato dextrose agar (shuck-split stage), or for later collections, incubated at 22-24 °C in covered flats. The percent fruit that became colonized by Phomopsis was recorded. Data were analyzed by ANOVA with mean separation by Least Significant Difference (LSD) ($P < 0.05$).

FINDINGS

The application of Benlate in dormant oil prior to bud break had no effect on the percentage of fruit that were latently infected at shuck split (8 April); over 90% of the fruit were latently infected. This indicated the high disease potential in this unpruned orchard. After each Benlate spray, there was a significant reduction of about 50% compared to the standard treatment in the percent fruit that were latently infected (Table 1). However, when fruit were collected at harvest (15 July) there were no differences between the Benlate treatments and the standard treatment. Compared to the standard treatment, Orbit was not effective in reducing the percent fruit that were latently infected at any time (Table 1).

In designing this experiment, a pre-harvest interval of 21 days or longer was chosen to allow for the decline of benomyl residues in the fruit before harvest. During this period, residual benomyl concentrations may have become too low to effectively eradicate latent infections or to prevent new infections during the last few weeks before harvest. Although Orbit was effective in laboratory tests in protecting ripening fruit from Phomopsis infection and in eradicating latent infections, it had no effect in this field test. Growers have also found that pre-harvest Orbit sprays do not control Phomopsis fruit rot. This was confirmed in the present test in which the trees in the Orbit treatments received one bloom, three cover, and two pre-harvest applications with no effect on Phomopsis infection and rot.

At present, control of Phomopsis fruit rot by fungicides alone does not appear to be promising. Efforts to control inoculum levels by cultural practices that include thorough pruning may be required to help control this disease.

ACKNOWLEDGMENTS

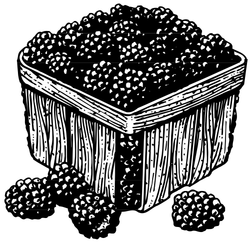
The authors thank Robert Bassham for assistance, and Gerber Products Co. for support.

Table 1. Field test of Benlate and Orbit to control latent infection of 'Babygold 5' peach fruit by *Phomopsis* sp., 1997.

	Fruit collection date				
Treatment	8 April	5-6 May	28-29 May	17 June	July 15
	——— % Fruit latently infected ———				
Standard[z]	90.7 a[y]	68.5 a	46.4 a	47.4 a	59.8 a
Benlate and oil	92.9 a	-	-	-	-
Benlate	-	42.4 b	23.4 b	29.5 b	68.6 a
Benlate (Benlate + oil)	-	49.0 b	24.4 b	21.1 b	60.4 a
Orbit	-	55.3 a	45.3 a	47.0 a	69.5 a
Orbit (Benlate + oil)	-	70.4 a	46.2 a	41.9 a	61.5 a

[z] The standard treatment included: $CuSO_4$ in dormant oil, Orbit at bloom, five cover sprays of sulfur or captan, and two pre-harvest Orbit sprays. The other treatments were superimposed on the standard treatment.

[y] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$). Values are the means of eight trees with 25 fruit/tree samples.



RESPONSE OF 'ARAPAHO' THORNLESS BLACKBERRY TO NITROGEN RATE AND SPLIT APPLICATION

Joseph Naraguma and John R. Clark[1]

IMPACT STATEMENT

Annual applications of nitrogen (N) fertilizers are recommended for blackberry production. Rates and times of application (one application or split applications) have often been recommended but only limited research has been done on this topic. No studies have been done on N rate response or time of application on the new thornless, erect blackberry cultivars from the University of Arkansas. This report includes findings from an evaluation of N fertilization rates and times of application on 'Arapaho' thornless blackberry. Treatments began in 1994 and were continued through 1996. These treatments included 0, 50, or 100 lb / acre N applied in a single spring application and 100 lb / acre applied in a split application (with one-half applied in the spring and one-half applied immediately after harvest). Ammonium nitrate was the N source. Findings indicated only limited response to N fertilization in that foliar N was increased by N fertilization but yield was not significantly influenced in any years by increasing N rate or by the split application. Our conclusions do not indicate a benefit from the split application nor the increased N rate above 50 lb / acre.

BACKGROUND

Applications of N fertilizer to blackberry plantings are a common practice in Arkansas. Growers make either one application in the early spring, or utilize a split application with the early spring application followed by a second application following harvest. Blackberries have a perennial root system, but the canes are biennial. First-year canes are known as primocanes, while second-year canes are called floricanes. The floricanes bear the crop and die following fruiting. The primocanes grow vegeta-

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[2] Both authors are associated with the Department of Horticulture, Fayetteville.

tively the first year and develop the fruiting area for next year's crop. A major question in fertilization of blackberries is the proper rate and timing of N applications for maximum fruit yield coupled with the full development of primocanes for next year's crop. The objective of our study was to determine the effect of N rate and time of application on 'Arapaho' thornless blackberry.

RESEARCH DESCRIPTION

This study was conducted at the University of Arkansas Fruit Substation, Clarksville. Treatments began in 1994 and these same treatments were continued through 1996. The treatments were; 1) control - no N applied, 2) 50 lb / acre N applied in a single application in early spring near budbreak, 3) 100 lb / acre applied in a single spring application, and 4) 100 lb / acre applied in a split application with one-half applied in the spring and one-half applied immediately after harvest. Ammonium nitrate was the N source. Fruit was harvested from the plots in June and total yield and average berry weight determined. Also, foliar samples were collected in August and elemental analysis conducted. Primocanes in each plot were counted at the end of the growing season. The experimental design was a randomized complete block containing three replications. Data was analyzed by analysis of variance and means separated by Least Significant Difference (LSD)($P < 0.05$).

FINDINGS

Over the three years, there were no significant treatment effects on yield, berry weight, or primocane number (Table 1); however, a trend toward higher primocane number with N application did occur. Of note was that on a numerical basis, the 50 lb / acre N single application produced the highest values for all of these variables. Foliar elemental content of N, phosphorus (P), potassium (K), calcium (Ca), sulfur (S), and manganese (Mn) were affected by either N rate or time of application treatments (Table 2). Foliar N content was highest for the split application but no other benefit was found from that practice and all other N rates were higher than the control (no N applied). A foliar level of 2.0% is often used to determine N deficiency in blackberries, and only the control was deficient. Nitrogen rate effects on P and K were only slight and were not of practical importance. Calcium was higher when no N was applied, and S and Mn tended to be higher with N fertilization.

Our data do not show a substantial response to N rate or time of application on yield, berry weight or primocane number for 'Arapaho' thornless blackberry. Although foliar levels were slightly deficient in the control, other N rates had adequate foliar N levels. From our data, no benefit was found from the split application, indicating that this often-recommended practice may not have value in blackberry fertilization. Overall conclusions indicate that the single application of 50 lb / acre is adequate for 'Arapaho'. Further research evaluating higher N rates should be considered since it is possible that the rates used in our study may not have explored the full range of N-rate responses on this blackberry cultivar.

Table 1. Primocane number, fruit yield, and average berry weight of 'Arapaho' thornless blackberry as influenced by nitrogen (N) fertilization over a three-year period (1994-1996).

Treatment	Primocane number[z]	Yield (lb/acre)	Berry weight (g)
Control-no N applied	18	4,719	4.4
50 lb/acre spring	26	5,740	4.6
100 lb/acre spring	21	5,275	4.4
100 lb/acre split	24	4,574	4.1
Significance[y]	NS[x]	NS	NS

[z] Total number of primocanes for a 10-ft plot produced by the end of the growing season.
[y] Significance by F test ($P < 0.05$).
[x] Not significant.

Table 2. Foliar elemental composition of 'Arapaho' thornless blackberry as influenced by nitrogen (N) fertilization over a three-year period (1994-1996).

	Leaf dry weight (%)						ppm
Treatment	N	P	K	Ca	Mg	S	Mn
Control-no N applied	1.94 c[z]	0.124 ab	1.09 ab	0.73 a	0.32	0.13 b	207 b
50 lb/acre spring	2.15 b	0.131 ab	1.09 ab	0.64 b	0.31	0.15 a	235 b
100 lb/acre spring	2.25 ab	0.119 b	1.03 b	0.63 b	0.29	0.15 a	441 a
100 lb/acre split	2.35 a	0.133 a	1.16 a	0.64 b	0.29	0.15 a	291 b
Significance[y]	0.01	0.01	0.01	0.02	NS[x]	0.01	0.01

[z] Means within column followed b a different letter are significantly different as determined by LSD ($P < 0.05$).
[y] Significance by F test ($P < 0.05$).
[x] Not significant.

EVALUATION OF NEW APPLE CULTIVARS IN ARKANSAS: THE NE-183 NATIONAL UNIFORM CULTIVAR EVALUATION TRIAL, 1998

Curt R. Rom and R. Andy Allen[1]

IMPACT STATEMENT

Selecting the appropriate apple cultivar is an important decision for the Arkansas orchardist. To make recommendations of appropriate cultivars, several apple cultivar evaluation tests are in progress. One current test is the NE-183 national evaluation trial providing rapid, scientific evaluation for local adaptablity of new apple cultivars with commercial potential. Twenty-one new cultivars were planted in 1995 and have cropped during the two most recent seasons. This trial has identified that some of the new cultivars are not adaptable to Arkansas conditions due to early bloom, exposing the trees to frost hazards, or early harvest, before traditional apple marketing season. Cultivars from other regions did not develop good quality and color under Arkansas conditions. However, some cultivars are viewed as promising and will give growers new choices for cultivars to expand or enhance their production systems.

BACKGROUND

One of the most important long-term decisions an orchardist can make is the selection of the cultivar which will be grown. Further, cultivars must be environmentally adaptable and mature at a time appropriate for marketing. Thus, an important area of the fruit research is cultivar evaluation. The goal of this research is to develop recommendations of useful and adaptable fruit cultivars for Arkansas.

The NE-183 project, "Multidisciplinary Evaluation of New Apple Cultivars and Selections", is a multi-state and multidisciplinary apple fruit cultivar evaluation program. Plantings were established at more than 25 sites in the US in 1995. Arkansas represents the southern-most test site. The objectives of the NE-183 project are;

[1] Both authors are associated with the Department of Horticulture, Fayetteville.

1) evaluate the horticultural and pest susceptibilities of new cultivars or breeding selections, 2) develop horticultural production and pest management systems for commercially-emerging cultivars, and 3) compare costs of production and profitability of new cultivars. Observations from the 1998 evaluation of the 1995 NE-183 apple cultivar are reported below.

RESEARCH DESCRIPTION

The NE-183 trial was planted at the University of Arkansas Agricultural Research and Extension Center, Fayetteville, in April 1995. The trial included 21 cultivars (Table 1) on either M9 EMLA or 'Mark' rootstocks. 'Golden Delicious' was included as a standard cultivar. Five replicate plots of each cultivar were planted. Trees were trained to a 6-ft stake in a modified short vertical axis system. In the first three seasons, minimal pruning was done except to remove damaged limbs or limbs which were excessively vigorous. Trees were deblossomed and not allowed to crop in the first two seasons, but were allowed to crop in 1997 and 1998. Crop loads were adjusted if determined to be visually excessive relative to tree size and growth. Annually, tree size, (height and width in two directions), and trunk cross-sectional area (TCSA) at 25 cm above the bud union were measured. In 1998, trees were evaluated for date of first and full bloom, and rated for subjective quantity of bloom (0-5 scale; 3 = horticulturally ideal for tree size). At fruit maturity, as determined using a starch iodine stain of fruit cortex (Cornell Scale; 1=9, 5 or 6 being pre-climacteric mature), fruit were harvested. Fruit were counted and weighed to determine total yield per tree and average fruit weight. From each tree, a 10-fruit subsample was weighted and assayed for soluble solids content, titratable acidity, and fruit firmness. Fruit were tasted for personal preference. Two of the plots were not sprayed after 10 June to allow manifestation of pest infestation and disease symptoms. There was significant codling moth and oriental fruit moth population pressure and damage during the 1998 season and very severe infections of white rot, black rot, and bitter rot were experienced. As a result, most yield in these two plots were lost. Results from the first season have been previously reported (Rom and Allen, 1998; Rom, *et al.*, 1998).

FINDINGS

The cultivars tested (Table 1) represent both red and yellow fruit with a range of genetic backgrounds. Many of the cultivars are chance seedlings while others are hybrid selections from breeding programs. Several cultivars are considered to have some resistance to spring diseases such as scab, cedar apple rust, powdery mildew, fireblight ('Enterprise', 'Goldrush', NY75414-1 and 'Pristine').

Tree height exceeded 6 ft for all cultivars and 9 ft for several ('Golden Delicious', 'Enterprise', 'Golden Supreme' and 'Shizuka') (Table 2). 'Braeburn', 'Honeycrisp', NY-75414-1 and 'Suncrisp' tended to have the smallest canopies.

The late winter and early spring period was marked by mild temperatures and high rainfall. The bloom period began only slightly earlier than normal. The bloom period had mild to warm temperatures with good sunlight conditions. There were several consecutively cloudy days during the post-bloom, fruit set period and temperatures were cooler than during bloom. The early fruit development period was warm with higher than normal rainfall. However, the midseason (June - August) through early harvest season (August - September) were characterized by drought and very high temperatures. Both flavor and color of fruits that ripened before midseason were notably poor in 1998. The warmest period of the season occurred during early September, when there were four consecutive days with temperatures at or above 100 °F. Harvest season for most cultivars was one-three weeks earlier than normal due to prolonged heat.

The average last killing frost (28 °F) is 10 April in Fayetteville. Cultivars which bloom before that date are subject to increased frost risk. Cultivars that bloomed very early included; 'Braeburn', 'Arlet', NY75414-1, 'Orin' and 'Pristine' (Table 2). Particularly of note are the cultivars 'Braeburn' and 'Arlet', which in other trials have bloomed very early when there are few other cultivars blooming for cross-pollination, and may be sensitive to frost and bloom. 'Honeycrisp' began its bloom and achieved full bloom relatively late compared to the other cultivars; 'Shizuka' was the last to achieve full bloom. Bloom quantities of most cultivars were rated as acceptable. However, the following had relatively light bloom: 'Yataka'/M9, 'Fuji'/M9, 'Goldrush'/M9, 'Pristine'/M9, 'Suncrisp'/M9 and 'Sunrise'/M9. 'Braeburn'/'Mark' had profuse bloom and potential for excessive crop load relative to tree size and vigor.

'Arlet', 'Ginger Gold', 'Honeycrisp', NY 75414-1, 'Pristine' and 'Sansa' all ripened too early in the season (late July, early August) to be used for the regional direct market or local markets (Table 2). The average tree yields were probably higher than measured (Table 2) due to the fact that trees in blocks four and five had significant fruit loss to insects and disease (see comments above) and much lower yields than the other blocks. On average, the highest yields per tree were observed for 'Pristine', 'Golden Supreme', and 'Cameo', while 'Braeburn', 'Enterprise', 'Goldrush', NY75414-1, 'Sansa' and 'Shizuka' had low to very low yields. 'Enterprise' and 'Goldrush' had good crops in 1997 and expressed a strong tendency for biennial bearing in 1998. The largest fruit were produced by 'Ginger Gold', 'Golden Supreme', 'Enterprise', 'Shizuka', 'Fuji', and 'Creston'. Fruits of 'Arlet', NY-75414-1 and 'Sansa' were small. The sample fruit weight more likely represents the size of marketable fruits.

Fruits of 'Goldrush', 'Suncrisp', 'Orin', 'Sansa', 'Gala Supreme', and 'Arlet' were the firmest. 'Fuji', NY-75414-1, and 'Pristine' all had relatively soft fruit (Table 3). The firmness was related to the starch rating, where fruit with greater starch content (indicating early stages of maturity) were firmer, and to fruit size, where larger fruit tended to be softer. 'Golden Delicious' and 'Gala Supreme' had the highest soluble solids concentration (Table 3) while the early maturing cultivars 'Pristine', 'Sunrise', 'Golden Supreme' and 'Arlet' all had relatively low soluble solids; these latter cultivars matured during a period of high temperatures.

Fruit color was poor in all cultivars in this year, especially those that matured prior to 10 September and very little over color developed in cultivars in 1998 (Table 3).

'Braeburn', 'Enterprise', 'Fortune', and NY-75414-1 all had the most color while fruit of 'Golden Delicious', 'Goldrush', 'Sansa', and 'Suncrisp' had relatively high russet ratings.

LITERATURE CITED

Rom, C.R. and R. Andy Allen. 1998. Apple cultivars and rootstocks for the Arkansas-Oklahoma region: Recent observations of the NE-183 Cultivar and NC-140 Root stock Trials. Proc. of the 17th Annual. Oklahoma-Arkansas Hort Industries Show, p. 153-160.

Rom, C.R., R.A. Allen, D.T. Johson, and R. McNew. 1998. The NE-183 Project: Multidisciplinary evaluation of new apple cultivars - A preliminary report from Arkansas. HortScience;(abstr.). 33:601.

Table 1. Apple cultivars in the 1995 NE-183 Trial planted at the University of Arkansas Agricultural Research and Extension Center, Fayetteville.

Cultivar	Parentage	Fruit color
Arlet	Gold Del. x Idared	Red
BC8m-15-10 ('Creston')	Gold Del. x BC381049	Red
Braeburn	Chance seedling	Red
Cameo	Chance seedling	Red
Enterprise (Coop 30)	PRI16612 x PRI16611	Red
Fortune (NY 429)	Red Spy x Empire	Red
Fuji	Red Del. x Ralls Janet	Pink/red
Gala Supreme	Chance seedling	Red
Ginger Gold	Chance seedling	Yellow
Golden Delicious (standard form)	Chance seedling	Yellow
Golden Supreme	Chance seedling	Yellow
Goldrush (Coop 38)	Gold Del. x Coop 17	Yellow
HoneyCrisp	Macoun x Honeygold	Red
NY75414-1	Liberty x Macspur	Red/purple
Orin	Open pollinated seedling	Yellow
Pristine (Coop 32)	Carnusat x PRI1659-10	Red
Sansa	Gala x Akane	Red
Senshu	Toko x Fuji	Red
Shizuka	Gold Del. x Indo	Yellow
Suncrisp (NJ55)	Gold Del x NJ303955	Yellow
Sunrise	(Mac. G.D.) x PCF3120	Pink/red
Yataka	Sport of Fuji	

Table 2. Tree growth of cultivars in the NE-183 1995 Apple Cultivar Evaluation Trial planting.

Cultivar	Tree stock	Tree height(m)	Width(m)	Full bloom Julian	Full bloom Calendar	Bloom rating(0-5)[z]	Harvest date[y] Julian	Harvest date[y] Calendar	Days to harvest	Yield (kg)
Braeburn	M9	2.75 a-e[x]	2.30 b-e	97.9 b-d	06-April	4.67 ab	274	01-October	176	2.32 f
Braeburn	Mark	2.18 e	1.67 f	98.1 b-e	07-April	5.00 a	274	01-October	176	0.33 f
Golden Delicious	M9	3.00 a-c	2.38 b-d	102.8 kl	11-April	3.60 bc	252	09-September	149	9.52 b-e
Golden Delicious	Mark	2.84 a-d	2.36 b-e	102.6 k	11-April	3.60 bc	252	09-September	149	9.95 b-e
Yataka	M9	2.82 a-d	2.60 ab	99.4 e-g	08-April	2.00 ef	236	24-August	137	8.80 b-e
Yataka	Mark	2.74 a-e	2.34 b-e	99.2 d-g	08-April	2.40 d-f	236	24-August	137	7.21 c-f
Arlet	M9	3.24 a	2.57 ab	96.6 a	05-April	2.40 d-f	211	30-July	114	11.32 b-d
Creston	M9	2.58 c-e	2.37 b-e	100.1 gh	09-April	2.09 d-f	236	24-August	136	7.36 b-f
Cameo	M9	2.51 c-e	2.47 a-d	102.3 i-k	11-April	3.33 b-d	252	09-September	150	13.26 a-c
Enterprise	M9	3.08 a-c	2.95 a	99.6 e-h	08-April	2.59 c-f	252	09-September	152	1.25 f
Fuji	M9	2.82 a-d	2.59 ab	100.2 gh	09-April	2.20 d-f	274	01-October	174	6.14 c-f
Gala Supreme	M9	3.23 ab	2.27 b-e	101.0 h-j	10-April	3.59 b-d	252	09-September	151	0.25 f
Ginger Gold	M9	2.84 a-d	2.66 ab	100.0 gh	09-April	3.00 c-e	219	07-August	110	7.14 c-f
Gold Supr.	M9	3.11 ab	2.45 a-d	103.5 kl	12-April	3.01 c-e	226	14-August	123	13.69 ab
Goldrush	M9	2.70 b-e	2.16 c-e	100.0 gh	09-April	1.60 f	274	01-October	174	2.35 f
Honeycrisp	M9	2.56 c-e	1.77 f	102.6 k	11-April	2.40 d-f	226	14-August	123	4.57 ef
Fortune	M9	2.98 a-c	2.62 ab	100.9 hi	09-April	2.33 d-f	252	09-September	151	5.20 d-f
NY 75414-1	M9	2.67 b-e	1.97 ef	96.7 ab	05-April	2.76 c-e	257	14-September	160	1.69 f
Orin	M9	2.85 a-d	2.09 c-f	98.6 c-f	07-April	3.67 a-c	252	09-September	153	9.54 b-e
Pristine	M9	2.61 c-e	2.54 a-c	97.6 a-c	06-April	2.00 ef	197	16-July	99	19.02 a
Sansa	M9	2.44 de	2.20 c-e	99.8 f-h	08-April	2.80 c-e	211	30-July	111	3.07 f
Shizuka	M9	3.28 a	2.37 b-e	104.1 l	13-April	3.09 c-e	252	09-September	148	1.55 f
Suncrisp	M9	2.59 c-e	2.07 d-f	102.5 jk	11-April	2.26 d-f	252	09-September	150	9.15 b-e
Sunrise	M9	2.62 c-e	2.44 b-d	99.2 d-g	08-April	2.20 d-f	204	23-July	105	6.61 c-f

[z] Bloom rating: 0 = no bloom, 3 = ideal bloom quantity for tree size and vigor, 5 = heavy bloom.
[y] Harvest determined by starch assay; all fruit on all replicate trees picked at same time.
[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

Table 3. Cultivar and rootstock effects on fruit size and quality in the NE-183 1995 Cultivar Evaluation Trial, Fayetteville 1998.

Cultivar	Stock	Avg. fruit weight	Length	Diameter	Starch firmness	Starch rating	Soluble solids	Color	Russet rating[y]
		(g)	(cm)	(cm)	(lbs)	(0-12)[z]	(%)	(%)	(0-5)
Braeburn	M9	173.17 b-g[x]	63.3 b-f	72.0 a-f	17.7 e-i	6.9 a-c	13.8 g-j	77 ab	1.0 e-j
Braeburn	Mark	134.57 e-h	58.6 b-g	63.9 ef	19.7 b-g	8.9 a	13.5 f-j	89 a	0.7 e-j
Golden Del.	M9	187.23 b-d	67.1 bc	74.3 a-c	18.0 e-h	6.1 b-d	17.4 a	0 e	3.2 bc
Golden Del.	Mark	172.82 c-f	64.0 b-e	73.7 a-d	18.5 d-g	6.5 bc	17.3 ab	0 e	3.3 ab
Yataka	M9	191.29 b-d	61.9 b-f	77.0 ab	17.4 f-i	4.7 e-h	14.5 f-i	0 e	1.7 e-h
Yataka	Mark	184.23 b-e	61.3 c-f	75.5 a-c	17.5 f-h	4.6 e-h	14.6 e-h	0 e	0.9 g-j
Arlet	M9	139.73 gh	58.2 e-g	67.3 f	20.2 b-d	4.2 f-j	13.8 h-j	1 e	4.4 a
Creston	M9	198.20 a-d	66.5 b-d	76.4 a-c	18.5 b-h	3.5 g-l	14.5 e-i	2 e	1.5 e-i
Cameo	M9	182.10 b-e	63.3 b-f	75.9 a-c	18.2 e-h	3.4 h-l	14.0 g-j	2 e	0.9 f-j
Enterprise	M9	202.93 a-c	65.5 b-e	80.0 a	19.0 b-g	5.1 c-h	14.2 f-j	77 ab	0.5 g-j
Fuji	M9	200.73 a-c	63.5 b-f	78.1 ab	16.1 hi	7.1 ab	14.6 e-i	18 de	0.5 g-j
Gala Supreme	M9	193.14 a-d	60.5 b-g	79.8 ab	21.0 bc	6.6 a-d	16.6 a-c	39 cd	1.5 e-i
Ginger Gold	M9	231.17 a	68.0 b	78.6 a	18.1 e-h	2.9 kl	14.4 f-i	0 e	0.2 ij
Gold Supreme	M9	208.92 ab	68.4 b	75.9 a-c	19.7 b-e	3.7 h-l	13.9 h-j	0 e	1.4 e-h
Goldrush	M9	194.55 b-d	68.0 bc	72.1 b-f	23.5 a	5.7 b-f	15.5 c-g	2 e	2.2 b-f
Honeycrisp	M9	184.93 b-e	60.7 d-f	75.6 a-c	16.5 hi	5.0 d-i	14.5 f-h	56 bc	0.6 h-j
Fortune	M9	203.08 a-c	76.2 a	78.8 ab	18.6 c-g	5.3 c-g	15.7 c-f	72 ab	0.5 g-j
NY 75414-1	M9	120.77 h	52.0 g	70.3 c-f	15.3 ij	5.0 d-h	16.0 a-e	82 a	1.5 e-h
Orin	M9	156.92 d-h	62.0 b-f	69.7 c-f	20.9 b	4.5 f-j	14.7 d-h	2 e	1.9 d-g
Pristine	M9	195.01 b-d	61.2 b-f	78.5 ab	13.9 j	3.7 h-l	12.7 j	2 e	0.0 j
Sansa	M9	146.25 f-h	56.4 fg	68.8 d-f	20.4 bc	3.1 j-l	16.2 bc	34 d	2.2 c-e
Shizuka	M9	211.38 a-c	68.4 a-d	77.3 a-c	19.3 b-f	6.3 b-e	16.4 a-d	2 e	1.5 e-i
Suncrisp	M9	174.42 c-f	65.0 b-d	73.2 a-e	23.4 a	4.1 g-k	15.4 c-g	0 e	2.9 b-d
Sunrise	M9	190.15 b-d	64.6 b-e	74.6 a-d	16.7 g-i	2.6 lk	13.1 ij	2 e	0.0 j

[z] Starch rating using the 1-12 Cornell Scale; 1 = cortex completely stained for starch, 12 = no starch stain visible in fruit cortex.
[y] Russet rating of 0 to 5 with 0 = no russet.
[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

FRUIT TREE TRAINING SYSTEMS RESEARCH

Curt R. Rom[1], R. Andy Allen[1], and Bryan Blackburn[2]

IMPACT STATEMENT

Orchard systems for apples and peach are being studied to provide new technologies for Arkansas orchards to improve economic sustainability with earlier and increased production. Tree density in apples is dictated by size-controlling rootstocks; however, with peaches there is a lack of size-controlling rootstocks and planting density is dictated by tree training system. For apples in 1998, the traditional Central Leader system (CL) had the largest yield per tree. However, the Slender Spindle (SS) and Vertical Axis (VA) had the greatest productivity. In the first six production years, SS and VA had greater accumulated yields than the CL. For peaches, the minimally pruned, Untrained (UT) trees had the greatest yields per tree but, along with the CL trees had the smallest fruit size. When tree size due to training is considered, the 2-Scaffold "V" (TSV) training system had the greatest productivity, and during the harvests of 1995-1998, had a 36% increase in yield compared to the traditional Open Center (OC) tree. These training systems provide options for Arkansas orchardists which are more productive and would generate earlier economic returns than traditional tree training systems.

BACKGROUND

For modern Arkansas orchards to be profitable, the orchard training system must produce fruit quickly in the life of the orchard allowing the grower flexibility in making decisions to change cultivars as demanded by the consuming public, to replant older low-productivity blocks, and to return money to either the operation or pay loans for the establishment of the new orchard.

Traditionally, apples are CL trained and planted at 200-250 trees / acre, and OC trained spreading peach trees are planted at 110-170 trees / acre. Many newer training systems have been developed in other fruit-growing regions, but few have been tested

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in this region. This report summarizes the current status of tree fruit training systems for apple and peach which are being evaluated by the Horticulture Department and the Arkansas Agricultural Experiment Station.

RESEARCH DESCRIPTION

Apple Training Systems. A trial of three apple training systems was planted in April 1990 at the Arkansas Agricultural Research and Extension Center, Fayetteville, as part of the NC-140 national uniform orchard systems trial (Barritt, *et al.* 1997). The trial contained trees in three training systems (CL = 445 trees / acres; SS=1012 trees / acres; VA=607 trees / acre) with two cultivars (Empire [EM], and Jonagold [JG]) on six rootstocks (B9, M9 EMLA, M26 EMLA, 'Mark', Ott.3, P.1). The systems and experimental design have been previously described (Allen, 1998).

Peach Training Systems. In April 1992, an orchard system trial was planted at the University of Arkansas Fruit Substation, Clarksville. Trees of 'Redhaven' on 'Lovell' rootstock, 5 / 8" diameter, were planted and trained to one of six training systems (Table 1). The training and management of the planting has been previously described (Rom and Blackburn, 1998).

FINDINGS

Apples. The traditional CL system produced relatively large trees and had the greatest yield / tree in 1998 and cumulative yield / tree (Table 2). However, all systems had similar yield / acre in 1998. The VA system had the greatest cumulative yield per acre. Although there were some growth differences between the cultivars EM and JG, both had similar production and cumulative yields. In these systems, all rootstocks had statistically similar size with the exception of 'Mark' which was significantly smaller than all other stocks. Trees on M26 had the greatest annual yield and trees on P.1 the least. Trees on M26 had the greatest cumulative yields / tree and yield / acre while trees on 'Mark' had the least. Trees on Ott.3 had the greatest tree loss, with more than 50% of trees in the study, lost primarily to root diseases (data not shown). Trees on 'Mark' did not perform well and most are not recommended for use in Arkansas.

Peaches. In 1998, there were no significant differences in tree height due to training system (Table 3). However, the pruning and training required to contain trees into the system resulted in the Leaning V (LV) and the TSV having the smallest trunk cross-sectional area, an indicator of above-ground vegetative growth of the tree (Table 3). Yield for all treatments was somewhat less in 1998 than for 1997 due to spring frosts (data not shown). Yield per tree in 1998 was greatest in the UT system and least in the LV, TSV, and CL system. However, fruit size in the UT and the CL systems were significantly smaller than fruit from other systems. Cumulative yield / tree was greatest in the OC and the UT systems and similarly less for all other systems. However, the production (yield / acre) for 1998, taking into account tree planting density, was greatest for the CL system and least in the OC and LV systems. Cumulative production from 1995-1998 was greatest in the TSV system; 36% greater than the OC system.

LITERATURE CITED

Allen, R.A. 1998. Light Relations and tree growth as affected by tree training systems. MS Thesis. Department of Horticulture, University of Arkansas.

Barrit, B.H., J.A. Barden, J. Cline, R.L. Granger, E.E. Hoover, M.M. Kushad, R.P. Marini, M. Parker, R.L. Perry, T. Robinson, C.R. Unrath, and M.A. Dilley. 1997. North American NC-140 Orchard Systems Trial. Acta Hort. 451: 443-452.

Rom, C.R. and B. Blackburn. 1998. Preliminary observations of new peach training systems: The first 5 years of growth and production. Proc. Of the 17th Annual Arkansas-Oklahoma Horticulture Industries Show, Horticulture Industries, pp. 113-117.

Table 1. The training systems used in the UA Peach Training Systems trial planted 1992, Fruit Substation, Clarksville.

System	In-row spacing	Between-row spacing	Tree density
	(ft)	(ft)	(trees/acre)
Open center — traditional	15	18	161
Untrained	15	18	161
4-Scaffold “V”	10	18	245
2-Scaffold “V”	6.5	18	375
Leaning-”V”	6.5	18	375
Central leader	8	18	300

Table 2. The effect of tree training system, cultivar and rootstock on tree growth and yield in the NC-140 1990 Orchard Systems trial, Fayetteville, 1998.

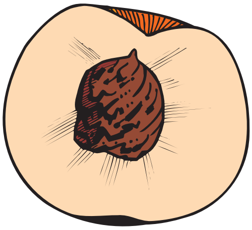
	1998										1990 - 1998	
Trt.[z]	Height (m)	Width (m)	Inc. in TCSA[y] (cm^2)	Root TCSA (cm^2)	Suckers (no.)	Bloom[x] rating (0-5)	Est. yield (kg)	Avg. frt yield (bu/ac)	Weight (g)	Yld eff. (kg/cm^2)	Est. cum. yld (kg)	Est.cum. production (bu/acre)
Training system												
CL	3.05 b[w]	2.57 a	79.86 a	10.89 a	2.67 a	2.06 a	14.87 a	348	172.21 a	0.210 a	94.2 a	2223 b
SS	3.23 b	2.05 b	66.64 a	7.96 a	0.28 a	1.36 b	7.06 b	375	158.65 a	0.129 a	60.8 b	2980 a
VA	3.52 a	2.40 ab	73.13 a	10.12 a	2.06 a	2.16 a	10.43 ab	333	166.89 a	0.183 a	85.2 a	2769 a
Cultivar												
EM	3.27 a	2.30 a	60.14 b	7.31 b	2.65 a	1.90 a	10.16 a	367	132.79 b	0.183 a	79.9 a	2477 a
JG	3.26 a	2.39 a	86.28 a	12.00 a	0.69 b	1.82 a	11.41 a	412	199.04 a	0.164 a	85.2 a	2844 a
Rootstock												
B9	3.10 b	2.25 b	58.04 b	7.84 ab	2.09 ab	2.06 ab	12.10 ab	642	174.47 ab	0.222 ab	84.5 b	3088 ab
M26	3.66 a	2.61 a	86.98 ab	10.17 a	0.00 b	1.35 b	15.15 a	418	153.24 b	0.173 bc	113.7 a	3051 a
M9	3.59 a	2.41 ab	78.15 ab	12.14 a	1.43 ab	1.34 b	9.45 b	401	160.41 ab	0.130 c	81.7 b	3693 bc
MARK	2.36 c	1.96 c	34.68 c	3.81 b	3.31 a	2.87 a	9.82 b	354	157.04 b	0.294 a	62.7 c	2177 d
OTT3	3.46 ab	2.40 ab	87.88 ab	13.99 a	0.94 ab	1.84 b	8.84 ab	314	185.13 a	0.118 c	70.7 bc	2315 bcd
P1	3.43 ab	2.42 ab	93.52 a	9.98 a	2.39 a	1.69 b	9.34 b	266	165.21 ab	0.106 c	66.9 bc	2187 cd

[z] Training systems: CL = Central Leader, SS = Slender Spindle, VA = Vertical Axis; Cultivar: EM = Empire, JG = Jonagold.
[y] TCSA = trunk cross sectional area.
[x] Bloom rating of 0-5 with 5 = heavy bloom.
[w] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

Table 3. Growth and yield performance of 'Redhaven'/ 'Lovell' peach planted in six training systems; trees planted 1992 and growth and yield for 1998 season; Fruit Substation, Clarksville.

System	Tree height (m)	TCSA[z] (cm^2)	Yield (kg/tree)[y]	Production (kg/acre)	Avg. frt. weight (g)	Yield (kg/tree)	Production (kg/acre)[y]	Cumulative yield (kg/tree)[y]	Est. cumulative production (kg/acre)[y]	%Yield of open center
Open center	3.53	109.5 a[x]	51.9 a	9509 b	155.3 a	45.7 b	7497 c	107.2 a	17,259 c	100.0
Untrained	3.93	97.8 ab	54.3 a	8891 b	126.2 b	58.9 a	9653 ab	126.7 a	20,286 ab	117.6
4-Scaffold "V"	3.31	87.4 bc	39.4 b	9697 ab	148.7 a	34.6 c	6683 c	76.2 b	18,676 bc	108.2
2-Scaffold "V"	4.24	80.5 cd	31.4 bc	11576 a	146.0 a	22.2 d	8198 ab	62.6 b	23,475 a	136.4
Leaning"V"	3.72	72.7 cd	29.3 c	10813 ab	146.4 a	27.2 cd	10080 c	48.1 b	18,038 bc	104.5
Central leader	4.35	71.4 d	31.7 bc	9355 ab	120.5 b	34.6 c	10202 a	66.2 b	19,860 ab	115.1
Significance[w]	NS									

[z]TCSA = Trunk cross-sectional area.
[y]To convert kg/tree to lbs/tree divide the number by 2.2. To convert kg/acre to tons/acre, divide by 1.1
[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P<0.05$).
[w] NS = Not significant, ($P < 0.05$).



FRUIT TREE ROOTSTOCKS, 1998 REPORT

Curt R. Rom[1], R. Andy Allen[1], and Bryan Blackburn[2]

IMPACT

Rootstocks have a significant impact on orchard productivity because of their adaptability, resistance to pathogens and pests, and effect on tree size, productivity and fruit quality. The selection and use of a rootstock is a long-term decision for the grower which cannot be changed unless the tree is pulled from the orchard. Rootstocks have been developed or discovered in various locations around the world but their adaptability must be tested locally. This project tested rootstocks for use in Arkansas orchards. Apple rootstock genotype and clone affected tree size and productivity in these trials. Peach rootstock had very little affect on tree size but a significant effect on time of bloom, harvest and yield per tree.

BACKGROUND

Fruit trees are a multi-genetic system comprised of a rootstock and scion cultivar. The scion cultivar is selected for an adaptable and marketable fruit. Similarly, the rootstock must be selected as adaptable and productive. For a rootstock to be used in Arkansas orchards, it must be suited to the soil and environment, have some tolerance or resistance to endemic pathogens and pests, and have good horticultural characteristics and productive capacity. Fruit tree rootstocks have profound effects on tree growth and orchard productivity. Rootstocks affect ultimate tree size, precocity (time for the tree to begin production), yield, time of scion bloom and harvest, and fruit size and quality. The effect of rootstock on tree size determines tree planting density and ultimate productivity of an orchard. Because of the rootstock effect on tree precocity, the early performance of rootstocks is critical to orchard operations and success

The NC-140 project, "Uniform Testing of Rootstock and Interstem Effects on Pome and Stone Fruits", is a national cooperative trial established in 1977 with the objectives of; 1) evaluating performance of rootstocks in various environment and management

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systems, 2) assessing and improving propagation of rootstocks, 3) improving ability to identify rootstocks, 4) developing new rootstocks through breeding, and 5) determining stress effects on trees in relations to rootstocks. Arkansas has been involved in the NC-140 project since its inception and has established more than 15 rootstock trials for apples, peaches, pears, cherries, and plums. Our research reports on the 1998 observations of two apple rootstock and one peach rootstock trial.

RESEARCH DESCRIPTION

1990 Apple Rootstock Trial. Trees of 'Gala' on eight rootstocks (Table 1) were planted at the Arkansas Agricultural Research and Extension Center, Fayetteville, in April 1990. Trees were spaced 1.6 m between trees and 3.25 to 4.5 m between rows and trained to the HYTEC, modified tall slender spindle system (Barritt *et al.*, 1997). Trees were supported by a bamboo pole (approx. 2.5 cm diameter) suspended from a single high-tensile wire strung at 3.3 m height. Trees were planted in two plots of six trees each for a total of 12 individual trees. Single trees were considered experimental units in a randomized complete block design.

Annually, tree size, (height, width in two directions) and trunk cross-sectional area (TCSA) at 25 cm above the bud-union was measured and trees were evaluated for date of first and full bloom, and rated for subjective quantity of bloom (0-5 scale; 3 = horticulturally ideal for tree size). Fruit were harvested at maturity, as determined using a starch iodine stain of fruit cortex. Fruit were counted and weighed to determine total yield per tree and average fruit weight.

1994 Apple Rootstock Trial. In 1994, 'Gala' on 21 rootstocks in "dwarf" and "semi-dwarf" size classes were planted at the University of Arkansas Agricultural Research and Extension Center, Fayetteville (Table 2). In the dwarf size class, the stocks FL56, Nic29, Pajam 1, Pajam 2, and T337, which are all clones of M9 selected for differences in tree size or nursery propagation ease, were included. The block was interplanted with 'Fuji'/M9 and 'Delicious'/M9 as pollinators. Trees were trained as a vertical axis to a bamboo pole suspended by a high-tensile wire at 3.3 m. Annually, growth and production were measured as described above.

The trial was separated into two sub-trials; 1) dwarfing rootstocks containing 17 rootstocks, and 2) semi-dwarfing rootstocks containing four rootstocks. In each size class test, M26 was planted as a uniform comparator. Ten replicates of single trees of each stock were planted.

1994 Peach Rootstock Trial. In 1994, 'Redhaven' on 15 rootstocks (Table 3) was planted at the Fruit Substation, Clarksville, as part of the NC-140 trial. Trees were planted at 4 m between trees and 5 m between rows and trained to a traditional open center system. Trees were not allowed to crop for the first two seasons, but have cropped in the past three seasons. Ten replicate trees of each rootstock were planted in a randomized complete block design.

Annually, tree size (height, width in two directions), and trunk cross-sectional area (TCSA) at 25 cm above the bud-union were measured. Trees were evaluated for date of first and full bloom, and rated for subjective quantity of bloom (0-5 scale; 3 = horticulturally ideal for tree size). Fruit were harvested at maturity, as determined by suture-softness and fruit background color. Trees were picked three times. Harvested fruit were counted and weighed to determine total fruit yield per tree and average fruit weight.

FINDINGS

1990 Apple Rootstock Trial. Trees ranged in height from 2.4 m with M27 to 4.3 m with P1 (Table 1). Bloom in this trial was adequate to good but yields were not very good relative to tree size. Trees on M9, although intermediate in size, had the highest yields. Trees on P1 were similar in many characteristics to those on M26 this year.

1994 Apple Rootstock Trial. In the 1994 'Gala' dwarfing trial, there were only small differences for tree size among the strains of M9 (Table 2). In this trial, trees on V1 produced the largest trees and trees on P22 and M27 produced the smallest trees. The M9 strains Nic29, Pajam 1 and FL56 tended to produce more root suckers than the other M9 strains. All trees had adequate to heavy bloom. Yields were significantly and highly correlated to tree size (data not presented) in this trial this year. This was different from the lack of correlation observed in previous years. Trees on V1, Nic29, and M26 had the greatest yields per tree. Trees on 'Mark', Nic29, Pajam 1, Pajam 2 and T337 tended to have lower yield efficiencies than other stocks. Cumulative yield during the first three harvest seasons was greatest for V1, Ott3, Nic29, M9, and M26 and trees on B469, B491, and P2 had the least cumulative yields. Cumulative yield was also correlated to tree size (data not presented).

Tree heights in this trial were 0.5-1.0 m taller than the 1994 semi-dwarfing rootstock trial (Table 2). Trees on P1 were the tallest and those on CG30 were the shortest with M26 and V2 being intermediate. Trees on CG30 had an excessive number of suckers. All trees had adequate to heavy bloom but fruit set was not as good as in the dwarfing stock trial. Trees on P1 had significantly lower yields than trees on the other stocks and very low yield efficiency as they continued to grow vigorously in this trial. Trees on V2 had the highest yields and those on CG30 had the best yield efficiency. Trees on CG30 and V2 had the greatest cumulative yield.

1994 Peach Rootstock Trial. Rootstock significantly affected the time of first and full bloom (Table 3) with trees on BY520-9 blooming 2-3 days earlier than average in this trial. Although trees on 'Myran' had among the latest bloom, the fruit tended to mature earlier. Trees with 'Ta Tao 5' interstem bloomed only 1-3 days later than average for the trial. Trees on 'Rubira' had the greatest yields while trees on 'Ishtara' had significantly less yields, only 1/3 as much, as trees on other stocks. Likewise, fruit weight was suppressed on these trees. Trees on 'Ishtara' did not grow well and did not expand much in trunk size or canopy size. No stocks had excessive root suckering.

LITERATURE CITED

Barritt, B.H., J.A. Barden, J. Cline, R.L. Granger, M.M. Kushad, R. P. Marini, M. Parker, R.L. Perry, T. Robinson, C.R. Unrath, and M.A. Dilley. 1997. Performance of 'Gala' at year 5 with eight apple rootstocks in an 8-location North American NC-140 Trial. Acta Hort. 451: 129-135.

Table 1. Rootstock effects on tree growth and yield of ‘Gala’ in the NC-140 1990 Apple Rootstock Trial, Fayetteville 1998.

Rootstock	Height (m)	Width (m)	TCSA[z] (cm)	Gain in TCSA (cm)	Root suckers (no.)	Bloom rating[y] (0-5)	Weight (g)	Yield (kg)	Yld eff. (kg/cm)
B9	3.69 bc[x]	2.53 bc	58.28 bc	6.65 c	0.13 a	4.63 a	140.53 a	16.02 ab	0.273 b
M26	4.26 a	3.01 a	99.36 a	14.66 b	0.13 a	2.76 bc	136.94 a	16.27 ab	0.161 c
M27	2.40 d	1.75 d	20.49 d	2.95 c	0.00 a	4.30 a	137.66 a	11.16 b	0.541 a
M9	4.00 ab	2.65 ab	61.99 b	6.41 c	1.35 a	3.10 b	135.21 a	19.09 a	0.308 b
MAC39	3.32 c	2.55 b	54.50 bc	5.92 c	0.04 a	3.86 ab	136.79 a	14.47 ab	0.273 b
MARK	3.19 c	2.24 c	41.79 c	4.40 c	0.07 a	4.38 a	123.63 a	12.55 b	0.306 b
OTT3	4.20 ab	3.03 a	97.05 a	21.84 a	2.50 a	1.50 c	150.26 a	5.78 b	0.060 c
P1	4.30 a	2.80 ab	106.13 a	14.65 b	0.50 a	2.13 c	122.29 a	15.62 ab	0.150 c

[z] TCSA = trunk cross-sectional area at 25 cm above graft union.
[y] Bloom Rating: 0 = no bloom, 3 = ideal bloom quantity for tree size and vigor, 5 = heavy bloom.
[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

Table 2. Tree growth and fruiting of 'Gala' in the NC-140 1994 dwarfing and semi-dwarfing apple rootstock trials, Arkansas Agricultural Research and Extension Center, Fayetteville, 1998.

Rootstock	Height (m)	Avg. width (m)	1998 TCSA[z] (cm)^2	Gain in TCSA (cm)^2	Root suckers (no.)	Bloom[y] rating (0-5)	Yield (kg/tree)	Avg. frt. wt. (g)	Yld eff. (kg/cm^2)	1996-98 cumulative yield (kg)
Dwarf stocks										
B469	2.11 f	1.88 f	14.33 g	2.34 e	0.59 b c	4.4 a-d	13.79 ef	120.18 d-g	0.975 a-e	34.5 d
B491	2.33 f	2.12 e	12.11 g	2.02 ef	0.16 bc	4.6 ab	12.49 e-g	129.4 b-f	1.035 a-d	33.2 d
B9	2.80 de	2.27 de	18.86 f	2.57 e	0.01 bc	4.6 ab	18.67 de	121.5 c-f	0.972 a-e	50.7 c
FL56 M9	3.20 bc	2.64 c	26.55 de	5.81 cd	3.10 a-c	4.0 b-f	23.19 cd	143.0 ab	0.872 c-e	49.9 c
M26	3.29 a-c	2.89 ab	31.97 bc	7.06 bc	0.69 bc	3.7 ef	31.15 ab	141.5 a-c	0.981 a-e	79.1 ab
M27	1.73 g	1.23 g	6.16 h	0.61 f	0.30 bc	4.5 a-c	7.32 g	103.9 g	1.200 a	17.15 e
M9 EMLA	3.31 a-c	2.69 bc	32.80 b	7.43 b	1.65 bc	3.7 d-f	26.36 bc	134.5 a-e	0.810 de	75.5 ab
MARK	2.21 f	1.81 f	14.49 g	1.22 ef	1.45 bc	4.5 a-c	11.16 fg	107.1 g	0.727 e	32.5 d
NIC29 M9	3.43 a-c	2.81 a-c	35.61 ab	8.10 b	6.53 a	3.7 ef	28.61 ab	142.4 ab	0.826 de	79.6 ab
OTT3	3.14 cd	2.69 bc	27.48 de	7.78 b	1.11 bc	3.4 f	24.93 bc	147.5 a	0.917 b-e	75.7 ab
P16	2.12 f	1.80 f	11.07 g	1.84 ef	5.01 ab	4.7 a	13.24 ef	119.2 e-g	1.152 ab	31.3 d
P2	2.74 e	2.35 d	24.42 e	4.52 d	0.00 c	4.2 a-e	21.90 cd	136.2 a-d	0.910 b-e	55.2 c
P22	2.02 fg	1.73 f	11.14 g	1.64 ef	0.36 bc	4.5 a-c	11.72 fg	113.5 fg	1.072 a-c	28.8 d
PAJAM1 M9	3.47 ab	2.76 bc	34.01 b	8.15 b	6.80 a	3.9 c-f	26.17 bc	148.9 a	0.777 e	70.1 b
PAJAM2 M9	3.31 a-c	2.95 a	35.06 b	7.00 bc	1.41 bc	4.1 a-e	24.89 bc	142.4 ab	0.724 e	71.1 b
T337	3.32 a-c	2.67 bc	29.07 cd	6.93 bc	1.04 bc	4.2 a-e	22.79 cd	146.0 a	0.812 de	56.7 c
V1	3.55 a	2.85 ab	38.80 a	9.71 a	4.25 a-c	3.8 d-f	32.05 a	133.6 a-e	0.834 c-e	84.1 a
Semi-Dwarf Stocks										
CG30	3.50 c	3.44 a	38.79 d	6.54 d	10.03 a	5.00 a	30.31 ab	143.31 a	0.744 a	79.9 a
M26	4.14 b	3.72 a	64.08 b	16.86 b	0.12 b	4.10 b	22.92 b	149.43 a	0.376 c	65.8 b
P1	4.37 a	3.68 a	98.07 a	28.54 a	0.90 b	3.60 b	5.95 c	125.44 b	0.062 d	31.4 c
V2	4.05 b	3.67 a	55.95 c	13.06 c	2.10 b	4.00 b	30.95 a	145.50 a	0.558 b	83.3 a

[z] TCSA = trunk cross-sectional area at 25 cm above graft union.

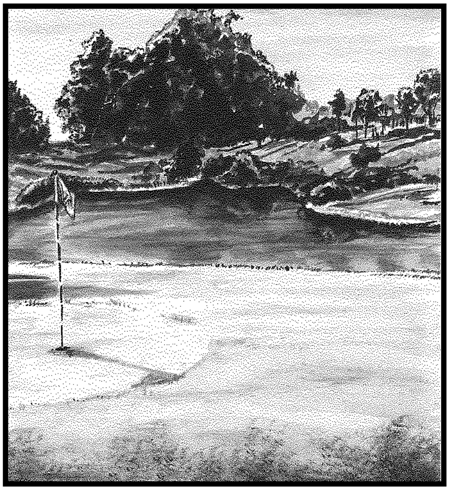
[y] Bloom rating: 0 = no bloom, 3 = ideal bloom quantity for tree size and vigor, 5 = heavy bloom.

[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

Table 3. The effect of rootstock on peach tree growth and yield in the NC-140 1994 peach rootstock trial, Fruit Substation, Clarksville, 1998.

Rootstock	Date of bloom		Date of 10% maturity[z]		Total yield	Avg. fruit	TCSA[y]	Root suckers
	Julian	Calendar	Julian	Calendar	(kg)	wt. (g)	(cm^2)	(no.)
Lovell	86.00 a-cx	27-March	183.43 ab	02-July	15.77 ab	159.36 a	41.87 de	0.00 a
Bailey	86.60 c	27-March	183.38 ab	02-July	20.10 ab	154.21 a	52.25 cd	0.00 a
TN Natural	86.30 bc	27-March	183.00 ab	02-July	19.72 ab	139.30 a	52.81 b-d	0.00 a
Nemaguard	86.67 c	27-March	182.00 ab	01-July	20.78 ab	138.03 a	59.46 b-d	1.00 a
Stark Redleaf	85.90 a-c	26-March	183.00 ab	02-July	21.67 ab	137.51 a	55.68 b-d	0.50 a
GF 305	85.80 a-c	26-March	183.00 ab	02-July	21.29 ab	139.89 a	56.65 b-d	0.00 a
Higama	85.80 a-c	26-March	183.63 a	02-July	14.79 b	136.05 a	56.24 b-d	0.00 a
Montclair	85.50 a-c	26-March	183.50 ab	02-July	19.59 ab	155.94 a	66.77 a-c	0.60 a
Rubira	86.50 c	27-March	183.38 ab	02-July	22.74 a	165.96 a	48.44 de	0.00 a
Ilstara	86.90 c	27-March	183.38 ab	02-July	6.38 c	85.66 b	25.35 f	0.00 a
Myran	86.80 c	27-March	182.25 a	01-July	16.29 ab	116.34 ab	70.28 ab	0.00 a
S.2729	86.30 a-c	27-March	185.14 ab	04-July	20.71 ab	140.06 a	56.24 b-d	1.90 a
BY520-8	84.80 ab	25-March	182.88 a	01-July	18.60 ab	138.74 a	59.30 b-d	0.00 a
BY-520-9	84.80 a	25-March	183.25 ab	02-July	17.98 ab	138.55 a	76.64 a	1.60 a
Ta Tao 5	86.80 c	27-March	186.25 b	05-July	15.69 ab	150.75 a	32.75 ef	0.00 a

[z] Date of first harvest when approximately 10% of crop was determined mature to harvest.
[y] TCSA = trunk cross-sectional area at 25 cm above graft union.
[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).



TURFGRASS & ORNAMENTALS

ZOYSIAGRASS HERBICIDE TOLERANCE

John Boyd and Brian Rodgers[1]

IMPACT STATEMENT

A series of studies were conducted to determine the tolerance of zoysiagrass to common, post-emergence herbicides. Up to five weekly applications of MSMA were found to be safely applied to 'El Toro' and 'Meyer' zoysiagrass. Metsulfuron caused temporary injury to zoysiagrasses but the grass recovered quickly if applied after green-up was complete. Zoysiagrass recovered quickly from diquat applied during spring green-up. Recovery from glyphosate and metsulfuron applied during spring transition was very slow. The safest timing and rate for applying glyphosate to actively growing zoysiagrass for tufted lovegrass control was 0.031 lb active ingredient / acre (a.i. / acre) applied in early July.

BACKGROUND

Arkansas is one of the most prolific producers of zoysiagrass sod in the United States due to limitations of nematodes to the south and a short growing season to the north. Increased demand for zoysiagrass on golf courses in the transition zone has made zoysiagrass an even more important product for Arkansas sod farmers. Golfers like the playability of zoysiagrass sod and turf managers welcome its superior cold tolerance. While zoysiagrass takes more time to produce, profit potential in sod production is greater due to a limited supply. 'Meyer' is by far the most commonly grown zoysiagrass cultivar in Arkansas. Its popularity is due to excellent performance and its status as a public cultivar with no royalty payments assessed at its sale. Proprietary cultivars such as 'El Toro' from the University of California-Riverside, and 'Cavalier' from Texas A&M University, are now produced to a limited extent in Arkansas. Because zoysiagrass is not as widely grown as bermudagrass, there is a limited amount of

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weed control research data available. This lack of information prompted us to initiate a series of studies to evaluate the ability of zoysiagrass to recover from injury caused by typical herbicides used in sod production. Herbicide tolerance in zoysiagrass is similar to bermudagrass but significant differences exist. Due to its slower growth rate, zoysiagrass may lack the ability to recover from MSMA applications that are common to bermudagrass. Because MSMA is the only selective herbicide available for dallisgrass control, knowledge of zoysiagrass MSMA tolerance is important.

The ability of zoysiagrass to withstand the triazine herbicides is also less than that of bermudagrass. An additional problem that has evolved in the Arkansas zoysiagrass industry in the invasion of tufted lovegrass (*Eragrostis pectinacea*) as a serious weed problem. MSMA, fluazifop-butyl, or fenoxaprop do not control this weed, which is rarely a problem in other sod crops. Preemergence control is limited because the commonly-used grass herbicides are root growth inhibitors which are problematic to sod farmers striving for rapid grow-in. Oxadiazon provides fair lovegrass control but is not used due to cost limitations. Triazine herbicides are an option but there is concern among sod farmers that repeated atrazine or simazine applications will reduce sod strength. Zoysiagrasses are particularly sensitive to metribuzin (Sencor). Non-selective herbicides such as glyphosate, diquat, and glufosinate are an important tool for winter weed control in dormant bermudagrass. Zoysiagrass, however, does not become completely dormant in the winter. This lack of dormancy led to the need to develop strategies for the use of non-selective herbicides with minimal injury to the zoysiagrass.

RESEARCH DESCRIPTION

Studies were conducted in central Arkansas on Winrock Sod Farm and Chenal Country Club, Little Rock, and at the Lonoke Extension and Research Center in Lonoke. All studies were conducted on either 'Meyer' or 'El Toro' zoysiagrass. Treatments were applied in a randomized block design with either three or four replications. Plot size varied from 6 by 12 ft to 10 by 30 ft. Herbicides were applied with a carbon dioxide (CO_2) - pressurized backpack sprayer. The carrier volume for all treatments was 20 gallons per acre (GPA). Spraying Systems 110-03XR flat fan tips located on 20-in. spacing were used. All evaluations were done visually using a rating scale of 0 to 100 where 0 = normal healthy turfgrass and 100 = dead or completely brown turfgrass.

FINDINGS

NONSELECTIVE HERBICIDES

In 1995, we applied glyphosate rates up to 1.5 lb a.i. / acre to semidormant zoysiagrass on (cv. Meyer) 31 January. At green-up, 90 days after treatment (DAT), no injury was visible in any of the glyphosate treatments. In the same trial, glufosinate at 0.75 lb a.i. / acre caused no injury. Previous reports of injury by glyphosate on dormant zoysiagrass were possibly due to high carrier volumes (80 to 100 GPA during application) or applying during green up in the spring. Since zoysiagrass rarely goes completely dormant, high carrier volumes would penetrate the canopy and possibly contact active tissues.

In the spring of 1998, we applied diquat and glyphosate to 'El Toro' and 'Meyer' zoysiagrasses that were at the 30% green-up stage (18 March) and to 'El Toro' which was in the 40% green-up stage of growth (27 March). 'Meyer' treated on 18 March with 0.5 lb a.i. / acre diquat completely recovered by 19 DAT while 'El Toro' treated on the same day required 33 days for recovery. 'El Toro', treated on 27 March, needed 57 days to grow out of the injury produced by 0.5 lb a.i. / acre diquat. In the same study, the number of days needed for recovery from 0.75 lb a.i. / acre glyphosate were 18 March application to 'Meyer'-57 days, 18 March 'El Toro' 33- days, 27 March 'El Toro'-47 days. On 7 July 1998, 0.19, 0.25, 0.31 lb a.i. / acre glyphosate applied to 'Meyer' zoysiagrass produced no visual injury symptoms at 21 DAT. The two highest rates of glyphosate provided 90 to 100% control of tufted lovegrass.

MSMA

Two studies were conducted in 1997 to evaluate zoysiagrass response to multiple applications of MSMA at 2.0 lb a.i. / acre. The first treatment was applied on 7 July 1997 and the final application on 4 August. 'Meyer' zoysiagrass recovered from five applications of MSMA applied at five-day intervals within 25 days of the final treatment. Recovery from four applications required the same amount of time. Injury was minimal and recovery rapid from three or fewer applications of MSMA 5 days apart.

METSULFURON

Metsulfuron is a postemergence, sulfonylurea herbicide that controls a broad spectrum of broadleaf weeds and 'Pensacola' bahiagrass. It is also very effective for aiding the transition of overseeded ryegrass to bermudagrass in the spring. This product has excellent safety in bermduagrass but injury to zoysiagrass has been reported. We conducted two studies in the spring and summer of 1997 to evaluate 'El Toro' and 'Meyer' tolerance during transition and after complete green-up. The transition treatments were applied 2 April and the complete green-up applications were made on 3 June. Metsulfuron rates were 0.075, 0.038, 0.019, 0.009 lb a.i. / acre. 'El Toro' sprayed during transition returned to normal 68 DAT but recovered in 30 days when treated after complete green-up. 'Meyer', treated in transition, recovered from all but the highest rate within 48 DAT. Recovery from the highest rate required 68 days. Actively growing 'Meyer' grew out of the metsulfuron injury from all rates within 22 DAT.

EVALUATION OF FIFTEEN PERENNIAL GARDEN ASTERS FOR USE IN ARKANSAS[1]

Lynn M. Goff, Gerald Klingaman, and A. E. Einert[2]

IMPACT STATEMENT

Fifteen garden aster cultivars were grown under outdoor growing conditions to test the effects of planting date, fertility, and pruning treatments. Nine of the 15 cultivars performed adequately and were judged suitable for production. The June planting date produced plants that averaged 36.4 cm tall and 49.1 cm wide. Bloom dates ranged from early August until early October. The largest plants were those fertilized with Osmocote 14-14-14 plus a weekly application of 500 ppm nitrogen (N) using 20-10-20 or those receiving a constant liquid fertilization regime of 180 ppm N using 20-10-20. Shearing proved to be as effective as hand pinching and had no effect on blooming time or duration. The most aesthetically appealing plants were produced by shearing treatments that consisted of monthly shearing until 1 August or 15 August.

BACKGROUND

Garden asters, especially selections of *Aster novae-angliae* (New England Aster), have been commonly grown as fall-flowering, herbaceous perennials throughout the century, but have typically been sold in the spring when not in flower. Around 1980, a Dutch greenhouse grower began experimenting with growing asters for summer and fall sales to compliment other fall crops such as chrysanthemums. Beginning about 1990, Yoder Brothers of Barberton, Ohio, began offering aster cultivars. Since little first-hand experience was available for growers concerning production techniques for this new crop, this study was conducted to answer basic questions regarding cultivar, planting date, fertility, and pruning management.

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[1] This work is based upon the 1993 thesis work of Lynn Marie Goff entitled "Perennial Garden Aster Production in Northwest Arkansas".

[2] All authors are associated with the Department of Horticulture, Fayetteville.

RESEARCH DESCRIPTION

Cultivar and Planting Date. The fifteen cultivars used in this trial consisted of three separate species; 1) *A. novi-belgii* 'Patricia Ballard', 'Shone Von Deitlikon', 'Winston Churchill' and 'Elta'; 2) *A. ericoides* 'Dark Pink Star', 'Monte Casino', 'Butterfly White', 'Butterfly Pink', 'Butterfly Rose' and 'Butterfly Blue'; and 3) selections of *A. novae-angliae* or its hybrids 'Painted Lady', 'Raspink', 'Purple Monarch', 'Lilac Blue Admiral' and 'Skipper'. Plants were grown in Pro-Mix BX (Premier Brands, Inc.) peat-based mix in 12-in. nursery pots for the 6 June planting date and 6-in. pots for the 1 July planting. Each selection was replicated five times at each planting date.

Fertility Trial. Six cultivars, 'Dark Pink Star', 'Raspink', 'Purple Monarch', 'Shone Von Dietlikon', 'Butterfly White', and 'Butterfly Pink' were subjected to common fertilization regimes used for chrysanthemums. The treatments were; 1) single application of Osmocote 14-14-14 at 9 g/12-in. pot or 6 g/6-in. pot; 2) Osmocote as above plus weekly fertilization with a 500 ppm solution (based on nitrogen) of Peter's 20-10-20; or 3) Osmocote plus constant liquid feed of 180 ppm N using 20-10-20. Plants were arranged in a split block with three fertilizer rates and five replications.

Pruning Trial. The pruning trial was designed to determine a method of pruning asters that would result in desirable plant form without affecting bloom quantity, quality or date, of bloom. Nine different pruning treatments were evaluated including; 1) type of pruning (pinching versus shearing); 2) interval of pruning; and 3) date on which pruning was discontinued. Six cultivars ('Monte Casino', 'Patricia Ballard', 'Lilac Blue Admiral', 'Winston Churchill', 'Butterfly Blue' and 'Butterfly Rose') were used in the pruning trial.

FINDINGS

Table 1 and Fig. 1 give the overall rankings and blooming times of the cultivars planted in both June and July. Plants ranged in height for the June planting date from 46.7 cm for 'Lilac Blue Admiral' to 26.0 cm for 'Raspink'. All plant heights represent measurements above the pot rim. Average plant height for the 15 cultivars was 36.4 cm. Average spread was 49.1 cm with 'Monte Casino' averaging 68.6 cm while 'Raspink' had the least spread at 40.1 cm. On average, the perennial asters were 1.3 times as wide as tall. 'Dark Pink Star', 'Shone Von Dietlikon', 'Butterfly Blue' and 'Raspink' had the highest overall quality ranking with their scores all over 9.0. Nine of the 15 cultivars had a quality ranking above 7.0 and were judged suitable for production. One cultivar, 'Butterfly White'- because of high susceptibility to aster rust, was judged completely unsuitable for production. The June planting date resulted in plants that averaged 10.2 cm taller than the July planting.

On average, the asters were in flower for a period of 29.7 days with first blooms appearing on 31 July for 'Shone Von Dietlikon' and last blooms reported on 'Monte Casino' on 7 October (Fig. 1). While the plants were in bloom for nearly a month, it should be recognized that, in most cases, the top of the plants were completely covered with blooms for only about 20 days. In most instances "peak bloom" was judged to be 7 to 10 days after the appearance of first flowers. The June planting tended to bloom about 7 to 10 days earlier than the July planting.

There were no differences between fertilization treatments used when bloom date, bloom duration, or plant height was considered. There was a difference (5.1 cm smaller) in plant spread with treatments receiving only Osmocote 14-14-14 than treatments receiving either the Osmocote plus a 500 ppm N application once a week or the constant liquid fertilization treatment of 180 ppm N using 20-10-20 (data not shown). There was no difference between the weekly fertilization method or the constant liquid fertilization method (data not shown).

Pruning had no significant effect on bloom date or duration (data not shown). The tallest plants were produced by shearing every three weeks until 15 July. The shortest plants were produced by hand pinching every two weeks until 15 August. From an aesthetic point of view, it was determined that the most appealing plants were those with average heights. Pruning treatments that best approximated those conditions were treatments of shearing every four weeks until 1 August or shearing every four weeks until 15 August. Hand pinching was inferior to shearing and required much more labor.

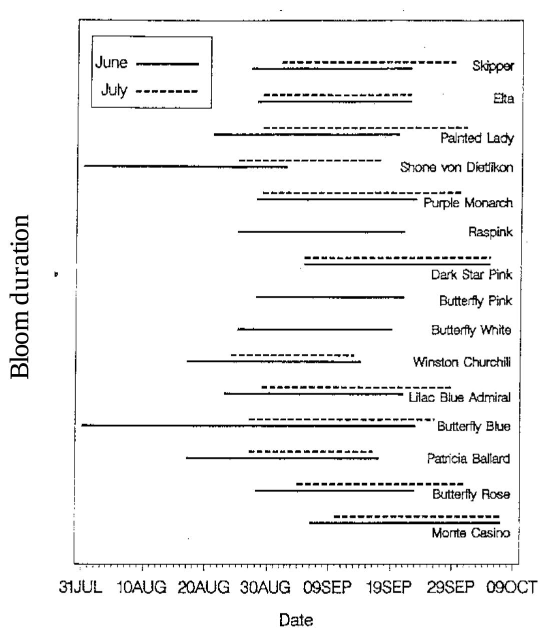


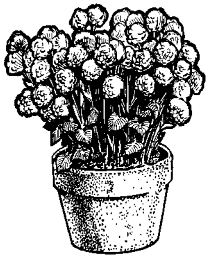
Fig. 1. Bloom duration of 15 aster cultivars in June and July cultivar trials. June trials transplanted as rooted cutting on 6 June 1992; July trials transplanted on 1 July. Lines represent bloom duration for each cultivar and planting date.

Table 1. Garden aster cultivar performance from the June and July planting dates.

	June planted		July planted		Aesthetic	
Cultivar name	Height	Spread	Height	Spread[z]	ranking[y]	Comments
Monte Casino	39.9	68.6	8.3	31.8	40.6	The latest cultivar to flower
Butterfly Rose	42.9	55.9	5.7	21.6	24.9	Smaller blooms 2.2 cm
Patricia Ballard	26.5	44.5	8.7	21.7	29.2	Largest blooms, rust problems
Butterfly Blue	28.4	47.0	9.7	23.0	32.3	Bloomed the longest, no rust
Lilac Blue Admiral	46.7	49.5	5.0	26.9	26.0	
Winston Churchill	32.3	45.5	7.0	21.6	33.7	Flower size 3.2 cm
Butterfly White	45.7	64.0			1.0	Very susceptible to rust
Butterfly Pink	45.7	64.0			7.7	
Dark Pink Star	26.7	42.9	10.0	20.6	29.6	
Raspink	26.0	40.1			9.0	Rust not a problem
Shone Von Dietlikon	28.3	41.9	9.7	11.4	18.4	Early bloom, little rust
Purple Monarch	43.2	47.2	6.0	29.7	28.9	Rust problems
Painted Lady	37.6	50.0	7.3	27.3	29.2	Little rust
Skipper	45.5	43.7	4.3	52.3	29.5	
Elta	45.5	43.7	6.0	32.1	34.3	

[Z] Average of maximum and minimum plant width.

[Y] Aesthetic ranking represents an approximation of aesthetic appeal with 1 = least desirable, 10 = most desirable. Evaluations were made when plants were at the full bloom stage and include characteristics such as; balance, proportionality, flower cover on the crown, appearance of the foliage, and freedom from disease. Represents the June planting date only.



GARDEN CHRYSANTHEMUM TRIALS, 1997

Chester P. Haynie, III and Gerald Klingaman[1]

IMPACT STATEMENT

Fifty-six garden chrysanthemums were evaluated for performance under northwest Arkansas conditions. Peak bloom for most cultivars occurred between 20 September and 10 October. Bloom times for a number of the cultivars did not correspond with reports published by cutting suppliers. There was no significant benefit to pinching cultivars twice, however the use of Florel as a branching aid, in combination with a single pinch, resulted in smaller plants and a six-day delay in flowering compared to plants receiving just one pinch and no Florel. This bloom delay could be used to extend the bloom period for a single cultivar allowing marketing for a longer period.

BACKGROUND

Garden chrysanthemums represent the third most important crop to Arkansas greenhouse growers after bedding plants and poinsettias. Chrysanthemums are grown after the bedding plant crop and during early stages of the poinsettia crop. In Arkansas, garden chrysanthemums are primarily grown outdoors in planting blocks ranging from 1,000 to over 250,000 plants. Retail garden centers often grow their own garden mum crop because it fits in with depressed summer retail sales, thus freeing labor for the growing activities. Garden chrysanthemums help enhance fall sales for retail garden centers as the weather cools and gardeners become interested in sprucing up their landscapes for fall.

Several hundred garden chrysanthemum cultivars are available from commercial suppliers. Growers often select cultivars without having any regional information about the performance of the cultivars. The usual approach is to mix cultivars so that plants will be in flower throughout the sales season which starts in late August and runs through

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Thanksgiving, depending on weather conditions. A mixture of colors is required for good sales. This evaluation was done to help growers choose cultivars that bloom during the period they sell plants.

RESEARCH DESCRIPTION

Rooted chrysanthemum cuttings were provided courtesy of Yoder Brothers Inc., Barberton, Ohio, and VanZanten of North America, Inc., Oxnard, California. Cuttings were potted on 21 and 22 June. Ten plants of each cultivar were grown in a block. The crop was grown in 8-in. pots which were spaced on 24-in. centers on an outdoor gravel pad at the Arkansas Agricultural Research and Extension Center, Fayetteville. The potting medium was a pine bark-based mix (Universal Mix, provided courtesy of Strong-Lite Corp., Pine Bluff). Plants were fertilized with Excel 21-5-20 (Scotts, Inc. Barberton, Ohio) on a constant liquid feed basis with 250 ppm nitrogen (N).

All plants received an initial pinch on 5 July. Half of the plants of each cultivar received a second pinch on 25 July. In a separate experiment, the effect of a single pinch, a double pinch or a single pinch plus a chemical branching aid was tested on three cultivars; Nicole, an early-season white; Jessica, a midseason yellow; and Sondoro a late-season purple. Florel (Florel Brand Fruit Eliminator, Fresno, California) was applied as a branching aid on 25 July. A single foliar application of 1000 ppm was applied until the foliage was fully wetted. Plants were arranged in a randomized block design (with cultivars as blocks) with four, three-plant replicates.

FINDINGS

Table 1 summarizes data collected on the performance of the 56 cultivars evaluated in this trial. Seventeen cultivars had at least some open flowers by 1 September with seven not having their first open flower until the end of September. The first flowering date is important even if plants are not in full bloom because consumers buy chrysanthemums based on color alone, not cultivar name. Peak bloom occurred as early as 14 September for 'Yellow Cloud 9' and as late as 24 October for VanZanten's 'Megan'. Most cultivars had blooming times clustered between 20 September and 10 October. Bloom time designations provided in published reports from the company often did not agree with our findings.

Cutting suppliers have not recommended a second pinch for garden mum crops because most new cultivars are very free branching on their own. Despite this recommendation, many growers give the plants a second pinch in the belief that it will result in a fuller plant. In this study, the time consuming job of providing a second manual pinch proved to be an unnecessary production step. By the time plants in the cultivar evaluation were in flower, it was not possible to tell the once-pinched plants from the twice-pinched plants so data were not collected on the pinching treatments.

In the detailed pinching study there was no statistical difference in plant height, plant spread, days to flower, bloom number, or bloom size for plants of 'Nicole', 'Jessica', or 'Sondoro' when pinched once or twice (Table 2). There was a trend for twice-pinched plants to bloom two to three days later than once-pinched plants, but the difference was not statistically significant.

The application of Florel as a pinching aid in combination with a single pinch was generally unsuccessful at producing a better plant. In comparing the effect of Florel on the size of plants produced, only in 'Jessica' was plant height and spread reduced (Table 2). The mean effect indicated that there was a trend toward production of smaller plants with Florel application, but the effect was not statistically significant. There was no effect from Florel on the number of blooms produced, except in 'Jessica' where fewer flowers formed on the significantly smaller plants receiving the Florel treatment. With fewer blooms on the plants, bloom size was significantly larger for 'Jessica'.

The most significant effect of Florel application was a delay in bloom. On average, bloom was delayed about six days compared to the pinch treatment. This delay would be undesirable if a grower was attempting to achieve earliness, but it might be possible to grow one cultivar, and by using Florel, extend the bloom (and sales) period for that cultivar.

Table 1. Characteristics and bloom times of garden chrysanthemum cultivars grown outdoors in the 1997 trial at Fayetteville.

Cultivar	Supplier[z]	Description[y]	Height[x]	Width[x] in.	Bloom[x] diam(in.)	First bloom	Peak bloom	Notes
Anna	Yoder	yellow daisy	8.0	15.5	1.5	14 September	5 October	
Baby Tears	Yoder	small white button	8.0	14.0	1.0	14 September	5 October	Septoria leafspot problem
Blushing Emile	Yoder	coral/apricot decorative	9.5	15.3	1.3	6 September	1 October	Turns pink with age
Bravo	Yoder	bright red decorative	8.5	14.3	1.8	25 August	21 September	Best early red
Buckeye	VanZan	red decorative	8.0	15.0	2.0	21 September	15 October	
Cherry Emile	Yoder	mauve/red decorative	10.0	15.3	1.3	28 September	18 October	Flowers fade to pink
Christine	Yoder	coral/red decorative	10.5	17.0	2.0	5 September	5 October	One of best midseason
Cockatoo	VanZan	white/yellow daisy	8.0	13.0	1.5	21 August	25 September	Deadheading, Septoria leafspot
Cognac	VanZan	burnt orange decorative	11.0	14.0	1.5	10 September	30 September	
Creme Frolic	Yoder	two-tone ivory decorative	9.5	14.0	1.8	30 August	30 September	
Egrit	VanZan	pale yellow decorative	8.0	13.5		8 September	30 September	Septoria leafspot
Emile	Yoder	two-tone purple decorative	11.5	16.5	1.8	4 September	3 October	
Felicia	Yoder	lavender daisy	9.5	15.0	1.8	5 September	30 September	Fades quickly
Fiery Barbara	Yoder	red-bronze pompon	10.0	14.5	1.1	1 September	30 September	Good color retention
Freedom	Yoder	yellow decorative	10.0	13.0		16 September	15 October	Good late yellow
Frolic	Yoder	white decorative	10.0	14.3	1.5	28 September	16 October	Very compact
Ginger	Yoder	two-tone bronze decorate	10.5	15.0	1.8	16 September	14 October	
Golden Grace	Yoder	golden/yellow daisy	9.8	15.0	1.8	30 August	28 September	Best early daisy
Goldmine	Yoder	golden/yellow pompon	7.5	13.5	1.5	25 August	24 September	Deadheading required
Grace	Yoder	orange/bronze daisy	9.8	16.0	1.3	10 September	28 September	Nice flower form
Harvest Emile	Yoder	two-tone orange decorate	9.5	16.0	2.0	10 September	1 October	Deadheading required
Helen	Yoder	dark-red decorative	11.5	19.0	1.5	25 August	25 September	Non-fading flowers
Holly	Yoder	golden/yellow pompon	11.3	14.5	1.5	10 August	5 October	Flower color holds well

continued

Table 1. Characteristics and bloom times of garden chrysanthemum cultivars grown outdoors in the 1997 trial at Fayetteville. Continued.

Cultivar	Supplier	Description	Height	Width in.	Bloom diam.	First bloom	Peak bloom	Notes
Jennifer	Yoder	bronze decorative	11.0	16.0	2.0	30 August	27 September	Flowers fade quickly
Jessica	Yoder	bright-yellow decorative	11.0	17.0	1.3	25 August	25 September	One of the best yellows
Kimberly	Yoder	pink daisy	11.5	16.5		7 October	22 October	Late bloom
Linda	Yoder	white decorative	11.3	14.8	1.5	14 September	8 October	Very compact
Lisa	Yoder	gold/yellow decorative	11.0	13.3	1.8	11 September	7 October	
Lorikeet	VanZan	purple decorative	9.5	14.5		8 October	22 October	
Lynn	Yoder	lavender decorative	9.5	14.3	1.5	5 September	3 October	
Megan	VanZan	purple w/yellow center	10.0	15.0	2.0	7 October	24 October	Late bloom
Megan	Yoder	lavender duplex daisy	10.5	17.0	1.5	30 August	29 September	Flowers long-lasting
Minnographer	Yoder	red decorative	10.5	14.3	2.5	5 September	3 October	Large red flowers
Naomi	Yoder	dark lavender daisy	12.3	17.5	1.8	25 August	22 September	Earliest Yoder cultivar
Nicole	Yoder	white decorative	8.5	14.5	1.5	18 August	20 September	Blooms turn pink in heat
Nightengale	VanZan	coral decorative	10.0	16.0	1.0	22 September	16 Oct.ober	
Peachy Lynn	Yoder	orange-peach decorative	7.5	14.5	1.3	7 September	2 October	Poor grower, fades quick
Racquel	Yoder	maroon/red decorative	8.5	14.3		7 October	20 October	Good late season
Radiant Lynn	Yoder	two tone salmon	8.5	14.3	1.3	7 September	3 October	Flowers long lasting
Red Remarkable	Yoder	red decorative	8.3	12.3		1 October	15 October	
Remarkable	Yoder	red/bronze decorative	9.5	13.0		27 September	14 October	Late-blooming
Robin	Yoder	orange/red pompon	8.5	14.3	1.3	28 August	29 September	
Rose Pink Deb	Yoder	rose/pink decorative	7.8	11.8	1.3	23 August	20 September	Flowers fade quickly
Sarah	Yoder	yellow spider	9.0	12.5	3.0	30 August	28 September	Compact
Shelly	Yoder	bronze/red pompon	7.3	13.5	1.3	26 August	30 September	

continued

Table 1. Characteristics and bloom times of garden chrysanthemum cultivars grown outdoors in the 1997 trial at Fayetteville. Continued.

Cultivar	Supplier	Description	Height	Width in.	Bloom diam.	First bloom	Peak bloom	Notes
Stargazer	Yoder	dark-lavender daisy	10.0	15.5	1.8	7 September	1 October	Flowers long-lasting
Stephanie	Yoder	white daisy	8.8	14.0	1.5	28 August	26 September	Uniform bloom
Sundoro	Yoder	wine-colored decorative	10.0	16.0	1.3	21 September	10 October	Nice plant form
Sunny Linda	Yoder	yellow decorative	8.3	12.8	1.8	28 August	1 October	Midseason bloom
Tannaga	Yoder	bronze-quilled daisy	8.8	14.3	1.8	3 September	2 October	Very dense form
Tolima	Yoder	white decorative	8.0	14.5	2.3	26 August	24 September	Septoria leafspot
Toucan	VanZan	pink decorative	7.0	12.5	2.3	10 September	1 October	Color fades in heat
Valerie	Yoder	purple decorative	9.5	14.0		28 September	15 October	Best late purple
Warm Megan	Yoder	orange duplex daisy	9.8	14.0	1.1	20 September	7 October	
Yellow Cloud 9	Yoder	yellow semi-incurved	9.5	16.0	3.5	10 August	14 September	Deadheading required Septoria leafspot
Yellow Jacket	Yoder	yellow daisy	9.5	14.5	1.2	1 September	2 October	

[z] Rooted chrysanthemum cuttings were received from Yoder Brothers, Inc., Barberton, Ohio, and VanZanten of North America Inc., Oxnard, California

[y] Flower descriptions represent the bloom types commonly used to describe chrysanthemum flower color and form.

[x] Height is plant height in inches above the pot rim; width is the average of the maximum and minimum crown diameter at full bloom; bloom diameter is the average diameter (inches) of the a typical flower. All measurements were made at the time of full bloom.

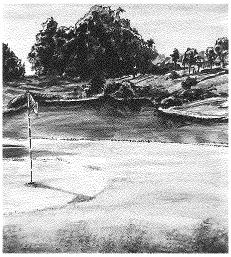
Table 2. Effect of pinching treatment and Florel spray on plant size and bloom characteristics 'Jessica', 'Nicole' and 'Sondoro' in the 1997 garden chrysanthemum trials.

Cultivar	Treatment[z]	Height[y]	Width[y]	Bloom[y] diam.	Days to flower	Number blooms
Nicole	Pinched once	13.0 a[x]	14.1 a	1.6 a	88.8 a	144.7 a
	Pinched twice	12.9 a	14.7 ab	1.6 a	95.3 ab	128.7 a
	1 Pinch + Florel[z]	13.1 a	15.7 b	1.6 a	97.0 b	137.5 a
Jessica	Pinched once	14.5 b	14.5 b	1.6 a	102.7 a	164.2 b
	Pinched twice	15.0 b	14.6 b	1.6 a	102.8 a	158.2 b
	1 Pinch + Florel	12.8 a	13.3 a	1.8 b	106.7 b	114.2 a
Sondoro	Pinched once	14.4 a	14.2 a	2.0 a	105.0 a	149.5 a
	Pinched twice	14.6 a	14.3 a	2.0 a	106.2 a	148.2 a
	1 Pinch + Florel	13.1 a	13.7 a	2.0 a	110.2 b	153.2 a
Mean	Pinched once	13.9 a	14.3 a	1.7 a	98.8 a	152.8 a
	Pinched twice	14.1 a	14.4 a	1.7 a	101.4 ab	146.7 a
	1 Pinch + Florel	13.0 a	14.3 a	1.8 a	104.6 b	133.3 a

[z] Plants were pinched on 5 July with either a second pinch or Florel applied at 1000 ppm on 25 July.

[y] Height is plant height in inches above the pot rim; width is the average of the maximum and minimum bloom size; bloom size is the average diameter of the a typical flower. All measurements were made at the time of full bloom.

[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).



IMPLICATIONS OF SEEDED BERMUDAGRASS PLANTING DATE AND MORPHOLOGY ON COLD TOLERANCE

Kevin L. Hensler[1], Michael D. Richardson[1], and John R. Bailey III[2]

IMPACT STATEMENT

An investigation was conducted to determine the effects of planting date on morphological traits of seeded bermudagrass cultivars and their implications on cold tolerance. Rhizome development was almost non-existent for all cultivars. Root biomass, stolon numbers, and stolon diameter were affected by planting date. Vegetative plantings of 'Tifway' were determined to have greater stolon diameter than seeded cultivars. Initial conclusions indicate morphological immaturity in late-seeded cultivars may reduce cold tolerance.

BACKGROUND

Seeded bermudagrass cultivars are known for quick, easy, and economical turfgrass establishment. The major drawback of seeded bermudagrasses is their lack of cold hardiness. Evaluations conducted in Mississippi indicated seeded cultivars suffered severe winter damage during establishment years, with overall plot survival of 0-3%, compared to 55% survival for vegetatively propagated 'Tifway' (Philley and Krans, 1998).

Morphological immaturity may play a major role in a plant's ability to withstand sub-optimal temperatures during its establishment year. Research conducted in Oklahoma (Ahring *et al.*, 1975) found that common bermudagrass must be planted prior to 25 May to permit sufficient time for cold-tolerant morphological characteristics (i.e. rhizomes and crown buds) to adequately develop. The objective of this research was to assess the affect of planting date and morphological development on cold tolerance of recently released seeded bermudagrass cultivars.

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[1] All authors are associated with the Department of Horticulture, Fayetteville.

RESEARCH DESCRIPTION

Each planting date treatment was initiated on approximately the fifteenth day of each month, beginning in April and ending in August. Seeded cultivars evaluated in the test were; 'Jackpot','Mirage','Pyramid','Sultan','Sundevil', and 'SWI-10'. 'Arizona Common' was used as a seeded standard cultivar and 'Tifway' was included as a vegetative standard. Sample cores (7.3-cm diameter by 6.35 cm deep) were collected from each plot on 10 November 1998. Stolons were counted and stolon diameters were measured on five stolons of each sample. Roots were collected from the sample cores and oven-dried at 38 °C to determine total dry weight.

FINDINGS

Rhizome development was virtually absent in all seeded cultivars, but was substantial in 'Tifway'. A correlation exists between rhizome density and winter survival. The lack of rhizome development in seeded cultivars may play a role in reported inadequacies of cold tolerance, as rhizomes and stolons are considered to be major carbohydrate storage organs for warm-season turfgrasses. There were no statistical differences between seeded cultivars for any morphological traits (data not shown).

A May planting date produced significantly greater stolon numbers per sample than those planted in June, July, and August, while an April date was greater than June and August, but similar to May and July (Fig. 1). Because seeded cultivars are dependant upon stolons as their sole means of carbohydrate storage, a greater number of stolons would probably allow a greater potential for winter survival. Plots seeded in April also had statistically superior stolon diameter than any other planting date (Fig. 1). Stolon diameter decreased as planting dates progressed through the summer, with stolon diameter conceivably being an indicator of morphological maturity.

Stolons and crown tissue are the most likely sites for carbohydrate storage in newly established bermudagrasses, and diameter may reflect total carbohydrate availability. 'Tifway' has been observed to have greater cold tolerance than seeded bermudagrasses (Philley and Krans, 1998), while in our study seeded cultivars had significantly smaller stolon diameters than 'Tifway' (data not shown). 'Arizona Common', a cold-sensitive bermudagrass, was found to have the smallest stolon diameter of any of the seeded cultivars evaluated.

Root dry weight was statistically greater when planted in April and May compared to other dates (Fig. 1). During spring green-up, DiPaola *et al.* (1982) observed 'Tifgreen' roots undergoing senescence as shoot initiation occurred, without any outward signs of new root initiation. This suggests the plant may be redirecting carbohydrates stored in the roots towards shoot and leaf tissue production. Photosynthesis can then sustain the plant and energy can be directed towards root synthesis. This may explain the three-week delay in root initiation observed by DiPaola *et al.*(1982).

Initial conclusions indicate that a lack of morphological development in seeded cultivars during the establishment year may inhibit cold tolerance. Potential users of seeded bermudagrasses should be aware that Arkansas summers may be too short to allow full growth and maturity which could reduce cold hardiness.

LITERATURE CITED

Ahring, R.M., W.W. Huffine, C.M. Taliaferro, and R.D. Morrison. 1975. Stand establishment of bermudagrass from seed. Agron. J. 67:229-232.

DiPaola, J.M., J.B. Beard, and H. Brawand. 1982. Key events in the seasonal root growth of bermudagrass and St. Augustinegrass. HortScience 17:829-831.

Philley, H.W. and J. V. Krans. 1998. Turf performance of seeded bermudagrass cultivars. Golf Course Management 11:62-66.

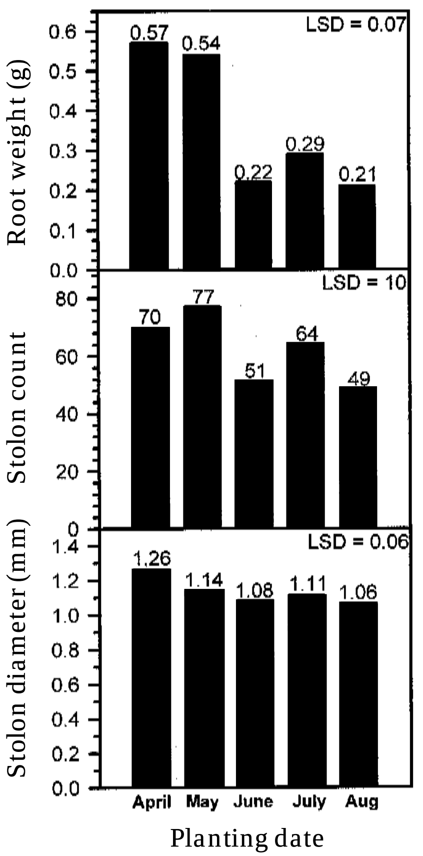

Fig. 1. Root weight, stolon weight, and stolon number of seeded bermudagrasses as affected by planting date.

OVERSEEDING WARM SEASON LAWNS WITH COOL SEASON TURFGRASS SPECIES

David E. Longer[1]

IMPACT STATEMENT

In 1988, a study was initiated at the Arkansas Agricultural Research and Extension Center, Fayetteville, to assess low-input methods of establishing cool season turfgrass species into established bermudagrass and zoysiagrass lawns. Early planted treatments (mid-September) performed better than the later planted treatments (mid-October) in all visual quality rating categories in bermudagrass. All treatments were superior to the dormant warm season species with regard to color. The data indicate that cool season turfgrass species may be able to provide aesthetically pleasing winter color when established in dormant, warm season lawns.

BACKGROUND

Warm season grasses such as hybrid bermudagrass and zoysiagrass have become the species of choice for many southern homeowners because of their ability to withstand prolonged periods of heat and drought. Improved zoysia cultivars have increased disease resistance and improved shade tolerance. A major drawback of zoysia and bermudagrass is that they turn an aesthetically unpleasant straw color with onset of cold weather. By overseeding cool season species into established warm season lawns, it is possible to extend the growing season of a green lawn. For broad appeal to homeowners, an overseeding program must be effective (in establishing year 'round green turf color), inexpensive, and simple.

RESEARCH DESCRIPTION

Cool season grass blends were obtained from Loft's Seed Co. The blend known as "Triplex" consisted of equal portions of three perennial ryegrass cultivars; 'Palmer III', 'Prelude III', and 'Repel III'. The other blend known as "Athletic Field Mix"

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consisted of 10% 'Palmer III' perennial ryegrass, 10% 'Preakness' Kentucky bluegrass and 80% 'Rebel III' tall fescue. In addition to the two blends, the effects of planting date and scalping or not scalping the warm season species prior to seeding were tested. Seeding rate for each blend was 5 lb / 1000 ft^2 and each plot was fertilized using a complete fertilizer (19-19-19) at the rate of 1 lb nitrogen (N)/ 1000 ft^2 two weeks after seeding to promote establishment. All other management inputs were in accordance with recommendations for warm season species. All plots were evaluated monthly for color, quality, density, and percent weeds.

The field test was established as a split, split-plot with blends being the main split and planting date and pre-plant scalping as subsequent splits. Immediately following both seedings, plots were irrigated daily until emergence, which occurred within 8 to 10 days after seeding. All plots were qualitatively rated monthly and mowed to 0.75 in. during periods of active growth.

FINDINGS

Initial data analysis showed treatment differences for seeding date only in bermudagrass. The early-planted (mid-September) treatments performed better than the late-planted treatments (mid-October) (Table 1). Although not statistically significant, the early seeding date had fewer winter weeds compared to late-planted treatments. The "Triplex" blend in bermudagrass rated 2.5 points higher for color, density, and texture in the early-seeded plots vs. the late-seeded plots (Table 1). Color and density were higher in early-planted "Athletic Field Mix" than late-planted and percent weeds were greater in the late-planted treatments when compared with the early-seeded plots. Treatment differences were not significant in the zoysia plots, although all treatments were superior to dormant zoysia with regard to color (Table 2).

Preliminary visual and quantitative analysis indicate that cool season turfgrass species may be able to provide aesthetically pleasing winter color when established in warm season, dormant lawns. All overseeded plots were no lower than 6 on the color scale and much better than the zoysia and bermudagrass controls until a late December period of very cold weather. Color ratings for the months of January and February should indicate how well they recovered.

In summary, perennial ryegrass blends and blends of Kentucky bluegrass, tall fescue and perennial ryegrass were overseeded into existing bermudagrass and zoysiagrass plots. Both blends showed promise by providing an extended season of green color to winter dormant bermudagrass and zoysiagrass lawns when overseeding occurred in mid-September.

Table 1. Quality ratings of cool season turfgrass blends overseeded into established bermudagrass turf, December 1998.

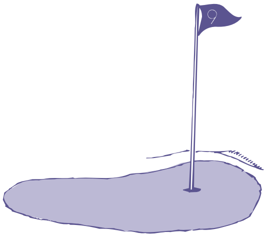
Cultivar/treatments	Color[z]	Density[z]	Texture[z]	Weeds (%)
Triplex Blend				
Early planted				
scalped	8	9	8	2
not-scalped	9	9	8	2
Late planted				
scalped	6	7	6	5
not-scalped	6	6	7	10
LSD ($P < 0.05$)	1.7	1.6	1.6	NS[y]
Athletic Field Mix				
Early planted				
scalped	8	9	6	2
not-scalped	8	9	7	2
Late planted				
scalped	6	6	6	5
not-scalped	6	6	7	15
LSD ($P < 0.05$)	2.0	2.2	NS	NS
Bermudagrass control[x]	1	5	6	2

[z] Color, density, and texture ratings are based on a scale of 1-9, with 9 being "best".
[y] Not significant.
[x] Bermudagrass was dormant at this rating time.

Table 2. Quality ratings of cool season turfgrass blends overseeded into established zoysia turf, December 1998.

Cultivar/treatments	Color[z]	Density[z]	Texture[z]	Weeds (%)
Triplex Blend				
Early planted				
scalped	7	7	7	0
not-scalped	7	7	8	2
Late planted				
scalped	7	6	6	2
not-scalped	6	5	6	0
LSD ($P < 0.05$)	NS[Y]	NS	NS	NS
Athletic Field Mix				
Early planted				
scalped	8	8	7	0
not-scalped	7	7	7	0
Late planted				
scalped	7	6	7	0
not-scalped	7	6	8	0
LSD ($P < 0.05$)	NS	NS	NS	NS
Zoysia control[x]	1	8	6	0

[z] Color, density, and texture ratings are based on a scale of 1-9, with 9 being “best”.
[y] Not significant.
[x] Zoysia was dormant at this rating.



ETIOLOGY AND CONTROL OF SUMMER DECLINE OF BENTGRASS PUTTING GREENS

Eugene A. Milus[1], *Michael D. Richardson*[2], *Kevin L. Hensler*[2], *and Chris T. Weight*[1]

IMPACT STATEMENT

Fungicides were evaluated for control of bentgrass summer decline in Arkansas, and the etiology of the disease was investigated. Registered and experimental chemicals in the strobilurin class of fungicides were the only effective treatments. Rate and timing of these fungicides did not appear critical because even one application of a low rate gave effective control and worked well as both preventive and curative treatments. *Idriella bolleyi* was the most commonly isolated fungus from diseased plants and is likely the pathogen responsible for the decline. Additional experiments are required to prove that *I. bolleyi* is the cause of the disease.

BACKGROUND

Maintaining the quality of bentgrass putting greens in the transition zone has been a perennial problem. Temperature and relative humidity are often too high during the summer in Arkansas for optimum growth of bentgrass which is used on putting greens of many golf courses. Various pathogens have been shown or are suspected to contribute to the summer decline syndrome. In Arkansas, the decline has often been attributed to "root Pythium" even though there has never been definitive data showing that *Pythium* sp. contributed to decline, and fungicides selective for this group of fungi were often applied as preventive and curative control measures. The objectives of this study were to identify the cause of summer decline and to determine which fungicides, rates, and timings are effective control measures.

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RESEARCH DESCRIPTION

This study was conducted at Fianna Hills Country Club in Fort Smith, on a 'Penncross' creeping bentgrass green with a history of summer decline. The grass was maintained at 5/32-in. mowing height and standard practices used at Fianna Hills were carried out including irrigation, fertilization, and weed control. The design was a randomized complete block with 26 fungicide treatments and four replications. Individual plots were 4 ft x 5 ft and were isolated using a rectangular spray shield during applications. Treatments were applied at 4 gal/1000 sq ft of water using a hand-held carbon dioxide (CO_2) - powered sprayer at 20 psi with a Tee-jet 800 2VS spray tip. Treatments were applied on approximate 14- or 28-day schedules as indicated in Table 1.

Disease severity ratings (percentage of plot diseased: 0, 2, 7, 15, 30, 50, 70, 85, 93, or 98%) and turf quality ratings (0 = no grass to 9 = perfect putting surface) were made on 30 June, 6 July, 23 July, and 21 August 1998, except that no turf quality ratings were taken on 23 July. Two 1-in. diameter by 3 in. long plugs were taken from each plot on 6 July and 21 August to determine the effect of treatments on root length. The average length of the largest three roots was considered to be the root length, and the root lengths in the two plugs per plot were averaged before statistical analysis. All statistical analyses were done using the SAS ANOVA procedure.

Samples of diseased turf were taken on several dates beginning 30 June. Samples were examined microscopically for symptoms and evidence of pathogens. Individual plants were thoroughly washed, disinfested using 10% bleach for 0.5 to 1.5 min, and plated on water agar and a medium selective for *Pythium* sp. Individual fungal colonies growing from plants were transferred to potato dextrose agar and allowed to sporulate so that the fungi could be identified.

FINDINGS

Disease first became evident on 26 June as small (1- to 4-in. diameter) spots of yellow, sunken turf with irregular and diffuse margins. On closer examination, the leaves and crowns had a water-soaked appearance. Leaves were yellow except for a dark-gray streak in the center from the base to about two-thirds of the length, and leaf sheaths were covered with a dark brown to black "crust". The spots quickly coalesced into larger areas of diseased turf that had a matted appearance, but plants remained alive. The most commonly isolated fungus was identified as *Idriella bolleyi* (synonyms *Microdochium bolleyi*, *Aureobasidium bolleyi*, and *Gloeosporium bolleyi*) commonly found on roots of grasses and has been identified as a minor root pathogen on bentgrass in Iowa (Hodges and Campbell, 1996). Additional experiments are required to prove that *I. bolleyi* is the cause of the disease.

By 6 July it was clear that only treatments of Heritage, BAS 500, BAS 505, or CGA 279202 controlled the disease (Table 1), and this pattern was maintained for subsequent ratings. All these chemicals are in the strobilurin group of fungicides. Of these, only Heritage is registered for use on bentgrass. Even treatments that contained a single application of Heritage at a low rate (0.2 oz/1000 sq ft) gave significant control. Heritage appeared to work both as preventive and curative applications, so timing did not appear critical. By 21 August, treatments with Daconil Zn, Spectro, and Bayleton + Daconil Ultrex had significantly more disease and significantly lower turf quality ratings than the non-treated checks. These treatments may have suppressed other microorganisms in the turf that naturally suppress the pathogen.

Treatments that controlled the disease generally had excellent turf quality (Table 1). Turf quality ratings were negatively correlated with disease severity ratings. Correlation coefficients ranged from -0.79 to -0.93 indicating that, in general, disease control played a major role in maintaining turf quality. Maximum treatment showed some efficacy against the disease, but turf quality was lower than expected for that level of control because the turf had a coarse appearance.

There were no differences in root length on 6 July (data not shown, overall mean = 7.7 cm) and only small differences significant at P = 0.10 on 21 August (Table 1). Two treatments (Daconil Zn and Bayleton + Daconil Ultrex) had roots significantly shorter than the non-treated checks, and no treatments had roots significantly longer that the non-treated checks.

LITERATURE CITED

Hodges, C.F. and D.A. Campbell. 1996. Infection of adventitious roots of *Agrostis palustris* by *Idriella bolleyi*. J. Phytopathology 144:265-271.

ACKNOWLEDGMENTS

We wish to thank Rodger Pevehouse, superintendent at Fianna Hills, for providing the green to conduct this research, and his grounds crew for maintaining the plots during the course of the study. We thank Bayer Garden and Professional Care, BASF Corporation, Cleary Company, Novartis Turf and Ornamental Products, Rohm and Haas Company, and Zeneca Professional Products for financial support.

Table 1. Results of turf fungicide test at Fianna Hills Country Club, Fort Smith, Arkansas, 1998.

		Disease severity				Turf quality			Root length
Treatment (rate of product/1000 ft^2)	Spray interval[z]	30 June	6 July	23 July	21 Aug.	30 June	6 July	21 Aug.	21 Aug.
	(days)	%				(0-9)			(cm)
BAS 500F, 0.28 fl. oz.	14	14	2	0	1	6.5	7.3	7.3	7.0
BAS 500F, 0.42 fl. oz.	14	12	9	0	1	6.5	6.8	7.5	7.6
BAS 500F, 0.52 fl. oz.	28	1	2	0	1	7.5	7.3	7.8	7.5
BAS 505 50DF, 0.14 oz.	14	10	2	1	2	6.5	7.0	7.5	7.6
BAS 505 50DF, 0.21 oz.	14	24	8	15	1	5.8	6.3	7.5	6.6
BAS 505 50DF, 0.28 oz.	28	3	0	0	1	7.3	7.8	7.5	7.3
CGA 279202 50WP, 0.15 oz. +Subdue Maxx 2E, 0.5 fl.oz.	14	12	2	1	1	6.3	5.5	7.5	7.3
CGA 279202 50WP, 0.3 oz +Subdue Maxx 2E, 0.5 fl.oz	14	8	1	1	8	6.3	7.3	6.5	7.7
Heritage 50WG, 0.2 oz.	14	10	1	0	1	6.5	7.8	8.0	6.9
Heritage 50WG, 0.2 oz. / alternated with Daconil Zn 4.17F, 6.0 fl. oz.	14	0	2	9	15	8.0	7.0	6.3	6.0
Daconil Zn 4.17F, 6.0 fl. oz.	14	2	14	90	98	7.0	6.0	1.0	5.8
Daconil Zn 4.17F, 6.0 fl. oz. + Aliette 80WDG, 4.0 oz.	14	38	48	91	93	5.8	5.0	2.0	6.8
Heritage 50WG, 0.4 oz.	28	5	1	0	1	7.0	7.5	7.5	7.4
Maximum 63WP, 10.0 oz.	14	4	23	73	17	6.5	4.0	5.5	6.8
Eagle 40WP, 1.2 oz. / alternated with Heritage 50WG, 0.4 oz.	14	9	14	14	2	6.5	6.3	6.5	6.7
Spectro 90WP, 8.0 oz.	14	2	6	75	90	7.0	6.7	3.0	6.4
Lynx 45WP, 0.28 oz. + Daconil Ultrex 82.5WP, 1.8 oz.	14	12	3	70	38	6.3	6.8	4.5	7.9
Lynx 45WP, 0.28 oz. + Heritage 50WG, 0.2 oz.	14	5	1	0	6	7.0	7.3	7.3	7.5
Bayleton 50DF, 0.25 oz. + Daconil Ultrex 82.5WP, 1.8 oz.	14	16	29	81	76	5.5	5.0	3.3	5.8
Bayleton 50DF, 0.25 oz. + Heritage 50WG, 0.2 oz.	14	9	2	0	3	7.0	6.8	6.8	7.2
Eagle 40WP, 1.2 oz (13 May); Terrazole 35WP 5.0 oz. (26 May); Heritage 50WG, 0.4 oz (9 June); Subdue Maxx 2E, 1.0 fl. oz. (6 July)	N/A	4	1	1	7	6.8	7.0	6.8	7.2
Chipco 26019 50WP, 2.0 oz. (13 May, 26 May, 9 June, 30 June, 6 July); Subdue Maxx 2E, 1.0 fl. oz. (23 July)	N/A	39	21	71	26	5.5	5.3	5.5	7.3
Prostar 50WP, 2.0 oz. (26 May, 9 June); Heritage 50WG, 0.2 oz. (6 July)	N/A	31	31	0	3	5.8	5.3	7.3	7.4

continued

Table 1. Results of turf fungicide test at Fianna Hills Country Club, Fort Smith, Arkansas, 1998. Continued.

Treatment (rate of product/1000 ft^2)	Spray interval	Disease severity 30 June	6 July	23 July	21 Aug.	Turf quality 30 June	6 July	21 Aug.	Root length 21 Aug.
	(days)	– – – – – – % – – – – – –				– – – (0-9) – – –			(cm)
Prostar 50WP, 2.0 oz. (26 May); Prostar 50WP, 2.0 oz. + Terrazole 35WP, 5.0 oz. (9 June); Heritage 50 WG, 0.2 oz. (6 July)	N/A	36	21	1	2	5.5	5.5	7.0	6.8
Nontreated check #1	—	23	29	81	46	5.5	5.3	4.8	7.0
Nontreated check #2	—	32	16	80	49	5.3	5.0	4.3	7.1
Prob. > F		– – – – – 0.0001 – – –				– – 0.0001 – – –			0.1
CV (%)		89	103	29	59	11.0	16.0	13.0	13.0
LSD (P = 0.05)		18	17	12	19	1.0	1.5	1.2	—
LSD (P = 0.10)		—	—	—	—	—	—	—	1.1

[z] N/A = not applicable

EFFECTS OF MYCHORRIZAL INOCULANTS ON CREEPING BENTGRASS ESTABLISHMENT

Michael D. Richardson[1], Kevin L. Hensler[1], and Jeff Elliot[2]

IMPACT STATEMENT

The development of methods to hasten the establishment of bentgrass putting greens would be a great advantage to golf course developers and renovators. A mycorrhizal inoculant, marketed as "Grow-In", showed highly significant beneficial effects on bentgrass growth and development compared to traditional establishment procedures.

BACKGROUND

Rapid establishment of creeping bentgrass greens is desirable to speed the opening of new golf courses and hasten renovation projects. A number of products, generally classified as soil additives or bio-stimulants, are currently being used to speed this process. The potential of using microbial inoculants such as mycorrhizae has been poorly studied in turfgrass systems, although it is widely known that these fungi are beneficial in nutrient-poor situations as is found in a sand-based putting green. However, specific organic formulations must be used in the delivery of these microbes to establish a sufficient mycorrhizal population in the soil that can ultimately impact the host grass. The objective of this project was to study the use of a new mycorrhizal formulation developed by Ocean Organics, Waldoboro, Maine, to hasten establishment of creeping bentgrass in sand-based putting greens. Initial information regarding the effects of the organic carrier material (marketed as "Grow-In") was also needed to compliment the effects of the microbial component.

RESEARCH DESCRIPTION

A field trial was established on a putting green at Chenal Country Club, Little Rock. This USGA green was seeded to creeping bentgrass (*Agrostis stolonifera* cv.

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Penn A1) on 8 April 1998 at 0.75 lb / 1000 ft^2. Prior to establishing plots, a slow-release, inorganic fertilizer was applied at a rate of 0.68 lb nitrogen (N), 0.93 lb phosphorus (P) and 0.17 lb potassium (K) per 1000 ft^2 and was incorporated lightly into the upper 2 in. of soil. Just prior to seeding, soil amendments were applied to the surface at 50 lb / 1000 ft^2 and lightly worked into the soil. Experimental treatments included the pre-plant fertility treatment alone (control), fertility plus Grow-In, and fertility plus Grow-In containing the mycorrhizal inoculant. Plot size was 8 x 8 ft and each treatment was replicated four times in a randomized complete block design. Rate of establishment was evaluated weekly and clipping weights were determined for each treatment. Nutrient analysis was also conducted on clippings. At eight weeks after establishment, soil cores (1-in. diameter) were extracted from each plot to 6-in. depth, sand washed from roots, and root weights recorded.

FINDINGS

Highly significant differences in seedling vigor and clipping yields were observed for the amended plots compared to the controls (Table 1). Clipping yields were generally increased around 50% by the amended plots, with as much as 100% increases on specific dates. However, there were no statistical differences between the plots receiving Grow-In and the Grow-In plus mycorrhizae plots (Table 1), indicating very little advantage from the mycorrhizae. Root samples failed to reveal any significant differences between the treated and untreated plots. It is noteworthy, however, that the tremendous increases in shoot growth observed did not occur at the expense of root growth.

Treatments containing Grow-In also had a significant effect on tissue nutrient content (Table 2), even though biomass was significantly increased. Increases in N, calcium (Ca), magnesium (Mg), and sulfur (S) were observed in all amended plots compared to controls. Mycorhhizae are known to have significant effects on P nutrition in many plant species, so it was anticipated that the mycorhhizal effects might be observed in the nutrient content. However, P level was not affected in this study. Microscopic analysis of the turf roots revealed that the mycorrhizae had colonized the roots and were apparently functional. These results further suggest that the impact of mycorrhizae were minimal.

In summary, a highly significant increase in shoot growth and establishment rates were observed when the products Grow-In and Grow-In plus mycorrhizae were incorporated into newly-seeded bentgrass greens. Chemical analysis of the actual products indicated that the material contained a quantity of N in organic form (data not shown) that could impact overall response of the grasses. However, additional studies not reported at this time have shown that when Grow-In is matched against similar-analysis quantities of soluble or slow-release fertilizer, the comparison products fail to yield matching results. This would suggest that fertility failed to account for the overall growth responses observed in this test.

Table 1. Seedling vigor and growth response of creeping bentgrass to an organic carrier (Grow-In) or an organic carrier amended with mycorrhizae.

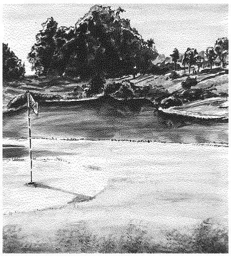
Treatment	Seedling vigor[z]	Dry clipping wt.			Root wt.
		29 May	8 June	18 June	19 May
		– – – – – – g – – – – – –			mg
Control	5.0 b[y]	16.5 b	51.5 b	31.0 b	112 a
Organic carrier	6.4 a	35.5 a	69.8 ab	53.0 a	105 a
Organic carrier + mycorrhizae	6.9 a	33.0 a	77.0 a	50.5 a	120 a
LSD ($P < 0.05$)	0.6	5.8	22.7	13.7	NS[x]

[Z] Seedling vigor rated on scale of 1 to 10 with 10 - best.
[Y] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).
[x] Not significant.

Table 2. Leaf nutrient content[z] (percent dry weight) of creeping bentgrass amended with an organic carrier (Grow-In) or an organic carrier amended with mycorrhizae.

Treatment	N	P	K	Ca	Mg	S
	– – – – – – – – – – – – – % – – – – – – – – – – – – –					
Control	2.92 b[x]	0.51a	1.56 ab	0.65 b	0.28 b	0.43 c
Organic carrier	3.67 a	0.59a	1.68 a	0.75 a	0.31 a	0.53 a
Organic carrier + mycorrhizae	3.49 a	0.50a	1.53 b	0.76 a	0.31 a	0.49 b
LSD ($P < 0.05$)	0.20	NS[y]	0.14	0.04	0.02	0.02

[z] Nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).
[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).
[y] Not significant.



MORPHOLOGICAL CHARACTERISTICS OF INTERMEDIATE RYEGRASS CULTIVARS (*Lolium perenne* x *Lolium multiflorum*)

Michael D. Richardson[1], *Sarah DaBoll, Jonna McDaniel, Mitzi Miller, and Keith Warner*

IMPACT STATEMENT

Intermediate ryegrass cultivars were evaluated to determine if these hybrid species have desirable characteristics for turf managers in Arkansas. Seven cultivars, including two annual, two intermediate, and three perennial ryegrasses, were compared in a greenhouse study to assess morphological characteristics that are commonly associated with turf quality. Results from the study indicate that one cultivar of intermediate ryegrass ('Pick-LHRT') has morphological traits similar to the turf-type perennial grasses, while the other intermediate ('Froghair') has characteristics more similar to annual grasses. Our preliminary conclusion is that intermediate ryegrasses may have promise as an overseeding grass in the transition zone.

BACKGROUND

Intermediate ryegrass (*Lolium perenne* x *Lolium multiflorum*) cultivars have been developed in recent years as a low-cost alternative to perennial ryegrass, with special emphasis on use as overseeding dormant bermudagrass in the deep South. Although two cultivars are currently being marketed, there is no information available on the characteristics of intermediate ryegrass relative to annual or perennial ryegrass. The objective of this research was to evaluate morphological characteristics of intermediate ryegrass compared to annual or perennial ryegrass.

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RESEARCH DESCRIPTION

Seven cultivars of intermediate, annual, and perennial ryegrasses were included in our greenhouse study (Table 1). Individual seedlings of each line were established in a 4-in. pot containing a commercial potting mix. Three seeds were placed near the center of each pot and covered lightly with additional potting mix. After germination, each pot was thinned to one seedling.

Pots were fertilized weekly with 100 ml of a complete nutrient solution containing 50 ppm nitrogen (N). At 6, 8, 10, and 12 weeks after planting, four replicate pots of each line were harvested at the soil surface and separated into leaf sheath and leaf blade materials. Data collected at each harvest included number of tillers, width of fully expanded leaf blades (average of four sub-samples), dry weight of leaves, dry weight of sheath, and average height of leaf collar (average of four sub-samples). Data collected were used to calculate total shoot weight, leaf blade weight tiller, and sheath weight tiller. For brevity, data from the first harvest are presented in this report. The experimental design was a randomized complete block and data were analyzed by ANOVA.

FINDINGS

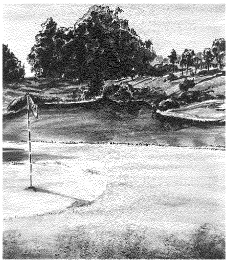
Cultivar differences were observed for all parameters measured. As expected, leaf texture (blade width) was significantly higher for annual compared to perennial cultivars (Table 1). However, leaf textures of the two intermediate cultivars were not truly intermediate between the other species. In fact, 'Froghair' had a leaf texture that was similar to the annual species, while 'Pick-LHRT' leaf texture was not significantly different from the perennial ryegrasses. Other parameters, including total weight per tiller, leaf weight per tiller, and sheath weight per tiller exhibited similar results.

Collar height was also significantly different between the two intermediate cultivars (Table 1). 'Froghair' had an average collar height of 61.0 mm, while 'Pick-LHRT' had a collar height of 43.3 mm. This parameter is significant for overall turf performance in that an elevated collar height reduces the amount of leaf production that occurs below the mowing height and subsequently affects turf density and quality. This data suggests that 'PickLHRT' may be much more adapted to close mowing than 'Froghair'.

Differences in morphological characteristics between 'Froghair' and 'Pick-LHRT' would suggest that, while these grasses are both intermediate species, 'Froghair' has more annual characteristics and 'Pick-LHRT' behaves much more like a perennial ryegrass. Preliminary results from a field trial comparing these varieties would also suggest that 'Pick-LHRT' has much better overall turf quality than 'Froghair' (data not shown). Although these initial observations suggest that certain intermediate ryegrass cultivars have desirable turf characteristics, long-term evaluations of these hybrids under field and controlled-environment conditions are needed to fully assess the value of intermediate ryegrass to Arkansas turf managers.

Table 1. Morphological characteristics of two intermediate ryegrass cultivars relative to annual and perennial ryegrass cultivars.

Species	Variety	Tiller no.	Leaf width (mm)	Collar ht.	Sheath wt.	Leaf wt.	Shoot wt.	Total wt./ tiller	Leaf wt./ tiller	Sheath wt./ tiller
Annual	Gulf	10.0	6.4	54.7	226	661	887	89	67	23
Annual	TAM-90	11.3	7.0	50.3	324	923	1246	112	84	29
Intermediate	Froghair	9.7	6.4	61.0	234	688	922	102	75	27
Intermediate	Pick-LHRT	16.7	3.8	43.3	174	478	652	39	29	11
Perennial	Racer	15.7	3.0	24.7	151	332	483	30	21	9
Perennial	Jiffie	10.3	2.9	26.7	116	265	381	39	27	12
Perennial	Calypso	10.7	3.2	27.0	69	238	307	30	24	7
	LSD ($P < 0.05$)	6.3	1.3	12.1	132	328	442	38	29	10



PERFORMANCE OF CREEPING BENTGRASS CULTIVARS IN ARKANSAS, 1998 REPORT

Michael D. Richardson[1], Kevin L. Hensler[1], John W. King[1], John W. Boyd[2], and Jeff Elliot[2]

IMPACT STATEMENT

A creeping bentgrass trial was established in Little Rock, to evaluate 19 bentgrass cultivars under typical putting green conditions. During the first year of evaluation, several newer cultivars exhibited superior heat tolerance and stand survival over some of the older cultivars. Preliminary conclusions are that recently released bentgrass cultivars 'Crenshaw', 'Imperial', and 'Century' are well-adapted to Arkansas growing conditions and show promise for golf course establishment or renovation.

BACKGROUND

Creeping bentgrass remains the grass of choice for putting greens in the northern United States and throughout the transition zone. This species is noted for its adaptation to close mowing, high shoot density, and superior putting quality. In recent years, a large group of new bentgrass germplasm has been developed by plant breeders in the U.S. This germplasm has been selected for characteristics such as overall turf quality and performance, heat tolerance, disease resistance, and salinity tolerance. Although these new cultivars began to appear in the market in the mid-1990s, there have been no evaluations of these cultivars in Arkansas. With the continued growth of the golf industry in Arkansas, and the widespread construction and renovation of golf courses in the state, a critical evaluation of these new conditions under Arkansas conditions was needed.

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RESEARCH DESCRIPTION

A replicated cultivar trial was established on 23 March 1998 at Chenal Country Club, Little Rock. The green on which the test was established had been constructed according to USGA specifications in the fall of 1997 and had remained fallow until the spring of 1998. Each plot was 4 x 8 ft and was individually hand-seeded at a rate of 0.5 lb / 1000 ft^2. An organic fertilizer (Hou-Actinite, 6-3-0) was incorporated with the seed at a rate of 0.75 lb N / 1000 ft^2. The experimental design was a randomized complete block with three replications of each cultivar.

Fertilization and pest control of plots were done according to routine practices used on the remainder of the greens at Chenal Country Club. Briefly, approximately 1 lb of N / 1000 ft^2 was applied to the plots monthly during the first three months of the experiment and approximately 0.25 lb of N / 1000 ft^2 per month was applied during the summer and early fall. A preventative fungicide program was followed to prevent brown patch and pythium and to control algae growth. The program included alternating applications of Daconil Ultrex (2 oz / 1000 ft^2) and Alliette / Fore (4 oz / 6 oz per 1000 ft^2) every 14 days. From June through September, Dursban was applied at 0.75 oz / 1000 ft^2 every 28 days to prevent cutworms.

Germination and establishment of the plots were assessed visually during the first two months after planting and turf quality was measured monthly. Following the severe heat and drought period of the summer of 1998 and into the fall recovery period, visual determinations of plot cover were made simultaneously with turf quality. Data were subjected to analysis of variance and means were separated using Least Significant Difference (P=0.05). For purpose of presentation, performance data were grouped by season and within-season analysis of variance performed.

FINDINGS

Germination was first observed within seven days after establishment and good cover for all plots was observed by 1 May. Several cultivars exhibited good seedling vigor and stand establishment (Table 1), including ‘SR 1020’, ‘Grand Prix’, ‘Crenshaw’, and ‘Cobra’. However, all cultivars produced acceptable stands within eight weeks after planting (data not shown). Overall spring quality was similar for most of the cultivars and no statistical differences were observed between the top 15 cultivars.

Many of the plots began to lose considerable cover during the summer and several cultivars exhibited substantial stand loss by the early fall. The cultivars ‘Providence’, ‘Penn G6’, ‘Cobra’, ‘L93’, ‘Putter’, and ‘Cato’ lost over 30% total stand by 1 September and experienced a substantial drop in overall quality (see fall quality Table 1). Cultivars that maintained good overall quality and cover under the extreme high-temperature summer of 1998 were ‘Crenshaw’, ‘Century’, ‘Imperial’, ‘Penn G1’, and ‘Grand Prix’.

Overall, cultivars developed by the Texas A&M University breeding program, with the exception of ‘Cato’, performed very well at this location. This may be partially explained by the fact that these cultivars were selected principally for heat tolerance, and Little Rock experienced termperatures >100 °F on 20 days during the summer of 1998. 'Crenshaw', 'Imperial', and 'Century' appear to be well-suited to the high-temperature conditions of Arkansas. Continuing evaluations of this test should be very valuable in providing cultivar recommendations to the golf industry in Arkansas.

Table 1. Performance data for bentgrass cultivars during the 1998 growing season at Chenal Country Club, Little Rock.

Cultivar	Seedling vigor[z]	% Cover August-October	Spring quality[z]	Summer quality[z]	Fall quality[z]	Avg. quality[z]
Crenshaw	6.9	92	6.9	7.1	6.8	6.9
Century	5.8	89	6.1	6.9	7.3	6.7
Imperial	5.7	89	5.9	6.2	6.7	6.2
Penn G1	-	94	4.7	6.9	7.5	6.1
Grand Prix	7.1	89	6.0	6.0	6.5	6.1
Penn G2	6.5	86	6.1	5.7	6.0	6.0
SR 1020	7.2	73	6.2	5.3	5.2	5.7
SR 1119	6.0	72	6.4	5.7	4.7	5.7
Penn A4	6.4	84	5.4	5.6	5.3	5.7
Viper	6.3	68	6.2	5.1	4.8	5.5
Providence	6.4	65	6.6	4.7	4.3	5.4
Penn G6	6.4	65	5.9	5.1	4.5	5.3
Trueline	6.4	72	5.6	5.0	4.5	5.1
Penncross	6.1	75	5.9	4.1	4.8	5.1
Cobra	6.8	64	5.8	4.3	4.7	5.0
Princeville	6.0	73	4.9	5.2	4.7	4.9
L93	5.2	64	5.6	4.0	4.3	4.8
Putter	6.3	58	5.4	3.8	4.0	4.6
Cato	6.3	51	4.9	3.5	3.7	4.1
LSD ($P < 0.05$)	0.8	15	1.4	1.1	1.4	0.8
CV (%)	8.4	11.8	15.1	12.3	15.8	8.7

[z] Rating scale of 1-9, with 1 = poor, and 9 = ideal.

VEGETABLES

MIXED COVER CROP AS AN ALTERNATIVE TO BLACK PLASTIC MULCH FOR TOMATO PRODUCTION

Nilda R. Burgos, Ronald E. Talbert, Lance A. Schmidt, and Jennifer J. Wells[1]

IMPACT STATEMENT

In 1996 and 1997, field studies were conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville. The objective of the studies were to compare the performance of tomato grown using black plastic mulch, grass/legume mixed cover crop, and no cover. At 30 days after transplanting tomato, rye plus vetch cover crop had reduced yellow nutsedge density by 95%, compared to black plastic. The use of a mixed cover crop produced tomato yields higher than or equal to black plastic or no cover crop. Cover crop mulch may delay tomato maturity and reduce early harvest but have no effect on total tomato fruit production. However with mixed cover crop, tomato harvest may be extended to early September. Considering the cost of black plastic and the environmental issues associated with the use of methyl bromide, cover crop systems may be a good fit in tomato production.

BACKGROUND

Tomato growers in Arkansas traditionally use black plastic as a soil cover or mulch. Black plastic allows producers to use soil fumigants such as methyl bromide to control weeds and soil-borne insect pests and diseases. Unfortunately, methyl bromide is implicated as one of the air pollutants contributing to the deterioration of the ozone layer. For lack of alternatives, methyl bromide is still being used, under strict regulations by the Environmental Protection Agency (EPA). Cover crops are considered an alternative to black plastic and as a complimentary tool for weed management in tomato production. When cover crops are mowed or desiccated with herbicides, the residue provides a physical barrier to weed emergence. In addition, allelopathic cover crops

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such as rye and wheat release toxic substances that can reduce weed emergence and growth (Barnes and Putnam, 1983; Putnam and de Frank, 1983). A major utility for cover crops in vegetable production is early-season weed suppression (Wallace and Bellinder, 1992). In previous studies, a mixed cover of rye and vetch provided the best early-season weed suppression compared to wheat, vetch, or rye alone (Burgos, 1994). The mixed cover crop did not reduce tomato yields compared to no cover. We conducted studies to verify the yield performance of tomato in mixed cover crop systems compared to black plastic mulch and conventional tillage system with no soil cover.

RESEARCH DESCRIPTION

In 1996 and 1997, field experiments were conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville. Four production systems were tested in 1996 including mixed cover crops of rye plus vetch or wheat plus vetch, black plastic mulch, and conventional system with no cover crop or mulch. Soil fumigation with methyl bromide was not included in any treatment. The treatments were arranged in a randomized complete block design with four replications on flat beds. Cover crops were planted into 15- by 17-ft plots on 29 September 1995. Cover crops were seeded in a mixture of 2 parts by volume of rye or wheat at 35 lb / acre and 1 part vetch at 12 lb / acre. Cover crops were desiccated on 1 May 1996 with paraquat, 0.75 lb / acre (0.84 kg / ha) and metribuzin, 0.35 lb / acre. Plots without cover crops were disced in April and trifluralin, (0.75 lb / acre) was incorporated in the top 2 in. of soil in tilled plots without cover on 9 May 1996. Black plastic was laid on designated plots on 10 May and 'Mountain Spring' tomatoes were transplanted to the field by hand. Each plot had three rows, 5 ft apart, with eight plants per row. Fertilizer was applied based on recommendation from soil analysis. The plants were staked and insecticide was applied as needed. Manzate was sprayed weekly, and plants were drip-irrigated as needed. Major weeds were yellow nutsedge, redroot pigweed, goosegrass, and large crabgrass. Sethoxydim, 0.22 lb / acre, was applied to plots with mixed cover crops for postemergence grass control and metribuzin, 0.25 lb / acre, was applied post-directed for residual weed control. Plots without cover and those with black plastic were treated with metribuzin twice to suppress yellow nutsedge. All plots also received post-directed treatment of paraquat, 0.67 lb / acre, for midseason control of yellow nutsedge. In the fall of 1996, the experiment was moved to a block with minimum yellow nutsedge infestation. This time, only rye plus vetch cover crop was planted because the 1996 experiment showed no difference in tomato yield between wheat plus vetch and rye plus vetch cover crops. Also, the whole experiment was established on raised beds as is the practice for tomato production in black plastic. The cover crops were desiccated on 30 April 1997 and weeds in plots without cover crop were burned down with glyphosate, 1 lb / acre. Trifluralin was soil-incorporated in plots with no mulch on 6 May and 'Mountain Spring' tomato plants were transplanted on 13 May. Each plot had four beds, 3.3 ft apart, 20 ft long. Metribuzin was applied post-directed to all plots on 9 July 1997. Only two central rows with 12 plants per row were harvested. Other management practices were done as before. Tomatoes were harvested from July to August for a total of eight harvests in 1996 and 10 harvests in 1997.

FINDINGS

Cover crops and black plastic reduced yellow nutsedge density 39 to 95% compared to no cover (Table 1). Yellow nutsedge was able to grow through the plastic cover. A mixed cover crop of rye plus vetch suppressed yellow nutsedge better than black plastic. However, wheat plus vetch did not produce as much biomass as rye plus vetch and so was less effective in suppressing yellow nutsedge.

In 1996, a significant yield difference was observed between production systems. Tomato plants in mixed cover crops had the highest yield of 16 lb / plant for eight harvests (Table 2). Plants in mixed cover crops yielded better than those in black plastic or no cover crop. Tomatoes grown in black plastic did not do well because the presence of plastic cover on flat beds resulted in poor drainage. Other researchers have reported a yield benefit for tomato with the use of cover crop (hairy vetch only) compared to black plastic or no mulch (Abdul-Baki and Teasdale, 1993). In general, yield in 1997 was inferior to the yield in 1996. We could not attribute the inferior yield to any single factor except for the change in location in 1997 and different climatic conditions between years. When tomatoes were grown on raised beds, there was no difference in total yield between production systems. Tomatoes in plots with rye plus vetch cover yielded as well as those in plastic or no cover.

Cover crop mulch could delay the maturity of tomato as shown by the fewer fruits harvested per plant in rye plus vetch mulch compared to other treatments in the first two harvests in 1997. This was compensated for by increased mid-and late-season fruit production of tomatoes grown with rye plus vetch mulch.

We conclude that mixed cover crops can be used effectively in Arkansas tomato production. Black plastic costs more per acre than cover crop, and should the EPA ban methyl bromide, use of a mixed cover crop is a good alternative to black plastic.

ACKNOWLEDGMENT

The authors wish to thank Dolores Parker for helping in the implementation and data gathering for this study.

LITERATURE CITED

Abdul-Baki, A. A. and J. R. Teasdale. 1993. A no-tillage tomato production system using hairy vetch and subterranean clover mulches. HortScience. 28:106-108.

Barnes, J. P. and A. R. Putnam, 1983. Rye residues contribute to weed suppression in no-tillage cropping systems. J. Chem. Ecol. 9:1045-1057.

Burgos, N. R. 1994. Cover crops in weed management systems for vegetable production. M.S. Thesis, Department of Crop, Soil,and Environmental Sciences, University of Arkansas, Fayetteville. 184 pp.

Putnam, A. R. and J. de Frank. 1983. Use of phytotoxic plant residues for selective weed control. Crop Prot. 2:173-181.
Wallace, R. W. and R. R. Bellinder. 1992. Alternative tillage and herbicide options for successful weed control in vegetables. HortScience. 27:745-748.

Table 1. Suppression of yellow nutsedge by cover crops in tomato plots, 30 days after transplanting, Fayetteville, 1996.

Treatment	Yellow nutsedge density	Suppression
	No. per m[z]	%
No cover crop	472 a[y]	—
Black plastic	107 b	71 b
Rye + vetch	19 b	95 a
Wheat + vetch	221 ab	39 c

[z] Average of four replications.
[y] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

Table 2. Yield of tomato in different production systems, Fayetteville.

Treatment	Number of tomato fruit harvested/plant: First two harvests 1996[z]	First two harvests 1997[y]	Last harvest 1996[z]	Last harvest 1997[y]	Total wt., all harvests (lb/plant) 1996[z]	1997[y]
No cover crop	1.8 a[x]	1.0 a	8.5 b	1.8 ab	13.8 ab	6.0 a
Black plastic	1.6 a	1.3 a	3.7 c	0.9 b	10.5 b	7.3 a
Rye + vetch	1.5 a	0.1 b	14.1 a	2.6 a	16.1 a	6.5 a
Wheat + vetch	1.6 a	—	9.0 b	—	16.2 a	—

[z] Planted on flat beds.
[y] Planted on raised beds.
[x] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

THE EFFECT OF DIFFERENT PLASTIC MULCH COLORS ON YIELD AND QUALITY OF TOMATOES

Paul E. Cooper[1]

IMPACT STATEMENT

Red plastic mulch was compared to standard black plastic mulch to determine its effect on tomato yield and quality. Data from the first year of this study did not indicate any major advantage of red vs. black plastic. The only positive effect was a slight increase in average fruit weight on red-mulched plants.

BACKGROUND

The use of black plastic mulch and drip irrigation is a standard practice in the tomato industry in southeastern Arkansas. Plastic mulch provides numerous benefits including weed control, water conservation, reduced fertilizer leaching, and disease control when used in conjunction with a soil fumigant. Researchers in other parts of the country have reported yield advantages by using red instead of a black mulch (Kasperbauer and Hunt, 1998). They concluded that red mulch reflected a better quality of light for plant growth. The purpose of this study was to compare the effects of a red plastic mulch on tomato yield and quality to those of the standard black plastic mulch. In addition, two tomato cultivars were used to determine any interaction between mulch color and cultivar.

RESEARCH DESCRIPTION

This study was conducted in 1998 on the Roger Pace commercial tomato farm in Drew County. The experimental design was a randomized complete block containing

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four replications. Tomato seeds were planted on 2 March 1998. Plants were transplanted from seedling flats and cupped on 18 March, and transplants set in the field on 14 April. Black plastic mulch was laid on all plots on 24 March. On 14 April, black plastic was removed from half of the pots and replaced with red plastic mulch. Plot size was 10 tomato plants spaced approximately 22 in. apart in the row. Yield and fruit weight data were taken from the six interior plants.

Two tomato cultivars, 'Mountain Spring' and 'Mountain Fresh', were used. Insects, diseases, and weeds were controlled using recommended practices. Plants were staked, tied, and pruned in accordance with standard cultural practices for the area. Fruit was harvested from 16 June through 7 July and was graded into four categories: 1) extra large #1, 2) large #1, 3) #2, and 4) #3 / unclassified. The first three grades were considered marketable fruit.

FINDINGS

Mulch color had no effect on yield of the various grades of tomatoes or total marketable yields (Table 1). Average fruit weight was significantly greater with the red mulch (Table 1). Our findings indicate there were no significant interactions between mulch color and cultivar.

The study will be repeated in 1999. Extremely hot weather in May and June of 1998 caused yields to be lower than normal and may have masked the potential benefits of the red mulch. Additionally, the effect on average fruit weight needs to be investigated closely.

LITERATURE CITED

Kasperbauer, M.J. and P.G. Hunt. 1998. Far-red light affects photosynthate allocation and yield of tomato over red mulch. Crop Sci. 38:970-974.

Table 1. Effect of mulch color on tomato yields (lb/plant) by grade[z] and average fruit weight 1998.

Mulch color	XL#1	L#1	#2	Total marketable yield	Avg. wt. (oz)
Black	4.49 a[y]	0.86 a	3.31 a	8.66 a	8.35 b
Red	4.47 a	0.75 a	3.12 a	8.33 a	8.77 a

[z] Grades are 1) XL#1 = extra large #1 2) L#1 = large #1 3) #2.

[y] Means within a column followed by a different letter are significantly different as determined by Duncan's multiple range test ($P < 0.05$).

TOMATO CULTIVAR TRIAL RESULTS, 1998

Paul E. Cooper[1]

IMPACT STATEMENT

The evaluation of tomato cultivars and advanced breeding lines continued in 1998. Cultivars differed as to yield of various sizes and grades, and to total marketable yield. Several cultivars and breeding lines, including NC 9559, 'Mountain Fresh', NC 95388, and NC 95449, compared very favorably with the industry standard, 'Mountain Spring'.

BACKGROUND

Cultivar selection is very important to the fresh-market tomato industry in southeast Arkansas. To remain competitive, the industry relies on the use of well-adapted cultivars that produce high yields of superior quality fruit. In 1992, 'Mountain Spring' was released by Dr. Randy Gardner of North Carolina State University and quickly became the industry standard due to its yields of high quality fruit (Gardner, 1992). New cultivars are developed and released annually by universities, private seed companies, etc. The purpose of this study was to evaluate some of these cultivars for their adaptability and potential use in southeast Arkansas.

RESEARCH DESCRIPTION

This study was conducted on the Roger Pace commercial tomato farm in Drew County. Similar yield trials were conducted there in 1995, 1996, and 1997. Cultural practices were essentially the same as those used by tomato producers in the area. Cultivars and breeding lines compared in the test were 'Mountain Spring', 'Mountain Fresh', 'Floralina', NC 9745, NC 95388, NC 96378, NC 9559, and NC 95449. Seeds were planted on 27 February 1998, plants were transplanted from seedling flats on 17 March and transplants were set in the field on 10 April.

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Black plastic mulch and drip irrigation were used and the beds were fumigated with methyl bromide / chloropicrin (67:33) at the time of laying the plastic. Insects, diseases, and weeds were controlled using recommended practices and plants were staked, tied, and pruned in a manner consistent with the area. Fruit were harvested from 15 June through 9 July and graded into the following categories: 1) extra large #1 (XL#1), 2) large #1 (L#1), 3) #2, and 4) #3 / Unclassified. Marketable fruit was composed of the first three grades. The experimental design was a randomized complete block containing four replications and plot size was four tomato plants.

FINDINGS

Yields in 1998 were overall lower than in the previous three years due to extremely hot weather in May and June. Marketable yields ranged from 9.35 lb to 12.05 lb per plant. The cultivars producing the highest yields of XL#1 fruit were 'Mountain Spring', NC 9559, and 'Mountain Fresh' (Table 1). NC 95388 and NC 95449 produced the most #2 fruit, while average fruit size was greatest for NC 9559 (Table 1).

NC 9559 performed very well in comparison with 'Mountain Spring' and 'Mountain Fresh' for total yield, XL#1 yield, and average fruit size. These results are similar to data for the 1996 and 1997 trials. NC 95449 and NC 95388 continued to perform well, but overall fruit size of NC 95388 was unsatisfactory for Arkansas production.

LITERATURE CITED

Gardner, R.G. 1992. 'Mountain Spring' tomato; NC 8276 and NC 84173 tomato breeding lines. HortScience 27:1233-1234.

Table 1. Yields of tomato cultivars by grade, total marketable yield, and average fruit weight, 1998.

Cultivar	XL#1[z]	L#1	#2	Total mkt	Avg. wt.
Mountain Spring	6.33 a[y]	0.74 bc	3.20 d	10.26 bc	9.35 b
NC9559	6.00 ab	0.18 e	5.18 a-c	11.37 ab	10.38 a
Mountain Fresh	5.53 ab	0.45 c-e	3.75 cd	9.74 c	9.20 bc
NC 95388	4.76 bc	1.14 a	6.16 a	12.05 a	8.14 e
NC 95449	4.06 cd	0.69 b-d	6.07 ab	0.82 a-c	9.12 bcd
Floralina	4.05 cd	0.32 de	5.52 ab	9.83 bc	9.25 bc
NC 9745	3.85 cd	0.87 ab	4.63 b-d	9.35 c	8.30 de
NC 96378	3.16 d	0.87 ab	5.94 ab	9.96 bc	8.50 cde

[z] Grades are 1) XL#1 = extralarge #1; 2) L#1=large #1; and 3) #2

[y] Means within a column followed by a different letter are significantly different as determined by Duncan's multiple range test ($P < 0.05$.)

TRANSGENIC SWEET CORN IN SOUTHEAST ARKANSAS

Paul E. Cooper, C. Robert Stark, Paul B. Francis, and Charles T. Allen[1]

IMPACT STATEMENT

Economically viable sweet corn production in southeast Arkansas has been limited to early summer production due to intense, late-season insect pressure. Extending the production season to include a profitable fall crop would allow double-cropping with the established tomato industry. Evaluation of sweet corn cultivars that contain the *Bacillas thuringensis* (Bt)gene was undertaken to examine economic advantages of transgenic vs. traditional, non-Bt sweet corn. Comparisons were made between Bt and non-Bt sweet corn planted in spring and fall following either corn or tomatoes. Marketable yields were significantly higher for Bt corn in both summer and fall crops. Limited economic difference was found between respective production systems.

BACKGROUND

Economically viable sweet corn production in southeast Arkansas has been limited to early summer production due to intense late-season corn earworm pressure. With the profitable and established tomato production enterprise of the area, growers are reluctant to produce sweet corn. Tomato farmers typically produce for a June/July harvest and then either plant a cover crop or leave the ground fallow. A successful corn insect management system could open opportunities for the development of a fall sweet corn industry in southeast Arkansas. If successful, net returns per acre could be increased if sweet corn was produced within a double-cropping system that utilized land preparations, irrigation inputs, and plastic mulch from the prior tomato crop. Transgenic sweet corn varieties have been released by commercial seed companies that contain the

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Bt gene and have resistance to the corn earworm. Using this advancement in technology, a fall sweet corn crop becomes a legitimate possibility.

RESEARCH DESCRIPTION

Small-plot tests of transgenic and non-transgenic sweet corn cultivars were planted on 6 May 1998 at the Southeast Research and Extension Center, Monticello. Final land preparation consisted of forming beds, installing drip irrigation tubing and covering the beds with black plastic mulch. The corn cultivars used were 'Attribute' (Bt) and 'Bonus' (non-Bt), both products of Novartis Seeds. Double-crop practices were utilized on half of the plots by culturing 'Bradley' tomato grown in the standard production system for of the area. After spring tomato and corn harvests were completed in July, all plots were cleared and planted with the same transgenic and non-transgenic sweet corn cultivars on 16 July 1998. The trickle irrigation system and planting beds were maintained from the early-season crops. Sweet corn was harvested on 23 September 1998 for both the Bt and non-Bt sweet corn cultivars.

The sweet corn was graded for marketability. All ratings were made after allowing for a 1-in. ear tip cutoff as commonly used in sweet corn marketing. "Marketable sweet corn" was defined as ears with at least 80% kernel fill and insect damage of less than 10%. This criteria corresponds closely with U.S. No. 2 or better sweet corn grades as defined by federal standards.

FINDINGS

For both the July and September sweet corn harvest, percent insect damage was greater for the non-Bt corn (Table 1). In the July harvest, only 12% of the Bt ears had any corn earworm damage, whereas, the non-Bt corn had corn earworm damage on 70% of the ears (data not shown).

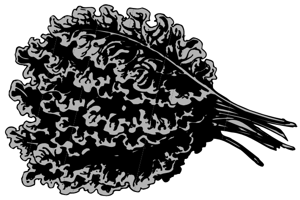
After harvest, the corn was graded using the criteria of ear length, kernel fill, and insect damage and this data was recorded as adjusted yield. Initially, the percentage of marketable ears (raw percent marketable yield) was the same for both cultivars for all planting dates (Table 1). After making yield adjustments, all of the Bt corn was rated as marketable (U.S. No. 2 or better) (Table 1). The non-Bt corn had 64% and 72% marketable ears in July and September, respectively. Bt corn following a crop of tomatoes produced a marketable yield of 100%, after adjustments (Table 1). Non-Bt corn following tomatoes produced 72% adjusted marketable ears.

These results indicate that the Bt gene in sweet corn offers the opportunity to control corn insects such as the corn earworm, which are a major obstacle to fall production. Also, if double-cropped after fresh-market tomatoes, better use of land, supplies, and equipment could be accomplished.

Table 1. Insect damage and marketable ears of Bt and non-Bt sweet corn.

			Yield of marketable ears					
	Insect damage rating[z]		Single-cropped				Double-cropped	
Cultivar	July	September	July		September			
			Raw	Adj.	Raw	Adj.	Raw	Adj.
			– – – – – – – – – –		%		– – – – – – – – – –	
Attribute (Bt)	1.12	1.08	50	100	39.6	100	44.9	100
Bonus (non-Bt)	2.32	2.13	50	64	33.2	72	35.4	72
F-test significance (P < 0.05)	–	–	NS[y]	–	NS	–	NS	–

[z] Insect damage rating on a scale of 1-5, with 1= no change and 5 = very severe damage.
[y] Not significant.



RELATION OF HEAT-SHOCK PROTEINS TO THERMOTOLERANCE DURING SPINACH SEED GERMINATION

Sue M. Hum-Musser, Teddy E. Morelock and J. Brad Murphy[1]

IMPACT STATEMENT

Spinach is a cool-season crop and as temperature increases from the optimal range, the germination rate decreases and stand establishment of the crop is dramatically affected; therefore, heat-tolerant cultivars are of interest. Several spinach cultivars exhibited a range of heat tolerances during germination. After a two-week incubation at 35 °C, the most heat-tolerant cultivar reached 82% germination. Spinach cultivars did not become thermodormant even after prolonged (44 days) incubation at high (35 °C) germination temperatures, since they were able to germinate when moved to optimum germination temperature (20 °C). Western blotting of sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) gels using an (HSP70) antibody indicated that cultivars with the highest degree of thermotolerance had higher levels of HSP70 expression than those with the lowest degree of thermotolerance during germination. These results suggest that thermotolerance could be further improved, either through classical breeding or possible genetic engineering.

BACKGROUND

Spinach seed germinates optimally around 20 °C, and unseasonably warm temperatures can result in poor germination and crop establishment (Suganuma & Ohno, 1984). During heat stress, seeds can be thermoinhibited (suppression of germination at high temperatures, which is relieved when transferred to favorable germination conditions) or thermodormant (secondarily induced dormancy - seeds cannot germinate upon transfer to optimal germination temperatures) (Small & Gutterman, 1992). During heat

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stress, organisms produce heat shock proteins of various molecular weights (Abernethy *et al*., 1989). HSPs may function as molecular chaperons, are possibly required for the development of thermotolerance, and may be crucial for cell survival during heat stress (Waters *et al*., 1996).

RESEARCH DESCRIPTION

Seeds from five spinach cultivars,'Fall Green', 'Imperial Spring', 'F-380', 'CXF 94675' and 'Cascade', were tested for heat tolerance during germination. Seeds from each cultivar were surface-sterilized in a 10% bleach solution and rinsed twice in filtered water. They were incubated in the dark on blotter paper dampened with 4 ml of filtered water in a covered Petri dish at constant 20 °C, 25 °C, 30 °C, and 35 °C for two weeks. Seed were checked daily to determine the germination rate, and water was added as necessary. In order to determine if the spinach seeds were thermoinhibited or became thermodormant in response to heat stress, seeds incubated at 35 °C were returned to the optimum germination temperature (20 °C) after 44 days. To assess the relation HSP and seed thermotolerance during germination, total protein extracts were obtained from germinated and ungerminated seeds incubated for 70 hours at 35 °C (until 'Fall Green' reached 50% germination) according to a modified protocol from Gifford *et al*. (1982). Total protein was quantified according to Bradford (1976). SDS-PAGE on 12% gels was performed using 20 ug of protein, after each sample was heated at 95 °C for five minutes in Tris-HCR sample buffer (Bio-Rad). Proteins were electroblotted onto an Immobilon PVDF membrane (Millipore) and incubated with HSP70 antibody overnight according to Sheng & Schuster (1992). Color development was performed using bromochloroindolyl phosphate / nitro blue tetrazolium (Harlow & Lane, 1988). Western blots were also performed using the HSP18.1 antibody.

FINDINGS

The heat tolerance tests showed that 'Fall Green' was the most heat tolerant cultivar during germination, followed by 'Imperial Spring', 'F-380', 'CXF 94675' and 'Cascade' (Table 1). In addition, we determined that these spinach cultivars do not become thermodormant even after prolonged (44 days) incubation at high (35 °C) germination temperatures, since they were able to germinate when moved to the optimum germination temperature (20 °C) for one week (Table 1). Results of Western blotting of SDS-PAGE gels of total protein using HSP70 antibody indicate that varieties of highest and lowest degrees of thermotolerance have different levels of HSP70 expression (data not shown). The HSP70 protein seems to be produced during normal (20 °C) germination; however, expression of this protein varies during germination under heat stress. The most heat-resistant spinach cultivars, 'Fall Green', 'Imperial Spring', and 'F-380' have higher levels of HSP70 than the heat-sensitive cultivars, 'CXF 94675' and 'Cascade', suggesting that HSP70 may be involved in thermotolerance during germination. Preliminary results of Western blotting with the HSP18.1 antibody show similar trends (data not shown).

LITERATURE CITED

Abernethy, R.H., D.S. Thiel, N.S. Petersen, and K. Helm 1989. Thermotolerance is developmentally dependent in germinating wheat seed. Plant Physiol. 89:596-576.

Bradford, M.M. 1976. A rapid and sensitive method for quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal. Biochem. 72:248-254.

Gifford, D.L., J.S. Greenwood, and J.D. Bewley 1982. Deposition of matrix and crystalloid storage proteins during protein body development in the endosperm of *Ricinus communis* L. cv. Hale seeds. Plant Physiol. 69:1471-1478.

Harlow, E. and D. Lane 1988. Antibodies: A laboratory manual. Cold Spring Harbor Laboratory. New York.

Sheng, S. and S.M. Schuster 1992. Simple modifications of a protein immunoblotting protocol to reduce nonspecific background. BioTechniques. 13:704-708.

Small, J.G.C. and Y. Gutterman 1992. Effects of sodium chloride on prevention of thermodormancy, ethylene, and protein synthesis and respiration in Grand Rapids lettuce seeds. Physiol. Plant. 84:35-40.

Suganuma, N. and H. Ohno 1984. Role of pericarp in reducing spinach (*Spinacia oleracea* L.) seed germination at supra-optimal temperatures. J. Jap. Soc. Hort. 53:38-44.

Waters, E.R., J.L. Garrett, and E. Vierling 1996. Evolution, structure, and function of the small heat-shock proteins in plants. J. Exp. Bot. 47:325-338.

ACKNOWLEDGEMENTS

Thanks to Dr. Ralph Henry, Department of Biological Sciences, University of Arkansas, for providing the HSP70 antibody, and to Dr. Elizabeth Vierling, University of Arizona, for the gift of the HSP18.1 antibody.

Table 1. Spinach cultivar seed germination response to temperature.

	Germination temperature (⁰C)				
Cultivar	20	25	30	35	35→20[z]
	% germination				
Fall Green	100.00 a[y]	99.50 a	97.50 a	82.00 bc	89.00 ab
Imperial Spring	98.75 a	97.50 a	92.00 ab	62.00 de	69.00 d
F-380	89.50 ab	89.00 ab	81.25 c	48.75 f	60.50 e
CXF 94675	98.75 a	95.50 a	73.25 cd	10.75 g	60.50 e
Cascade	95.75 a	94.25 a	60.75 e	10.50 g	60.00 e

[z] Seeds exposed to 35 ⁰C for 44 days and then moved to 20 ⁰C.

[y] Means within a column followed by a different letter are significantly different as determined by LSD ($P < 0.05$).

CAROTENOID ANTIOXIDANT LEVELS IN SPINACH: PRELIMINARY SCREENING

J. Brad Murphy and Teddy E. Morelock[1]

IMPACT STATEMENT

Increased interest in the health benefits of spinach prompted an investigation of the levels of antioxidant carotenoids in commercial cultivars and University of Arkansas breeding lines of spinach. Significant differences were found, suggesting that a directed breeding program could enhance carotenoid antioxidant levels in spinach.

BACKGROUND

Plant carotenoids perform a critical function as antioxidants, providing protection against a variety of reactive oxygen species generated primarily during photosynthesis (Pallet & Young, 1993). When ingested by humans, these compounds maintain their antioxidant activities and are receiving considerable attention in relation to beneficial health effects, including prevention of cancer (Cowley, 1998). While the best-known and most-studied carotenoid is *B*-carotene, other carotenoids are now being investigated due to their higher antioxidant activity compared to *B*-carotene. One of these is lutein (Khachik *et al*., 1995), which is a dihydroxy *B*,ε-carotenoid, as opposed to *B*-carotene, which is a non-hydroxylated *B*,*B*-carotene (Pallett & Young, 1993).

Most dark-green leafy vegetables, such as spinach and kale, are relatively high in carotenoids, especially lutein (Mangels *et al*., 1993; Khachik *et al*., 1995). Since it would be desirable to increase overall carotenoid antioxidants and lutein content in spinach, a study has been initiated to screen a number of commercial cultivars and UA breeding lines to determine variation within and between genetic lines.

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RESEARCH DESCRIPTION

Mature (fully expanded) leaves from 18 spinach breeding lines and hybrids were collected on 15 December 1997, at the University of Arkansas Vegetable Substation, Kibler, from a fall-planted breeding nursery. Single leaves from five separate plants from each line were harvested, placed in plastic ziploc bags in an ice chest, and transported to Fayetteville where they were stored frozen at –20 °F until extracted for carotenoid analysis.

Leaf discs of *ca*. 100 mg (1.3-cm diameter) were punched from the frozen leaves, weighed, and extracted in 2.5 ml of acetone-ethyl acetate (3:2 v/v). Water (2 ml) was added, the mixture centrifuged, and the ethyl acetate phase recovered. The volume was brought to 2 ml with ethyl acetate, then a 1 ml aliquot was filtered through a 0.2 u Polypure filter (Alltech Assoc.). A 10 ul sample was separated on a Spherisorb ODS1 column (Waters Assoc.) using a 30-minute gradient of ethyl acetate (0 to 67%) in acetonitrile-water-triethylamine (9:1:0.01 v/v) at a flow rate of 1 ml per minute (Norris *et al*., 1995). Carotenoids were monitored at 440 nm and identified and quantified by comparison to standards.

FINDINGS

In this initial study, significant differences in the average content of both lutein and *B*-carotene were found between genetic lines of spinach (Fig. 1). Some lines exhibited considerable variation between plants, while others were highly uniform. There was a very high correlation ($r^2 = 0.95$) between lutein content and *B*-carotene content, suggesting that their syntheses are coordinately regulated and the branch pathways do not compete for precursors.

The significant difference between lines suggests that improvement of general carotenoid antioxidants and lutein could be obtained through a breeding program.

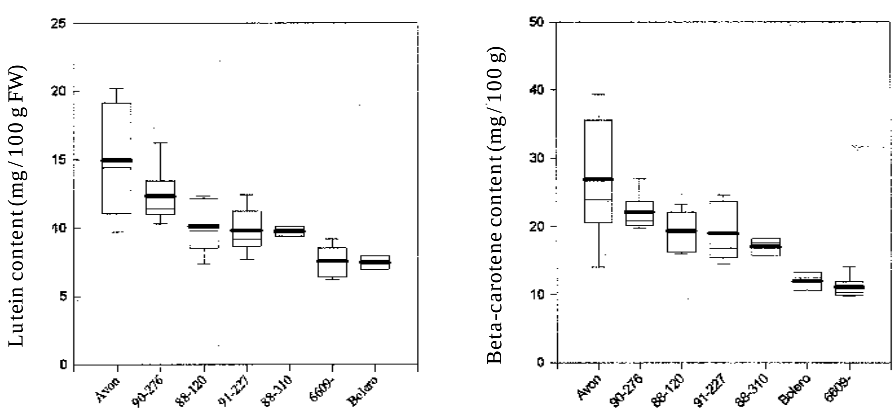


Figure 1. Content of lutein and *B*-carotene in seven genetic lines of spinach analyzed in the initial survey.

LITERATURE CITED

Cowley, G. 1998. Cancer & Diet. Newsweek. Nov. 30, 1998.

Khachik, F., G.R Beecher, and J.C. Smith, Jr. 1995. Lutein, lycopene, and their oxida tive metabolites in chemoprevention of cancer. J. Cell. Biochem. Supp. 22: 236-246.

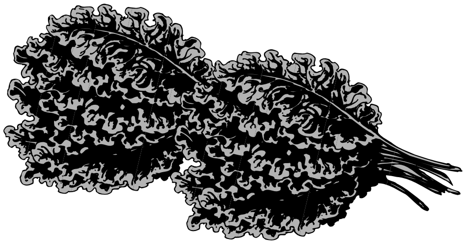
Mangels, A.R., J.M. Holden , G.R. Beecher, M.R. Forman, and E. Lanza. 1993. Carotenoid content of fruits and vegetables: an evaluation of analytic data. J. Amer. Diet. Assoc. 93: 284-296.

Norris, S.R., T.R. Barrette, and D. DellaPenna. 1995. Genetic dissection of carotenoid synthesis in *Arabidopsis* defines plastoquinone as an essential component of phytoene desaturation. Plant Cell 7: 2139-2149.

Pallett, K.E. and A.J. Young. 1993. Carotenoids. *In:* (p. 59-87) R.G. Alscher, and J.L. Hess (Eds.). Antioxidants in higher plants. CRC Press, Boca Raton, Florida.

ACKNOWLEDGMENTS

Thanks to Ms. Brooke Burden for technical assistance in sample preparation.



SPINACH RESPONSE AND WEED CONTROL FROM NEW AND EXISTING HERBICIDE TECHNOLOGIES

Ronald E. Talbert and Lance A. Schmidt[1]

IMPACT STATEMENT

Field evaluations of potential herbicides for spinach were conducted in 1997 and 1998 at the University of Arkansas Vegetable Substation, Kibler. A preemergence application of metolachlor applied at 1.12 kg a.i./ha continues to be the standard herbicide treatment at Kibler. Metolachlor is used under a Section-18 clearance in most states in this region. Fully registered herbicides in Arkansas spinach production include phenmedipham at 0.56 kg a.i/ha applied postemergence which controlled broadleaf weeds effectively, and cycloate at 2.24 kg a.i./ha applied pre-plant incorporated that was marginal in controlling the spectrum of weeds at Kibler. Of the new herbicides evaluated, dimethenamid at 0.56 kg a.i./ha applied preemergence, provided the greatest level of selective control for the weed species present. Fluroxypyr and triflusulfuron did not provide satisfactory control of the weeds present, and halosulfuron was too injurious to spinach.

BACKGROUND

Weed control is one of the most significant problems for spinach growers, and weed competition may significantly reduce yields in spinach. In addition, weeds that are present at harvest will lead to contamination of the raw product. Therefore, it is essential to maintain weed-free spinach fields in order to ensure high spinach quality and yields. The choices of herbicides that growers have available for weed control in spinach are very limited. Currently, there are two post-emergence herbicides (sethoxydim and phenmedipham) and one preemergence herbicide (cycloate) with full federal labeling in spinach for control of annual weeds. Sethoxydim is used for grass weed con-

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trol while phenmedipham provides control of broadleaf weeds. Cycloate, which is a pre-plant incorporated herbicide, is labeled but has been inconsistent for control of broadleaf weeds. Metolachlor has a Section 18 label for use on spinach, which requires annual renewal. The full federal label request package for metolachlor at 1.12 kg a.i./ha was submitted to the Environmental Protection Agency (EPA) in July 1998 by IR-4. Because of the need for more weed control options, experiments were conducted to evaluate new herbicides in spinach production.

RESEARCH DESCRIPTION

These studies were conducted in the fall of 1997 and 1998 at the University of Arkansas Vegetable Substation, Kibler. The soil type for this location was a Roxana silt loam with 1% organic matter and a pH of 6.9. The experimental design for the test area was a randomized complete block containing four replications. The plot size was 1.6 by 5 m and consisted of seven spinach rows spaced 23 cm apart. The spinach cultivars used were 'Fall Green' in 1997 and 'F-380' in 1998.

Pre-plant incorporated (PPI), preemergence (PRE), and postemergence (POST) herbicide treatments were applied with a hand-held, carbon dioxide (CO_2) pressurized back-pack sprayer. Treatments were applied in a water carrier volume of 20 gal/acre at a pressure of 241 kPa. In 1997, postemergence treatments were applied to 6.5 cm spinach, 2.5 cm henbit, 1.25 cm shepherdspurse, and 1.25 cm sibara. In 1998, POST treatments were applied to 8.0 cm spinach, 1.9 cm henbit, 1.0 cm shepherdspurse, 0.5 cm sibara, 3.2 cm annual bluegrass, and 1.9 cm pineappleweed. Spinach production practices common to the area were used and overhead irrigation was applied as needed.

Percentage of weed control by species was visually estimated: 0 represented no effect and 100 represented complete control. Ranges for weed control were as follows: 70 to 79%, fair; 80-89%, good; and 90-100%, excellent. Crop injury was assessed by visual estimation of percent injury: 0 represents no injury and 100 represents complete plant desiccation. Spinach injury less than 30% represents crop tolerance. Statistical analyses were conducted on all data using the ANOVA procedure. Means were separated by Least Significant Difference (LSD) ($P < 0.05$).

FINDINGS

The standard of metolachlor at 1.12 and 2.24 kg a.i./ha applied PRE continued to be an excellent treatment at nine weeks after treatment on the weed spectrum present, except for poor cutleaf eveningprimrose control with the 1.12/kg/a.i./ha rate (Table 1). However, cutleaf eveningprimrose was controlled effectively with metolachlor at 1.12 kg a.i./ha followed by a POST application of phenmedipham at 0.56 kg a.i./ha or tank-mixed with phenmedipham at 0.28 kg a.i./ha in a total POST program. A POST application of phenmedipham at 0.56 kg a.i./ha controlled the broadleaf weed population, but was less effective on annual bluegrass. Cycloate at 2.24 kg a.i./ha applied PPI provided marginal control of the weed spectrum, except for 90% control of annual bluegrass.

The new herbicide dimethenamid applied PRE at 0.56 and 1.12 kg a.i./ha controlled the weed spectrum, except for cutleaf eveningprimrose. Other new herbicides evaluated included POST applications of halosulfuron at 0.02 and 0.04 kg a.i./ha, fluroxypyr at 0.14 and 0.28 kg a.i./ha, and triflusulfuron at 0.018 and 0.035 kg a.i./ha. Fluroxypyr and triflusulfuron provided marginal control of the weed spectrum. Halosulfuron gave excellent control of sibara and shepherdspurse.

In 1997 and 1998, spinach tolerance at five weeks after treatment was observed with all herbicides, except halosulfuron which was very injurious to spinach (Table 2).

Table 1. Evaluation of weed control in spinach at nine WAT[z] in 1997 and 1998, Kibler.

Herbicide	Rate	Timing[x]	Weed species[y] LAMAM 1997	LAMAM 1998	SIBVI 1997	SIBVI 1998	CAPBP 1997	CAPBP 1998	POANN 1998	OEOLA 1998
	(kg a.i./ha)		% Control							
Untreated check	—	—	0	0	0	0	0	0	0	0
Cycloate	2.24	PPI	72	88	78	79	90	85	90	61
Metolachlor	1.12	PRE	92	95	92	93	88	93	93	67
Metolachlor	2.24	PRE	95	93	89	95	92	94	93	89
Dimethenamid	0.56	PRE	90	92	92	72	92	92	94	45
Dimethenamid	1.12	PRE	92	-[w]	90	-	95	-	-	-
Metolachlor fb	1.12	PRE	-	95	-	98	-	97	97	98
Phenmedipham	0.56	POST								
Phenmedipham	0.56	POST	-	91	-	90	-	90	76	89
Phenmedipham +	0.28	POST	95	95	95	95	83	96	97	95
Metolachlor	1.12	POST								
Fluroxypyr	0.14	POST	68	78	82	26	73	20	73	71
Fluroxypyr	0.28	POST	-[w]	80	-	79	-	25	55	38
Halosulfuron	0.02	POST	68	26	74	91	78	91	59	40
Halosulfuron	0.04	POST	59	31	76	94	83	93	33	53
Triflusulfuron	0.0175	POST	-	28	-	38	-	45	35	24
Triflusulfuron	0.035	POST	-	25	-	83	-	79	46	23
LSD ($P < 0.05$)			26	11	29	12	32	10	14	17

[z] WAT = weeks after treatment. Nine weeks after PPI and PRE applications and six weeks after POST applications.
[y] LAMAM=Henbit, SIBVI=Sibara, CAPBP=Shepherdspurse, POANN=Annual bluegrass, and OEOLA=Cutleaf eveningprimrose.
[x] PPI = Pre-plant incorporated, prior to planting; PRE = Preemergence, immediately following planting, and POST = Postemergence, over-the-top of emerged spinach and weeds.
[w] Treatment not included.

Table 2. Herbicide injury to spinach at five WAT[z] in 1997 and 1998 at Kibler.

Herbicide	Rate	Timing[y]	1997	1998
	(kg a.i./ha)		– – – % Injury– – –	
Untreated check	—	—	0	0
Cycloate	2.24	PPI	1	6
Metolachlor	1.12	PRE	10	8
Metolachlor	2.24	PRE	16	19
Dimethenamid	0.56	PRE	8	13
Dimethenamid	1.12	PRE	23	---[x]
Metolachlor fb	0.56	PRE	---	17
Phenmedipham	0.56	POST		
Phenmedipham	0.56	POST	---	9
Phenmedipham +	0.28	POST	1	8
Metolachlor	1.12	POST		
Fluroxypyr	0.14	POST	6	23
Fluroxypyr	0.28	POST	---	28
Halosulfuron	0.02	POST	49	70
Halosulfuron	0.04	POST	33	78
Triflusulfuron	0.0175	POST	---	8
Triflusulfuron	0.035	POST	---	11
LSD ($P < 0.05$)			10	8

[z] WAT = weeks after treatment. Five weeks after PPI and PRE applications and two weeks after POST applications.

[y] PPI = Pre-plant Incorporated, prior to planting; PRE = Preemergence, immediately following planting, and POST = Postemergence, over-the-top of emerged spinach and weeds.

[x] Treatment not included.

CONTROL OF YELLOW NUTSEDGE IN CUCURBITS

Jennifer Wells and Ron Talbert[1]

IMPACT STATEMENT

Halosulfuron is a herbicide that shows promise in the control of yellow nutsedge in cucurbits. When applied preemergence (PRE) or postemergance (POST), it caused little injury to cantaloupe, watermelon, or summer squash, while providing good control of yellow nutsedge. Halosulfuron performed significantly better than other herbicides evaluated. Assuming residue levels in fruit are acceptable, producers and consumers should benefit from the labeling of this herbicide for cucurbits.

BACKGROUND

Yellow nutsedge is one of the most troublesome weeds in the world (Lorenzi and Jeffery, 1987), and is a problem weed in field crops, ornamentals, turf, pastures, gardens, and waste areas. However, effective control is difficult to achieve by any current method. Hand weeding and cultivation do not control this weed due to its underground tubers that are located 1 to 6 in. below the soil surface (William and Warren, 1975). Each tuber has the ability to sprout several times during the growing season, especially when the foliage is removed by cultivation or hand weeding. Complete foliage regrowth can occur within two weeks.

There are no herbicides currently labeled for use in cucurbits that provide adequate yellow nutsedge control. In Virginia, studies were conducted in the absence of crops to determine control of yellow nutsedge by several acetolactate synthase-inhibiting herbicides (Ackley *et al.* 1996). Populations of yellow nutsedge were sprayed at the four- to six-leaf stage and were controlled best with halosulfuron (88 to 94% control), and chlorimuron of (78 to 91% control). Surviving plants were stunted 34% by halosulfuron and 38% by chlorimuron.

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RESEARCH DESCRIPTION

Herbicidal control of yellow nutsedge in cantaloupe (cv. Mission Hybird), watermelon, (cv. Crimson Sweet), and summer squash (cv. Dixie Hybird) was evaluated during the summer of 1998 at the Arkansas Agricultural Research and Extension Center, Fayetteville. All tests contained the same treatments and were planted similarly. The cucurbits were planted in rows spaced 6 ft apart, with one row 6 ft long per plot. There were four replications of each treatment. After emergence, the plots were thinned to three plants per plot. Experiments were located in a field naturally infested with yellow nutsedge (approximately 200 to 500 plants / m^2). The entire area was sprayed with ethalfluralin at 1.68 kg a.i. / ha after planting to suppress emergence of annual weeds other than yellow nutsedge. Other annual weeds that emerged were removed by hand weeding.

The PRE herbicide treatments were applied the day of planting. PRE treatments compared sulfentrazone at 0.28 kg a.i. / ha, and halosulfuron at 0.027 and 0.053 kg a.i. / ha, to bensulide at 6.7 kg a.i. / ha, which is the currently labeled industry standard. Bentazon at 0.84 kg a.i. / ha and halosulfuron at 0.04 and 0.02 kg a.i. / ha. POST treatments were applied 28 days after planting. Visual ratings of percent crop injury and percent yellow nutsedge control were taken. Final yield of watermelon and cantaloupe was assessed by harvesting and counting the number of fruit per plot, while harvest weights were obtained for squash. All data were analyzed by analysis of variance and means separations were determined by Least Significant Difference (LSD).

FINDINGS

Halosulfuron provided the best yellow nutsedge control in cantaloupe (Table 1). A PRE application of halosulfuron provided 78 to 85% control of yellow nutsedge, but caused 15 to 20% crop injury. The POST treatments controlled yellow nutsedge 50 to 65%. Bentazon caused minimal injury to cantaloupe but controlled yellow nutsedge only 30% at six weeks after planting. Sulfentrazone (PRE) provided 50% control of yellow nutsedge, but caused 30% injury to the cantaloupe. Finally, bensulide did not injure cantaloupe, but did not control yellow nutsedge

Halosulfuron also provided the best control of yellow nutsedge in watermelon (Table 1). The PRE applications did not cause any observable injury to watermelon and controlled yellow nutsedge 78 to 85%. Bentazon applied POST caused 10% crop injury and controlled yellow nutsedge only 30%. Sulfentrazone caused even more damage to watermelon (40%) than cantaloupe (30%) and controlled yellow nutsedge only 40%. Bensulide did not injure watermelon but failed to control yellow nutsedge.

Herbicide performance in summer squash was similar to that in cantaloupe and watermelon (Table 1). Halosulfuron was the best herbicide in terms of low crop injury and highest yellow nutsedge control. The PRE application of halosulfuron did not injure squash, and controlled yellow nutsedge 85 to 90%. POST applications caused slightly more injury (13 to 20%) than PRE applications but only controlled yellow nutsedge 75 to 78%. Bensulide did not injure the squash, but did not control yellow nutsedge.

LITERATURE CITED

Ackley, J.A., H.P. Wilson, and T.E. Hines. Yellow Nutsedge (*Cyperus esculentus*) control POST with acetolactate synthase-inhibiting herbicides. Weed Technol. 10:576-580.

Lorenzi, H.J. and L.S. Jeffery. 1987. Weeds of the United States and their control. Van Norstrand Reinhold Company, New York.

William, R.D. and G.F. Warren. 1975. Competition between purple nutsedge and vegetables. Weed Sci. 23:317-323.

Table 1. Visual ratings of injury, percent yellow nutsedge control, and yield of cucurbits in 1998 at Fayetteville.

Treatment	Rate	Application time[z]	Cantaloupe % Injury	Cantaloupe % Control	Cantaloupe Yield[y]	Watermelon % Injury	Watermelon % Control	Watermelon Yield[y]	Summer squash % Injury	Summer squash % Control	Summer squash Yield[x]
	(kg a.i./ha)										
Untreated			0	0	2	0	0	4	0	0	2.9
Halosulfuron	0.03	PRE	15	78	7	0	78	3	3	85	4.2
Halosulfuron	0.05	PRE	20	85	4	0	85	5	0	90	5.1
Sulfentrazone	0.28	PRE	30	50	7	40	40	4	25	33	2.2
Bensulide	6.73	PRE	0	0	6	0	0	4	5	0	3.5
Bentazon	0.84	POST	10	30	8	10	30	4	23	38	1.7
+ Agri-dex 1.25%											
Halosulfuron	0.02	POST	8	65	8	5	58	6	13	78	3.7
+ AG-98 0.25%											
Halosulfuron	0.04	POST	13	50	8	10	48	3	20	75	2.5
+ AG-98 0.25%											
LSD ($P < 0.05$)			13	15	4	5	16	3	10	8	3.3

[z] PRE = Pre-emergent at time of planting; POST = post-emergent at 28 days after planting.
[y] Yield of cantaloupe and watermelon is number of fruit/plot.
[x] Yield of summer squash in kg/plot.

Conversion Table

		U.S. to Metric	Metric to U.S.		
to convert from	to	multiply U.S. unit by	to convert from	to	multiply metric unit by
length			length		
miles	kilometers	1.61	kilometers	miles	.62
yards	meters	.91	meters	yards	1.09
feet	meters	.31	meters	feet	3.28
inches	centimeters	2.54	centimeters	inches	.39
area and volume			area and volume		
sq yards	sq meters	.84	sq meters	sq yards	1.20
sq feet	sq meters	.09	sq meters	sq feet	10.76
sq inches	sq centimeters	6.45	sq centimeters	sq inches	.16
cu inches	cu centimeters	16.39	cu centimeters	cu inches	.06
acres	hectares	.41	hectares	acres	2.47
liquid measure			liquid measure		
cu inches	liters	.02	liters	cu inches	61.02
cu feet	liters	28.34	liters	cu feet	.04
gallons	liters	3.79	liters	gallons	.26
quarts	liters	.95	liters	quarts	1.06
fluid ounces	milliliters	29.57	milliliters	fluid ounces	.03
weight and mass			weight and mass		
pounds	kilograms	.45	kilograms	pounds	2.21
ounces	grams	28.35	grams	ounces	.04
temperature			temperature		
F	C	5/9(F-32)	C	F	9/5(C+32)