HORTICULTURAL STUDIES 2001

**Edited by John R. Clark
and Michael R. Evans**

ARKANSAS AGRICULTURAL EXPERIMENT STATION
Division of Agriculture University of Arkansas
July 2002 Research Series 494

HORTICULTURAL STUDIES 2001

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PREFACE

We are pleased to bring you the fourth edition of *Horticultural Studies*. This publication, beginning with *Horticultural Studies 1998*, has continued to bring to the citizens of Arkansas the latest reports about horticultural crop research being conducted throughout the University of Arkansas Division of Agriculture.

Our original goal with this publication was to bring annual up-to-date findings to the horticultural community in Arkansas so that you could utilize these new findings and/or contact the researchers for further information. We hope that this goal is being met. *Horticultural Studies 2001* has the largest assemblage of articles thus far. Noteworthy in this year's compilation is an increased coverage of vegetable research, including southernpeas and tomatoes. Additionally, there are articles in other areas of horticulture from cultivar testing and evaluation of new cultural systems to pest control and various other topics. As editors, we strive to make this publication reader-friendly, timely, and hopefully of value to you, a user of the resulting technology, who we in the Department of Horticulture are working to serve.

Finally, several people should be commended for work on this publication. Cindy Kuhns, Shirl St. Clair, and Jo Salazar in the Horticulture Department office worked diligently in the manuscript revision process and their efforts are much appreciated. Likewise, many thanks to Camilla Romund and Howell Medders in the Agricultural Communications Unit for the technical editing, design, and printing of this document.

We hope you find value in *Horticultural Studies 2001*. Contact us with any comments or questions!

This publication is also available on the Internet at the following address:
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SPECIAL THANKS

Thanks are expressed to the donors listed below who contributed to horticulture programs in 2001. External support of all programs is critical to the continuing enhancement of horticultural industries in Arkansas.

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Oklahoma State University, Dr. Jim Motes
Organic Farm Research Foundation, Santa Cruz, Calif.
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United States Golf Association
Van Hoorn Nurseries, Inc.
VanBloem Nurseries, Inc.
Western Colorado Research Center, Colorado State University

2001 Highlights

2001 was a very good year for the Department of Horticulture. With the arrival of Dr. Mike Evans, who joined the department in April 2001, the department has a full academic staff in Fayetteville for the first time in several years. Dr. Evans teaches the greenhouse and the floriculture courses and has developed a graduate course, Research in Controlled Environments, with Dr. Doug Karcher. Dr. Evans has developed an aggressive and successful research program.

Dr. Paul Cooper, Area Extension Specialist, retired during 2001. He was a member of the Extension Horticulture Section. Paul worked with tomato and vegetable growers in Southeast Arkansas. Paul's expertise will be missed.

Kelly Irvin, Research Specialist in vegetable crops, and Scott Starr, Research Specialist in ornamentals, left the department in 2001. However, several new research specialists joined the department: Brad Fausett (fruit crops with Dr. Curt Rom), Margaret Secks (transferred from turf to molecular biology with Dr. Brad Murphy), Cynthia Stewart (ornamentals with Drs. Gerald Klingaman and James Cole), John McCulla (turf with Dr. Mike Richardson), Eric Stafne (fruit crops with Dr. John Clark), and Chris Weight (turf with Dr. Karcher). Additionally, Sallie Robert joined Extension horticulture in Little Rock as a horticulture program specialist with Ms. Janet Carson and Dr. Jim Robbins. Nanci Murray joined the department as accountant and works for both Horticulture and Entomology. Marilyn McCord became the official special projects coordinator for Horticulture when her position became a part-time staff position. Jason Collins joined the farm staff as agriculture farm technician and Serenity Guedel joined the Fruit Substation staff as administrative secretary. The hard work and dedication of faculty and staff make this an outstanding epartment.

Several graduate students joined the department in 2001. These include: Mr. Scott Renfro (advisor Dr. Jon Lindstrom), Mr. Phil Stewart (advisor Dr. Clark), Mr. Luis Mass (advisor Dr. Teddy Morelock), Mr. Chris Weight (advisor Drs. Karcher/Richardson), Mr. John Rash (advisor Dr. Rom), Mr. Randy Fry (advisor Dr. Richardson), Ms. Mary Gachukia (advisor Dr. Evans), Ms. Leisha Vance (advisor Dr. Evans), Mr. John Kahia (advisor Dr. Klingaman), Ms. Mengmeng Gu (advisor Drs. Robbins/Rom). Graduate students finishing their course of study during 2001 include: Ms. Erin Taylor (advisor Dr. Robbins), Ms. Aletta Mazebedi (advisor Dr. Craig Andersen), Ms. Natalie Huber (advisor Dr. Murphy), Ms. Sue Hum-Musser (advisor Dr. Murphy), Ms. Chrislyn Drake (advisor Dr. Clark), Mr. Brent Burkett (advisor Dr. Lindstrom) and Mr. Scott Maxwell (advisor Dr. Rom).

Programs - Teaching

Undergraduate education in horticulture continues to make progress. Minor changes were made to the curricula. Several classes underwent major reconstruction. Scholarships for horticulture students topped $70,000.00 for 39 students in 2001.

Recruitment of undergraduates has been more aggressive. We have developed several new printed materials and have sent posters for display at points of employment, country extension offices and in southwest Missouri high schools. Ms. McCord has done an outstanding job in connecting with and tracking potential horticulture students.

A non-thesis master's degree in horticulture is now officially on the books. This degree is aimed at folks who desire greater technical training in horticulture but are not interested in pursuing a research-related degree.

The Horticulture Display Gardens adjacent to Plant Science continue to develop and fill the entire courtyard. The garden has become a place for people to gather and for outdoor events. Additionally, the gardens provide many new display materials for teaching.

The department hosted Mr. George Anderson, Head of the School of Horticulture at the Royal Botanic Garden, Edinburgh, Scotland, for a week-long visit. Mr. Anderson gave three presentations during his visit. We have had two students do internships at the Garden. Dr. Hensley visited with horticulturists in Scotland in February 2001.

Programs – Extension

Extension had a very busy year. The Master Gardener program trained some 538 new Master Gardener volunteers in 2001. Nearly 16,000 active Master Gardeners shared their talents statewide for a total pool of 2,118 Master Gardeners in Arkansas. Almost 4,000 Master Gardeners have been trained since 1988. Mass media continue to be a strong part of the horticulture extension program. Besides weekly newspaper columns by Ms. Carson and Dr. Klingaman, horticulture extension specialists participated in weekly radio shows and numerous news stories and interviews. "Today's Garden," a 30-minute television show that airs on local cable access channels statewide and AETN, continues to gain viewers. A new magazine, *Arkansas Gardener*, features articles by several extension specialists.

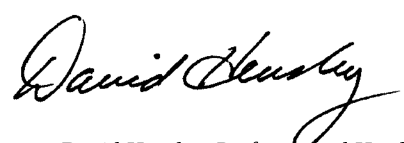
The Arkansas Flower & Garden Show in Little Rock attracted more than 11,000 participants in 2001 to view gardens, hear seminars and gather new information. Similarly, the Arkansas River Valley Lawn & Garden Show in Fort Smith continued to grow in 2001. Both shows generously provide scholarships for undergraduate horticulture students. We thank and applaud their efforts.

Dr. Robbins' program has expanded its web presence and is training candidates for the Arkansas Nursery Certification program. Dr. Klingaman continued working with the commercial greenhouse industry and ornamental trade associations.

Dr. Andersen, Vegetable Extension Specialist, assisted farmers' markets across Arkansas. Dr. Keith Striegler continued developing trials and research on grapes, strawberries, and other commercial fruit crops across Arkansas.

Programs – Research

Research programs grew in several areas during 2001. Several faculty were successful in obtaining significant funding. Accomplishments by faculty and students in Horticulture and other departments are discussed in the following reports.



David Hensley, Professor and Head,
Department of Horticulture

HORTICULTURAL STUDIES 2001

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HORTICULTURE INTERNSHIPS: COMPLEMENTING EDUCATION WITH EXPERIENCE

Curt R. Rom[1]

IMPACT STATEMENT

For the contemporary and competitive job market, students must have both excellent academic preparation as well as experience in the technology and business of their chosen career. However, with constraints of curricula imposing a large set of core requirements, reducing degree requirement credits, and placing an emphasis on graduating students in a timely manner, it is often difficult to balance a fundamentally sound science-based curriculum with the need for practical knowledge and experience that employers desire. Further, many students have not had a career-related employment prior to seeking a career position. Students without employment experience, and specifically without "hands-on" horticulture experience, may be at a competitive disadvantage for career hiring. To enhance the educational experience of students, support experiential learning objectives, and to assist horticulture employers, the Univ. of Arkansas Horticulture (HORT) Department developed and implemented a required student internship experience for the B.S.Ag.-HORT degree in 1998.

Since required internships were implemented in the HORT curricula, internship course enrollment has increased 10-fold from approximately 2-3% to 25% of the students annually enrolled in Horticulture degree programs. The impact of the internship program is several-fold and response to the experience by both students and internship providers (employers) has been positive. When students return from internships, they see relevance in the classroom experience and the need for their academic preparation. In many students, faculty observe greater focus and effort in their school work during the final semesters of their degree programs. Students returning from an internship have employment experience which appears on their resume or in their portfolio. In some cases, the internships have become "pre-employment training" for the student and they are offered employment at that operation upon graduation. Occassionally, internships do not live-up to the outlined objectives and the student's expectations and in some cases the internship has helped a student decide that the chosen career path is not correct. This allows them to redirect their interests. An additional beneficial impact of the internship program is that it helps connect horticulture employers and businesses with the Horticulture Department and faculty.

BACKGROUND

In the Horticulture curricula, an internship class designated HORT 462v ["v" meaning variable credit] Landscape Design and Urban Horticulture (LDUH) Internship was begun in the 1980s as an elective course choice for students enrolled in the LDUH major. When the HORT curricula were revised in 1998, this course name was changed to Landscape Horticulture Internship and three additional internship courses were added (HORT 463V Horticulture Internship, HORT 464V Turf Management Internship, HORT 465V Horticulture Merchandising Internship) to match the other degree programs in HORT. An internship experience (enrolling in one of the above courses) became a degree requirement for the B.S.Ag. in the two majors Horticulture and Turf and Landscape Horticulture. At that time, there were few other required internship requirements within the other degree programs of the College of Agricultural, Food and Life Sciences. The rationale for the requirement was based upon employer surveys conducted by the College and Department, and curricula review and revision by faculty. Employer surveys indicated a need for "real world" experience to compliment academic training. As the curricula was reduced from 132 to 124 credit hours, several required classes were eliminated from degree requirements, classes were consolidated or restructured, and curricula emphasis was placed on academic instruction. Thus, experiential learning and experiences, often provided in laboratories, was thought to be best-gained through an internship experience with a horticulture operation or related business.

PROGRAM DESCRIPTION

For each of the HORT majors degree programs (Horticulture, and Turf and Landscape Horticulture), one of the specific HORT internship courses (HORT 462v, 463v, 464v, 465v) is required. To be eligible to enroll and participate on an internship, a student must have completed a minimum of 30 credit hours (be a rising junior), have a minimum "C" grade average (2.00 cumulative grade point average), be in good standing at the University, and have successfully completed the course HORT 3901 Career Development. Students must complete the internship prior to the last 10 hours of their degree program, or prior to their last semester of enrollment. During the internship, a student is expected to work 12-15 weeks (one semester) of full-time employment for which they receive three credit hours. Students may complete up to eight credit hours of internship as part of their degree program. To facilitate uniformity in internships preparation, experience, and evaluation, the Department faculty developed and published an "Internships for

[1] Department of Horticulture, Fayetteville.

Horticulture Handbook" in 1999, which is revised annually after faculty review. For each internship class, specific faculty are designated as internship advisors. The internship advisors work in accord with the Department Undergraduate Program Committee which provides supervision to the internship program.

Internships are provided by companies in Arkansas and across the nation. Students have completed internships in Scotland, France, and New Zealand as well many states in the U.S. The internship providers are considered employers of the students. Most internships are paid-positions, and some direction and experience structure is given by the intern provider in exchange for work provided. Internships associated with botanical gardens, arboreta, or institutions often have an educational emphasis and require course work in addition to work experience. Some internships, however, do not pay the student for the work provided and some have little structure. Upon completion, interns are required to evaluate and rate both their internship provider and the experience they received. Students are evaluated by their employer for their job performance, and by the internship advisor based upon written and oral reports of their experience. Beginning in 2001, each intern was required to make a public presentation on the experience and have an oral examination with their internship advisor for their graded evaluation.

To facilitate students finding internships, the Department maintains a current file of several hundred internship employment opportunities. New internship opportunities are electronically posted on a horticulture student listserve via e-mail to quickly inform students. Students utilize the Career Development Office of the University to seek and secure internships. Students may work with individual faculty to identify and secure internship employment. Internships in Horticulture can also be found through weekly and monthly trade publications, and on several internet sites. Additionally, the Horticulture Department will facilitate internship providers in identifying and matching appropriate students for internships upon their request.

FINDINGS

During the period 1992-1997, prior to requiring an internship experience in 1998, only approximately 4% (range of 2-8%) of the students enrolled in HORT degree programs enrolled in HORT internship classes (Table 1). However, the number of students enrolled has increased to approximately one-quarter of the HORT undergraduate student body annually. Since 1999, five students have enrolled for more than three credits or had multiple internship experiences. During the 10 year period, the percentage of students enrolling in an internship during the spring, summer and fall semesters was 29, 40, and 31%, respectively. However, since 1998, only 16% of the students enrolled in the spring semester with the majority enrolling in summer or fall. There is a tendency for students to enroll in the fall semester following their internship as opposed to concurrent enrollment and experience during the summer semester. Simultaneous to the increase in internship enrollment, enrollment in internship prerequisite HORT 3901 Career Development has increased from an average of 18.6 (1998-2001) to 58 students in the 2002 spring semester.

Table 1. The number and percentage of Horticulture students enrolled in internships for credit during the 10-year period, 1992-2001.

Year	Number of internships	% of student enrollment
1992	2	3
1993	4	7
1994	1	2
1995	2	3
1996	1	3
1997	6	8
1998[z]	9	12
1999	21	23
2000	24	25
2001	23	26
Total 1992-2001	93	--

[z] Mandatory internships and multiple sections of internship started summer semester 1998.

FRUITS

MUSCADINE CULTIVAR EVALUATION IN SOUTHWEST ARKANSAS

Manjula Carter[1], Keith Striegler[2], John R. Clark[2], and Mike Phillips[1]

IMPACT STATEMENT

The market for muscadine grapes (*Vitis rotundifolia*) has increased recently since the discovery that they are a good source of ellagic acid and resveratrol. Muscadines are native to the southeastern United States and are generally well adapted to the climate of central and southern Arkansas. However, cultivars can differ in winter hardiness, quality, and productivity. Care must be taken in selecting the most suitable cultivar for a particular location. Although there is no muscadine breeding program at the University of Arkansas, evaluation of currently available fresh market and processing cultivars continues at the Southwest Research and Extension Center at Hope (hardiness zone 7b). Fruit evaluations began at Hope when the vines reached maturity in 1999 and will continue for another 3 years. Cultivar differences were observed for yield and berry weight at this location. The cultivars Carlos, Granny Val, Ison, Jumbo, Nesbitt, Southern Home, and Summit were consistently high-yielding in all 3 years. ‘Black Beauty’ was very productive in 2001 (84 lb/vine) despite lower yields in the previous 2 years. Cultivars that yielded poorly (46 lb/vine or less on average) included ‘Early Fry’, ‘Fry’, NC67A015-26, ‘Sugargate’, ‘Scarlet’, and ‘Sterling’. ‘Black Beauty’ and ‘Sugargate’ had the largest berries, approximately 10 g. ‘Early Fry’, ‘Fry’, ‘Granny Val’, ‘Jumbo’, ‘Nesbitt’, ‘Scarlet’, ‘Sterling’, and ‘Summit’ had medium-large berries (6 to 8 g). ‘Carlos’, ‘Ison’ and ‘Southern Home’ had small berries (5 g or less). Based on these preliminary findings, ‘Black Beauty’, ‘Carlos’, ‘Granny Val’, ‘Ison’, ‘Nesbitt’, and ‘Summit’ show potential for commercial planting in Southwest Arkansas and other areas with a similar climate.

[1] Southwest Research and Extension Center, Hope
[2] Department of Horticulture, Fayetteville

BACKGROUND

Muscadines have been produced commercially in Arkansas since 1972 (Moore, 1972). Most of the muscadine cultivars currently available to growers in Arkansas were developed by the Universities of Georgia and North Carolina State in cooperation with the U.S. Department of Agriculture (USDA), and by Ison’s Nursery of Brooks, Ga. Several of these cultivars were evaluated at the University of Arkansas Fruit Substation, Clarksville (west central Arkansas, hardiness zone 7a) from 1987 to 1998. Cultivar differences in susceptibility to winter injury, and subsequent productivity, were apparent at the Clarksville site (Clark, 2001). To corroborate these results, a muscadine planting was established at the Southwest Research and Extension Center (SWREC), Hope, Ark., and the most promising cultivars from the Clarksville trial along with new cultivars were included for evaluation at this site. December and January are the coldest months at this site with lows ranging from 28 to 36°F, and there is a 90% probability of freezing temperatures occurring after March 16. The objective of our trial was to determine the most productive cultivars at this location so that cultivar recommendations could be made to Arkansas growers.

RESEARCH DESCRIPTION

The muscadine planting was established in 1996 on a Bowie fine sandy loam soil. The vines were spaced 20 ft apart and trained to a single-wire trellis using a bilateral cordon training system. Rows were spaced 10 ft apart and vines arranged in a completely random design with six replications of each cultivar. Each spring 0.5 lb of 13-13-13 was surfaced applied to each vine and vines were drip irrigated throughout the summer. Five fungicidal sprays were appllied in 2001. The cultivars evaluated were ‘Black Beauty’, ‘Carlos’, ‘Cowart’, ‘Doreen’, ‘Early Fry’, ‘Fry’, ‘Granny Val’, ‘Ison’, ‘Jumbo’, ‘Late Fry’, NC67A015-17, NC67A015-26, ‘Nesbitt’, ‘Sugargate’, ‘Southern Home’, ‘Scarlet’, ‘Sterling’, ‘Summit’, ‘Supreme’, ‘Tara’, and ‘Triumph’. Total yield per vine, berry weight, and percent soluble solids were measured. Prior to harvest, the percent soluble solids was measured weekly with a refractometer on randomly harvested berries from each plot. A cultivar was harvested when the average soluble solids was 16% or more for all replications. In 1999, only one harvest was performed for each vine since this was the first year of production and yields were low. In 2000 and 2001, vines of cultivars used for fresh market, except ‘Sugargate’, were harvested twice during the season. At the first harvest only the ripest berries were picked and at the second harvest the vines were stripped. This method of harvesting is typical of a commercial situation where the first hand-picked berries are used for fresh market and the remainder are harvested mechanically for processing. ‘Sugargate’, although a fresh market cultivar, was harvested only once to minimize yield loss since its early ripening made it more susceptible to raccoon damage. For the cultivars used solely for processing, only a once-over harvest was performed. In 2000 and 2001, the vines were rated for vigor, susceptibility to Macrophoma rot, angular leaf spot, and magnesium deficiency. All data were analyzed using SAS and means were separated by least significant difference (LSD), $P < 0.05$.

FINDINGS

The date of first harvest ranged from 19 Aug. for 'Sugargate' to 9 Oct. for 'Southern Home' (Table 1). The average date of first harvest for all cultivars was 30 Aug. For most fresh market cultivars the second harvest accounted for 50% or more of the total yield. Exceptions to this were 'Black Beauty', 'Cowart', 'Ison', and 'Granny Val' where most of the yield came from the first harvest. The cultivar x year interaction was significant for yield indicating that annual variations in climate influenced productivity. However, for most cultivars, yield increased significantly each year from 1999 to 2001 as the vineyard matured (Table 1). In 2001, the highest yielding cultivar was 'Jumbo', which produced 100 lb/vine, followed by 'Summit', 'Southern Home' and 'Black Beauty' (95, 88, and 84 lb/vine, respectively). 'Carlos', 'Granny Val', 'Ison', and 'Nesbitt' produced approximately 78 lb/vine. 'Fry', 'Sterling', and 'Sugargate' had the lowest yields ranging from approximately 41 to 55 lb/vine. 'Sugargate' was a vigorous vine that rated well for disease resistance (data not shown). However, it was the earliest ripening cultivar and was subject to damage by raccoons in 2000 and 2001, which may have contributed to its low yield measurement.

Berry weight was not significantly different among years for all cultivars except 'Fry', 'Summit', and 'Supreme' (Table 1). For 'Summit', berry weight increased each year and was significantly higher in 2001 than in 1999. For 'Fry' and 'Supreme', berry weight was lower in 2000 than in the previous 2 years. In 2001, 'Black Beauty' and 'Sugargate' had the largest berries weighing approximately 10 g. 'Early Fry', 'Fry', 'Granny Val', 'Jumbo', 'Late Fry', 'Scarlet', 'Sterling', 'Summit', 'Supreme', and 'Tara' all had similar average berry weight of 8 to 9 g. 'At 4 to 5 g, Doreen', 'Carlos', 'Ison', NC67A015-26, NC670A15-17, and 'Southern Home' had the smallest berries.

Percent soluble solids was significantly higher in 1999 than in 2000 and 2001 for all cultivars except 'Cowart', 'Granny Val', 'Nesbitt', and 'Triumph' (data not shown). 'Cowart', NC67A015-26, 'Sugargate', 'Scarlet', 'Sterling', 'Supreme', and 'Tara' had the highest average percent soluble solids (17.8 to 18.7 %), and 'Carlos', 'Doreen' and 'Jumbo' had the lowest (14.7 to 15.6 %; data not shown). In 2001, the soluble solids at harvest for many cultivars was lower than 16% and this might be attributed to the higher yields in 2001 compared to other years.

Incidence of Macrophoma rot and angular leaf spot was low in 2001 due to adequate control with fungicides, and there were no cultivar differences in susceptibility to these diseases (data not shown). However, in 2000 and 2001, symptoms of severe magnesium deficiency were observed in 'Doreen' and 'Early Fry', and these two cultivars had poor vigor (data not shown). Vines with good vigor in 2001 included 'Black Beauty', 'Carlos', 'Cowart', 'Ison', 'Jumbo', NC67A015-17, 'Sugargate', 'Southern Home', 'Scarlet', 'Summit', and 'Supreme'(data not shown).

'Black Beauty', 'Carlos', 'Ison', 'Nesbitt', and 'Summit' were the most productive cultivars at this site. The performance of these cultivars over the next 3 years of data collection will determine whether they can be recommended for commercial planting.

LITERATURE CITED

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Moore, J.N. 1972. Performance of muscadine grape cultivars in Arkansas. Ark. Agri. Expt. Sta. Report Series 200.

Table 1. Muscadine cultivar use, avg. harvest date, yield, and berry weight 1999-2001, Southwest Research and Extension Center, Hope, Ark.

Cultivar	Use[z]	Avg. date first harvest	Yield (lb/vine) 1999	Yield (lb/vine) 2000	Yield (lb/vine) 2001	Berry weight (g) 1999	Berry weight (g) 2000	Berry weight (g) 2001
Black Beauty	F, H	8/28	10 d-f[y]	43 e-g	84 a-c	10.6 a	10.7a	10.3 a
Carlos	F, H, P	9/17	25 a-c	71 a-d	81 b-d	3.9 f	4.6 i-k	4.9 ef
Cowart	F, H, P	8/28	6 f	49 d-f	72 c-e	6.7 de	5.5 g-j	6.3 d-f
Doreen	H, P	9/20	29 ab	41 e-g	61 e-h	3.9 f	4.9 h-k	4.1 f
Early Fry	F, H	8/25	7 ef	34 fg	58 e-h	10.0 ab	9.4 a-c	8.8 ab
Fry	F, H	8/29	17 c-e	42 e-g	49 gh	9.6 a-c	7.9 b-f	8.9 ab
Granny Val	F, P	9/21	35 a	84 a	82 b-d	8.1 b-d	6.7 e-h	8.9 ab
Ison	F, H	8/31	29 ab	65 a-e	79 b-d	4.7 ef	5.5 g-j	5.5 ef
Jumbo	F, P	9/9	35 a	77 a-c	100 a	8.0 b-d	7.9 b-f	8.2 a-c
Late Fry	F	9/21	----	50 b-f	56 e-h	-----	7.4 c-g	7.9 a-d
NC67A015 -17	F, P	9/6	15 c-f	37 fg	66 d-g	4.1 f	4.0 jk	5.3 ef
NC67A015-26	F, P	8/30	15 c-f	32 fg	63 d-h	3.6 f	3.3 k	4.1 f
Nesbitt	F, H	8/27	29 ab	49 d-f	80 b-d	6.9 d	5.7 g-j	6.1 c-f
Sugargate	F, H	8/19	2 f	17 g	54 f-h	-----	9.5 ab	10 a
Southern Home	F, H	10/9	20 b-d	60 a-e	88 a-c	4.1 f	3.8 jk	4.8 ef
Scarlet	F, P	8/31	----	27 fg	66 d-f	8.5 a-d	8.7 b-d	9.4 ab
Sterling	P	9/2	11 def	47 d-f	44 h	7.6 cd	8.0 b-e	8.6 ab
Summit	F, P	8/30	25 bc	61 b-e	95 ab	7.2 d	7.3 d-g	9.0 ab
Supreme	F, P	8/26	13 def	43 ef	77 cd	9.5 a-d	6.1 f-i	8.0 a-d
Tara	F, H	8/22	6 f	45 d-f	73 c-e	8.4 b-d	8.5 b-e	9.1 ab
Triumph	F, H	8/20	14 c-f	38 fg	69 c-f	6.5 de	6.9 d-g	7.1 b-e

[z] F= fresh market, H=home, P=processing use.

[y] Within a column, numbers followed by the same letter(s) are not significantly different as determined by LSD ($P < 0.05$).

LSD for comparing years within a cultivar are 14 for *Yield* and 1.4 for *Berry weight*, above

EFFECTS OF PRUNING AND CROPPING ON FIELD-GROWN PRIMOCANE-FRUITING BLACKBERRIES

Chrislyn Drake and John R. Clark[1]

IMPACT STATEMENT

Primocane-fruiting blackberry selections have recently been developed by the University of Arkansas, but proper cane-management practices for the new germplasm have not been determined. It was observed in previous trials that primocane-fruiting selections flowered and fruited in late July and early August in Arkansas, which is often the hottest part of the summer and earlier than desired. Therefore, this study was conducted to determine the effects of primocane tipping on cane and fruit characteristics, and to determine the effect of floricane presence on primocane performance. In Fayetteville, one-year-old plants of selections APF-8 and APF-12 were used to apply the four primocane-tipping treatments in combination with the two cane management treatments (presence or absence of floricanes). Tipping treatments and genotype had a significant effect on both primocane yield and harvest date, but that cane treatment had little effect overall.

BACKGROUND

In recent years, blackberries have become a widely-grown horticultural crop in Arkansas and elsewhere in the southern United States. Today, one of the largest blackberry-breeding programs worldwide is at the University of Arkansas. Since the program began in 1964, 10 cultivars have been released, each of which has one or more desirable characteristics such as erect canes, large fruit, or thornless canes. A current goal of the breeding program at the University of Arkansas is to develop primocane-fruiting (fall-fruiting) cultivars to allow fruiting into autumn.

Currently, the primocane-fruiting trait is almost exclusively found in red raspberry (Moore et al., 1999). Lopez-Medina (2000) studied the inheritance of the primocane-fruiting trait in blackberry. From his seedling populations, 13 primocane-fruiting selections resulted that displayed desirable characteristics. However, some concerns exist regarding these primocane-fruiting selections. The primocanes fruit during late July, August, and September, when temperatures in Arkansas are often high enough to damage fruit. Examples of high temperature effects on blackberry fruit are small, crumbly berries and poor flavor. A second concern with the primocane-fruiting selections is that their primocane yields are low compared to floricane yields of floricane-fruiting cultivars. We hypothesized that the practice of tipping primocanes may both delay time of fruiting and increase yields. Also, research in primocane-fruiting red raspberries showed that tipping primocanes has some effect on primocane period of fruiting and yield (Jordan and Ince, 1986; Richter et al., 1989). As primocane-fruiting blackberries can be managed in a double cropping (producing both a primocane and floricane crop) or a single cropping (producing only a primocane crop) system, it is also important to determine if a floricane crop has effect on the primocanes.

Because no information is available for field management of primocane-fruiting blackberries, the goal of this research was to investigate some fundamental cane management practices on the newly-developed primocane-fruiting blackberry selections. Therefore, the objectives of the study were to determine the effect of floricane presence on primocane performance, and the effect of primocane tipping fruiting.

RESEARCH DESCRIPTION

In order to determine the effects of cane treatment and tipping treatment on primocanes, the two most promising selections from Lopez-Medina's crosses, APF-8 and APF-12, were chosen (J. R. Clark, personal communication). The study was conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville. This replicated planting of APF-8 and APF-12 was established in the spring of 1999 and was, therefore, in its second year for this study. The planting consisted of 10 plots (10 ft in length and 3 ft in width) each of APF-8 and APF-12, with five plants in each plot. The field was planted in a randomized incomplete block design and was irrigated and fertilized according to standard cultural practices for floricane-fruiting blackberries in Arkansas. To determine the effect of floricane cropping on primocane performance, floricanes were removed from half of the plants of each selection on 6 March 2000, before growth had begun. Five randomly selected plots of each selection were pruned so that floricanes were removed from the first, third, and fifth plants in the plot, and the remaining five plots were pruned so that floricanes were removed from the second and fourth plants in the plot. Plants that retained floricanes were pruned according to standard cultural practices for floricane-fruiting blackberries, which consisted predominately of shortening laterals to approximately 15 in. in length.

On the same plants, four tipping treatments were imposed to determine the effect of tipping on harvest period, yield, and primocane growth. The treatments were: 1) soft tip when primocanes reached 3 ft in height, 2) soft tip at inflorescence appearance, 3) soft tip 2 weeks after inflorescence appearance, and 4) an untipped control. Soft tip was defined as the removal of 1 to 2 in. from the distal end of the cane.

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

Measurements taken were peak harvest date and total yield. Fruit werepicked twice a week during the harvest period and were weighed immediately following harvest. Peak harvest date was determined at the end of the season by using the date that the cane produced the highest weight of fruit. Data analysis was performed with the Statistical Analysis Systems Program and mean separation was by multiple t tests (P = 0.05).

FINDINGS

The cane and tipping treatments both affected primocane performance, but the two genotypes did not always behave similarly. The two late tipping treatments performed poorly overall. Difference in performance between double-crop and single-crop plants was not as large as expected. No interaction effects were observed, so only main effect means will be discussed. All data are on a per primocane basis.

Primocane yield varied significantly among tipping treatments. The canes tipped at 3 ft and the untipped canes had the highest yields overall (77.8 g and 66.2 g, respectively), and the canes tipped at inflorescence appearance and at 2 weeks after inflorescence appearance had the lowest (16.9 g and 9.9 g, respectively). Heat damage could be the cause of the low yield for the two late tipping treatments. During the last two weeks of August, when canes tipped at inflorescence appearance and at two weeks after inflorescence appearance were blooming, the average high temperature was 97°F and only a trace of rain fell. These extremely hot and dry conditions may have resulted in poor pollination, which in turn caused berries from the two late treatments to be extremely small and crumbly, while berries from canes tipped at 1 m and the untipped canes were usually well-sized and whole. The main effect of genotype on primocane yield showed that APF-12 had significantly higher yields than did APF-8, with 56.0 g per cane compared to 29.4 g. The higher yield of APF-12 compared to APF-8 may be due to the primocanes of APF-12 blooming earlier on average than those of APF-8, therefore allowing it to escape much of the heat during bloom that APF-8 experienced. APF-8 had higher levels of fruit non-set than APF-12: approximately 50% of the flowers produced fruit for APF-12, while only 40% of the flowers produced fruit for APF-8.

The main effect of cane treatment, which was the presence or absence of floricanes, on primocane yield resulted in no significant difference in primocane yield between double cropping and single cropping, with the double crop treatment averaging 37.3 g per cane and the single crop treatment averaging 48.1 g. This non-effect of cane treatment on primocane yield was rather unexpected. Prior to this study, it was thought that the primocanes in the single-crop treatment would perform better than the primocanes in the double-crop treatment due to the greater amount of carbohydrates that would be available because of the absence of the floricanes. This non-effect of cane treatment could be due to a lack of competition between primocanes and floricanes for carbohydrates.

Tipping treatment and genotype were the only main effects that were significant for peak harvest date. For peak harvest date, the canes tipped at 3 ft and the untipped canes were the earliest, and were only separated by one day (23 Aug. and 24 Aug., respectively). The canes tipped at inflorescence appearance and at 2 weeks after inflorescence appearance had the latest peak harvest date, and were approximately 2 weeks later than the other treatments (8 Sept. and 5 Sept., respectively). While a delay in fruiting was attained by using the two late tipping treatments, fruiting characteristics were negatively impacted. The mean peak harvest date for APF-12 was significantly earlier than APF-8, with 9 days separating the two treatments (26 Aug. and 4 Sept., respectively). Cane treatment did not have a significant effect on mean peak harvest date, with only 1 day separating the single-crop and double-crop treatments (30 Aug. and 31 Aug., respectively).

Although the presence of floricanes did not have the impact on primocane performance that was anticipated, some very valuable information about the management of primocane-fruiting blackberries was learned—for example, double-cropping the plants was not detrimental to the primocane crop in the same year. However, the long-term effects of double-cropping primocane-fruiting blackberries are still unknown, and future studies could determine if any long-term effects do exist.

From the tipping treatment studies, it was learned that tipping after plants have shifted to the reproductive mode was detrimental to yield at this location. The canes tipped at 3 ft either performed better or the same as the untipped canes. Future studies with tipping treatments could look at the effects of severity of tipping early in the season, perhaps even before the canes have reached 3 ft in height. Also, these genotypes may perform differently in other climates, particularly those with more moderate late summer and fall temperatures. In these climates, cane tipping to delay or extend harvest in the fall may be valuable, particularly if some method of protected culture such as "high tunnels" is used.

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GRAPE SCALE BIOLOGY AND MANAGEMENT OF GRAPES IN ARKANSAS

Donn T. Johnson, Barbara A. Lewis, and J. David Whitehead[1]

IMPACT STATEMENT

In this study, we relate the seasonal biology of grape scale crawlers and males in Arkansas to calendar date and degree day (DD) accumulations, and note the efficacy of a bud swell application of chlorpyrifos against subsequent generations of grape scale.

BACKGROUND

The grape scale, *Diaspidiotus uvae*, is a pest of grapes from Florida to New Jersey, and west to Texas (Comstock, 1880; Zimmer, 1912). Grape scale caused significant vine death after 1950 in Arkansas (Whitehead, 1963). Zimmer (1912) and Whitehead (1963) described the biology and control of the grape scale. Adult scale are whitish-gray in color and are easily detected on the canes during dormant pruning. Vigorous canes are less likely to be attacked.

A DD model would aid growers to time insecticide applications against crawlers. To date, a cumulative DD model is not available for grape scale. The following formula was used to calculate DD = [(daily max. ºF + daily min. ºF)/2 -50º F]. Based on similarities in development of San Jose scale, *Quadraspidiotus perniciosus* and grape scale, the lower developmental threshold of grape scale was set at 50º F (Jorgensen et al. 1981). Grape scale overwinter as mated females. Thus, a biofix, such as first male flight, would not work with grape scale. So, the starting date for accumulating DD was set at bud swell (1 April).

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RESEARCH DESCRIPTION

In 1994 and 1996, studies were concluded in a 'Concord' vineyard in Lowell, Ark. (19 acres, 516 vines per acre). Grape scale crawlers and scale males were monitored using double-sticky ScotchTM tape (3M Co., St. Paul, Minn.) wrapped around scale-infested canes. Crawlers were counted on five tapes each on 12 vines (1994), and two tapes each on 10 vines (1996).

The Baskerville and Emin (1969) sine-wave method with no upper threshold was used to calculate daily DD for Fayetteville, Ark. for 1959 to 1962, 1994, and 1996 (NOAA). These temperature records were within 9.3 miles of Lowell and Tontitown.

In 1996, vines with similar grape scale levels were selected as a non-completely randomized design. On 16 April, an air blast sprayer treated vines with chlorpyrifos at the rate of 1 lb (AI)/acre. Tapes were wrapped around two scale-infested canes on each of 10 treated and untreated vines (10 replicates). Scale crawlers and males were counted as above.

FINDINGS

First-generation crawler emergence (Table 1) began on 14 May (493 DD after 1 April), peaked by 20 May (640 DD) and was 80% complete by the last week of May (990 DD). First- generation, winged males began emerging by 26 June (1429 DD) and peaked on 13 July (1948 DD). Second generation crawlers emerged by 20 July (2098 DD) and peaked on 12 Aug. (2788 DD). Second generation, wingless males emerged by 31 Aug. (3342 DD) and peaked on 18 Sept. (3646 DD). Degree day values for the crawlers for beginning or peak emergence varied by ± 78.3 DD (equates to about 2 to 3 days). Calendar dates for when crawlers began or had peak emergence varied by ± 3.3 days (range of 3 to 3.5 days).

The insecticide efficacy study found that chlorpyrifos applied at bud swell caused an eight-fold reduction in captures of crawlers on tapes on vines treated (Table 2). Significantly fewer crawlers per tape were trapped on treated vines (< 6.2) than on untreated vines (163.8) on all sample dates, except 11 June. Chlorpyrifos persisted for at least 65 days against grape scale (Johnson et al., 1999). Howell and George (1984) reported a similar persistence of chlorpyrifos against San Jose scale on peach bark. NOTE: The EPA would not add grape scale on grapes to the Lorsban (chlorpyrifos) 4E label.

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ACKNOWLEDGMENTS

We thank J. Bishop, Lowell, Ark. for use of his grape vineyard. Lorsban 4 E was provided by Dow Elanco. This research was funded in part by IR-4 Project # 05130.94-AR04.

Table 1. Calendar dates and physiological time accumulations of degree-days (DD) (±standard deviation) after April 1 (50°F) for stages of grape scale in Lowell and Tontitown, Ark.[z]

Generation and stage	Avg. date	Avg. DD±SE
Spring		
1st crawler	14 May 1.0	493 32.9
Peak crawler	20 May 3.0	641 83.7
1st male	26 June 3.5	1,429 54.9
Peak male	13 July 4.7	1,994 115.0
Summer		
1st crawler	20 July 3.8	2,099 29.2
Peak crawler	12 Aug. 3.5	2,788 72.9
1ar male	31 Aug. 8.3	3,342 120.1
Peak male	18 Sept. 6.7	3,636 166.9

[z] Averages of data reported by Whitehead (1963) from Tontitown, Ark. and from this study conducted in Lowell, Ark.

Table 2. Effects of chlorpyrifos applied at bud swell to 'Concord' grapevines on counts of grape scale crawlers per sticky tape in Lowell, Ark. (1996).

Date	Spray	Control
23 May	6.2b[z]	163.8a
3 June	2.7b	104.0a
11 June	1.1a	8.8a
17 July	0.05b	12.7a
26 July	0.9b	78.2a
1 Aug.	3.9b	60.4a
9 Aug.	4.6b	94.0a
15 Aug.	1.0b	34.0a
28 Aug.	3.4b	79.1a
9 Sept.	4.6b	30.6a

[z] Untransformed means in rows followed by the same letter(s) are not significantly different (LSD, P> 0.05). Data transformed by log10 (X + 1), then analyzed.

TRAPPING BROWN STINK BUGS IN PEACH

Donn T. Johnson[1], Barbara A. Lewis[1], and Russ F. Mizell, III[2]

IMPACT STATEMENT

Pheromone-baited, yellow pyramid traps were evaluated for monitoring stink bug (SB) entering peach orchards. The brown SB, *Euschistus servus*, (Fig. 1) was the major species caught in these orchards. Peach monocultures had < 45 SB/trap/season compared to 140 SB/trap/season caught in a truck farm with apples, blackberries, eggplant, peaches, squash, and tomatoes. New SB catfacing damage exceeded 1% as counts exceeded 60 SB/baited yellow trap or 1.5 SB/limb jarring. This economic threshold should be tested in additional peach plantings and other crops attacked by SB throughout the southern region.

BACKGROUND

The key insect pests of peach in the southern U.S. include oriental fruit moth *Grapholita molesta*, plum curculio *Conotrachelus nenuphar*, several stink bug (SB) species, and tarnished plant bug (TPB) *Lygus lineolaris*. The later three pests persist from year to year by overwintering in ground debris in woodlots adjacent to orchards.

The problem is that most growers follow a calendar-based spray program to keep fruit damage below the economic injury level of 2%. Typically, growers apply eight or more full-orchard applications of insecticide per season. In the southern U.S., SB attained pest status after EPA began canceling organophosphate use in peaches (Johnson et al., 2002). As SBs feed, they inject a toxin into the fruit that destroys cells and locally inhibits fruit development at the feeding wound causing scarring referred to as “catfacing”.

Catfacing damage by TPB before petal fall and SB after petal fall was significantly reduced in orchards by eliminating flowering hosts from the groundcover in and around peach orchards by mid-March (Killian and Meyer, 1984).

Timing insecticide applications against the remaining SB population has resulted in four or fewer insecticide sprays per season. Gorsuch and Miller (1984) and Johnson (1989) or Johnson et al. (1994; 1996) recommended using an economic threshold of 0.2 SB per 5 minutes of limb jarring. However, growers were not inclined to jar limbs to make spray-timing decisions. Thus, an alternative SB monitoring method and a threshold was needed.

A new SB monitoring method was developed after the aggregation pheromone for brown SB group, *Euschistus* spp., was identified as methyl (2E, 4Z)-decadienoate (Aldrich et al., 1995; Cottrell et al., 2000). The purpose for this study was to derive an economic threshold by comparing weekly percent catfacing damage of peach to SB counts from limb jarring and yellow pyramid traps baited with SB aggregation pheromone.

RESEARCH DESCRIPTION

On 1 June 2000, baited, yellow pyramid traps were set out at densities of five in Conway, and three in Nashville (all commercially sprayed orchards). By 1 April 2001 four baited, yellow pyramid traps were placed in each of four orchards (two discussed here).

Weekly scouting: Estimates were made of the numbers of SB/limb jarring and SB/trap in adjacent peach trees. These SB traps were re-baited each time they were checked. The percent catfacing was estimated by inspecting 30 fruit on each of 10 trees near traps SB. All collected SB specimens were identified as to species. These demonstration orchards in Arkansas followed an IPM Program in 2000 and 2001.

Statistics: Data analysis compared weekly counts of SB/trap and SB/limb jarring adjacent to these traps to percent new catfacing damage. The economic threshold was identified as the respective number of SB/trap or SB/limb jarring when percent new catfacing exceeded 1%.

FINDINGS

In 2000 and 2001, the Conway orchard had the most SB trapped/season (Figs. 2 and 3). Of those sampled, only this farm was diversified with apples, blackberries, peaches, squash, pears, tomatoes, and eggplant. Only five (in 2000) and two (in 2001) insecticide sprays/season were applied in Conway compared to eight (in 2000) and five (in 2001) insecticide sprays/season for Nashville.

The brown SB (Fig. 1) accounted for 91% (in 2000, Fig. 2) and 98% (in 2001, Fig. 3) of the season total trap catch of SBs. These adults were caught in traps from late March through harvest in August (Figs. 2 and 3). In comparison, between 1 to 4% of the season trap total was green SB, *Acrosternum hilare*. These adults were caught from late June to mid-July (Fig. 2, 3). Less than 1% of the season total catch was dusky SB, *E. tristigmus* (Figs. 2 and 3), or red-shouldered SB, *Thyanta accerra* (Figs. 2 and 3).

Yellow, baited SB traps may become the preferred method for monitoring SB in peaches and other crops. An economic threshold (ET) has

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been proposed as >60/trap or >1.5/limb jarring. These ET values occurred on 24 June 2001 and equated to the only period when new catfacing damage was ≥1% (Fig. 4 - arrow).

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Fig 1. Brown stink bug.

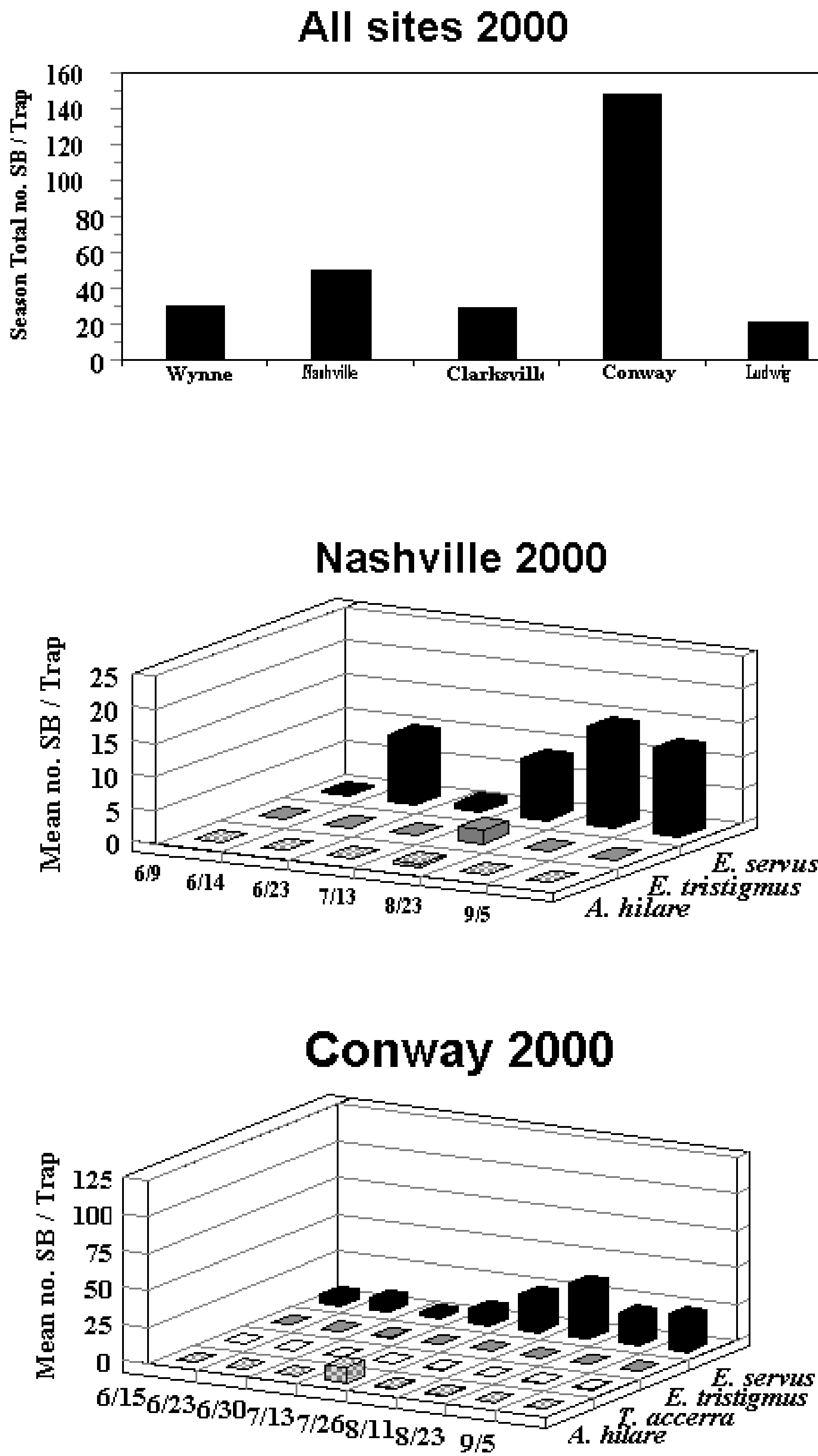

Fig. 2. Stink bug trap catches for 2000.

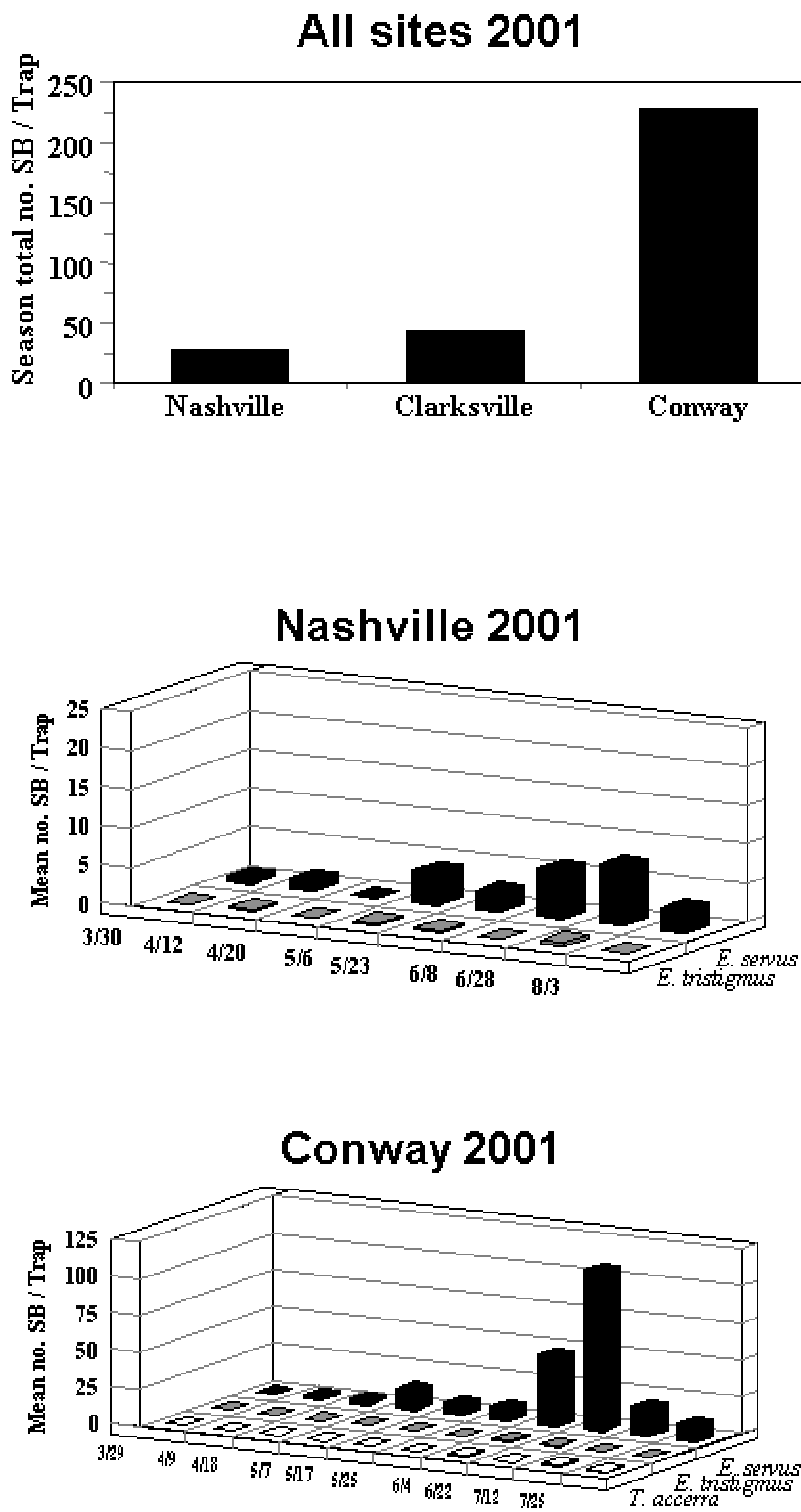

Fig. 3. Stink bug trap catches for 2001.

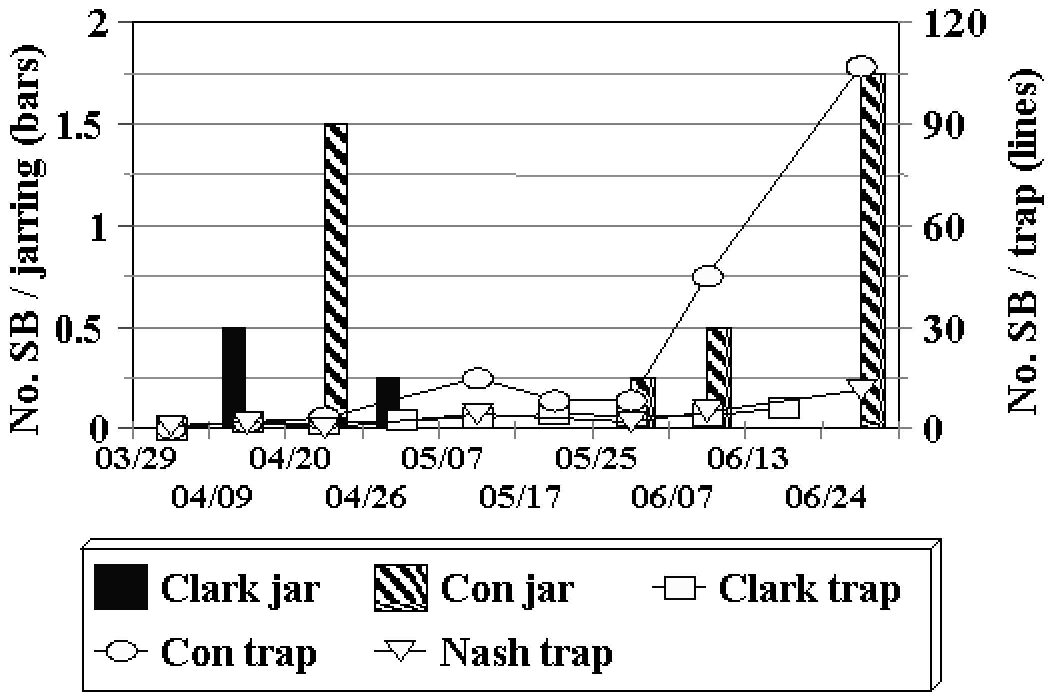

Fig. 4. Limb jarring and trap catch 2001 where arrow indicates counts exceeding tentative economic threshold (>1.5 SB/limb jarring or >60 SB/trap). Clark=Clarksville; Con=Conway; Nash=Nashville—sites of the collections.

DEMONSTRATING THE NEED FOR ALTERNATIVE APPLE FRUIT THINNING METHODS FOR ORGANIC GROWERS

Curt R. Rom[1]

IMPACT STATEMENT

Fruit crop thinning of apple during the bloom and immediate post-bloom period is essential to ensure large fruit size and reliable annual cropping. In conventional orchards, fruit thinning is accomplished either by use of synthetic plant growth hormones or their analogs, herbicides, or flowers and fruitlets are mechanically removed by hand. Because of the significant expense of hand-removal of flowers and fruitlets, most fruit thinning technology development research has focused on chemical methods and several chemical products are currently registered for use. However, none of these chemicals are acceptable or certified for organic fruit producers. There is, in fact, a dearth of research information on certifiable organic alternatives to these chemical thinners. To demonstrate a need for this information the organic growing industry, a survey was conducted by mail and internet. The survey typified organic apple orchards in the U.S., demonstrated the need for research in this area, and created a database of current best practices used by certified organic apple growers.

BACKGROUND

For an apple orchard to be economically sustainable, it must annually produce a large crop of high quality fruit. To ensure this, it is absolutely essential that fruit growers control the cropping on the tree. Maintaining an appropriate crop load (number of fruit per tree) is particularly important as the number of fruit per tree has two significant impacts on long-term cropping and fruit quality. First, as fruit number per tree increases, individual fruit size decreases. Further, fruit value is largely associated with fruit size. Thus, a relatively large crop of small, low-value apples has a lower crop value than a moderate crop of large, high-value fruit.

The second issue is of regular cropping. Apple flowers are formed in late spring through early summer (May-July), the season prior to bloom and fruit development. Thus, flowers for next year's crop develop simultaneously to the development and growth of the current-season crop. The developing apples can inhibit or reduce the formation of flowers and there is a negative correlation between crop load and return bloom. Thus, a large crop in a given year will be followed by a small crop the following year. To prevent this biennial bearing, excessive fruit must be removed in the first 30-45 days after bloom as flowers for the following season's crop are being initiated. Delaying crop thinning until after this time will have little to no positive effect on flower initiation or fruit size.

Several different strategies are used for fruit thinning. Mechanical or hand thinning is used either at bloom or approximately 20-45 days after bloom. Hand thinning is expensive and some economic reports have indicated that this single operation may constitute 5-20% of pre-harvest orchard operation expense. Chemical thinning is used following two specific strategies. Chemicals, typically caustic compounds, herbicide-related compounds, or synthetic plant growth hormone analogs, are applied at bloom to prevent pollination by desiccating or killing the pistils of flowers. Post-bloom thinners are typically synthetic plant growth hormone analogs that either cause seed abortion in some fruitlets and thus their abscission and drop, or enhance the competitive advantage of some fruits allowing them to better compete for carbohydrate resources of the tree. Research has shown that photosynthetic-inhibiting herbicides cause smaller, less competitive fruits to drop.

A thorough search of the literature indicated a dearth of knowledge of possible thinning alternatives that may be certifiable organic methods. Organic apple orchards constitute approximately 7% of the national crop and the acreage is increasing annually. Currently, organic growers are receiving higher prices for their fruit per packed box than are conventional growers. To support the organic fruit industry, the status of production technology and the needs of the industry must be assessed and technology developed based upon those expressed needs.

RESEARCH DESCRIPTION

Key questions regarding the status of organic apple growers in the U.S., the needs for fruit crop management and thinning, and potential certified organic thinning methods were identified during a series of meetings with organic growers and other pomologists. From these questions a survey was developed and tested with a few growers and other scientists. Average response time to complete the survey was approximately 20 minutes.

A database of organic apple growers in the U.S. was developed by contacting organic certification agencies and state agriculture departments in the top 10 apple producing states and other states (including Arkansas). From a list of approximately 500 growers, 330 surveys were mailed to randomly selected names based upon a proportion of names and the acreage of apples that particular state grew. Surveys had a pre-

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addressed and stamped return envelope. A mail-back deadline of 45 days after mailing was indicated. Simultaneously, a web-based HTML form was posted on the http://www.uark.edu/ArkHort/ site. The survey form was on the website for 45 days.

FINDINGS

Of the mailed surveys, 82 were returned completed (24.8% response rate) within the return deadline. An additional 24 responses were returned completed from the internet site for a total of 106 completed responses from 15 states in the U.S., one province in Canada, and one from New Zealand. No surveys were returned from Arizona, which has a large acreage of organic orchards but very few growers.

The responses represented a reported 6,297 acres in the U.S (some acreage not reported) comprised of 2,489 acres of certified organic production, 542 acres of transitional production (from conventional to organic), and 3,896 acres of conventional orchard. This survey represented 19.6% of the estimated certified organic apple production in the U.S. For organic orchards, the average size was 15.4 acres (range of 1-489 acres) and the cultivars comprising the largest area were 'Gala', 'Braeburn', and 'Fuji' with 23 other cultivars being reported; 55% of the acreage reported did not list a cultivar. Less than 1% of the reported acreage produced scab-resistant and spring-disease resistant cultivars. Of the respondents, 45% intended to increase production, 42% reported no change in organic production, and 12% reported decreasing production.

When queried on their reasons for organic apple production, 76% indicated the basis for organic production was economics and crop value, while 69% and 47% reported that organic production was practiced for environmental and ethical reasons, respectively. The respondents could be categorized as capitalists with conscience.

The great majority of the respondents indicated that thinning was important or very important to their production system. When asked why growers desire to thin the fruit crop, respondents indicated the primary and most important reasons were to increase fruit size, increase return bloom, and reduce biennial bearing.

Surveyed growers were given choices of treatments that they utilize for organic fruit thinning. The greatest percentage of respondents indicated that post bloom hand removal (30% of responses) was used for crop regulation with the highest level of perceived or rated success. Calcium poly-sulfide (lime-sulfur) applied at full bloom ([1-2%] vol/vol) was used by 16% of the respondents with low to acceptable success. An additional 8% of the respondents used one or more of the following thinning treatments: petal-fall lime-sulfur application, prebloom hand removal, or full-bloom hand removal of blossoms. Of the respondents, 10% did not provide any information about their thinning practices. Approximately 20% of the respondents indicated using multiple methods of thinning.

This survey demonstrated that organic apple growers realize the importance of fruit thinning to their operation, profitability, and sustainability. Further, determining new and novel methods of fruit thinning and crop regulation, that are organic certified, have high success and are reliable, would be valuable for growers.

ACKNOWLEDGMENTS

This project was funded in part from grants from the Organic Farm Research Foundation (Santa Cruz, Calif.), and Gerber Products Company (Freemont, Mich.). The project was done in cooperation with Mr. Steve Ela, Silver Spruce Orchards (Hotchkiss, Colo.), and Mr. Shane Max, Research, Research Superintendent, Western Colorado Research Center - Colorado State Univ. (Grand Junction, Colo.)

THE EFFECT OF MULCH ON EARLY YIELDS OF 'APACHE' BLACKBERRY

Curt R. Rom[1]

IMPACT STATEMENT

Blackberries are an expanding fruit crop in Arkansas and the U.S. due to the development of new high-quality cultivars being introduced. The Arkansas Agricultural Experiment Station has been responsible for the introduction of many new cultivars that have not only quality fruit but are also erect-caned and thornless. An example is the cultivar 'Apache'. With the development of the new erect-cane genotypes, new management systems should be developed to maximize their production potential. In a study comparing 'Apache' blackberries grown with hardwood mulch compared to no mulch, mulching significantly increased yield, berry size, and fruit sweetness. Other benefits to mulching were observed.

BACKGROUND

Blackberry is a relatively new domesticated crop with high-quality cultivars having been first developed and released in the 20th century. Until recently, most cultivars were trailing or vining forms that required a trellis to keep vines off the ground and support the fruit crop. Since 1964 the University of Arkansas fruit breeding program has released a number of free-standing, erect-cane blackberries eliminating or reducing the need for a trellis. One of the most recent introductions was 'Apache' thornless blackberry (Clark and Moore, 1999). Because the erect-cane genotypes are essentially a new crop, new cultural practices must be developed to maximize their productive potential. One of the cultural practices warranting investigation is ground cover management, which affects weed control, soil moisture availability, and nutrition of the crop and may manifest effects on growth and cropping.

The effect of mulches on blackberry production has not been thoroughly evaluated and there are no reports in the literature of the effect of mulch on erect-cane blackberries. The effects of mulch on raspberries in northern latitudes has been studied. For raspberries, it has been reported that straw mulch increased cane growth and yield (Trinka and Pritts, 1992), but increased the incidence of Phytophthora root rot (Wilcox, et al., 1998). Yield of micropropagated raspberries during the establishment period was reportedly reduced by use of wood bark mulch (Warmund et al., 1995). Mulch increased seasonal photosynthetic rate of 'Heritage' raspberry (Percival et al., 1998). In blackberry, wood chips and straw mulch reduced yield efficiency (inflorescence number per cm2 cane diameter) of semi-erect blackberry, but not other components of yield (Archbold et. al, 1989). Wood chip mulch increased blackberry cane diameter but had no effect on cane number per plant. Due to a lack of information on ground cover management on erect-cane blackberries in southern latitudes, a study of the effects of mulch on growth and productivity of 'Apache' was initiated at the Arkansas Agricultural Research and Extension Center, Fayetteville.

RESEARCH DESCRIPTION

Stem cuttings of 'Apache' blackberry were propagated under mist in small pots in a greenhouse in late winter and early spring, 1999. The resulting plants were then planted in the field in June, 1999. Plots (10 ft [3 m] long x 3.1 ft [1m] wide) were established by planting plants two ft (60 cm) apart in the row and rows eight ft (2.5 m) apart. During the first growing season, plants were allowed to trail on the ground as new primocanes emerged. All plots received similar annual applications of pesticide (calcium polysulfide), fertility, and supplemental trickle irrigation as needed. Preemergence herbicide was applied in the springs of 2000 and 2001.

The experimental treatments were established after approximately 60 days growth. Two treatments (no mulch versus mulch) were applied to plots in a completely random design with four replications of each treatment. In August, semi-erect canes in the mulch-treatment plots were lifted and plots were mulched with a hardwood refuse mulch to approximately 1 in. (2.5 cm) depth. In late spring 2000 and 2001, an additional in. (2.5 cm) of mulch was added.

Canes fruited in the second season (2000) and were harvested at 4-day intervals for 2 weeks. In the third season (2001) fruit from each plot were harvested at 3-4 day intervals beginning 22 June and continuing for nine harvests. At each harvest, fresh fruit was weighed and average fruit weight was calculated from a 25-fruit sample randomly selected from each plot. The fruit sample was then homogenized to measure fruit soluble solids. After harvest (Sept. 2001) dead floricanes were removed, dried and weighed. After harvest, weed density was estimated by sampling six 5.3 ft 2 (0.5 m^2) random areas per plot. Primocanes per plot were counted at that same time.

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FINDINGS

Weed density was significantly reduced in mulched versus non-mulched plots (9.1 vs 18.1%, and 2.2 vs 14.3%, for 2000 and 2001, respectively). There was no difference in 'Apache' floricane number the first fruiting season (2000) due to treatments. Although not statistically different in 2000, mulched plots had 19.4% more primocanes in mid-summer than non-mulched plots and a statistically significant 54% more primocanes in 2001. There was no statistical difference in the weight of floricanes among mulch treatments after the 2001 season. However, the weight of pruned floricanes was 27% higher from the mulched plots reflecting both an increase in cane number and size (weed density and cane data not shown).

Mulched plots produced an average 11% increase in the total first-year harvest (2000), and a significant 43% increase in the second year (2001) over non-mulched plots (Table 1). Thus there was a 40% increase in cumulative yield for the first two seasons. Although treatments did not affect fruit size in 2000, fruits from mulched plots were significantly larger (average of all harvests) in 2001, and had higher soluble solids content than fruits from non-mulched plots.

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Table 1. Effect of mulch on the yield and fruit size of 'Apache' erect-cane blackberry after two seasons (2000 and 2001) grown in Fayetteville, Ark.

Treatment	Total yield lb/acre 2000	Total yield lb/acre 2001	Cumulative yield lb/acre	Berry size (g) 2000	Berry size (g) 2001	Soluble solids %
Non-mulched	1,507	10,903 b[z]	12,411 b	6.0	8.3 b	10.0 b
Mulched	1,680	15,629 a	17,310 a	6.0	9.1 a	10.7 a
	NS			NS		

[z]Mean separation within a column by F-test (P≤0.05); NS=not significantly different (P≤0.05).

FIRE BLIGHT SYMPTOM EXPRESSION IN APPLE RESEARCH ORCHARDS - 2001

Curt R. Rom and J. Brad Fausett[1]

IMPACT STATEMENT

Fire blight, (caused by *Erwinia amylovora*), is a destructive bacterial disease of apple. This disease can develop quickly during warm, moist springtime conditions destroying much of the crop by killing limbs or whole trees. Epidemics typically occur during bloom or shortly thereafter and an epidemic can be exacerbated by tree damage caused by spring hails. Fire blight is typically controlled by bacteriostatic applications of copper or sulfur, use of preventive antibiotic sprays, or the selection of resistant cultivars. Tremendous variation in fire blight severity has been reported in other states among various cultivars and rootstocks. During the 2001 growing season, environmental conditions and a hail storm at the Arkansas Agricultural Research and Extension Center, Fayetteville (MAIN) led to a fire blight outbreak. Apple trees in three trials, the Arkansas Apple selection evaluation trial (AA), the NE-183 National Apple Cultivar evaluation trial (NE-180), and the NC-140 1994 dwarf rootstock trial (NC-140) were rated for fire blight symptoms. Tremendous variation among selections, cultivars, and rootstocks was expressed. These data will be useful in the evaluation of selections, cultivars, and rootstocks for use in Arkansas, and the information may help guide fruit growers in cultivar selections.

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BACKGROUND

Although the fire blight bacterium is endemic and may occur on many Rosaceous species, infections on apples are common in some regions, especially in Arkansas. Apple flowers and spur leaves are susceptible to infection and may express blossom and/or spur blight. Shoot blight may occur as bacteria enter through wounds created by wind, hail, pruning cuts, and possibly sucking insects. This blight may cause whole limbs or entire trees to die as bacteria spread via the phloem, which results in significant production loss.

A large number of apple cultivars is available to fruit growers and cultivars vary in susceptibility to the disease (Thompson, 1972; Thomas and Jones, 1992). Planting susceptible cultivars may result in disease epidemics and crop failure. Rootstocks may affect tree susceptibility (Cummins and Aldwinkle, 1975; Keil and van der Zwet, 1975; Rom and Slack, 1971). Size-controlling rootstocks such 'M26' and 'M9' used in high density orchards have been reported to be fireblight susceptible. It has also been observed that rootstocks may cause variation in scion cultivar susceptibility.

Although fireblight infections may be prevented or controlled with the use of antibiotic spray applications (streptomycin), bacterium resistance to fire blight has been observed. As antibiotics become less useful as a control method, and concerns about their agricultural use in food production increase, farmers will look for other means for disease control. Copper and sulfur sprays, during the growing season and during dormancy, may provide some preventive control. However, these compounds may cause fruit russet and/or phytotoxicity, thus reducing fruit marketability and tree productivity.

For orchardists, selecting a resistant cultivar and rootstock will provide the most cost effective and environmentally sustainable method of preventing disease epidemics. In order to provide information of cultivar and rootstock fireblight resistance in Arkansas conditions, the severity of infection following an epidemic in 2001 was evaluated.

RESEARCH DESCRIPTION

Selections of the Arkansas apple breeding program were evaluated at the Fruit Research Substation (FRSS) in Clarksville, and the MAIN station in Fayetteville (Table 1) for crop load and fire blight infection. The NE-183, (Table 2), and the NC-140 ('Gala' as the scion; Table 3) trials were also evaluated at MAIN.

Trees in these trials were rated for crop load and fire blight infection during 2002 June for severity of shoot and spur fire blight infections. Crop load was rated on a scale of 0 to 5; 0=no crop, 3=horticulturally optimum crop, 5=very heavy crop. Fire blight was rated using the shoot/spur infection scale described by Thomas and Jones (1992) where 10=no infection; 9=1-3% infection; 8=4-6% infection; 7=7-12% infection; 6=13-25% infection; 5=26-50% infection; 4=51-75% infection; 3=76-88% infection; 2=89-99% infection; 1=100% infection.

For the AA trial at both MAIN and FRSS, multiple trees (2-5) on 'M.106', 'M.26' or their own seedling roots were evaluated. For the NE-183 trial, trees were planted as single trees of five replications using a randomized complete block design. In the NC-140 trial, rootstock treatments were replicated 10 times in a completely random design. For each trial, multiple independent ratings were made and the data were analyzed and means separated using an LSD means separation test.

FINDINGS

The 2001 growing season could be regarded as a moderate to good cropping season but a moderate to severe fire blight infection season.

AATrial. The crop load on most AA selections was good (crop load ratings: MAIN=2.3; FRSS=2.7; Avg.=2.4). Of the 115 selections evaluated at the FRSS and MAIN sites, fire blight ranged from severe, with approximately 50% or more of the shoots and spurs of AA82 and AA79 being infected, to selections with no symptoms. Within either location, spur and shoot infections were significantly correlated (FRSS $r^2 = 0.63$; MAIN $r^2 = 0.48$). At neither location was spur or shoot infection correlated to crop load. This indicates that infections of shoots and spurs likely occurred simultaneously but were not limited to bloom infection, and that there was a relationship between genotype and infection susceptibility of the shoots and spurs. However, there was not a significant correlation of infection ratings between the FRSS and MAIN locations indicating a significant environmental effect this season. On average, fire blight severity was only slightly greater at the MAIN than FRSS sites (fire blight ratings of 8.93 and 9.14, respectively). At the MAIN site, shoot infection tended to be more severe than spur infection but the reverse was observed at FRSS.

Any selection with rating of 7 or less (approximately 10% or greater shoot and/or spur infection) would be rated as being moderately to highly susceptible to fire blight. This would include the following selections (in order of severe to moderate symptom expression): 82, 75, 76, 101, 131, 135, 95, 55, 89, 169, 132, 144, 96, 87, 62, 73, 65, and 93. The selections that showed consistently less than 3% infection at both sites include (in order from no symptoms to mild symptoms): 35, 155, 104, 136, 160, 134, 128, 139, 141, 105, 110 123, 156, 71, 79, 64, 108, 88, and 100.

NE-183 Trial. This season represented the sixth cropping season of this trial and the trees were regarded as mature. Crop load ratings ranged from 0 (‘Sansa’, AA59, AA75, and ‘Himekami’) to 4.5 (AA74) with an average rating of 2.8, or slightly less than horticulturally optimum (Table 2). This crop load rating was reflected in the yields of these trees (data not presented). Cultivars or selections expressing a fire blight rating of 7 or less (approximately 10% or greater shoot and/or spur infection) and rated as being moderately to highly susceptible to fire blight include the following (in order of severe to moderate symptom expression): ‘Cameo’, ‘Honeycrisp’, ‘Gingergold’, AA73, AA86, ‘Creston’, AA77, AA89, ‘Golden Delicious’, and ‘Gala Supreme’. Several cultivars and selections that were developed specifically for some resistence to fire blight showed minimal or no infection. These include the cultivars or selections: NY75414-1, ‘Goldrush’, ‘Enterprise’, and ‘Fortune’. The AA selections 73, 86, 77, and 89 had moderate infections in this trial, similar to the AA trial (Table 1). However, the selections AA 63, 64, and 84 had less fire blight in this trial, showing no symptoms.

NC-140 Trial. All trees in the NC-140 Trial, with the exception of trees on ‘Mark’ and ‘P22' rootstocks, had heavy to very heavy crop loads (Table 3). Crop load was significantly correlated to yield per tree at harvest (r^2=0.73). Although all trees had the scion cultivar Gala, which is considered to be moderately to very susceptible to fire blight, there was significant variation for fire blight infection ratings among rootstocks. Trees on ‘M9-NIC29' had very severe fire blight. Moderate to severe fire blight was observed on ‘M9-Pajam2', ‘M26', ‘B9', ‘Ottawa 3', and ‘M9-FL56'. The other stocks expressed less severe fire blight symptoms. The fire blight ratings were not well correlated to tree size, expressed as either tree height or trunk cross-sectional area. However, there was a significant, but small, correlation to crop load rating (r^2 =0.35) and number of suckers per tree (r^2=0.30). It is interesting to note the variation among the six strains of ‘M.9' used in this trial with ‘M9-NIC29' expressing severe symptoms while ‘M9-T337' and ‘M.9 EMLA’ had only mild fire blight expression.

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Table 1. Crop load and fire blight infection ratings of Arkansas Apple (AA) Selections at the Fayetteville (MAIN), and the Fruit Research Substation (FRSS), Clarksville, during the 2001 growing season. Selections are ranked in order from worst to least fire blight infection as the average of both spur and shoot blight at both sites.

	MAIN			FRSS			
AA sel. no.	Crop load rating (0-5)[z]	Fire blight infection rating[y] Spur	Fire blight infection rating[y] Shoot	Crop load rating (0-5)	Fire blight infection rating[x] Spur	Fire blight infection rating[x] Shoot	Avg. fire blight infection rating[x]
82	3.83 a-f[w]	5.33 lm	4.17 lm	--	--	--	4.75
75	2.75 e-j	3.75 m	2.50 m	4.00 ab	7.50 a-d	9.00 ab	5.69
76	3.17 b-h	7.50 e-j	6.33 h-k	2.00 cd	6.00 c-d	5.00 d	6.21
101	1.00 l-m	8.00 b-h	4.50 kl	--	--	--	6.25
131	0.50 nm	7.25 f-k	7.50 d-i	2.00 cd	6.00 c-d	5.00 d	6.44
135	1.50 j-m	5.50 k-m	7.50 d-i	--	--	--	6.50
95	--	--	--	4.00 ab	6.00 c-d	7.00 c	6.50
55	3.50 b-g	5.25 lm	8.50 a-f	--	--	--	6.88
89	4.17 a-d	6.83 h-l	5.33 j-l	3.00 bc	8.00 a-d	7.67 bc	6.96
169	--	--	--	2.00 cd	7.00 a-d	7.00 c	7.00
132	--	--	--	1.00 de	7.00 a-d	7.00 c	7.00
144	--	--	--	2.00 cd	5.00 cd	9.00 ab	7.00
96	0.00 n	8.50 a-h	6.50 g-j	--	--	--	7.50
87	3.83 a-f	6.00 i-l	8.17 a-h	4.00 ab	7.00 a-d	9.00 ab	7.54
62	2.50 f-k	8.83 a-g	7.17 e-j	4.00 ab	6.00 c-d	8.50 a-c	7.63
73	--	--	--	3.00 bc	7.50 a-d	8.00 bc	7.75
65	--	--	--	3.50 a-c	7.50 a-d	8.00 bc	7.75
93	2.67 e-j	5.83 j-l	6.00 i-l	2.00 cd	10.00 a	10.00 a	7.96
138	--	--	--	1.00 de	8.00 a-d	8.00 bc	8.00
69	--	--	--	4.00 ab	9.00 ab	7.00 c	8.00
172	--	--	--	0.00 e	9.00 ab	7.00 c	8.00
159	--	--	--	2.00 cd	7.00 a-d	9.00 ab	8.00
129	--	--	--	2.00 cd	8.00 a-d	8.00 bc	8.00
79	3.00 c-i	10.00 a	9.67 ab	2.00 cd	4.50 d	8.00 bc	8.04
86	3.33 b-h	8.67 a-h	7.50 d-i	--	--	--	8.08
72	5.00 a	9.00 a-f	9.00 a-e	3.00 bc	8.00 a-d	7.00 c	8.25
151	0.50 nm	9.25 a-e	7.00 f-j	2.00 cd	9.00 ab	8.00 bc	8.31
85	2.83 d-j	9.50 a-d	7.50 d-i	--	--	--	8.50
158	0.00 n	10.00 a	10.00 a	1.00 de	6.00 c-d	8.00 bc	8.50
140	--	--	--	3.00 bc	8.00 a-d	9.00 ab	8.50
80	--	--	--	4.00 ab	7.00 a-d	10.00 a	8.50
70	4.50 ab	7.00 g-l	7.00 f-j	5.00 a	10.00 a	10.00 a	8.50
92	3.00 c-i	7.50 e-j	6.50 g-j	5.00 a	10.00 a	10.00 a	8.50
77	2.67 e-j	8.67 a-h	8.00 b-h	2.00 cd	9.00 ab	9.33 ab	8.75
84	3.33 b-h	7.83 c-i	7.17 e-j	3.00 bc	10.00 a	10.00 a	8.75
3	0.00 n	10.00 a	7.00 f-j	4.00 ab	9.00 ab	9.00 ab	8.75
98	2.00 h-l	9.17 a-e	8.50 a-f	--	--	--	8.83
81	3.33 b-h	7.67 d-i	7.83 b-i	3.00 bc	10.00 a	10.00 a	8.88
63	3.50 b-g	9.17 a-e	8.00 b-h	4.50 ab	9.00 ab	9.50 ab	8.92
177	--	--	--	5.00 a	9.00 ab	9.00 ab	9.00
186	--	--	--	1.00 de	9.00 ab	9.00 ab	9.00
67	--	--	--	3.50 a-c	8.50 a-c	9.50 ab	9.00
20	--	--	--	5.00 a	9.00 ab	9.00 ab	9.00
171	--	--	--	2.00 cd	9.00 ab	9.00 ab	9.00
146	--	--	--	5.00 a	9.00 ab	9.00 ab	9.00
122	2.50 f-k	9.00 a-f	9.00 a-e	--	--	--	9.00
157	0.00 n	10.00 a	10.00 a	1.00 de	7.00 a-d	9.00 ab	9.00
106	1.25 k-m	7.25 f-k	9.00 a-e	1.00 de	10.00 a	10.00 a	9.06
83	3.00 c-i	9.33 a-e	7.50 d-i	4.00 ab	10.00 a	10.00 a	9.21
90	1.50 j-m	8.50 a-h	8.33 a-g	3.00 bc	10.00 a	10.00 a	9.21
137	1.00 l-m	10.00 a	10.00 a	1.00 de	8.00 a-d	9.00 ab	9.25
116	3.25 b-h	10.00 a	10.00 a	2.00 cd	9.00 ab	8.00 bc	9.25

Table 1. Crop load and fire blight infection ratings of Arkansas Apple (AA) Selections at the Fayetteville (MAIN), and the Fruit Research Substation (FRSS), Clarksville, during the 2001 growing season. Selections are ranked in order from worst to least fire blight infection as the average of both spur and shoot blight at both sites. Continued...

	MAIN			FRSS			
		Fire blight infection rating[y]			Fire blight infection rating[x]		Avg.
AA sel. no.	Crop load rating (0-5)[z]	Spur	Shoot	Crop load rating (0-5)	Spur	Shoot	fire blight infection rating[x]
113	3.50 b-g	9.00 a-f	9.50 a-c	--	--	--	9.25
107	2.00 h-l	10.00 a	10.00 a	4.00 ab	9.00 ab	8.00 bc	9.25
119	4.50 ab	9.00 a-f	9.50 a-c	--	--	--	9.25
121	2.00 h-l	10.00 a	10.00 a	2.00 cd	9.00 ab	8.00 bc	9.25
18	2.00 h-l	10.00 a	10.00 a	5.00 a	9.00 ab	8.50 a-c	9.38
99	2.25 g-l	9.625 a-c	9.13 a-d	--	--	--	9.38
64	4.17 a-d	9.667 a-c	9.00 a-e	2.00 cd	10.00 a	9.00 ab	9.42
153	0.50 nm	10.00 a	7.75 c-i	3.00 bc	10.00 a	10.00 a	9.44
71	0.00 n	10.00 a	10.00 a	5.00 a	9.00 ab	9.00 ab	9.50
100	2.667 e-j	9.00 a-f	9.00 a-e	3.00 bc	10.00 a	10.00 a	9.50
161	--	--	--	0.00 e	9.00 ab	10.00 a	9.50
163	--	--	--	2.00 cd	9.00 ab	10.00 a	9.50
97	--	--	--	3.00 bc	9.00 ab	10.00 a	9.50
88	3.83 a-f	9.50 a-d	8.83 a-f	2.33 cd	10.00 a	10.00 a	9.58
78	3.33 b-h	9.50 a-d	9.67 ab	--	--	--	9.58
108	3.00 c-i	9.00 a-f	9.50 a-c	3.00 bc	10.00 a	10.00 a	9.63
123	2.75 e-j	10.00 a	10.00 a	2.00 cd	9.00 ab	10.00 a	9.75
120	0.25 n	10.00 a	9.50 a-c	--	--	--	9.75
110	1.13 k-m	10.00 a	10.00 a	4.00 ab	10.00 a	9.00 ab	9.75
156	0.00 n	10.00 a	10.00 a	2.00 cd	9.00 ab	10.00 a	9.75
105	2.25 g-l	10.00 a	10.00 a	2.00 cd	10.00 a	9.00 ab	9.75
118	4.00 a-e	9.50 a-d	10.00 a	--	--	--	9.75
74	3.50 b-g	9.75 ab	10.00 a	--	--	--	9.88
109	--	--	--	2.00 cd	10.00 a	10.00 a	10.00
134	1.75 i-m	10.00 a	10.00 a	4.50 ab	10.00 a	10.00 a	10.00
136	4.00 a-e	10.00 a	10.00 a	2.00 cd	10.00 a	10.00 a	10.00
125	--	--	--	2.00 cd	10.00 a	10.00 a	10.00
180	--	--	--	3.00 bc	10.00 a	10.00 a	10.00
141	0.00 n	10.00 a	10.00 a	3.00 bc	10.00 a	10.00 a	10.00
128	1.00 l-m	10.00 a	10.00 a	3.00 bc	10.00 a	10.00 a	10.00
168	--	--	--		10.00 a	10.00 a	10.00
182	--	--	--	2.00 cd	10.00 a	10.00 a	10.00
139	0.50 n	10.00 a	10.00 a	2.00 cd	10.00 a	10.00 a	10.00
160	0.00 n	10.00 a	10.00 a	2.00 cd	10.00 a	10.00 a	10.00
181	--	--	--	4.00 ab	10.00 a	10.00 a	10.00
35	3.50 b-g	10.00 a	10.00 a	4.00 ab	10.00 a	10.00 a	10.00
173	--	--	--	0.00 e	10.00 a	10.00 a	10.00
183	--	--	--	3.00 bc	10.00 a	10.00 a	10.00
184	--	--	--	2.00 cd	10.00 a	10.00 a	10.00
175	--	--	--	2.00 cd	10.00 a	10.00 a	10.00
94	2.75 e-j	10.00 a	10.00 a	--	--	--	10.00
91	2.67 e-j	10.00 a	10.00 a	--	--	--	10.00
117	4.50 ab	10.00 a	10.00 a	--	--	--	10.00
148	--	--	--	3.00 bc	10.00 a	10.00 a	10.00
102	4.25 a-c	10.00 a	10.00 a	--	--	--	10.00
176	--	--	--	3.00 bc	10.00 a	10.00 a	10.00
13	2.50 f-k	10.00 a	10.00 a	--	--	--	10.00
115	2.50 f-k	10.00 a	10.00 a	--	--	--	10.00
145	--	--	--	1.00 de	10.00 a	10.00 a	10.00
111	4.25 a-c	10.00 a	10.00 a	--	--	--	10.00
50	--	--	--	5.00 a	10.00 a	10.00 a	10.00

Table 1. Crop load and fire blight infection ratings of Arkansas Apple (AA) Selections at the Fayetteville (MAIN), and the Fruit Research Substation (FRSS), Clarksville, during the 2001 growing season. Selections are ranked in order from worst to least fire blight infection as the average of both spur and shoot blight at both sites. Continued...

	MAIN			FRSS			
		Fire blight infection rating[y]			Fire blight infection rating[x]		Avg.
AA sel. no.	Crop load rating (0-5)[z]	Spur	Shoot	Crop load rating (0-5)	Spur	Shoot	fire blight infection rating[x]
104	3.75 a-f	10.00 a	10.00 a		10.00 a	10.00 a	10.00
179	--	--	--	0.00 e	10.00 a	10.00 a	10.00
185	--	--	--	0.00 e	10.00 a	10.00 a	10.00
147	--	--	--	2.00 cd	10.00 a	10.00 a	10.00
165	--	--	--	4.00 ab	10.00 a	10.00 a	10.00
127	0.00 n	10.00 a	10.00 a	--	--	--	10.00
103	0.00 n	10.00 a	10.00 a	--	--	--	10.00
154	0.00 n	10.00 a	10.00 a	--	--	--	10.00
162	0.00 n	10.00 a	10.00 a	--	--	--	10.00
155	0.00 n	10.00 a	10.00 a	4.00 ab	10.00 a	10.00 a	10.00
164	0.00 n	10.00 a	10.00 a	--	--	--	10.00
130	3.00 c-i	10.00 a	10.00 a	--	--	--	10.00

[z] Crop load rating: 0=no crop, 3=horticultural optimum crop load, 5=very heavy crop load.

[y] Fire blight rating numbers relate to the percentage of shoots or spurs infected by fire blight using the following scale: 10=no infection; 9=1-3% infection; 8=4-6% infection; 7=7-12% infection; 6=13-25% infection; 5=26-50% infection; 4=51-75% infection; 3=76-88% infection; 2=89-99% infection; 1=100% infection.

[x] Unweighted average fire blight infection rating of selections at both sites.

[w] Mean separation within columns by LSD ($P \leq 0.05$).

Table 2. Crop load and fire blight infection ratings in the 1994, NE-183 National Multidiscplinary Evaluation of Apple Cultivars and Selections, Fayetteville, 2001. Cultivars are ranked in order from worst to least fireblight infection as the average of spur and shoot blight ratings.

		Fireblight infection rating[y]		
Cultivar or selection	Crop load rating (0-5)[z]	Spur	Shoot	Avg.
Cameo	3.33 b-h[x]	4.50 d	8.00 bc	6.3
Honeycrisp	2.75 e-j	6.00 c-d	7.00 c	6.5
Gingergold	1.50 j-m	7.50 a-d	6.50 c	7.0
AA73	4.17 a-d	6.00 c-d	8.50 a-c	7.3
AA86	3.33 b-h	8.00 a-d	7.00 c	7.5
Creston	3.33 a-f	8.00 c-d	7.50 bc	7.8
AA77	2.75 e-j	7.50 a-d	8.00 bc	7.8
AA89	3.00 c-i	7.50 a-d	8.00 bc	7.8
Golden Delicious	3.83 a-f	8.00 a-d	7.67 bc	7.9
Gala Supreme	4.17 a-d	7.00 a-d	9.00 ab	8.0
AA83	2.75 e-j	9.00 ab	7.00 c	8.0
Arlet	3.33 b-h	7.50 a-d	9.00 ab	8.3
Coop 32	3.33 b-h	7.00 a-d	10.00 a	8.5
Yataka	1.25 k-m	9.00 ab	8.00 bc	8.5
Sunrise	2.00 h-l	9.00 ab	8.00 bc	8.5
Sansa	0.00 n	9.00 ab	8.00 bc	8.5
AA40	2.00 h-l	9.00 ab	8.50 a-c	8.8
AA85	2.67 e-j	9.00 ab	9.00 ab	9.0
AA82	3.50 b-g	8.50 a-c	9.50 ab	9.0
AA49	3.50 b-g 0 n	9.00 ab	9.00 ab	9.0
AA59	0.00 n	9.00 ab	9.00 ab	9.0
Braeburn	3.00 c-i	9.00 ab	9.333 ab	9.2
AA74	4.50 ab	9.00 ab	9.50 ab	9.3
Suncrisp	3.00 c-i	10.00 a	9.00 ab	9.5
Kogetsu	2.00 h-l	9.00 ab	10.00 a	9.5
AA75	0.00 n	10.00 a	9.00 ab	9.5
NY 75414-1	1.00 l-m	10.00 a	9.00 ab	9.5
AA70	3.50 b-g	9.50 ab	10.00 a	9.8
Golden Supreme	5.00 a	10.00 a	10.00 a	10.0
Goldrush	2.67 e-j	10.00 a	10.00 a	10.0
Himekami	0.00 n	10.00 a	10.00 a	10.0
Fuji	2.67 e-j	10.00 a	10.00 a	10.0
Late Yellow	4.25 a-c	10.00 a	10.00 a	10.0
Fortune (NY429)	2.67 e-j	10.00 a	10.00 a	10.0
Enterprise	3.83 a-f	10.00 a	10.00 a	10.0
Orin	2.25 g-l	10.00 a	10.00 a	10.0
Senshu	3.75 a-f	10.00 a	10.00 a	10.0
Shizuka	2.25 g-l	10.00 a	10.00 a	10.0
AA63	3.50 b-g	10.00 a	10.00 a	10.0
AA64	2.50 f-k	10.00 a	10.00 a	10.0
AA84	3.17 b-h	10.00 a	10.00 a	10.0

[z] Crop load rating: 0=no crop, 3=horticultural optimum crop load, 5=very heavy crop load.

[y] Fire blight ratings relate to the percentage of shoots or spurs infected by fireblight using the following scale: 10=no infection; 9=1-3%; 8=4-6%; 7=7-12%; 6=13-25%; 5=26-50%; 4=51-75%; 3=76-88%; 2=89-99%; 1=100%. Avg. = average of shoot and spur infection ratings.

[x] Mean separation within columns by LSD, ($P \leq 0.05$).

Table 3. Crop load and fire blight infection ratings in the NC-140 1994 National Uniform High Density Apple Rootstock Trial with 'Gala' as the scion, Fayetteville, 2001. Rootstocks are ranked in order from worst to least fire blight infection as the average of spur and shoot blight ratings.

Rootstock cultivar or selection	Crop load rating (0-5)[z]	Fireblight infection rating[y]		
		Spur	Shoot	Avg.[x]
M9 - NIC29	5.00 a[w]	4.50 d	5.00 d	4.75
M9 - Pajam 2	4.50 a	6.00 c-d	7.00 c	6.50
M26	4.50 a	6.00 c-d	7.667 bc	6.84
B9	3.75 ab	7.00 a-d	7.00 c	7.00
Ottawa3	4.25 ab	6.00 c-d	8.00 bc	7.00
M9- FL56	3.25 bc	7.50 a-d	8.00 bc	7.75
M9- Pajam 1	4.25 ab	7.00 a-d	9.00 ab	8.00
P22	2.75 cd	8.50 a-c	8.00 bc	8.25
P16	3.00 c	7.50 a-d	9.00 ab	8.25
B491	3.25 bc	8.00 a-d	8.50 a-c	8.25
B469	3.50 bc	7.50 a-d	9.333 ab	8.42
VI	4.25 ab	8.00 a-d	9.00 ab	8.50
M9 - T337	4.25 ab	9.00 ab	10.00 a	9.50
M9 EMLA	3.75 ab	10.00 a	9.333 ab	9.67
M27 EMLA	2.00 de	9.50 ab	10.00 a	9.75
P2	4.25 ab	10.00 a	9.50 ab	9.75
Mark	1.50 d	10.00 a	10.00 a	10.00

[z] Crop load rating: 0=no crop, 3=horticultural optimum crop load, 5=very heavy crop load.

[y] Fire blight ratings relate to the percentage of shoots or spurs infected by fireblight using the following scale: 10=no infection; 9=1-3%; 8=4-6%; 7=7-12%; 6=13-25%; 5=26-50%; 4=51-75%; 3=76-88%; 2=89-99%; 1=100%.

[x] Avg .= average of shoot and spur infection ratings.

[w] Mean separation within columns by LSD, ($P \leq 0.05$).

GENETIC RELATIONSHIPS AMONG ARKANSAS BLACKBERRY CULTIVARS AS DETERMINED BY RANDOM AMPLIFIED POLYMORPHIC DNA

Eric T. Stafne, John R. Clark, and Matthew C. Pelto[1]

IMPACT STATEMENT

There is an increasing reliance upon molecular DNA studies to determine genetic similarities or differences among plant types. In our study, random amplified polymorphic DNA (RAPD) analysis was used to determine genetic similarity among seven Arkansas blackberry cultivars. Differences were found among the cultivars. However, the cultivars were similar in nature suggesting a lack of genetic diversity in this group. Bootstrap analysis showed that all cultivars were highly related. The weakest join being between the 'Choctaw'/ 'Chickasaw'/ 'Shawnee' cluster and the 'Apache'/ 'Navaho' cluster suggests that the clusters are different.

BACKGROUND

Rubus is a highly diverse genus, of which only a few species have economic importance. The breeding of new *Rubus* cultivars has led to a narrowing of the genetic diversity, with most being closely related and difficult to differentiate morphologically (Jennings, 1988). The lack of genetic variability in *Rubus* can lead to erroneous identification by purely phenotypic or morphological evaluation. Thus, improvement in the area of cultivar identification must be a high priority for *Rubus* breeders to provide verification of identity and assist in comfirming proprietary rights. Furthermore, once cultivar differentiation has been obtained, further research could allow important traits to be located with quantitative trait loci (QTL) analysis and used in marker-assisted selection (MAS).

The objective of this study was to create a reliable technique for differentiating cultivars using polymerase chain reaction (PCR) technology and RAPDs to provide the groundwork for future endeavors in gene identification and MAS.

RESEARCH DESCRIPTION

Actively growing shoot tips were collected from Arkansas blackberry cultivars growing in the field during summer 2001 at the Arkansas Agricultural Research and Extension Center, Fayetteville and the Fruit Substation, Clarksville. Shoot tip tissue (100 mg) was ground to a fine powder in liquid nitrogen with a mortar and pestle, and then the DNA was extracted (according to the manufacturer's protocols) from the tissue using a Qiagen DNeasy Plant Mini Kit (Valencia, Calif.). The DNA was then quantified using a Bio-Rad Versafluor fluorometer. The PCR reaction mixtures were comprised of reagents from the PCR Core System II kit from Promega (Madison, Wisc.). Components were mixed in PGC Scientifics (Gaithersburg, Md.) 0.65 mL thin-walled microcentrifuge tubes. Primers were from Operon (Almeda, Calif.) kits A (2, 3, and 13), B (5, 6, and 7), and D (2, 3, and 8). A positive control supplied with the Promega PCR Core System II kit was run in all experiments.

The PCR reactions were carried out in a Hybaid PCR Sprint thermocycler programmed to cycle through the temperature regime as described by Levi et al., 1993. After the PCR reaction, each sample was mixed with 9 µl of loading buffer. Then, 15 µl of the loading buffer-PCR product mixture was loaded into wells imprinted on a 1% agarose gel immersed in 1X TBE running buffer. The 1 Kb Plus DNA ladder (Life Technologies, Rockville, Md.) was run alongside the samples so that the size (in base pairs) of DNA fragments could be estimated. The gel was run in an Owl horizontal electrophoresis system under 120 volts for ~3 hours. Following electrophoresis, the gels were stained for with ethidium bromide and digitally photographed using an Alpha Innotech ChemiImage gel documentation system.

Genetic similarities were calculated using Nei and Lei's genetic distance formula and average linkage clustering was done with Unweighted Pair-Groups Method Average (UPGMA) from the FreeTree program (Pavlicek et al., 1999). Clustering phylograms were visualized using TREEVIEW (Page, 1996). Bootstrap analysis was done using the Nei and Lei distances, UPGMA tree-construction method, and 250 resampled datasets.

FINDINGS

Forty-three ten-base oligonucleotide primers were screened for the presence of consistent bands using 'Apache'. The PCR reactions were repeated to insure reproducibility of bands. The primers that gave reproducible bands were then evaluated against 'Apache', 'Arapaho', 'Chickasaw', 'Choctaw', 'Kiowa', 'Navaho', and 'Shawnee'. The high degree of similarity among cultivars is displayed in the genetic similarity matrix (Table 1). This result was expected due to the recurrent use of similar parents in the background of all the cultivars. 'Chickasaw' and 'Shawnee' were the most similar according to the genetic similarity calculation (76%), closely followed by 'Apache' and 'Navaho' (75%) and 'Choctaw' and 'Shawnee' (73%). 'Chickasaw', 'Choctaw', and 'Shawnee' all have a high level of 'Brazos' genes being donated from both sides of parental lineage. The most divergent pair of cultivars were

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'Arapaho' and 'Kiowa' (49%). However, even a genetic similarity of 49% suggests a high degree of association.

A phylogram was created (Fig. 1) to group the cultivars into clusters. 'Chickasaw', 'Choctaw', and 'Shawnee' were clustered, as were 'Apache' and 'Navaho'. 'Arapaho' and 'Kiowa' were the final two cultivars that clustered. The results of the clustering are consistent with what is known of the parentage of each cultivar. Although 'Arapaho' is outside of the Apache/Navaho cluster, of which it would have been intuitively placed due to A-631 being one of its parents, as it is for 'Navaho', it was still closely related. This could be owing to the fact that A-631 is a male parent in 'Navaho' and a female parent in 'Arapaho', thus leading to a different segregation of genes or a cytoplasmic contribution from 'Arapaho'.

'Kiowa' was the most divergent of the cultivars tested. It also has a semi-erect cane habit differing from other cultivars. Even though it is the most different of these cultivars, it is still closely related by most standards.

Bootstrap analysis was done with 250 resampled datasets to check the reliability of the phylogram (Hampl et al., 2001). Bootstrapping allows for a confidence interval to be applied to the phylogram, thus giving a reasonable idea of the statistical accuracy of the data. All clusters joined with a bootstrap value of 100%, indicating that they are of the same species and highly related (an expected result). The bootstrap values indicated non-monophylogenic clustering among the 'Choctaw'/ 'Chickasaw'/ 'Shawnee' cluster (55% and 58%) as well as the 'Apache'/ 'Navaho' cluster (83%). Also, the bootstrap value was lower between the two groups, suggesting that they are somewhat genetically diverse. 'Arapaho' connected to these two groups at 39%. 'Kiowa' was the last to join.

Overall, the cultivars tested displayed a high degree of similarity. Yet, it also yielded the ability to differentiate among the cultivars even though the similarities were apparent. Therefore, the continuation of studies such as this may generate advances in the ability to identify unknown cultivars, distinguish gene segregation in progeny of two cultivars, and eventually characterize important genes such as thornlessness and primocane-fruiting.

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ACKNOWLEDGMENTS

Thanks to Dr. Jon T. Lindstrom for use of his lab facilities and to Dr. Jim Correll for his advice.

Table 1. Genetic similarity matrix between pairs of seven blackberry cultivars.

Cultivar	% Similarity						
Apache	100						
Arapaho	56	100					
Chickasaw	62	63	100				
Choctaw	61	59	65	100			
Kiowa	61	49	58	58	100		
Navaho	75	61	61	62	59	100	
Shawnee	57	61	76	73	59	69	100
	Apache	Arapaho	Chickasaw	Choctaw	Kiowa	Navaho	Shawnee

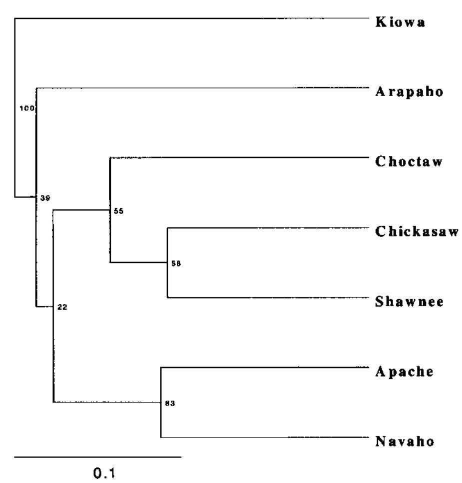

Fig. 1. Phylogram based on primer data for seven blackberry cultivars. Bootstrap values are listed at the joining of each cluster.

CHILL AND HEAT ACCUMULATION AT FOUR SITES IN ARKANSAS, 1990 - 2000

Leisha A. Vance[1] and Curt R. Rom[2]

IMPACT STATEMENT

Growth and productivity of horticultural plants and crops is dependent upon the adaptability to the local environment and can be limited by the environmental hazards such as temperature extremes (winter freezes and summer heat), late spring or early autumn killing frosts, and drought. A number of meteorological models have been established during the past two decades to assist horticulturists in plant selection. These models include the USDA Hardiness Zone model, the American Horticultural Society (AHS) Heat Zone model, a dormancy completion model, and growing degree-day growth or pest management model. This paper employs these models to evaluate temperature variation at four geographically distinct locations in Arkansas; the Arkansas Agricultural Research and Extension Center, Fayetteville (MAIN), the Fruit Research Substation - Clarksville (FRSS), the Southwest Research and Extension Center - Hope (SWREC), and the Eastern Arkansas location of Wynne.

BACKGROUND

Plant growth and productivity is based upon the environmental adaptability and the ability of the plant to withstand environmental extremes and grow at an optimum rate when temperatures are an optimum. In 1960 and again in 1965, the USDA developed a "Hardiness Zone" map of the U.S., which was revised in 1990 (Anon, 1990, USDA-ARS) based upon long term weather records. This map indicated thermoclines dividing the U.S. into 10 hardiness zones based upon average annual low winter temperature in 10°F (5.6ºC) increments. These zones have been further subdivided into "A" and "B" zones based upon 5°F (2.8ºC) increments.

Just as winter temperatures can limit growth, so can excessive and or prolonged summer temperatures. In 1997, the AHS published a Heat-Zone model map (Cathey, 1997). For this map, the continental U.S. was divided into 12 zones that indicate the average number of days exceeding 86°F (30ºC) based upon National Weather Service reporting station data from the period 1974-1995.

In the temperate zone, many plants have a physiologically controlled winter dormancy during which the plant must be exposed to cool temperatures prior to breaking bud in the spring, which is an evolutionary survival mechanism to ensure that plants do not bloom during periods of warm winter weather. The classic example of plants expressing this attribute are peach and apple, although it is universally common in other temperate-zone deciduous plants. A model was proposed to predict when peach trees would complete their dormancy after exposure to winter cold temperatures (Richardson et al., 1974) based upon the hourly accumulation of chill units (CU). The CU model was a partial sine-wave or extended quadratic model where one chill unit was accumulated when flower buds were exposed to 1 hour at a temperature 45°F (7.2ºC). No CU is accumulated at temperatures below freezing (32°F [0°C]) or at 55°F (12.8°C) and there is a negative CU response at 70°F (21°C). In 1990 (Linvil, 1990) a modified model utilizing daily high and low temperatures was developed.

Plants and many other biological organisms grow in direct response to the exposure to warm temperatures (T). There has been extensive agronomic use of a growing degree days (GDD) model following the formula:

$$\textbf{GDD = (daily maximum T + daily minimum T)/2) - } T_{base}$$

where T_{base} is the minimum temperature eliciting a growth response. This model may be used to predict Department of Agricultural Economics harvest or pest infestations.

RESEARCH DESCRIPTION

Meteorological data of the daily high and low temperatures are as recorded by the National Weather Service at three Arkansas Agricultural Experiment Station sites (MAIN - Fayetteville, FRSS - Clarksville, SWREC - Hope) and another location (Wynne, Ark.) for the period of 1990-2000. Only data until 31 Dec. 1999 were available for the Wynne site. Data were entered into a Microsoft Excel® spreadsheet software developed by D. Linvil and based upon previous reports (Linvil, 1990). This program calculated daily CU following a revised sine-wave model of Richardson, et al. (1974). The model was modified to start the onset of accumulated CU when a minimum of 50 CU had been accumulated without an interruption of 1 day with temperatures exceeding 70°F (21°C) based upon other published reports. The program calculated daily GDD accumulation based upon input T_{base} using T_{base} = 50°F (17.8°C). A function to calculate days above 86°F (30°C) following the AHS Heat Zone model was added. From the data, the average last spring and first autumn killing frost of 28°F (-2°C) was determined and the average annual low winter and high summer temperatures calculated.

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FINDINGS

Wynne had the earliest average last killing frost and MAIN had the latest frost (Table 1). The FRSS site had the greatest variation in spring frost dates of almost 20 days. The first average autumnal killing frost came earliest at MAIN and last at FRSS. However, the FRSS site again had the greatest variation during the study period. Calculating frost free days (FFD), MAIN, FRSS, SWREC, and Wynne had an average of 229, 254, 246, and 249 FFD, respectively.

The average coldest winter temperature during this period was at MAIN and warmest at Wynne. All sites were about one hardiness zone warmer during the observation decade than predicted by the USDA map but had 1-3 years where the lowest temperature would have been predicted by the Hardiness Zone map. The number of summer days with temperatures greater than 86°F (30°C) was consistent with the AHS Heat Zone map prediction. Using these variables as indicators of environmental stability or variation, the FRSS site had the most variable conditions.

The onset and amount of CU accumulation is important in determining species and cultivar recommendations for tree fruits. Based upon the model, CU accumulation began first at the FRSS and MAIN sites, and last at SWREC, although due to large variation, the dates were not significantly different (Table 2). The amount of CU accumulated at various dates at each site was similar, especially at SWREC and Wynne. Likewise, the four sites, MAIN, FRSS, SWREC, and Wynne accumulated CU at a similar average daily rate (9.1, 9.6, 9.0, and 9.8 CU/day, respectively). Both SWREC and Wynne had high annual variation in CU accumulation. The dates of CU accumulating to key benchmarks are presented in Table 2. By mid to late February, all sites had achieved 1000 CU. However, at the SWREC site, 900 CU or more was only achieved in 7 years, and in only 1 year did SWREC achieve 1500 CU. In 1999, no site achieved 800 CU based upon this model due to an abnormally late start of CU accumulation (avg. of sites 5 Dec.). Knowing that apples typically require 1000-1500 CU for flowering, the SWREC site is not suitable for apples because only three times during the study period were more than 1000 CU accumulated. Wynne tended to have the greatest variation in CU accumulation and the MAIN site had the least variation.

There were significant differences in GDD accumulation among the sites by 15 Aug. annually, with MAIN having the lowest GDD accumulation and Wynne the highest (Table 3). However, by 15 Sept., only the MAIN and Wynne sites were different with the other sites having intermediate GDD accumulation. The rate of average GDD accumulate during the season (1 April to 15 Sept.) for the sites MAIN, FRSS, SWREC, and Wynne were similar (21, 20, 23, and 23 GDD/day, respectively).

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Table 1. Frost dates, winter and summer extreme temperatures, and the number of winter and summer days at four locations in Arkansas during the 1990-2000.

Location	Avg. date of last killing frost[z] (± sd in days.)	Avg. date of first killing frost (± sd in days.)	Avg. coldest winter temp. °F (± sd °F)	Avg. warmest summer temp. °F (± sd °F)	Number of winter days < 32°F (± sd in days)	Number of summer days > 86°F (+ sd in days)
Main - Fayetteville	22 Mar (12.5)	6 Nov (17.1)	5.5 (6.4)	99.0 (3.5)	79.3 (10.0)	66.0 (14.3)
FRSS - Clarksville	12 Mar (19.8)	21 Nov (21.6)	11.6 (7.8)	99.5 (3.5)	75.5 (7.7)	84.6 (12.1)
SWREC- Hope	15 Mar (12.2)	16 Nov (16.1)	12.5 (5.8)	100.9 (5.7)	59.0 (13.8)	94.9 (13.1)
Wynne[y]	11 Mar (17.1)	15 Nov (18.4)	13.2 (5.3)	98.3 (1.7)	47.2 (13.3)	87.5 (16.4)

[z] Killing frost = 28°F (-2 o C); numbers in parenthesis represent the standard deviation.

[y] Wynne data analyzed for 1990-1999.

Table 2. Average date of onset of chill accumulation, average annual chill (CU) accumulation, and average date of benchmark CU accumulation (± standard deviation) at four sites in Arkansas, 1990-2000 (Wynne 1990-99).

Location	Avg. date of onset of chill (± sd in days)	Avg. annual chill unit accumulation on this datel (± sd in days)				Avg. date of benchmark chill accumulations[z] (± sd in days)				
		15 Jan	1 Feb	15 Feb	1 Mar	750 CU	900 CU	1000 CU	1200 CU	1500 CU
MAIN-	8 Nov	630.7	771	903	1024	31 Jan	16 Feb	^{9}23 Feb	^{7}9 Mar	^{7}4 Apr
Fayetteville	(11.2)	(121.0)	(134.5)	(141.5)	(164.2)	(14.3)	(18.0)	(14.8)	(13.5)	(9.0)
FRSS-	7 Nov	688.0	843	966	1081	23 Jan	10 Feb	^{9}16 Feb	^{5}8 Mar	^{4}28 Mar
Clarksville	(10.4)	(122.6)	(138. 2)	(149.4)	(172.1)	(17.5)	(17.8)	(11.8)	(10.1)	(24.8)
SWREC-	20 Nov	525.2	678	796	901	11 Feb	^{7}14 Feb	^{6}21 Feb	^{3}24 Feb	^{1}16 Mar
Hope	(17.1)	(198.7)	(218.2)	(250.8)	(280.2)	(28.5)	(16.2)	(12.3)	(12.0)	(0.0)
Wynne[y]	11 Nov	650.6	826	954	1069	30 Jan	^{9}14 Feb	^{8}21 Feb	^{3}22 Feb	^{2}8 Mar
	(13.8)	(189.4)	(195.7)	(229.7)	(255.6)	(16.3)	(23.1)	(22.5)	(19.5)	(24.0)

[z] Dates with superscripts indicate the number of years that this number of CU was achieved and used in this calculation.

[y] Wynne data analyzed for years 1990-1999.

Table 3. Average growing degree day (GDD) accumulation (± standard deviation), at four sites in Arkansas, 1990-2000.

Location	Average annual growing degree day accumulation between 1 Apr. and 15 Sept. (± sd in GDD)				
	15 Apr	15 May	15 July	15 Aug	15 Sept
MAIN-Fayetteville	112 (32.0)	454 (64.8)	1902 (149.9)	2803 (175.4)	3616 (234.0)
FRSS-Clarksville	125 (35.2)	532 (70.1)	2094 (132.2)	3019 (143.2)	3890 (205.8)
SWREC-Hope	136 (45.4)	572 (68.0)	2191 (136.4)	3164 (167.2)	4050 (226.0)
Wynne[z]	152 (48.0)	611 (85.4)	2305 (188.0)	3242 (198.7)	4066 (242.5)

[z] Wynne data analyzed for 1990-1999.

EVALUATING THE USAGE OF STEM CUTTINGS TO DETERMINE CHILLING REQUIREMENT IN SIX ARKANSAS BLACKBERRY CULTIVARS

Dayanee Yazzetti, John R. Clark, and Eric T. Stafne[1]

IMPACT STATEMENT

Woody perennial plants including blackberries (*Rubus* subgenus *Rubus*) require chilling below 45°F (7°C) during the dormant season for successful bud break the following year. Arkansas-developed blackberry cultivars are being grown in various climates worldwide, and all cultivars need chilling requirement estimates for accurate recommendations of adaptation. Determining chilling requirement using stem cuttings collected from field-grown plants rather than whole plants is a desirable system, since this is much easier to use than growing and handling whole plants. We conducted a study to determine the chilling requirement of six Arkansas blackberry cultivars. Ten 12-node stem cuttings of each cultivar were collected at 100-hour intervals of chilling up to 1000 hours below 45°F and placed under mist. There was a significant chilling interval x cultivar interaction. 'Arapaho' had a chilling requirement of 400 to 500 hours, 'Kiowa' 200 hours, and 'Shawnee' 400 to 500 hours. The cultivars Choctaw and Apache did not display clear chilling interval differentiation in the study.

BACKGROUND

Woody perennial plants such as blackberry require chilling or rest during the dormant season for successful budbreak and normal shoot and flower development to occur the next season. Rest period is defined as the duration that a plant must be exposed to cold temperatures at or below 45°F, while chilling requirement is the amount of cold needed to satisfy that rest period and is species and often cultivar specific (Ryugo,1998). Failure to meet this requirement results in reduced and erratic budbreak, poor shoot growth, reduced flowering, and reduced fruit yields the next year.

Arkansas-developed blackberry cultivars are being grown not only in Arkansas, but worldwide, in locations with different amounts of chilling than where they originated. Chilling requirement estimates are needed for all cultivars to ensure accurate recommendations of adaptation. Limited formal research has been performed on chilling requirement of blackberry cultivars. Drake and Clark (2000) reported chilling requirement of 'Arapaho' was 400 to 500 hours and 'Navaho' was 800 to 900 hours using whole plants in a study with controlled artificial chilling of constant 38°F (3°C).

In the fall of 2000-2001, a study was conducted to evaluate the use of stem cuttings to estimate chilling of six blackberry cultivars. The objective of this study was to determine the feasibility of using blackberry stem cuttings receiving natural chilling to identify chilling requirement.

RESEARCH DESCRIPTION

Blackberry cultivars released from the University of Arkansas breeding program include 'Apache', 'Arapaho', 'Chickasaw', 'Choctaw', 'Kiowa', 'Navaho', and 'Shawnee', and all were used in our study. In order to measure natural field chilling, a biophenometer (BIO-51, Wescor, Logan, Utah) was placed in the planting to record the number of hours below 45°F. Ten stem cuttings from lateral branches of mature canes of each of the cultivars were collected from the field at 100-hour intervals of chilling up to 1000 hours. However, due to a severe ice storm in December, the 900 hour chilling interval cuttings were not taken because of the inability to collect the cuttings. Also, 'Arapaho' cuttings were only collected for 100 to 600 hours of chilling due to the shortage of lateral branches in the planting for this cultivar. Following collection, the field cuttings were placed in a heated greenhouse under an intermittent mist system in a completely randomized design. Incandescent lighting was provided to lengthen the daylength to 16 hours in the greenhouse.

Data collection consisted of a budbreak count of each cutting for each cultivar weekly for 10 weeks. A bud was considered broken when the first leaf became visible as it unfolded from the bud. Budbreak data after 10 weeks for each study were analyzed separately using Statistical Analysis Systems.

FINDINGS

The chilling interval x cultivar interaction was significant for this study, indicating that budbreak differed among the cultivars for the various chilling intervals. Our first noteworthy finding, that of a similar estimate of chilling response of 'Arapaho' stem cuttings exposed to field chilling compared to that found by Drake and Clark (2000) using whole plants of 400 to 500 hours, provided confidence in the stem cutting method used (Fig. 1).

Another important finding was the unusual budbreak at low chilling level for 'Kiowa'(Fig. 2). This cultivar was released in 1996, and has not been planted as widely as cultivars such as 'Shawnee', 'Choctaw', or 'Arapaho'. Therefore, reports from growers and researchers have not yet surfaced as to its chilling response. It was

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observed in the testing of 'Kiowa' prior to its release that it had earlier spring budbreak compared to 'Shawnee' and 'Choctaw' (Moore and Clark, 1996), and this might reflect either a lower chilling requirement or a lower heat requirement for bud development. 'Kiowa' had substantial budbreak at 200 hours, and at most other chilling intervals (Fig. 1b). There was a reduction in budbreak at 300 hours for 'Kiowa', due to the death of several cuttings collected for this chilling interval. There was a notable reduction for 'Kiowa' at the 800 and 1000 hours, likely due to winter injury sustained from extreme low temperature (2°F) during this chilling interval. Based on these findings, it appears that 'Kiowa' has the lowest chilling requirement of the Arkansas cultivars, possibly as low as 200 hours.

Field observations of 'Choctaw' in more subtropical climates of the world have shown it to have a lower chilling requirement than other Arkansas cultivars released prior to 1989 (J.N. Moore, personal communication). 'Choctaw' showed no budbreak until 400 hours, with higher budbreak at other chilling intervals (data not shown). Budbreak never exceeded 32% for 'Choctaw' at any interval, however, which was lower than most other cultivars. We conclude that for 'Choctaw' data were inconclusive in substantiating the low chilling observations that have been reported previously. Reasons for this were not clear, but could include the possibility of cold injury to buds during the study, or could relate to the heat requirement necessary to instigate growth.

'Shawnee' has been the most widely grown Arkansas blackberry cultivar, with widespread planting in the southern U.S. Prior evidence of lack of chill has not been reported (J.N. Moore, personal communication). In our study, 'Shawnee' appeared to have a chilling requirement of 400 to 500 hours due to the greatly increased budbreak between these two intervals. Since most of southern states receive this amount or more chilling, one would expect a cultivar not to experience chilling requirement shortfalls at this chilling level. The chilling requirement seen in our data supports this observation. The budbreak levels were among the highest of all cultivars after these chilling treatments, providing further confidence in our method.

The two newest Arkansas cultivars, 'Apache' and 'Chickasaw', have no field-chilling observations available. 'Chickasaw' had substantial budbreak at 700 hours of 50%, a major increase in budbreak compared to lower chilling intervals (data not shown). 'Chickasaw', therefore, had a chilling requirement between 600 to 700 hours, a higher chilling requirement than 'Shawnee' by 200 hours. Budbreak did not remain as high for 'Chickasaw' at 800 and 1000 chilling intervals, which again might be due to winter injury to some buds. Further research and observation should be done to substantiate the chilling requirement of this new cultivar. 'Apache' had low budbreak at all chilling intervals, with the highest level at 800 hours of 20% (data not shown). We anticipated that 'Apache' would have chilling near to that of 'Navaho' (800 to 900 hours as found by Drake and Clark, 2000), as 'Navaho' is one of 'Apache's' parents. Due to the low budbreak at all intervals, we believe our results are inconclusive in estimating chill requirement for 'Apache', thus further investigation to determine chilling requirement is needed.
For the majority of the cultivars evaluated in our study, the use of stem cuttings receiving field chilling was a successful method of chilling requirement determination. We suggest that this investigation be repeated to verify the results, and that bud viability of cultivars be determined prior to forcing to ensure that winter injury does not contribute to reduced budbreak.

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Moore, J.N. and J.R. Clark. 1998. 'Kiowa' blackberry. HortScience 31:286-288.

Ryugo, K. 1998. Fruit culture: Its science and art. John Wiley and Sons, London.

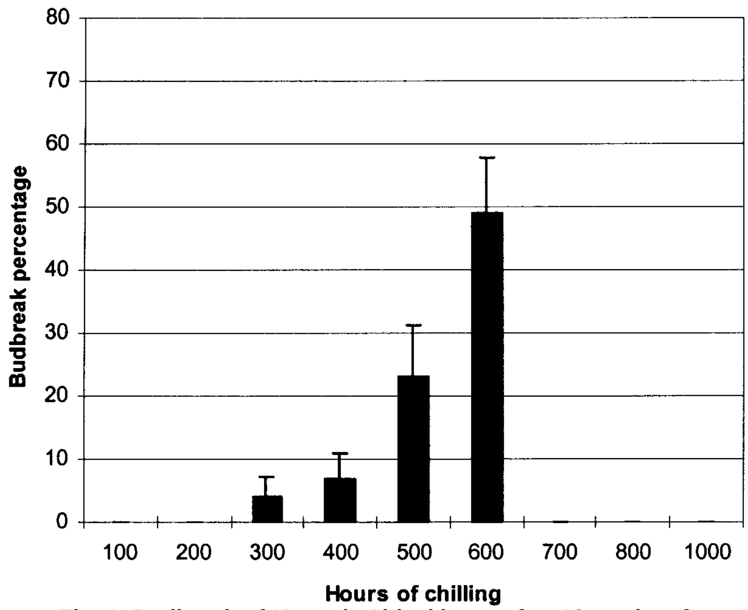

Fig. 1. Budbreak of 'Arapaho' blackberry after 10 weeks of forcing in a heated greenhouse following 100 through 1000 hours of chilling, below 45°F.

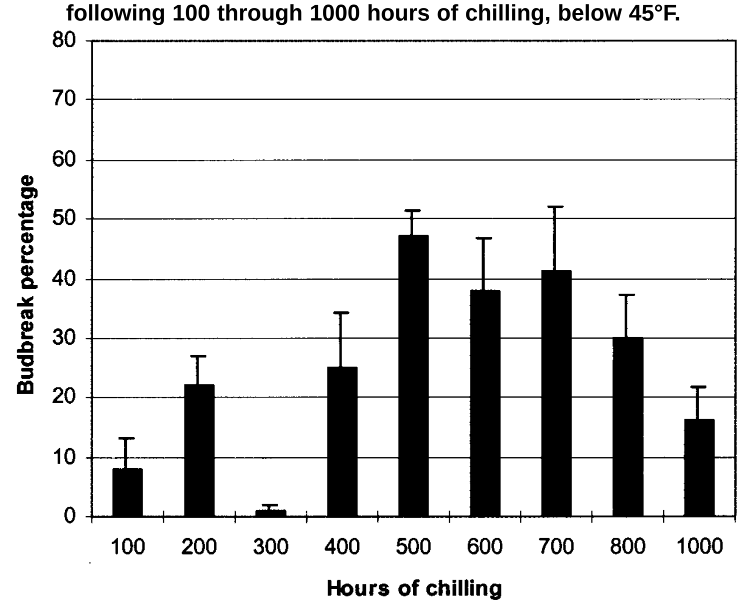

Fig. 2. Budbreak of 'Kiowa' blackberry after 10 weeks of forcing in a heated greenhouse following 100 through 1000 hours of chilling, below 45°F.

VEGETABLES

EFFECT OF HARVEST INTERVAL ON YIELD OF 'CLEMSON SPINELESS' OKRA, 2001

Paul E. Cooper[1]

IMPACT STATEMENT

Different harvest intervals of 'Clemson Spineless' okra were evaluated as to their effect on yield and quality of okra. It was found that okra yields can be greatly manipulated by various harvesting procedures.

BACKGROUND

Okra is a very popular vegetable sold at farmers markets and roadside stands in Arkansas. The immature pod is the edible part of the okra plant. As with all vegetables, quality is extremely important to the consumer. Quality of okra refers primarily to age of the pod or pod length. Sistrunk et al. (1960) found that fiber content of okra pods increases the longer the pods remain on the plant, which eventually renders them unsuitable for human consumption. Likewise, Iremiren et al. (1991) found that pods harvested more than 7 days after pod-set were of lower quality. The reduction in pod quality was due mainly to an increase in crude fiber and a decrease in moisture.

Various state extension services recommend that pods be harvested when they are 2 to 5 in. in length. This is about 4-6 days after flowering. Based on this rapid growth, it is critical that okra be harvested at the proper time. Depending on growing conditions, okra may need to be harvested every day, or at least several times per week.

The purpose of this study was to examine okra pods and to relate growth to the optimumal harvesting schedule as it pertains to yield and quality.

[1] Southeast Research and Extension Center, Monticello

RESEARCH DESCRIPTION

This study was conducted at the Univ. of Arkansas Southeast Research and Extension Center (SEREC) at Monticello. The cultivar Clemson Spineless was grown on raised beds covered with black plastic mulch with drip irrigation. Beds were 2 ft wide and 6 ft center to center. Double rows of okra were planted 12 in. apart on the beds. Within each row, plants were spaced 12 in. apart. Plot length was 15 ft.

In Part 1 of this study, okra pod growth was examined. Individual flowers were tagged and dated on the day of flowering. Beginning the following day, individual pod measurements were made on a daily basis to chart their growth. Measurements were taken for 10 days.

In Part 2 of the study, three harvest intervals were used to collect data on yield and quality of the pods. The three treatments were: 1) daily harvest of every pod more than 2 in. long; 2) daily harvest of every pod more than 2.5 to 3 in. long (personal discretion was used); and 3) harvest every other day every pod that was more than 2 in. long. A fourth harvest treatment (harvest every third day) was begun, but was discontinued because too many large and unmarketable pods were being harvested.

The harvest period of this study lasted from 22 July through 31 Aug. 2001. Growing conditions were excellent for okra, as indicated by temperatures recorded near the plots. Most of the daily maximum temperatures were in the low to mid 90°F (average high was 91.6°F.). The average daily low was 70°F.

FINDINGS

Okra pods grew rapidly in this study (Table 1). One day after flowering, the pods were slightly more than .5 in. long. On day 2, the pods averaged almost 1 in. length. By day 4, they averaged 2 1/4 in. length; they were now at the marketable stage. On day 6, the pods were more than 4 in. long. This is the maximum recommended length. On day 9, the pods had reached their maximum lengths measured in the study.

Pod growth data supported most recommendations that okra pods should be harvested 4-6 days after flowering. If a pod is 3 in. or shorter, harvest could be delayed 1 day. However, any further delay in harvest date result in unmarketable pods with length greater than 5 in. (Table 1).

Harvest interval had a significant effect on yield of okra (Table 2). Harvesting 2 in. pods on a daily basis resulted in pods that had an average weight of 9.0 g (Table 2). Harvesting on a daily basis, and using some discretion, increased the average weight of the pods to 10.8 g (Table 2). When harvested every other day, the average pod weight increased to 11.1 g.

Pod size distribution was greatly affected by harvest interval (Table 3). When 2 in. pods were harvested daily, most pods were harvested at a length of less than 3 in. (90.2%). By using discretion and allowing the pods to increase in length before harvesting, a much smaller percentage of small pods was harvested (66.6%). When pods 2 in. or longer were harvested every other day, pod size was evenly distributed between 2 and 4 in. with pods measuring 3 in. and longer making up 54.1% of that treatment (Table 3).

By examining the growth rates in Table 1, it is assumed that the treatment that would produce the highest yields of quality okra would be a daily harvest using a stricter discretion than the one used in this study. Harvesting pods when they reached a length of between 3 and 4 in.

might be the best strategy. However, labor costs and type of market should also be factored into this type of a decision. Additionally, growing conditions could greatly affect harvest interval.

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Sistrunk, W.A., L.C. Jones, and J.C. Miller. 1960. Okra pod growth habits. Proc. Amer. Soc. Hort. Sci. 76:486-491.

Table 1. Length of 'Clemson Spineless' okra pods 1-10 days after flowering, 2001.

Days after flowering	Pod length (in.)
1	0.6 a[z]
2	1.0 b
3	1.5 c
4	2.3 d
5	3.1 e
6	4.1 f
7	5.3 g
8	6.2 h
9	6.5 i
10	6.5 i

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

Table 2. Average weight of 'Clemson Spineless' okra pods as affected by harvest interval, 2001.

Harvest interval[z]	Avg. wt. (g)	% Increase
D	9.0 b[y]	–
DD	10.8 a	20.5
2D	11.1 a	23.8

[z] D=Daily harvest of pods 2 in. and longer; DD=daily harvest of pods 2.5 to 3 in. and longer (some discretion used); 2D=harvest every other day of pods 2 in. and longer.

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

Table 3. Effect of harvest interval on pod length of 'Clemson Spineless' okra, 2001.

	Length (in.)				
Harvest interval[z]	2-2 1/2	2 1/2 -3	3-3 1/2	3 1/2 -4	4 +
			%		
D	44.9	45.3	8.7	1.2	0.0
DD	20.2	46.4	27.6	5.4	0.5
2D	21.6	24.2	25.3	23.2	5.6

[z] D=daily harvest of pods 2 in. and longer; DD=Daily harvest of pods 2.5 to 3 in. and longer (some discretion used); 2D=harvest every other day of pods 2 in. and longer.

TOMATO CULTIVAR TRIAL RESULTS, 2001

Paul E. Cooper[1]

IMPACT STATEMENT

Eight tomato cultivars and breeding lines were evaluated in 2001. Due to severe infestations of tomato spotted wilt virus (TSWV) in recent years in the commercial tomato crop in southeast Arkansas, close evaluation of three "TSWV–resistant" cultivars/lines was very important. TSWV occurrence was very limited in 2001and the industry standard 'Mountain Spring' along with 'Mountain Fresh' were highest yielding. The TSWV resistant cultivars did not perform comparatively well in this trial with absence of TSWV disease pressure.

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 N.C. State Univ. and quickly became the industry standard because of 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 continue to evaluate new tomato cultivars for their adaptability and potential use in southeast Arkansas.

A second, and equally important, purpose of this study was to evaluate three cultivars/lines that were touted to be resistant to TSWV. Results from a study in 2000 indicated a high degree of tolerance to TSWV by 'BHN-444' and '1405037' (Asgrow line) when subjected to extreme pressure from TSWV (Cooper, 2001).

[1] Southeast Research and Extension Center, Monticello.

RESEARCH DESCRIPTION

This study was conducted on the Roger Pace commercial tomato farm in Drew County. Basic cultural practices used by tomato producers in the area were followed. Eight cultivars and breeding lines were compared in the test, including the standard 'Mountain Spring' and three cultivars/lines reputed to be resistant to TSWV (Table 1). Tomato seeds were planted on 26 Feb. 2001, plants were transplanted from seedling flats on 15 March, and transplants were set in the field on 10 April.

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. Fruits were harvested from 18 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 plots consisted of four plants.

FINDINGS

Total marketable yields ranged from 13.9 lb/plant to 7.4 lb/plant. 'Mountain Fresh' and 'Mountain Spring' produced the most marketable fruit while 'BHN-555' produced the least amount of marketable fruit (Table 1). 'Mountain Spring' yielded the most #1 fruit (8.0 lb/plant), followed by 'Mountain Fresh' (6.8 lb/plant). 'BHN-444' produced the highest yield of #2 fruit (8.1 lb/plant). 'Mountain Spring' produced the least amount of #2 fruit (3.5 lb/plant) (Table 1). Average fruit weight ranged from 13.1 oz (HA-3028) to 9.7 oz ('BHN-555'). Average fruit weight of 'Mountain Spring' was 12.5 oz (Table 1).

In this study, the standard 'Mountain Spring' continued to perform extremely well, as did 'Mountain Fresh'. Both yielded very good compared to the other cultivars, and produced a high percentage of #1 tomatoes, especially 'Mountain Spring' (data not shown).

'BHN-444', 'BHN-555', and '1405037', all tolerant to TSWV, did not perform as well as either 'Mountain Spring' nor 'Mountain Fresh', in the absence of tomato spotted wilt virus. However, under extreme pressure from this disease, 'BHN-444' and '1405037' have been shown to perform very well (Cooper, 2001).

LITERATURE CITED

Cooper, P.E. 2001. Tomato cultivar results, 2000. In: J.T. Lindstrom and J.R. Clark (eds.). Horticultural Studies - 2000. Ark. Agri. Exp. Sta. Res. Ser. 483:48-49.

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 and average fruit size, 2001.

	--------------------Lb/plant--------------------			
	Grade			
Cultivar	#1	#2	Total mkt. yield	Average fruit wt. (oz)
Mountain Spring	8.0 az	3.5 c	11.5 ab	12.5 ab
Mountain Fresh	6.8 a	7.1 ab	13.9 a	11.4 bc
HA-3026	4.5 b	6.0 ab	10.5 b	11.1 bc
HA-3028	3.5 b	5.3 bc	8.8 bc	13.1 a
Florida 91	1.6 c	7.7 a	9.3 bc	12.8 ab
BHN-444 *	1.6 c	8.1 a	9.7 bc	11.7 ab
1405037 *	1.6 c	7.5 a	9.1 bc	11.9 ab
BHN-555 *	0.8 c	6.6 ab	7.4 c	9.7 c

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

* Resistant/tolerant cultivars to TSWV.

A COMPARISON OF TWO TOMATO CULTIVARS MOUNTAIN SPRING VS. BHN-444

Paul E. Cooper and C. Robert Stark, Jr.[1]

IMPACT STATEMENT

A comparison of two tomato cultivars was made utilizing data from four studies in 2001. ‘Mountain Spring’ produced more high-quality fruit than did ‘BHN-444' in each of the studies. There was no difference in the yield of total marketable fruit. Average fruit weight of ‘Mountain Spring’ was slightly larger than ‘BHN-444'.

BACKGROUND

The tomato cultivar Mountain Spring was released in 1992 by N.C. State Univ. (Gardner, 1992) and is now the standard of the industry in southeast Arkansas. However, it is not resistant nor tolerant to tomato spotted wilt virus (TSWV), which has rendered much of its fruit unmarketable in recent years. Researchers are working to develop tomato cultivars that possess good resistance/tolerance to TSWV. One such release is ‘BHN-444'. It has shown a high degree of tolerance to TSWV when susceptible cultivars have been severely damaged (Cooper, 2001). However, tomato producers have not adopted it due to concerns about yield and fruit quality. Therefore, the purpose of these studies was to quantify yield and quality characteristics of ‘BHN-444' as compared to ‘Mountain Spring’.

RESEARCH DESCRIPTION

All four studies were conducted in 2001. There was very little pressure from TSWV in any of the plots. Similar cultural practices were used. In Studies 1, 2, and 3, seeds were planted on 26 Feb. 2001, transplanted into cups on 15 March, and transplanted to the field on 10 April. These three studies were conducted on the Roger Pace Farm in Monticello, Drew County. In Study 4, seeds were planted 14 Feb., transplanted into cups on 28 Feb., and transplanted to the field on 4 April. This study was conducted at the Univ. of Arkansas Southeast Research & Extension Center (SEREC), Monticello.

Harvest for Study 1 was from 18 June through 9 July. Harvest for Studies 2 and 3 was from 19 June through 11 July. Harvest for Study 4 was from 4 June through 10 July. Fruits from each study were 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.

FINDINGS

In all four studies, ‘Mountain Spring’ produced more #1 fruit than did ‘BHN-444' (Table 1). Most of this #1 fruit was extra large (XL). ‘BHN-444' produced the most #2 fruit in each of the studies. Total marketable fruit was basically the same in each study. Although ‘Mountain Spring’ was larger than ‘BHN-444' in each of the studies, statistically, it was only significantly larger in Study 4 (Table 1). Although ‘BHN-444' produces as well as ‘Mountain Spring’, it did not grade as well.

LITERATURE CITED

Cooper, P.E. 2001. Tomato cultivar results, 2001. In: J.T. Lindstrom and J.R. Clark (eds.). Horticultural Studies - 2000. Ark. Agri. Exp. Sta. Res. Ser. 483:48-49.

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ACKNOWLEDGMENTS

The authors wish to thank Mr. Roger Pace of Monticello, Ark. for his assistance in the conducting of these studies.

[1] Southeast Research and Extension Center, Monticello.

Table 1. 2001 yields (lbs) of 'Mountain Spring' and 'BHN-444' tomatoes by grade and average fruit weight.

Cultivar	Grades #1	Grades #2	Total mkt.	Avg. wt. (oz)
		Study 1		
Mountain Spring	8.0 a	3.5 b	11.5 a	12.5 a
BHN-444	1.6 b	8.1 a	9.7 a	11.7 a
		Study 2		
Mountain Spring	8.3 a	4.7 b	12.9 a	11.3 a
BHN-444	3.3 b	8.5 a	11.9 a	10.3 a
		Study 3		
Mountain Spring	9.7 a	4.1 b	13.8 a	11.1 a
BHN-444	4.3 b	11.4 a	15.7 a	10.7 a
		Study 4		
Mountain Spring	6.9 a	5.2 b	12.0 a	9.9 a
BHN-44 4	5.0 b	7.3 a	12.3 a	8.6 b

Means separation within study by Duncan's multiple range test (P<0.05).

THE EFFECT OF TOMATO TRANSPLANT CONTAINER SIZE ON YIELD AND QUALITY OF FRESH-MARKET TOMATOES

Paul E. Cooper, C. Robert Stark, Jr., Paul B. Francis, Amy Gibson, Jason Green, Marsha McGraw, and Brandon Truax[1]

IMPACT STATEMENT

Various tomato transplant container sizes were evaluated as to their effect on tomato production. Five containers sizes, and two tomato cultivars were tested. Overall yields of tomatoes were not affected by container size, but early yields were increased by the use of larger transplant containers.

BACKGROUND

Tomato transplant quality is very important to the ultimate production of the tomato crop. Both transplant size and age have been shown to affect production. One study, involving the indeterminate cultivar Traveler 76, showed that as container size increased, total yields were unaffected, but early yields were increased (Cooper, 1990). In a more recent study, it was shown that as transplant container size increased, both the yield of extra-large tomatoes and total fruit increased (Vavrina and Arenas, 1997).

Estimates from a tomato budget indicated that tomato transplants cost approximately $0.10 each (Bryant, et al., 1995). This was based on the use of the 24-cup container that is used predominantly in southeast Arkansas. The objective for this study was to compare five sizes of transplant containers and to evaluate their effect on yield and quality of two tomato cultivars.

RESEARCH DESCRIPTION

This study was conducted at the University of Arkansas, Southeast Research and Extension Center, (SEREC) Monticello. Two cultivars, Mountain Spring and BHN-444, were used. Seeds were planted on 14 Feb. 2001, seedlings were transplanted into containers on 28 Feb., and the transplants were set in the field on 4 April. Black plastic mulch and drip irrigation were used on beds 2 ft wide and 8 in. high. Plants were spaced 22 in. apart in the rows, which were 6 ft from center to center. Plants were staked, tied, and pruned in a manner consistent with the method used in the area.

Plastic trays containing individual cups were used to grow the transplants. The number of cups per container was 18, 24, 38, 50, or 72. The cups in the 18-cup container had a volume of approximately 280 cm3. As number of cups per container increased, the volume of each individual cup decreased. The volume of an individual cup of the 72-cup container was approximately 50 cm3.

Transplant quality was determined at the time of transplanting to the field (4 April). At that time stem diameters were measured at the cotyledons. Then some plants from each treatment were dried for dry-weight measurements. Bloom dates were recorded on the transplants set in the field.

Fruits were harvested from 4 June through 10 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 consisted of the first three grades. The experimental design was a randomized complete block with four replications and plot size was eight tomato plants.

FINDINGS

The 18-cup containers produced the highest quality ‘BHN-444' transplant, based on stem diameter and dry weight (Table 1). Also, plants from these containers and the 24-cup containers were the first to bloom in the field. As cup size decreased, the quality of the transplant also decreased; stem diameters were smaller and dry weights were lower. The number of days for the plants to bloom after transplanting also increased.

Transplant container size had no effect on total marketable yield or on average fruit weight for ‘Mountain Spring’ (Table 2). Likewise, the yield of #1 tomatoes was unaffected by container size. Only the yield of #2 tomatoes was affected by container size (Table 2). The effect of container size on ‘BHN-444' was similar to the effect on ‘Mountain Spring’. Container size had no effect on yield or quality over the course of the entire season (Table 2).

The early yield of ‘Mountain Spring’ was significantly affected by container size. As container size increased, early yields also increased (Table 3). Other yield and quality measures were unaffected during early season. Total marketable yield of ‘BHN-444' was also significantly affected in the early season by container size. As container size increased, yield increased. The yield of #2 tomatoes was affected in a similar manner (Table 3).

In summary, transplant container size did not affect the yield or quality of tomato fruit production for the total season. However, container size did have an effect on production during the early part of the harvest season. The larger the container, the higher the yield. These conclusions are similar to results from other studies of this nature.

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Economic data will be incorporated into this study to determine the most profitable scenario for the tomato producer. If total production is the primary goal, the smaller containers would seem to be the most profitable. However, if earliness is of prime importance, the larger containers should probably be used.

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Table 1. Effect of tomato transplant container size on quality attributes of 'BHN-444' tomato transplants.

Container size	Stem diameter (mm)	Dry weight (g)	Days to first bloom
18	5.95 a	1.08 a	19.85 a
24	5.29 b	0.69 b	21.20 a
38	4.76 c	0.51 c	23.99 b
50	4.17 d	0.41 d	24.27 b
72	3.84 d	0.29 e	26.16 c

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

Table 2. Effect of transplant container size on 'Mountain Spring' and BHN-444 tomato yields (lb/plant), 2001 (total season).

		Yield		
Container size	#1	#2	Total mkt.	Avg. wt. (oz)
		Mountain Spring		
18	7.4	5.1 a[z]	12.6	9.75
24	6.9	5.2 a	12.0	9.87
38	8.3	3.9 b	11.8	9.86
	NS		NS	NS
		BHN-444		
18	4.7	7.0	11.7	8.89
24	5.0	7.3	12.3	8.59
38	5.9	5.9	11.7	8.33
50	4.9	6.0	10.9	8.27
72	4.4	6.5	10.8	8.99
	NS	NS	NS	NS

[z] Means with a column followed by a different letter are significantly different as determined by Duncan's multiple range test (P≤0.05);
NS=non-significance among means.

Table 3. Effect of transplant container size on 'Mountain Spring', and 'BHN-444' tomato yields (lb/plant), 2001(early season).

	Yield			
Container size	#1	#2	Total mkt.	Avg. wt. (oz)
		Mountain Spring		
18	4.1	1.9	6.1 a[z]	9.54
24	3.6	1.3	4.9 b	9.07
38	3.2	0.9	4.0 b	8.90
	N.S.	N.S.		N.S.
		BHN-444		
18	3.2	2.3 a	5.4 a	8.37
24	2.7	1.9 ab	4.5 ab	8.50
38	2.8	1.3 bc	4.0 bc	7.82
50	2.4	1.3 bc	3.7 bc	7.99
72	2.1	1.1 c	3.1 c	8.35
	NS			NS

[z] Means within a column followed by a different letter are significantly different as determined by Duncan's multiple range test ($P<0.05$); NS=non-significance among means.

SOUTHERNPEA CULTIVAR AND ADVANCED BREEDING LINE TRIALS

Stephen Eaton[1], Larry Martin[1], D.R. Motes[1], and T. E. Morelock[2]

IMPACT STATEMENT

This three-year study evaluated Arkansas southernpea breeding lines with commercial cultivars to compare yield, maturity dates, and plant types. Some Arkansas breeding lines had similar or higher yields than the cultivars that are currently being grown for commercial production. Some of these breeding lines will continue to be evaluated with the potential of being released as cultivars.

BACKGROUND

Southernpea is an important commodity for home gardeners and commercial processors in the South. The University of Arkansas conducts a large southernpea breeding program. This program creates advanced lines that need to be evaluated for their potential use as new commercial or home gardening cultivars. Until the past few years, the main commercial and garden cultivars grown were the blackeyes ‘California Blackeye #5’, ‘California Blackeye #46', and the pinkeyes ‘Coronet’, ‘BVR’, along with ‘Mississippi Silver’ (brown crowder), and ‘White Acre’ (cream). Recently, the main commercial cultivars have switched to ‘Early Scarlet’ (pinkeye), ‘Early Acre’ (cream), and ‘Arkansas Blackeye # 1’.

Breeding lines with the highest potential are then entered into the Southern Regional Southernpea Cooperative Trial and evaluated in the different regions of the southern United States. If they continue to do well, they may be released as a cultivar. Our study was conducted to delineate the most worthy selections for further trials and possible release.

RESEARCH DESCRIPTION

The trials were planted in 1999, 2000, and 2001, in a Roxana silt loam soil type at the Vegetable Substation located in the Arkansas River Valley near Kibler, Ark. The trial consisted of six blackeye, three crowders, five creams, and 10 pinkeyes. The plots were fertilized before planting with 15-30-15. Herbicide treatment was Treflan (trifluralin) and Pursuit (imozethapyr) at recommended rates, pre-plant incorporated. Planting dates in all years were near the optimal planting date for southern peas in this region, 10-24 June. The plots were 30 ft long with four rows 36 in. apart and a seeding rate of three to four seed per foot in-row. Irrigation was used to supplement rainfall to ensure the plots received at least 1 in. of water every 7 days, especially during the critical times of bloom and the week after bloom for pod fill. Each plot was harvested with a combine, and the peas were dried, weighed, and yields recorded. Means provided are for the 3 years of the trials.

FINDINGS

No significant differences for yield were observed among ‘Arkansas Blackeye #1’ and the four Arkansas blackeye breeding lines (Table 1). However, ‘Arkansas Blackeye #1’ and 95-648 did have significantly higher yields than ‘California Blackeye #46’. ‘Arkansas Blackeye #1’ and the remaining blackeye breeding lines matured an average of 20-25 days earlier than ’California Blackeye #46' (Table 1). All blackeye types except ‘California Blackeye #46' are erect-type plants. Breeding line 96-918 yielded significantly lower than all other cream types including the standards ‘Early Acre’ and ‘Erect Set’. All cream entries matured very near the same date and were erect-type plants.

The Arkansas brown crowder breeding lines 92-674 and 95-306 had a higher yield than ‘Mississippi Silver’. Both Arkansas brown crowder lines also matured 5-7 days ahead of ‘Mississippi Silver’ and were also erect in plant type. The best five yielding pinkeye entries were 96-854, 96-868, ‘Early Scarlet’, 96-1022, and 92-552. The five lowest-yielding pinkeye entries were ‘Excel’, 87-435-68, ‘Coronet’, ‘C.T. Pinkeye’, and ‘BVR’. All breeding lines have erect-type plants.

Four breeding lines that fit very specific industry needs have

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been identified, tested in the southern cooperative trial, and the release process initiated. The lines are: 95:552, which is a high yielding, late-maturing pinkeye that is also resistant to root knot nematode and will be named ‘Empire’; 95-104, an early-maturing, small seeded cream that has a seed size similar to ‘White Acre’ and will be named ‘Empress’; 87-435-68, a bush, pinkeye, purple hull with some tolerance to blackeye cowpea mosaic virus, and also tolerant to high soil pH, which will be named ‘Excel Select’; and 92-674, a bush-type brown crowder that has a superior plant type to the industry standard and will be named ‘Epic’.

Table 1. Southernpea breeding line and cultivar yields, plant type and days to maturity at the University of Arkansas, Vegetable Substation, Kibler. Data are averaged for 3 years.

Cultivar/line	Yield (lb/acre)	Plant type	Days to maturity
	Blackeye		
95-648	773 a[z]	Erect	54
AR BE #1	770 a	Erect	59
91-308	706 ab	Erect	55
91-298	683 ab	Erect	59
92-574	661 ab	Erect	54
Cal BE #46	586 b	Vining	80
	Brown Crowder		
92-674	718 a	Erect	63
95-306	660 ab	Erect	61
Miss. Silver	555 b	Vining	68
	Cream		
95-105	811 a	Erect	61
95-104	801 a	Erect	61
Early Acre	770 a	Erect	61
Erect Set	706 a	Erect	63
96-918	466 b	Erect	63
	Pinkeye		
96-854	973 a	Erect	59
96-868	810 ab	Erect	58
Early Scarlet	756 bc	Erect	56
96-1022	750 bcd	Erect	56
92-552	686 bcde	Erect	65
Excel	505 efgh	Erect	61
87-435-68	500 efgh	Erect	62
Coronet	412 fgh	Vining	63
C.T. Pinkeye	364 gh	Vining	63
BVR	323 h	Vining	63

[z] Means within the same eye type with the same letter are not significantly different ($P \leq 0.05$).

REGIONAL SOUTHERNPEA COOPERATIVE TRIAL AT THE VEGETABLE SUBSTATION, KIBLER, ARK., 2001

Larry Martin[1]*, Stephen Eaton*[1]*, D.R. Motes*[1]*, and T. E. Morelock*[2]

IMPACT STATEMENT

The evaluation of southernpea breeding lines grown in different soil types under varying environmental conditions provides very important information to plant breeders. The regional southernpea cooperative trial is an annual vehicle to achieve this goal.

BACKGROUND

The Southernpea Cooperative Trial is an annual trial for southernpea breeders to have advanced breeding lines evaluated in different soil types under varying environmental conditions. The breeding lines are evaluated and compared to existing germplasm.

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

There were a total of ten trial locations planted in the southern states with three in Arkansas and one each in Missouri, Oklahoma, Texas, Louisiana, Mississippi, Tennessee, and Alabama. Only the trial planted at the Vegetable Substation near Kibler, Arkansas will be discussed.

RESEARCH DESCRIPTION

The trial was divided into two parts. The replicated trial consisted of advanced lines, while the observation trial consisted of less advanced or screening lines. The difference between the two is that the replicated entries had four replications whereas the observationals had two replications. ‘Early Acre’ (cream type), ‘Coronet’ (pinkeye type) and ‘Arkansas Blackeye #1’ (blackeye type) were used as controls in both parts of the trial.

The trial was planted at the Vegetable Substation in a Roxana silt loam soil. Pre-plant fertilizer of 15-30-15 was incorporated. A herbicide treatment consisting of Pursuit 2AS at the rate of 4oz/acre and trifluralin 4EC at the rate of 1 pint/acre was applied in a tank mix, pre-plant incorporated. The trial had a row spacing of 3 ft with four seed per foot in the row. Planting date was 13 June 2001. The plot received 5.1 in. (128.8 mm) of rainfall with an additional 5.1 in. of irrigation provided from an overhead linear system. The trial was cultivated twice and harvested on 29 Aug. 2001 with a plot combine after the seedpods were dry. Yields on lb/acre were recorded and data analyzed.

FINDINGS

In the blackeye replicated trial (Table 1), all four of the breeding lines produced as well as the control, ‘AR Blackeye #1', although none exceeded the control. For the cream replicated trial, two of the three breeding lines produced as well as the ‘Early Acre’ control, while AR 96-918 was lower in yield. The pinkeye-replicated data showed that two of the four breeding lines produced as well or better than ‘Coronet’ and the performance of LA 96-21 was the most outstanding.

For the blackeye observation trial (Table 2), none of the three breeding lines produced as well as the control. In the cream observation trial, all sevenbreeding lines produced as well as the control. However, four of the breeding lines showed the potential to exceed the control in yields. Finally, in the pinkeye observation trial, all four of the breeding lines produced as well as the control. Southernpea breeders have breeding lines that have the potential to match the production of the controls and some will surpass the controls. Further work will continue in the evaluation of these and other lines in the future, and new cultivars will emerge from these trials for commercial production.

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Table 1. Replicated southernpea breeding line and cultivar yield for three types grown at the Vegetable Substation, Kibler, Ark.

Cultivar/line	Yield
Blackeye	
AR Blackeye #1	1051 a[z]
TX 159 BE	1024 a
TX 128 BE	1010 a
US 1033	758 a
AR 92-574	742 a
Cream	
Early Acre	756 a
TX 139 CM	735 a
LA 92-180	674 ab
AR 96-918	617 b
Pinkeye	
Coronet	620 ab
LA 96-21	962 a
TX 164 PE	620 ab
TX 149 PE	486 b
TX 148 PE	354 b

[z] Means within type followed by the same letter are not significantly different (P≤0.05).

Table 2. Yield of observational southernpea breeding lines and cultivars yield for three types grown at the Vegetable Substation, Kibler, Ark.

Cultivar/line	Yield
Blackeye	
AR Blackeye #1	1051 a[z]
TX 123 BE	768 b
TX 158 BE	446 c
TX 160 BE	421 c
Cream	
Early Acre	756 abc
LA 95-62	873 a
US 1031	784 ab
LA 96-7	632 abc
US 1070	574 abc
US 1032	542 bc
US 1069	499 bc
US 1068	466 c
Pinkeye	
Coronet	620 a
TX 162 PE	896 a
LA 92-86	810 a
AR 96-1022	808 a
TX 158 PE	742 a

[z] Means within type followed by the same letter are not significantly different (P≤0.05).

WHAT'S HOT? WHAT'S NOT? EVALUATION OF CAPSAICINOIDS IN *CAPSICUM* SPP. FRUIT USING HIGH PERFORMANCE LIQUID CHROMATOGRAPHY

Margaret E. Secks, J. Brad Murphy, and Teddy E. Morelock[1]

IMPACT STATEMENT

Fruit of some *Capsicum* spp., the chile peppers, are known for the sensation of heat produced when consumed. Capsaicinoids are alkaloid compounds responsible for the heat sensation and include primarily capsaicin, dihydrocapsaicin, and nordihydrocapsaicin. The popularity of capsicum fruit in prepared foods and sauces warrants quantitative measurement of capsaicinoids. High performance liquid chromatography (HPLC) is a reliable method of quantifying capsaicinoid levels and is far less subjective than the traditional Scoville Heat Unit (SHU) method. The capsaicinoids in various *Capsicum* spp. and of individual plants within JM3, a breeding line developed from *Capsicum annuum* var. okala were analyzed using HPLC. There was wide variation in capsaicinoid levels between species and among the genetically similar JM3 plants.

BACKGROUND

The fruit of *Capsicum* spp. vary greatly in size, shape, color, flavor, and pungency and are used worldwide for adding flavor and zest to foods and for use in traditional folk remedies. The strong sensation of heat from consumption or application of *Capsicum* spp. fruit is due to the presence of lipophilic alkaloids known as capsaicinoids. The main contributors to pungency are capsaicin (CAP) and dihydrocapsaicin (DHC), which comprise 80 to 90% total capsaicinoids in capsicum fruit (Govindarajan and Sathyanarayana, 1991). Several analogs of CAP are minor contributors to pungency, including nordihydrocapsaicin (NDHC). Synthesis and excretion of capsaicinoids have been localized to the placental tissue of the capsicum fruit (Iwai et al., 1979).

The pungency of *Capsicum* spp. varies with cultivar (Bosland and Votava, 1997), fruit maturity (Contreras-Padilla and Yahia, 1998), environmental growing conditions (Johnson and Decpteau, 1996; Zewdie and Bosland, 2000), and imposed stresses to the plant (Harvell and Bosland, 1997). Genotype and environmental interactions control pungency level, and it appears that environment has the greater influence (Harvell and Bosland, 1997).

Measurements of pepper pungency have traditionally been with SHU. Scoville Heat Units are based on a sensory taste test developed in 1912 by Wilbur Scoville. Using this technique, pepper extracts are diluted with sugarwater until a majority of tastetesters can no longer detect pungency. For example, a SHU of 10,000 means that a 1:10,000 pepper extract to sugar-water solution is the dilution at which heat can no longer be detected by a majority of palates. Peppers above 10,000 SHU are considered hot, and those in a range below 2,500 SHU are considered mild. More reliable and accurate methods for measuring the heat or the capsaicinoid levels have been developed. High performance liquid chromatography is widely accepted and, unlike the subjective SHU test, has repeatable and accurate results. In addition, SHU can be estimated from HPLC results, where 1 ppm total capsaicinoids is equivalent to approximately 15 SHU.

In this study, we analyzed the heat level of various *Capsicum* spp. and of individual plants within JM3, a breeding line developed from C. annuum var. okala.

RESEARCH DESCRIPTION

Various species of *Capsicum* were grown at the Arkansas Agricultural Research and Extension Center, Fayetteville, during the summer of 2001. Fruits from several plants of each *Capsicum* spp. were randomly harvested to make a composite sample, and two sub-samples from each composite were analyzed for capsaicinoid levels. For individual plants of the JM3 line, approximately 10 pods from 129 plants were harvested for non-replicated analysis. Fruits were freeze-dried and ground to a powder in a coffee mill. A 50 mg sample was homogenized in 3.5 mL methanol in a glass mortar and pestle using a Barnant mixer. The sample mixture was poured into a centrifuge tube, and the mortar and pestle were rinsed with an additional 3.5 mL methanol and added to the centrifuge tube. The sample mixture was centrifuged for 5 minutes at 4000 g in a Jouan GR412 centrifuge. Supernatant was removed, and volume of each sample was standardized to 5 mL with methanol. A 1 mL aliquot was filtered through a 0.2 um filter prior to injection into HPLC. The HPLC setup consisted of a Waters 2690 Alliance Separations Module with a Waters 996 Photodiode Array Detector (Waters Corporation, Milford, Mass). A Waters Spherisorb® S5ODS1 (C18) (4.6 X 250 mm, 5um, part no. PSS830615) column was used to separate capsaicinoids. Signals from the detector were monitored at 280 nm and quantified using Millennium[32] v. 3.05.01 software (Waters Corporation, Milford, Mass).

Calibration curves to correlate elution peaks to capsaicinoid amounts were created using standards of capsaicin (8-methyl-N-vanillyl-6-nonanamide) and dihydrocapsaicin (8-Methyl-N-vanillynonanamide) (M-2028 and M-1022, respectively, Sigma Chemical

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Company, St. Louis, Mo.) prepared in methanol. The amount of nordihydrocapsaicin in samples was calculated using the capsaicin calibration curve since no standard was available. Peak identity was based on retention times and spectral characteristics relative to the standards.

FINDINGS

There was considerable variability in capsaicinoid levels of the *Capsicum* spp. tested (Fig. 1). 'Habanero', JM3, 'Tabasco', and JM2 ranked much higher in total heat levels (Fig. 1). Capsaicin was the most abundant compound, followed by dihydrocapsaicin. 'Serrano' and 'Anaheim' had the lowest total heat levels, and PC1 had no detectable capsaicinoids. There was also variation among the 129 individual plants in the *C. annuum* line, JM3 (Table 1). There was a four-fold difference in total capsaicinoids and SHU between the highest and lowest JM3 plants (Table 1). Variability among individual plants within a line may be due to genetic variability, differences in fruit maturity at harvest, or the result of stress to individual plants during fruit ripening. Although the analysis of various *Capsicum* spp. fruit was of random and representative composite harvests from several plants, the results of this analysis might vary under another environmental growing condition, different fruit maturation stage, or genetically different plant material. Additionally, such wide variation among genetically similar plants raises important concerns on the need for ample sampling of plant material across season and location, and it also points out the importance of understanding and managing what controls pungency levels in order to grow a standard product for industry.

The proportion of CAP to DHC to NDHC varied among species. For 'Habanero', 70% of total heat was attributed to CAP, while only 28% and 2% was from DHC and NDHC, respectively (Fig. 1). For JM2, only 55% total heat was from CAP and 38% and 7% was from DHC and NDHC, respectively (Fig. 1). Previous studies have shown the ratio of CAP to DHC for *C. frutescens* and *C. annuum* var. *annuum* to be around 2:1 and 1:1, respectively (Govindarajan and Sathyanarayana, 1991). In this analysis, 'Habanero' had a 2.5:1 ratio CAP to DHC and JM2 had a 1.5:1 ratio (Table 1).

For the 129 individual plants within the JM3 line, the proportion of CAP to DHC to NDHC remained fairly consistent. The average ratio of CAP to DHC to NDHC was 1.7:1:0.4 (Table 1). Because the relative proportion remained consistent, capsaicinoid compound ratios may be genetically controlled. Overall, the heat level of all *Capsicum* species tested was lower than anticipated. In Oklahoma, for example, where growing conditions are generally hotter and drier, total capsaicinoid levels of JM3 plants were higher (personal communication, J. Motes). In Fayetteville, growing conditions may have been milder, resulting in lower total capsaicinoid levels.

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ACKNOWLEDGMENTS

The authors would like to give special thanks to Dr. Jim Motes, Oklahoma State University for providing the JM2 and JM3 seeds.

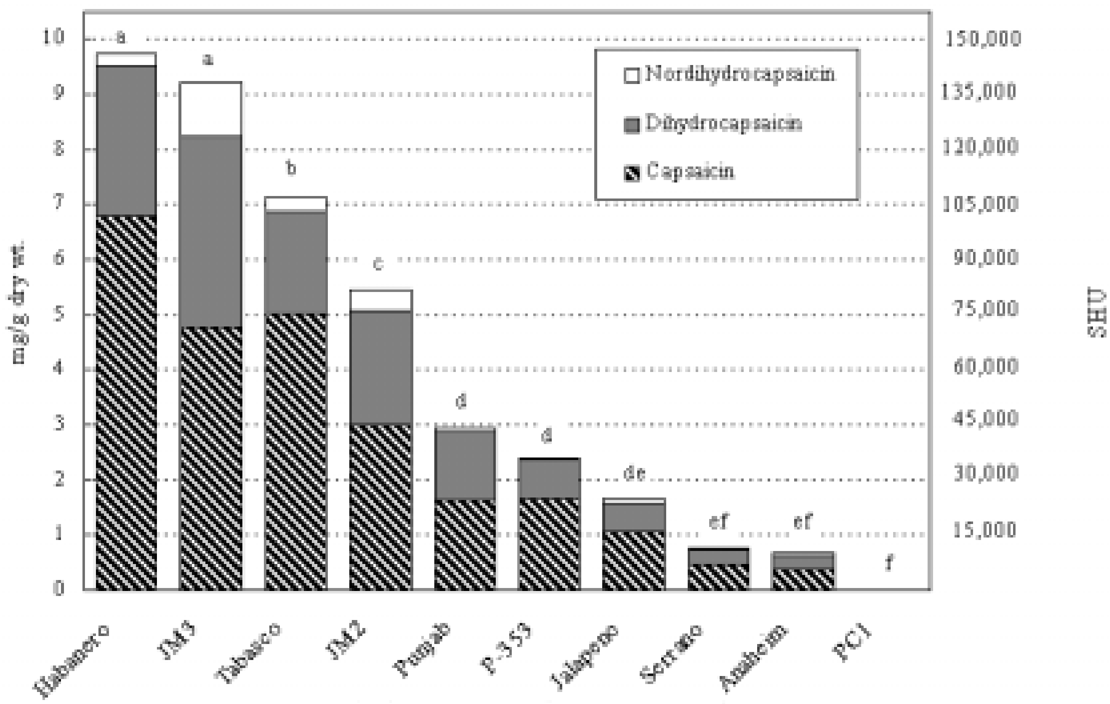

Fig. 1. Fruit capsaicinoid levels, detected by HPLC, of selected *Capsicum* spp. grown in the field during the summer of 2001 at the Arkansas Agricultural Research and Extension Center, Fayetteville. Scoville Heat Units were calculated from HPLC results. Letters above bars indicate mean separation by t-test (P<0.05) for total capsaicinoids.

Table 1. Capsaicinoid levels (mg/g dry wt., Scoville Heat Units calculated from HPLC data, and percent total) in capsicum fruit harvested from representative individual plants (highest, lowest, and average total capsaicinoid level of 129 samples) of JM3, a breeding line of *Capsicum annuum* var. okala, grown during the summer of 2001 at the Arkansas Agricultural Research and Extension Center, Fayetteville.

	Capsaicin			Dihydrocapsaicin			Nordihydro-capsaicin[z]			Total heat	
Plant	mg/g	SHU	%	mg/g	SHU	%	mg/g	SHU	%	mg/g	SHU
JM3-15	14.59	218,905	57	7.85	117,763	31	3.19	47,894	12	25.64	384,563
JM3-11	3.76	56,469	57	2.31	34,722	35	0.48	7,238	7	6.56	98,429
JM3 avg.	8.97	134,578	56	5.24	78,637	33	1.82	27,299	11	16.03	240,514
Std. dev.	2.5	37,061		1.4	20,345		0.6	8,346		4.2	63,566

[z] Calibration curve for capsacin was used to calculate nordihydrocapsaicin quantities.

TOMATO STAKE LIFE: A BREAK-EVEN ECONOMIC COMPARISON

C. Robert Stark, Jr., Paul E. Cooper, and Paul B. Francis[1]

IMPACT STATEMENT

Declining prices received by Arkansas fresh-market tomato producers has led to a greater consideration of the initial cost and expected useful life for all production inputs. One such decision involves the use of traditional oak stakes versus imported pine stakes. Pine stakes were found to have a higher percentage of reusable stakes compared to oak. However the higher cost of pine stakes does not fully justify their use.

BACKGROUND

Most Arkansas fresh-market tomato producers use a stake and twine tying system to improve fruit quality by keeping plants and fruit off the ground and providing better spray coverage. The staking procedure also facilitates the harvest process by raising and exposing the fruit. Stakes used in this system have traditionally been driven in the ground by hand soon after the transplants are moved to the field. They remain in the field at least three months before removal and storage after the fruit has been harvested. For many years, oak stakes have been used by the producers for their strength and durability. Recently, input suppliers have introduced a pine stake imported from Jamaica. The pine stake has been promoted to have a longer useful life, but has a higher initial cost.

RESEARCH DESCRIPTION

This one-year study (2001) sought to compare the useful life of oak and pine stakes by simulating natural exposure effects on tomato stakes. Prices were obtained for each stake type and break-even useful lives were estimated on the basis of percentage stakes reusable.

Both stake types were randomly distributed over a tomato research plot at the University of Arkansas at Monticello campus. The production system consisted of raised beds covered with black plastic mulch. Supplemental water was applied as needed through a plastic drip tube irrigation system on top of the beds and under the mulch. Transplants were taken to the field on 4 April and the stakes/twine tying system was fully put in place within 1 week. Final harvest of the fruit was made on 10 July. Rather than remove and store the stakes immediately following the last fruit harvest, stakes were left in the field until 26 Sept. to simulate the maximal weathering and deterioration from use. Stakes of each type were then manually evaluated to determine whether they could be reused.

FINDINGS

Pine tomato stakes were shown to have a higher percentage (81.2%) of reusable stakes per acre than the traditional oak stakes (69.9). Applying these reusable percentages with the expected cost per stake for each type, total replacement cost per year was found to be more than twice as high for the longer-life pine stakes ($94.70 based on 0.25/stake) compared to the oak stake ($45.15 based on 0.075/stake). This indicates that the difference between reusable percentages for each stake type must be much greater to justify the higher initial cost of the pine stakes. Based on the per-stake costs used in this study, pine stakes would require a 70% higher reusable rate than oak stakes to offset the higher initial cost of the pine (Table 1). Stated differently, producers replacing all of their oak stakes on an annual basis could only justify use of the pine stakes if the pines were 70% or greater reusable on an annual basis.

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Table 1. Break-even percentages by tomato stake type[z].

Stake type	Annual number of stakes replaced	% Stakes replaced	Price/stake ($)	Total cost/year
Oak	2000	100%	.075	$150.00
Pine	600	30%	.250	$150.00

[z] Assumes 2000 total stakes required per acre of tomatoes.

[1] All authors are associated with the Southeast Research and Extension Center, Monticello.

TURFGRASSES AND ORNAMENTALS

FIVE PERENNIAL ORNAMENTAL GRASSES' GROWTH RESPONSE TO THREE LIGHT INTENSITIES

James T. Cole[1]

IMPACT STATEMENT

Ornamental grasses that can survive and retain their visual qualities in densely shaded environments would be a beneficial landscape alternative to other herbaceous perennials. Determining the shade tolerance of ornamental grasses will allow their incorporation in landscape niches that are typically hard to fill. The objective of this multi-year study is to determine the growth response of five field-grown perennial grasses in three light intensities. Some of the grasses tested were capable of performing well in low-light environments.

BACKGROUND

Managed landscapes in Arkansas and the U.S. often include difficult to landscape areas due to heavy shade. Light intensity may decrease as much as 90 to 95% with extensive cloud or tree cover (Barrios et al., 1986). Some grass species can perform well outside their optimum environment (Cole and Cole, 2000). Determining shade tolerance of ornamental grasses will allow their incorporation into typically hard to fill landscape niches.

Plants typically respond to dense shade in several ways. Commonly, leaf-area ratio, leaf-to-stem mass ratio, and stem length increase (Boardman, 1977). Specific leaf weight, plant dry weight, leafblade thickness, and root growth relative to shoot growth frequently decrease (Boardman, 1977). Reduced light intensities can produce enlarged stems as a result of the partitioning of photosynthates by the plant. However, in dense shade, reduced photosynthate production limits all plant development. In a turfgrass study with bermudagrass, phenotypically diverse clones responded to reduced light intensity with shorter leaves, shorter internodes, and reduced dry weights (Gaussoin et al., 1988). The objective for this study was to evaluate five perennial ornamental grasses under three light levels.

RESEARCH DESCRIPTION

Growth of sideoats grama (*Bouteloua curtipendula*), red rays switch grass (*Panicum virgatum* 'Rotstrahlbusch'), 'Karl Foerster' feather reed grass (*Calamagrostis acutiflora*). 'Strahlenquelle' moor grass (*Molinia caerulea*) and Chinese fountain grass (*Pennisetum orientale*) were evaluated in field experiments in 100%, 70%, or 40% light intensity. This study is being conducted over multiple growing seasons with first year results reported here. The study is being conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville. The different light intensities are created by using woven shade cloth on rebar and t-post frames. The plants were watered to keep moisture levels equal in all light treatments, which were monitored throughout the growing season. Recorded measurements include plant height, width, number of inflorescences, leaf area, and shoot dry weight. The experimental design was a randomized complete block and data were analyzed by analysis of variance with means separated by Tukey's test.

FINDINGS

Shoot dry weight was not significantly different between sideoats grama and 'Karl Foerster' feather reed grass subjected to variable light intensities (Table 1). There were significant differences among light treatments for red rays switch grass, 'Strahlenquelle' moor grass, and Chinese fountain grass (Table 1). Leaf area was significantly different in response to different light treatments for red rays switch grass and Chinese fountain grass.

There were no significant differences in plant height among the light treatments for red rays switch grass, 'Strahlenquelle' moor grass, and Chinese fountain grass (Table 2). Significant differences in plant width were not seen regardless of treatment for 'Karl Foerster' feather reed grass as well as those species that did not have significant differences in plant height. 'Karl Foerster' feather reed grass did not develop inflorescences in the first season. Of the species that flowered, only sideoats grama did not have a significant difference among light treatments for number of inflorescences.

Some of the grass species being tested may continue to perform well in low-light environments. The project will continue in 2002.

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ACKNOWLEDGMENTS

The author thanks Cynthia Stewart for assistance with data collection, Jimmy Moore, Brian Hamilton, and Jason Collins for assisting in building and setting up the shade structures, and a special thanks to Greenleaf Nursery for the donation of plant materials.

Table 1. Shoot dry weight and leaf area of five perennial ornamental grasses after one growing season (2001) in 100, 70, and 40% light in the field.

Species	Light intensity	Shoot dry wt. (g)	Leaf area (cm)
Bouteloua curtipendula	100%	190.5 a[z]	7000 a
(sideoats grama)	70%	116.0 a	4204 a
40%	137.1 a	5907 a	
Panicum virgatum 'Rostrahlbusch'	100%	390.3 a	12750 a
(red rays switch grass)	70%	273.5 b	8518 b
40%	193.9 b	6607 b	
Calamagrostis acutiflora 'Karl Foerster'	100%	129.2 a	2832 a
(Feather Reed Grass)	70%	93.2 a	4824 a
40%	88.4 a	5008 a	
Molinia caerulea 'Strahlenquelle'	100%	12.0 a	251 a
(Moor Grass)	70%	7.7 ab	152 a
40%	5.8 b	142 a	
Pennisetum oriental	100%	290.3 a	10182 a
(Chinese fountain grass)	70%	266.6 a	9753 ab
40%	177.6 b	6515 b	

[z] Mean separation within species by Tukey's test ($P \leq 0.05$).

Table 2. Height, width, and number of inflorescences of five perennial ornamental grasses after one growing season (2001) in 100, 70, and 40% light in the field.

Species	Light intensity	Height (cm)	Width (cm)	Number of inflorescences
Bouteloua curtipendula	100%	86.3 b[z]	23.3 a	147 a
(sideoats grama)	70%	102.8 ab	18.5 ab	92 a
	40%	110.3 a	16.0 b	100 a
Panicum virgatum 'Rostrahlbusch'	100%	88.5 a	44.5 a	289 a
(red rays switch grass)	70%	106.5 a	30.8 a	215 ab
	40%	95.0 a	25.3 a	159 b
Calamagrostis acutiflora 'Karl Foerster'	100%	55.8 b	16.5 a	*
(feather reed grass)	70%	68.0 a	17.3 a	*
	40%	79.0 a	14.3 a	*
Molinia caerulea 'Strahlenquelle'	100%	62.0 a	9.0 a	34 a
(moor grass)	70%	67.8 a	8.3 a	16 b
	40%	87.0 a	7.5 a	8 b
Pennisetum orientale	100%	84.0 a	49.8 a	285 a
(Chinese fountain grass)	70%	87.0 a	22.3 a	237 ab
	40%	90.3 a	18.3 a	159 b

[z] Mean separation within species by Tukey's ($P \leq 0.05$).

* Species did not produce inflorescences in the first season.

PAPER MILL SLUDGE AS A MULCH DURING TURFGRASS ESTABLISHMENT

Doug Karcher and William Baser[1]

IMPACT STATEMENT

The use of paper sludge, a waste product of paper milling, as a mulch during turfgrass establishment would be a positive alternative to landfilling. The objective for our research was to determine if paper sludge is effective as a mulch in establishing turfgrass without negatively impacting the physical properties of the underlying soil. Throughout this study, paper sludge was not significantly different from the commercial product hydromulch with regard to the height of germinating turf plants or percent turf cover of the plots. In addition, paper sludge did not significantly reduce water infiltration compared to the other mulches.

BACKGROUND

Sludge is a paper mill waste by-product that is produced in great quantities daily. Most of the sludge is land filled, creating financial and environmental burdens. A typical paper mill produces approximately 900 tons of sludge per day. The daily cost of landfilling this waste is $2,250 ($2.50/ton). The current legislative trend in many states is to restrict the amount and type of materials permitted into landfills. This may limit the paper sludge disposal options of mills in the near future. Finding an alternative use for paper sludge would benefit paper mills financially while also having positive environmental effects such as prolonging the life of landfills.

Paper sludge is composed of cellulose fibers, clay fillers, and coating agents (Norrie and Gosselin, 1995). Past research has demonstrated that paper sludge has potential as a turfgrass soil amendment. Paper sludge additions decreased the bulk density of the soil when mixed with a heavy soil to grow Kentucky bluegrass (Poa pratensis), (Laganiere et al., 1995). Conversely, other studies have shown that the positive effects of using paper sludge as a soil amendment are limited (Fierro et al., 1995).

Another possible way to utilize paper sludge is as a mulch during turfgrass establishment. Mulches are used during establishment to reduce evaporative water loss from the soil, buffer temperatures near the seedbed, and prevent the washing of seeds during precipitation and irrigation. Since paper mill sludge has similar physical properties to other commercially available turfgrass mulches, it may be able to enhance turfgrass germination and establishment. However, since sludge is composed partly of clay, when used as a mulch, it could have a negative impact on water infiltration into the underlying soil.

The objectives of the following research were: 1) to determine if paper mill sludge could be used effectively as a mulch during turfgrass establishment compared to straw and hydromulch; and 2) determine the effects of the mulch treatments on water infiltration into the underlying soil.

RESEARCH DESCRIPTION

Turf plots were established in the greenhouse in plastic tubs (15 x 20 x 5 in.) with holes drilled in the bottom for drainage. The tubs were packed with a sandy loam soil to a bulk density representing typical field conditions (~1.6 g/cm3). Tall fescue (*Festuca arundunacea* cv. Millenium) was seeded in the tubs at a rate of 20 g/m2. Immediately following seeding, tubs were mulched with either paper mill sludge, straw, hydromulch, or nothing (control). Mulch rates are given in Table 1. Through the remainder of the study, the turf was maintained according to Table 2. The mulches were evaluated throughout the study in accordance with Table 3.

Each mulch treatment was replicated four times in a randomized complete block design. One-way analyses of variance (ANOVA) were performed on the data from each evaluation parameter to determine if mulch effects were significant. When mulch effects were significant ($P < 0.05$), treatment means were separated according to Fisher's least significant difference test.

FINDINGS

Plant height. All of the mulches were equally effective with regard to initial germination date. Over time, however, the straw mulch proved to have quicker establishment in terms of seedling height (Table 4). By 12 days after seeding, all mulch treatments had significantly greater plant height than the control.

Percent cover. The straw mulch initially had significantly greater turf cover than the other treatments (Table 4). However, by 37 days after seeding, the paper sludge and hydromulch treatments were not significantly different from the straw. At 23 days after seeding, the control treatment had significantly lower percent cover than all other mulch treatments. Over time, the seed in the control plots eroded into low areas within the plots, negatively impacting percent cover. All three mulch treatments were effective in preventing the erosion of seed.

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

Infiltration. The infiltration rates for the four different mulch treatments were not significantly different ($P < 0.73$) (Table 4). The infiltration values ranged from 22.9 to 26.6 cm/hr. Although the paper sludge is composed partly of clay material, it did not significantly impede water movement into the soil in this study.

This experiment showed that the straw mulch provided faster turf establishment than the other three treatments during the first 23 days after seeding. In addition, the paper sludge treatment performed equally to, and in some cases out-performed, the hydromulch treatment. This experiment showed the importance of using some type of mulch during turfgrass establishment as the control treatment performed significantly worse than all of the mulches throughout the study. These data showed that paper mulch can be used effectively during turfgrass establishment and may provide an alternative to landfilling for paper mills.

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Table 1. Information on mulches used in the turfgrass mulch study.

Mulch type	Source	Application rate
Paper mill sludge	Fort James, Muskogee, Okla.	170 g m^{-2}
Wheat straw	Univ. of Ark. Res. and Ext. Center, Fayetteville, Ark.	290 g m^{-2}
Hydromulch	Conwed Fibers, Statesville, N.C.	170 g m^{-2}
Control		

Table 2. Turf management practices utilized in the turfgrass mulch study.

Management practice	Description
Mowing height	2.5 in.
Mowing frequency	Once per week after seedlings reach 4 in. height.
Irrigation	During germination, 0.1 in. water once per day. Once established, 0.5 in. water three times per week.
Fertility	Starter fertilizer (1:2:1) applied at seeding at a rate of 10 g $P_20_5m^{-2}$. Upon germination, soluble N applied biweekly at 2.5 g/m^{-2}N.
Pest control	None.

Table 3. Treatment evaluations used in the turfgrass mulch study.

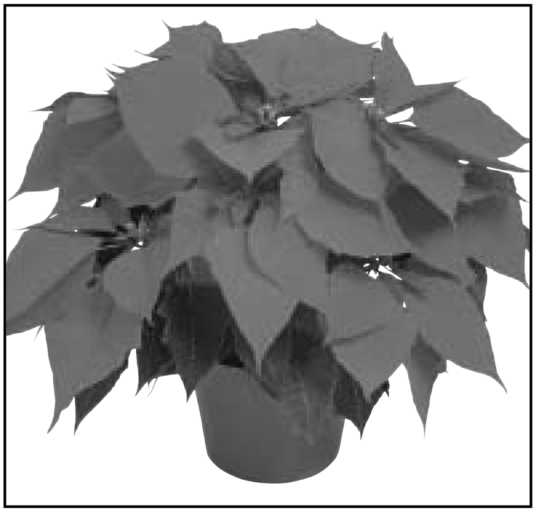
Evaluation	Description
Emergence date	Following seeding and mulching, the plots were checked daily for seedling emergence. The date of first seedling emergence was recorded for each tub.
Plant height	After plants emerged, average plant height was recorded three times per week and plant density was evaluated once weekly. Average plant height was determined by measuring plant tissue height from the soil surface at four randomly selected areas with each tub. Plant height was recorded in each tub until plants had reached 4 in. height.
Plant cover	Plant cover was evaluated weekly by taking overhead digital images of each tub and downloading them to a PC for cover analysis in SigmaScan software.
Infiltration	Infiltration rates for each tub were determined approximately 4 months following germination using a double-ring infiltrometer.

Table 4. Effects of mulch treatment on plant height, infiltration, and percent plant cover.

Mulch	Plant height mm			Infiltration cm/hr	Plant cover %						
	8 das[z]	10 das	12 das	90 das	10 das	15 das	23 das	30 das	37 das	43 das	57 das
Check	10.4 b[y]	26.7 c	43.3 c	26.0 a	.17 b	1.9 b	12.6 c	33.0 c	44.3 b	53.8 c	57.6 b
Straw	22.7 a	56.0 a	75.1 a	26.6 a	15.4 a	27.0 a	63.1 a	79.7 a	88.5 a	92.8 a	78.6 a
Hydromulch	13.9 b	38.1 b	57.6 b	29.1 a	.77 b	4.3 b	30.6 b	67.2 b	78.7 a	85.0 b	81.1 a
Sludge	15.1 b	34.5 bc	67.1 ab	22.9 a	1.2 b	5.0 b	33.4 b	68.3 ab	80.3 a	87.9 ab	82.4 a
P value	0.0015	0.0008	0.0027	0.7344	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0014

[z] das=Days after seeding.

[y] Within a column, means sharing a letter are not significantly different ($P<0.05$).



POINSETTIA CULTIVAR EVALUATION AND CONSUMER ACCEPTANCE SURVEY

Gerald Klingaman and Cynthia Stewart[1]

IMPACT STATEMENT

Sixty-seven poinsettia cultivars were evaluated over a 2-year period to determine growth characteristics, vigor, and bloom date to assist greenhouse growers select from the numerous cultivars now available from commercial sources. Earliest bloom dates were 10 Nov. with the latest cultivar blooming 10 Dec. Cultivars were ranked for vigor as compared to the most popular cultivar on the market, 'Freedom Red'. In the consumer preference portion of this study, 8 of the top 10 cultivars were red. These had positive approval ratings of from 83 to 68% and negative ratings usually below 10%. Novelty cultivars such as those marked with the "jingle bell" breaks (speckling on the bracts) scored significantly lower on consumer acceptance than their non-broken counterparts. The new purple cultivar Plum Pudding had only a 35% approval rating.

BACKGROUND

Poinsettia (*Euphorbia pulcherrima*) is the most valuable potted greenhouse crop in the U.S. with an estimated 75 to 80 million plants sold annually at a value of $250 million. In recent years a number of new cultivars and plant distributors has appeared that has added to the cultivar choices available for growers. Paul Ecke Ranch, Encinitas, Calif. offers 92 cultivars in its 2001 catalog while Fischer Poinsettia, Boulder, Colo. lists 40 cultivars. Growers need to base cultivar selection on performance under local conditions, blooming date, and consumer acceptance. This study was undertaken to examine the performance of some of the newer cultivars and provide a basis for assessing adaptability under conditions of the mid-south. Additionally, a consumer preference study was undertaken to determine which types of cultivars appealed most strongly to poinsettia buyers.

RESEARCH DESCRIPTION

Rooted cuttings of 50 poinsettia cultivars were provided by Paul Ecke Ranch, for the 2000 and 2001 study. Twenty-five of these were grown in both years. Fischer Poinsettia provided rooted cuttings of 10 cultivars for the 2001 study. All plants were grown as pinched, single-stemmed plants in 6 in. pots in Stronglite Universal Mix (a pine bark mix manufactured by Stronglite Inc., Pine Bluff, Ark.). Cuttings were planted on 1 Sept. 2000. In the 2001 trial, Fischer cuttings were planted on 22 Sept. and Ecke cuttings on 25 Sept. Six plants of each cultivar were grown in a non-replicated block. Plants were grown under natural-light conditions.

Fertilization was provided by constant liquid fertilization using Peter's General Purpose Fertilizer (17-16-15) at 200 ppm N for the 2000 study, while Peter's Poinsettia Special (15-5-25) was used at 250 ppm for the 2001 study. Fertilization was discontinued during the first week of November in both years. Temperatures were maintained in the polyethylene greenhouses at 65°F night and 80°F day temperature until the first week of November in both years at which time the night temperature was dropped to 60°F. Plants were pinched to leave five to six mature leaves on 11 Sept. 2000 and 5 Sept. 2001. Spacing was pot to pot until 21 Sept.; on 10 in. centers until 10 Oct.; 14 in. centers for final spacing. Whitefly control was provided by application of 1% Marathon (imidocloprid) granules during the third week of September. No growth retardants were used in the study.

The consumer preference survey was conducted in 2001 only. It was conducted at Westwood Garden Center, Fayetteville, Ark. on 1 and 2 Dec., during the firm's Poinsettia Open House. Twenty-four cultivars were displayed side by side on a greenhouse bench and identified by a letter. Consumers were given a score sheet and asked to rank each cultivar independently on a scale of 1 to 7 with a ranking of 1 strongly dislike and 7 strongly like. If consumers had no strong feelings one way or the other they were encouraged to mark "4", the neither strongly like or strongly dislike ranking. One hundred forms were collected in the study. Approximately 75% of the survey participants were women.

FINDINGS

The 67 cultivars evaluated are listed in Table 1 . The planting date in 2000 (1 Sept.) was scheduled to the University teaching schedule and is probably too late for most greenhouse producers. The 2001 date was pushed back one week for planting on 22 and 25 Aug. to give more time for plant growth before the beginning of shortening day length on 21 Sept. While plant size was increased in year 2 of the study and most plants met the 15 in. height requirement set by many chains, a starting date of mid August would provide extra time for plant growth. The "Freedom" family of cultivars from Ecke, and 'Orion Red' from Fischer were the earliest to reach full bloom (judged to be when 50% of the cyathia produced pollen) around 10 Nov. Bract color was well advanced, about 5 days before that date. The largest number of cultivars reached peak bloom date about 20 Nov. Late cultivars reached full

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blooms after the first of December. One cultivar from Fischer, '845', did not reach full bloom until 10 Dec.

In addition to bloom date and plant size, growers need to have an estimate of relative plant vigor so that growth regulator applications and fertilization regimes can be adjusted. In this study, a vigor index (Table 1) was devised by summing plant height and minimal and maximal spread and dividing by the value obtained from 'Freedom Red'. 'Freedom Red' is a good plant to compare because it has been on the market since 1990 and most growers have experience with its performance. Cultivars with a value over 1.0 were more vigorous than' Freedom Red' while cultivars with a value below 1.0 were less vigorous than 'Freedom Red'. 'Orion Red' was the most vigorous cultivar in the study with a vigor index of 1.2. 'Strawberry & Cream' was lowest in vigor (of the conventional growth forms) with a vigor index of 0.69. Because of its low vigor, Ecke recommends this cultivar only for smaller pot sizes.

Consumer preferences of the 24 cultivars is provided in Fig. 1. The highest ranking cultivar was 'Sonora Fire' with a numeric ranking of 5.8 of 7 (data not shown). The top 10 cultivars all had ratings above 5.0. Eight of the 10 cultivars were red, with one each of a pink ('Freedom Rose'), white ('Snowcap White') and variegated ('Silverstar Red'). The negative ratings for the top ten cultivars were usually under 10% except for 'Winter Rose Dark Red', which, while still in the top ten, had a negative rating of 20%. The positive ratings for the top ten cultivars ranged from 83 to 68%. 'Prestige', a 2000 introduction from Ecke with the darkest foliage and darkest red bracts of the cultivars evaluated, ranked third in popularity even though its plant size was smaller than the more vigorous Fischer cultivars in first and second place. 'Freedom Red', the most common cultivar in the marketplace, ranked forth in preference.

Cultivars with the "jingle bell" flecks on the bracts ranked considerably less popular than similar red cultivars. 'Jester Jingle Bells' and 'Freedom Jingle Bells' ranked near the bottom of the list while their red counterpart, 'Freedom Red' and 'Jester Red' ranked in the top ten. The purple cultivar Plum Pudding represents a new color for poinsettias but ranked next to the bottom in numeric score (3.9 out of 7) with a 45% disapproval rating and only a 35% approval rating. 'Monet Twilight', a 6-year-old cultivar that represents another dramatic color break from traditional shades, was mid-rank and may provide evidence that consumers warm to new colors after seeing them for several seasons.

Table 1. Poinsettia Trial summary for 2000 and 20001.

Cultivar	Source[z] & year	Bloom date[y]	Total ht.[x]	Spread[w] max.	Spread[w] min.	Bloom nbr.[v]	Vigor index[u]	Comments
Red								
Bright Red Sails	E-01	1 Dec.	14.1	16.7	14.0	7.0	1.01	Large floppy, dark red bracts
Carousel	F-01	5 Dec.	14.5	15.3	12.5	6.5	0.95	Late red
Classic Red	E-01	27 Nov.	15.3	16.2	14.8	6.0	1.05	A pink-red, uninspiring
Cortez Dark Red	F-01	28 Nov.	15.6	17.9	16.0	6.0	1.12	Vigorous, red
Cortez Fire	F-01	20 Nov.	14.8	18.2	15.2	5.0	1.09	Large red, limb breakage problems
Cortez Red	F-01	24 Nov.	15.3	18.3	16.1	6.4	1.12	One of the nicest reds
Cranberry Punch	E-00	16 Nov.	14.4	13.5	13.5	7.5	0.93	Nice pinched, a purple - red
Freedom Bright Red	E-b	10 Nov.	14.5	15.1	13.3	6.3	0.97	Not as nice as Freedom Red
Freedom Fireworks	E-b	27 Nov.	14.0	18.3	15.9	5.6	1.09	Bracts long and narrow, layered top
Freedom Red	E-b	9 Nov.	14.7	15.3	14.3	6.3	1.00	The standard red
Jester Red	E-01	18 Nov.	14.5	16.8	14.3	6.8	1.03	Oak-leafed bracts, distinctive form
Max Red	E-01	24 Nov.	13.8	12.1	10.5	5.7	0.82	Made little impression
Orion Red	F-01	8 Nov.	15.1	20.1	17.7	7.9	1.20	Earliest to color; most vigorous
Peterstar Orange	E-b	26 Nov.	13.2	14.9	12.8	5.6	0.92	Orange-red bracts; form acceptable
Peterstar Red	E-b	21 Nov.	13.9	14.4	12.9	5.6	0.93	Average kind of plant
Petoy Red	E-00	28 Nov.	12.5	16.0	14.0	6.6	0.96	Bracts large w/ large cyathia
Prestige	E-b	20 Nov.	13.2	13.6	12.7	5.8	0.89	Excellent form, darkest foliage & leaves
Red Baron	E-00	28 Nov.	10.9	8.0	7.6	4.2	0.60	Burgundy blooms; poor grower
Red Splendor	E-00	28 Nov.	11.9	13.2	12.2	6.4	0.84	Cyathia too large
Red Velvet	E-b	26 Nov.	13.7	14.6	12.9	5.2	0.93	Dark red, refined plant
Redberry Punch	E-01	15 Nov.	13.8	14.3	11.5	7.0	0.90	Cyathia large; color hot
Sonora Fire	F-01	25 Nov.	16.0	17.7	15.9	7.0	1.12	Bracts crinkled, good pinched
Sonora Red	F-01	19 Nov.	15.7	18.3	16.0	7.6	1.13	Limb breakage a problem
Subjubi Red	E-00	30 Nov.	12.0	11.6	11.0	5.8	0.78	Losing favor
Success Red	E-b	4 Dec.	15.0	16.3	13.5	6.2	1.01	Smooth, medium-red, bracts flat
Strawberry & Cream	E-01	1 Dec.	11.8	9.7	8.9	5.3	0.69	For 4-in. pots perhaps in color bowls
Pink								
Amazone Peppermint	E-b	20 Nov.	13.9	14.2	13.3	5.8	0.93	Large, creamy pink bracts
Freedom Coral	E-b	12 Nov.	11.6	13.4	12.2	6.4	0.84	An early hot-pink shade
Freedom Rose	E-b	14 Nov.	12.5	13.6	12.6	6.4	0.87	Early, deeper pink
Freedom Salmon	E-b	9 Nov.	13.1	13.6	11.8	6.6	0.87	Hot pink
Maren Pink	E-b	28 Nov.	12.5	14.8	12.8	5.5	0.91	Good form, hot pink
Peterstar Pink	E-b	20 Nov.	13.9	16.2	14.9	5.5	1.01	An average pink
Pink Pepermint	E-00	28 Nov.	13.3	14.4	12.9	6.4	0.92	Light shell pink
Snowberry Punch	E-01	11 Nov.	12.8	13.1	11.0	5.7	0.83	Unusual purple-pink
Strawberry Punch	E-00	14 Nov.	12.5	14.8	12.2	6.0	0.77	A hot pink
Success Pink	E-00	4 Dec.	12.0	11.0	11.0	6.0	0.77	Poor bract development
Novelty								
Freedom Jingle Bells	E-01	17 Nov.	14.1	17.9	15.7	6.1	1.08	Typical 'Freedom' habit but speckled
Jester Jingle	E-01	20 Nov.	15.5	15.6	11.8	6.1	0.97	Distinctive form with speckled bracts
Jingle Bells	E-00	4 Dec.	15.0	12.0	11.4	6.8	0.87	Good grower but somewhat unstable
Jingle Bells 3.0	E-00	4 Dec.	11.6	11.0	10.4	4.0	0.74	Poor plant performance
Jingle Bells 4.0	E-01	9 Nov.	13.0	14.7	13.1	6.0	0.92	The most stable chimera so far
Candycane	E-00	4 Dec.	13.2	15.8	14.4	5.8	0.98	Light pinkish but chimera unstable
Monet	E-00	30 Nov.	11.7	14.2	12.0	6.6	0.86	Unique color

Table 1. Poinsettia Trial summary for 2000 and 20001, continued.

Cultivar	Source[z] & year	Bloom date[y]	Total ht.[x]	Spread[w] max.	Spread[w] min.	Bloom nbr.[v]	Vigor index[u]	Comments
Monet Twilight	E-b	4 Dec.	12.9	13.6	12.6	5.8	0.88	Darker cranberry speckles than 'Monet'
Plum Pudding	E-b	25Nov.	15.0	17.0	14.9	7.0	1.06	Bracts tend to be small/very purple
Winter Rose Red	E-00	26 Nov.	13.0	9.7	9.0	6.3	0.72	The standard red of the type
Winter Rose Dark Red	E-01	24 Nov.	16.7	12.1	9.9	6.0	0.88	Growing is a challenge for this group
Winter Rose Deep Pink	E-01	25 Nov.	13.0	11.0	8.9	5.7	0.74	Little difference to other pink
Thanksgiving	E-01	12 Nov.	13.3	15.3	14.0	5.7	0.96	Dark orange-red; average kind of plant
845	F-01	10 Dec.	16.0	16.9	14.1	7.3	1.06	Very late, dark foliage type
White								
Freedom White	E-b	18 nov.	15.1	17.1	15.7	6.3	1.08	Large, floppy white bracts
Pearl	E-01	28 Nov.	11.2	12.4	11.0	6.2	0.78	Cyathia overly large
Pepride White	E-01	28 Nov.	11.2	11.3	9.7	5.3	0.73	Not a good performer
Peterstar White	E-b	20 Nov.	14.4	16.4	15.1	5.9	1.04	A fair white
Snowcap White	E-b	26 Nov.	15.9	17.1	14.3	6.9	1.07	The best white both years
Variegated								
Heirloom Peach	E-00	20 nov.	11.6	13.0	12.0	6.6	0.83	Foliage white variegation/bracts peach
Heirloom Pink	E-00	28 Nov.	12.3	14.2	13.6	7.6	0.91	Foliage white variegation/bracts pink
Heirloom Red	E-00	4 Dec.	10.7	11.0	10.2	4.8	0.72	Not a strong grower
Hollypoint	E-b	11 Nov.	11.5	10.4	9.7	5.3	0.71	For 5 in. pots or less
Marble Star	E-b	26 Nov.	14.2	15.3	13.3	6.3	0.97	Cream variegation on bracts and leaves
PeprideMarble	E-b	4 Dec.	12.3	11.9	9.5	5.4	0.76	For 5 in. pots or less
Peterstar Marble	E-b	20 Nov.	12.8	14.2	11.8	4.7	0.88	Cream variegation
Peterstar Silverbell	E-00	24 Nov.	11.4	12.2	12.2	6.4	0.81	White variegation on bracts and leaves
Silver Star Red	F-01	24 Nov.	14.6	16.1	14.3	6.1	1.02	Foliage white variegation/bracts red
Winter Rose Jingle Bells	E-01	24 Nov.	12.0	6.8	5.3	3.8	0.54	Poor performer
Winter Rose Pink	E-b	23 Nov.	15.3	11.5	8.8	6.7	0.81	Produced most symmetrical plants
Winter Rose White	E-b	19 Nov.	15.4	13.2	10.0	5.6	0.87	Plants still prone to fall apart

[z] Rooted poinsettia liners were provided by Paul Ecke Ranch (designated E) in 2000 and 2001. In 2001 poinsettia cuttings were provided by Fischer Poinsettias (designated F).

Cultivars marked with "b" were grown in both years.

[y] Bloom date as judged by 50% of the cyathia at the pollen release stage.

[x] Total height of the plant in inches from the bottom of the pot to the highest point on the plant. Values represent the means of six plants.

[w] Mean maximum and minimum spread in inches. Values represent the means of six plants.

[u] Mean number of bracts produced on pinched plants. Values represent the average of six plants.

[v] Vigor index when compared to 'Freedom Red'. The value represents the sum of height, maximum, and minimum spreads diveded by the value obtained for 'Freedom Red'.

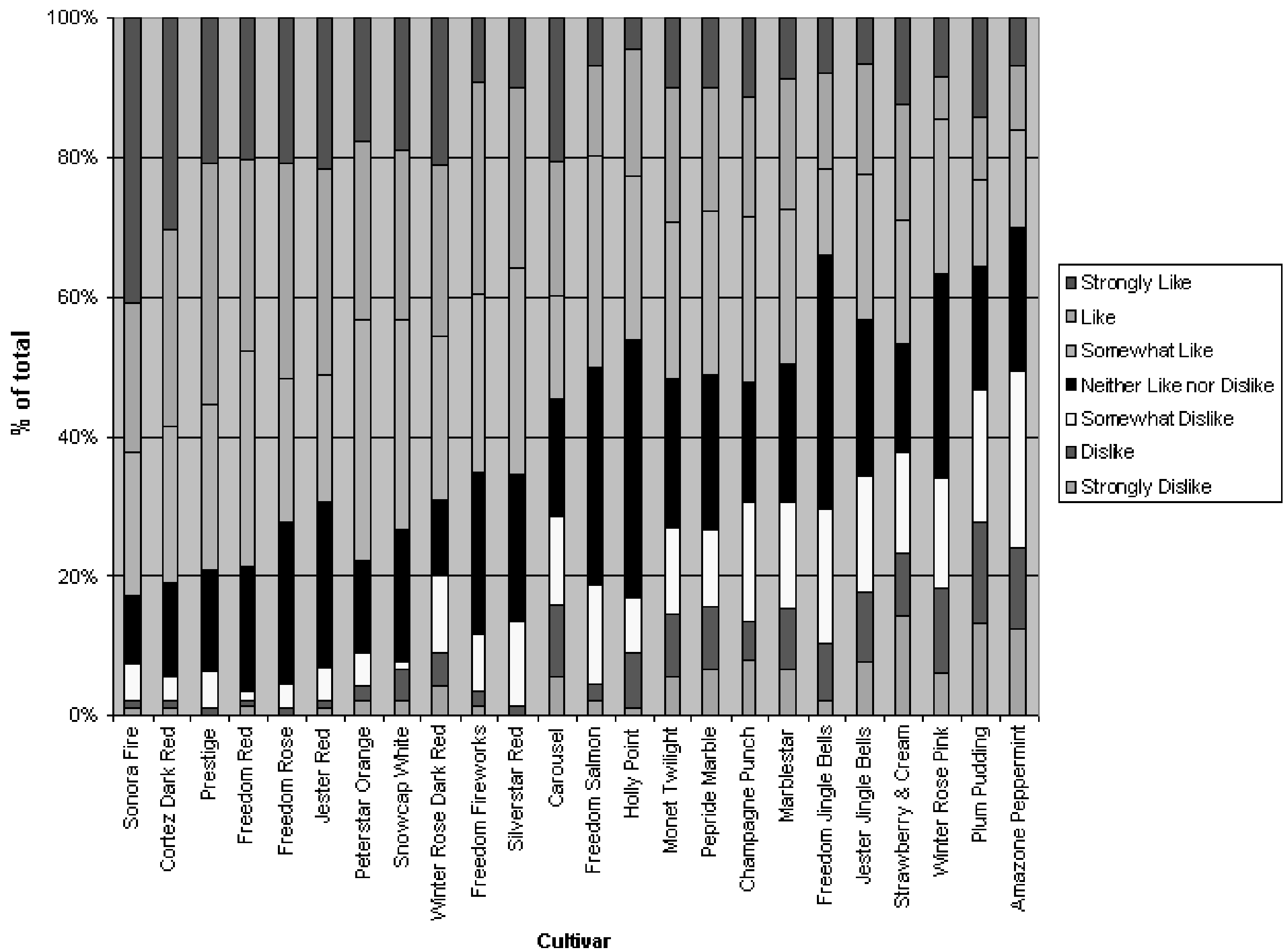

Fig. 1. Consumer preference of 24 poinsettia cultivars as based on the percentage of the total for each of the seven ranking categories.

USING IN VITRO PROPAGATION TO PRODUCE *Buddleja davidii* FOR SPRING GARDEN CENTER SALES

Jon T. Lindstrom, Brent M. Burkett, and Matthew C. Pelto[1]

IMPACT STATEMENT

An important problem associated with the marketing of *Buddleja davidii*, butterfly bush, is flowering time. These attractive, summer-blooming shrubs are not in flower during peak spring sales in garden centers. The goal of this study was to develop a system for the in vitro production of butterfly bush plants so that they could be scheduled to flower in spring. *Buddleja davidii* 'Dubonnet' shoot tips were established and multiplied on a Murashige and Skoog medium containing 1.0 µM BA and 0.1 µM NAA. Microshoots were taken out of culture, rooted, and grown in the greenhouse. Plants placed in the greenhouse in March flowered 56 to 81 days after removal from culture.

BACKGROUND

Butterfly bush, *Buddleja davidii*, is a popular ornamental plant with showy flowers that are continually produced throughout the summer. Cultivars of this species exhibit a wide variation in flower color, size and growth habit. The current nursery practice is to produce these cultivars from single-node cuttings.

One of the problems in marketing *Buddleja davidii* is that they are not in bloom during peak garden center sales in the spring. If butterfly bush could be produced in flower during this time of the year, sales would increase. Producing flowering butterfly bush plants through conventional cutting propagation poses two problems. To produce flowering plants for the spring requires that cuttings be taken in late summer or early fall or from greenhouse-grown material in the winter. If the cuttings were collected in the fall the plants would have to be grown in the greenhouse throughout the winter, resulting in increased production costs. If the cuttings were collected from greenhouse plants in the winter, stock plants would have to be maintained under long days in the greenhouse, again increasing production costs.

An alternative method for propagating *Buddleja* that has not been developed is micropropagation. By using in vitro culture to produce *Buddleja* plants, the need for stock plants is eliminated. Production can be scheduled to produce flowering plants at the exact time the plants are needed for sale. Another benefit is that only a small portion of plant material is needed to produce a large number of plants in tissue culture; therefore, it would be inexpensive for a nursery to increase or maintain a large variety of cultivars.

RESEARCH DESCRIPTION

Actively growing shoots of the *B. davidii* 'Dubonnet' were collected from greenhouse-grown plants, rinsed under running water for 1 hour, then surface-sterilized for 15 minutes in a 10% v/v chlorine bleach solution (0.6% w/v sodium hypochlorite). Lateral buds from disinfected shoots were transferred aseptically to baby food jars containing 50 ml of Murashige and Skoog medium with minimal organics (Linsmaier and Skoog, 1965). To establish the optimum auxin type and concentration, an experiment was set up using either NAA or IBA at concentrations of 0.01, 0.1, 0.2, and 0.5 µM. For these experiments the cytokinin concentration in all experiments was 2 µM BA. Five replications of each auxin concentration were used and the experiment was repeated four times. The number of usable shoots (1-2 cm in length) was counted after 6 weeks in culture. After the optimal auxin concentration was determined, a similar experiment was conducted to determine the optimum cytokinin concentration. BA concentrations of 0, 0.5, 1.0, 2.0, 4.0, and 10 µM were used. Five replications of each cytokin concentration were used and the experiment was repeated three times. Shoots were transferred to these media and the number of usable shoots was counted after 6 weeks in culture. For both auxin and cytokinin experiments, the data collected on the number of usable shoots were analyzed for significance at the $P \leq 0.05\%$ level using the PROC GLM SAS procedure (SAS Institute, Cary, N.C.)

Microshoots from these cultures were used to produce plants for greenhouse experiments. Clumps of shoots were removed from culture, separated, and the basal end of each shoot placed for 10 seconds into a 1:10 dilution of Dip 'N Grow® (Dip 'N Grow, Clackamas, Ore.). Treated shoots were placed individually into a 60-cell plugs (Bio-Dome seed starter, Park Seed Co., Greenwood, S.C.) and rooted under a 16-hour photoperiod at a constant 68˚ F air temperature. Beginning 16 Oct. 2000 and continuing every 2 weeks until 13 Apr. 2001, 24 rooted plants were potted into 4 in. containers and acclimated to greenhouse conditions. Plants were grown to flowering without the use of supplemental lighting. Flowering date, shoot length, and node number were recorded and analyzed by SAS.

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FINDINGS

Optimal proliferation of *Buddleja davidii* 'Dubonnet' occurred with 0.1 µM IBA (Fig. 1) and 1.0 µM BA (Fig. 2). Microshoots produced using this combination of auxin and cytokinin rooted easily and readily acclimated to greenhouse conditions.

Daylength affected flowering of *Buddleja davidii* 'Dubonnet'. Plants taken out of culture in October flowered the following May, or over 5-1/2 months (165 days) later (Fig. 3). This is in contrast to plants taken out of culture in March that flowered 56 to 81 days later. Plants taken out of culture in April did not flower earlier. Length of shoot or number of nodes did not affect time to flowering. The number of nodes ranged from 7.4 to 18.0, depending on when plants were removed from in vitro culture, but had no relation to time to flower.

Micropropagation offers a means to produce and schedule *Buddleja* cultivars for spring flowering. Additional experiments are needed to determine the critical daylength required for floral initiation. Plants removed from culture in February will need supplemental lighting in order to flower in time for peak, spring garden-center sales.

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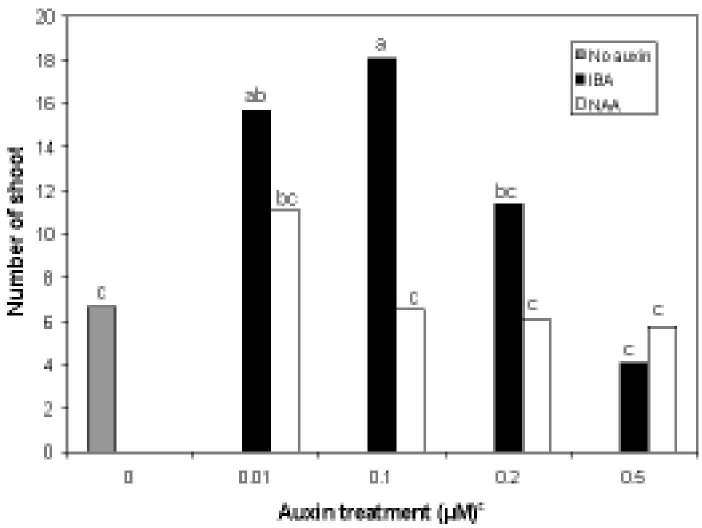

Fig. 1. Auxin treatment effects on *buddleja* tissue culture propagation. Treatments with the same letter are not significantly different (P<0.05).

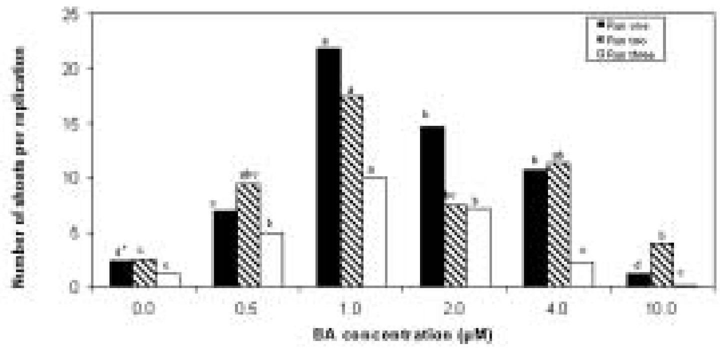

Fig. 3. Number of days for tissue cultured plants to flower in the greenhouse. Treatments with the same letter are not significantly different (P<0.05).

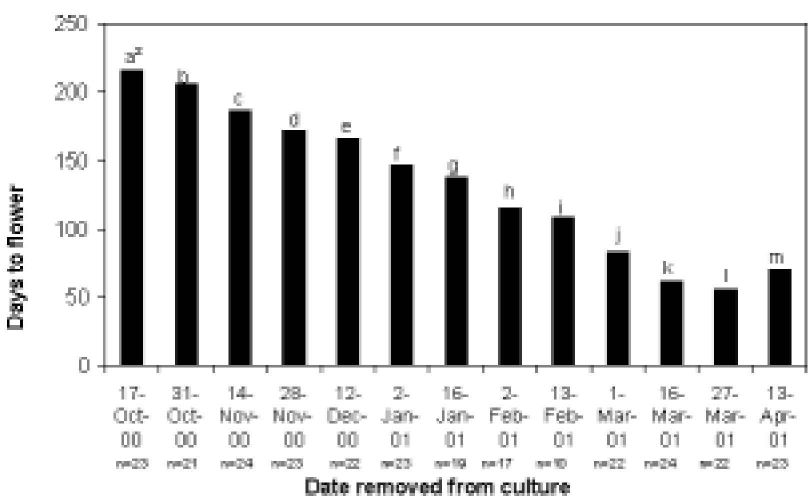

Fig. 2. Cytokinin treatment effects on *buddleja* tissue culture propagation. Treatments within the same run with the same letter are not significantly different (P<0.05).

COMMERCIAL COMPOSTS AS SOIL AMENDMENTS TO ENHANCE ORNAMENTAL PLANT GROWTH AND PERFORMANCE

Lee Ramthun and James T. Cole[1]

IMPACT STATEMENT

Soil compaction, soil structure degradation, and decreased fertility are common occurrences in many urban soils. Into this less than ideal situation, landscape professionals and homeowners attempt to plant and grow ornamental landscape plantings. Composts have been shown to decrease soil bulk density, increase water retention and the number of stable aggregates, and they have been utilized for their value as fertilizers. Three commercially available compost products were evaluated to determine their effect on soil properties and their ability to enhance plant growth and performance. The application of commercial compost was usually valuable and resulted in higher growth indices for most species at most locations compared to a non-compost control.

BACKGROUND

In Arkansas, urban growth is utilizing land previously used for farming for housing developments. These farmlands have been cultivated for crops or used as pastures and hayfields for many years. Over time, soil deteriorates and loses organic matter (Avnimelech et al., 1992). Composts can improve soil fertility and soil structure (Avnimelech et al., 1992; Pascualet al., 2000), bulk density (Avnimelech and Cohen, 1988), and water holding capacity (Avnimelech et al., 1992). Few studies have evaluated more than one product, or the use of compost in landscaping (Fitzpatrick, 1989). The object of this study was to evaluate three compost products for landscape use.

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RESEARCH DESCRIPTION

This experiment was conducted at Fayetteville, Keiser, and Monticello, Ark. Compost products investigated were from Humalfa, Inc., Shattuck, Okla., EarthCare Technologies, Inc., Lincoln, Ark., and American Composting, Inc., North Little Rock, Ark.

Plants of *Buddleja davidii nanhoensis* 'Nanho Blue' (Nanho blue compact butterfly bush) (BB), *Hibiscus syriacus* (althea or Rose of Sharon) (RS), and *Jasminum nudiflorum* (winter jasmine) (WJ) were planted on 5-ft centers. Composts were applied at the recommended rates (approx. 2 in. depth and incorporated) and mulch applied to all plots. Commercial fertilizer was applied to control plots (no compost) equal to the nutrient value of the compost.

Measurements taken included plant growth index and soil bulk density. At each location, a one-factor (compost treatment) completely randomized design with five replications was used. Sampling time (season) formed a repeated measure or split-plot factor. Data were combined over location and analyzed as a split-split plot. Means were separated by using a protected LSD (least significant difference) procedure ($P \leq 0.05$).

FINDINGS

The American Composting product had the lowest bulk density of all the treatments. (Table 1). At Keiser and Monticello, bulk densities of the American Composting plots and the EarthCare plots were significantly lower than the Hu-More and control plots.

Bulk density increased over time at all test locations (data not shown). Only the initial measurement at all locations in the fall of 2000 was significantly lower than the other measurements. With the effects of tilling and the continuous breakdown of the compost organic material diminishing over time, this was not unexpected.

The plant growth index of BB at the Fayetteville site in plots treated with EarthCare was significantly higher than the control plots (Table 2). At the Monticello site, the EarthCare plots had a significantly higher plant growth index than the other treatments or control for BB. No significant difference in plant growth index for BB was seen at Keiser.

All compost treatments had significantly higher plant growth indices for RS compared to the control at Fayetteville for fall 2001 (Table 2). The Hu-More and the EarthCare treatments also had significantly higher indices than the American treatment. At Keiser for fall 2001, RS had a significantly higher plant growth index in the American treatment compared to the other treatments and the control, and the Hu-More treatment was significantly lower than the control. At Monticello, the EarthCare treatments had a significantly higher plant growth index for RS compared to the other treatments and the control. Hu-More and American treatments were significantly higher for plant growth index of RS compared to the control for fall of 2001. There was no significant difference among treatments at any location in the spring of 2001 (data not shown).

For WJ at Fayetteville, all compost treatments contributed to a higher plant growth index than the control, but were not significantly different from each other for the fall of 2001 (Table 2). Plants of WJ at Keiser had a higher growth index in the control plot compared to plants in the compost treatment plots. At Monticello, the American treatment had a significantly higher plant growth index for WJ compared to other treatments and the control. Hu-More and EarthCare treatment plants were also significantly higher for plant growth index of WJ than the plants in the control plots.

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ACKNOWLEDGMENTS

The authors wish to thank Cynthia Stewart for assistance with data collection and a special thanks to Greenleaf Nursery for the donation of plant materials.

Table 1. Soil bulk density at Fayetteville, Keiser, and Monticello.

Compost product	Fayetteville	Keiser	Monticello
American	1.0049 a[z]	0.9837 a	0.9379 a
Hu-More	1.1327 b	1.1010 b	1.2173 b
EarthCare	1.0971 b	1.0136 a	0.9843 a
Control	1.3664 c	1.1423 b	1.2495 b

[z] Mean separation by LSD (P≤ 0.05).

Table 2. Plant growth index for *Buddleja davidii nanhoensis* (BB), *Hibiscus syriacus* (RS), and *Jasminum nudiflorum* (WJ) at Fayetteville, Keiser, and Monticello, Fall 2001.

Compost product	Fayetteville	Keiser	Monticello
	Buddleja davidii nanhoensis (BB)		
American	1.6537 ab[z]	3.0718 a	3.0484 b
Hu-More	1.9767 ab	4.0319 a	1.3549 a
EarthCare	2.5776 b	3.4519 a	4.4578 c
Control	1.2027 a	3.7652 a	2.1035 ab
	Hibiscus syriacus (RS)		
American	0.5581 bz	0.9284 c	0.7819 b
Hu-More	0.9121 c	0.1866 a	0.6214 b
EarthCare	0.9989 c	0.3152 ab	1.7166 c
Control	0.1710 a	0.4072 b	0.1849 a
	Jasminum nudiflorum (WJ)		
American	0.8726 bz	0.6272 b	1.2513 c
Hu-More	1.0933 b	0.5170 b	0.8038 b
EarthCare	0.8570 b	0.2929 ab	1.1902 bc
Control	0.4271 a	1.2147 c	0.3200 a

[z] Mean separation in columns within species by protected LSD (P≤ 0.05).

SEEDING DATE AND CULTIVAR INFLUENCE WINTER SURVIVAL OF SEEDED BERMUDAGRASS

Michael Richardson[1], Douglas Karcher[1], John McCalla[1], and John Boyd[2]

IMPACT STATEMENT

Seeded bermudagrasses have been improved for turfgrass quality parameters, but very little is known about their establishment and performance under the cold winters of the upper transition zone. The cultivar Yukon has superior cold tolerance to other seeded bermudagrasses currently on the market. Early planting dates were important for first-season survival under cold weather conditions.

BACKGROUND

Several high-quality seeded bermudagrass (*Cynodon dactylon*) cultivars have recently been introduced to the turf market. These genetic advances will likely increase the utilization of seeded bermudagrasses on golf turf surfaces. This research effort addresses a significant problem impeding the wide-spread use of seeded bermudagrass cultivars in the transition zone, that of first-year winter survival. Seeded bermudagrasses failed to produce rhizomes during their first growing season (Hensler et al., 1998). This lack of rhizome production predisposes the seeded grasses to winter injury, as rhizomes are generally considered a major morphological feature associated with winter survival. Our objective was to determine the effects of seeding date and cultivar on morphology and freeze tolerance of newly seeded bermudagrass.

RESEARCH DESCRIPTION

This study was conducted at the University of Arkansas Research and Extension Center, Fayetteville, Ark. on a Captina silt loam soil, with a pH of 6.2. The seeded bermudagrass cultivars Princess, Jackpot, Mirage, Mohawk, Nu-Mex Sahara, and Yukon were used. A replicated trial of the six cultivars was planted on or near 15 April, 15 May, 15 June, and 15 July 2000. Each plot was seeded at 1.0 lb of seed per 1000 ft^2. A uniform stand was attained for each planting date and data collected on germination, stand establishment, and turf quality (data not shown). These plots were evaluated during the winter of 2000-2001 for morphological development, and field evaluations of winter injury and spring recovery were determined in the spring of 2001. Recovery from winter injury was assessed using digital image analysis of the amount of green turf present in a plot at three observation dates during April and May of 2001 (Richardson et al., 2001).

FINDINGS

Morphological analysis included evaluations of stolon density, stolon weight, and weight per stolon. In addition, rhizome quantification was attempted in these plots, but no differences were observed for any cultivar across all seeding dates. Weight per stolon was affected by both cultivar and planting date (Fig. 1). 'Yukon' had the highest weight/stolon of any seeded cultivar across all planting dates, while an April seeding resulted in significantly higher wt/stolon than any of the other planting dates. Stolon number was more affected by planting date than by cultivar, but 'Yukon','Mohawk', and 'Jackpot' were able to maintain more uniform stolon densities across all planting dates than did 'Mirage', 'Sahara', and 'Princess' (data not shown).

The most important data obtained from this study were the recovery of the plots from the significant winter injury that occurred during the harsh 2000-2001 winter (Fig. 2). During the months of December and January, temperatures at the Fayetteville location routinely dropped into the low single digits Fahrenheit (Fig. 2) and the plots experienced a snow/ice cover for more than 40 days during that period. 'Yukon' had much higher recovery from winter injury compared to any other seeded bermudagrasses, followed by 'Jackpot' (Fig. 3) . 'Princess' had the lowest overall recovery from winter injury, with less than 20% recovery by early May. Planting date also had a significant effect on winter survival and recovery, with April and May seeding dates producing much higher recovery from winter injury than June or July seedings (Fig. 3).

Early seeding dates were critical in the upper zones of bermudagrass use. Genetic advances in cold tolerance have been made in recent years and the cultivar Yukon will have great potential in regions where other bermudagrasses have not been adapted.

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[1] Department of Horticulture, Fayetteville
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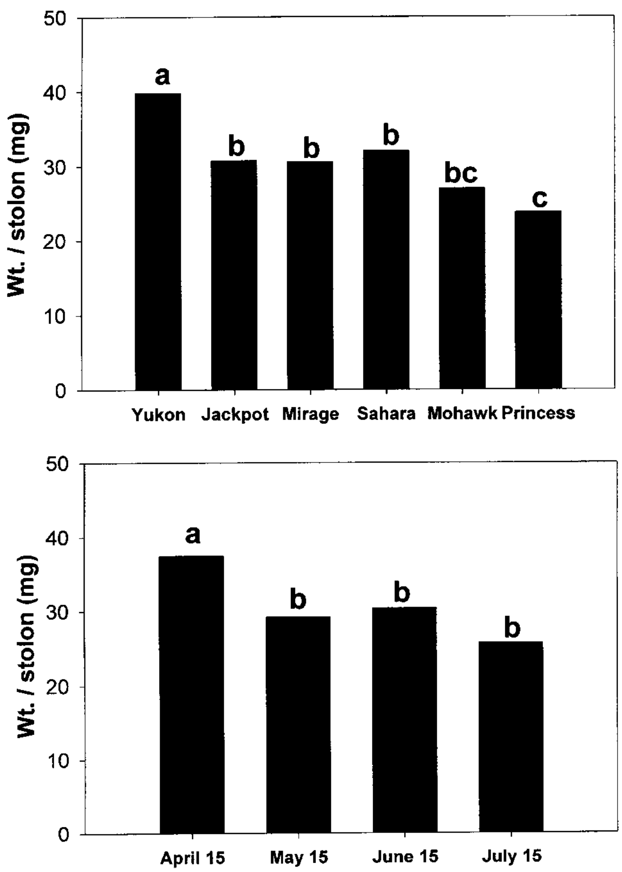

Fig. 1. Weight per stolon of seeded bermudagrasses, as affect by cultivar (top) and seeding date (bottom). Different letters indicate a significant difference (P = 0.05) between treatments, as determined by analysis of variance.

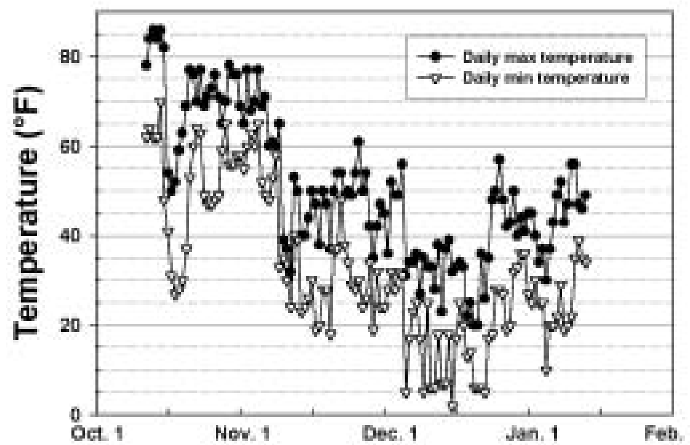

Fig. 2. Maximum and minimum temperatures at the University of Arkansas Research and Extension Center, Fayetteville, during the 2000-2001 winter.

Fig. 3. Winter recovery of seeded bermduagrass, as affected by cultivar (top) and seeding date (bottom). Different letters indicate a significant difference (P = 0.05) between treatments, as determined by analysis of variance.

COLD TOLERANCE OF BERMUDAGRASS CULTIVARS, AND BREEDING SELECTIONS - REPORT FROM THE 1997 NTEP BERMUDAGRASS TRIAL

Michael Richardson, John McCalla, and Doug Karcher[1]

IMPACT STATEMENT

Bermudagrass (*Cynodon dactylon*) continues to be the predominate turfgrass species used on Arkansas golf courses, sports fields, home lawns, and utility turf situations. Identifying adapted cultivars for the region remains a central focus of the turfgrass research program. A bermudagrass cultivar trial planted in 1997 at Fayetteville, Ark., was exposed to severe winter temperatures during the winter of 2000-2001. Several cultivars survived the harsh conditions with minimal injury, while other cultivars were almost completely eradicated by low-temperature injury. Promising cultivars for low-temperature sites included 'Riviera', 'Blackjack', 'Midlawn', OKC 81-4, OKC 19-9, and 'Cardinal'. These studies will help turfgrass managers identify bermudagrass cultivars with improved adaptability to areas that routinely experience winter injury.

BACKGROUND

Bermudagrass remains the most commonly used turfgrass for golf, sports, lawns, and other activities in Arkansas and throughout southern and transition zone environments. Bermudagrass has many positive attributes that have made it a successful turfgrass species, including good heat and drought tolerance, pest resistance, traffic tolerance, and tolerance to a wide range of soil types and water quality. However, a major weakness of bermudagrass is a lack of cold tolerance, especially as turfgrass managers move this species farther into the northern transition zone.

Major breeding efforts with bermudagrass have been conducted over the past several decades at sites in southern Georgia, Oklahoma, and New Mexico, while minor efforts have been ongoing at various sites throughout the country. Although these efforts have led to many new cultivars of bermudagrass with improved quality, color, and adaptability to low mowing heights, there are currently only one or two cultivars with any degree of cold weather tolerance. The cold tolerant cultivars Midlawn and Quickstand have been shown to have good adaptability to northern environments, but they lack specific attributes that make them usable in a wide range of applications.

The National Turfgrass Evaluation Program (NTEP) is an organization within the U.S. Dept. of Agriculture that annually oversees turfgrass cultivar evaluation experiments at various sites throughout the U.S. and Canada. The most recent NTEP bermudagrass trial saw a significant increase in the number of cultivars in the trial and many of those cultivars have shown excellent turfgrass quality (Morris, 2001). However, there has not been significant winter injury on these plots since their planting in the spring of 1997. In this report, we describe the winter injury ratings of 17 seeded bermudagrass cultivars and 10 vegetatively planted bermudagrass cultivars at Fayetteville, Ark.

RESEARCH DESCRIPTION

The cultivar and breeding selection experiment was planted on 1 June 1997 at the University of Arkansas Research and Extension Center, Fayetteville. The plot size was 4 x 8 ft and there were three replications of each entry. The vegetative geotypes were planted as small plugs (1-2 in. diameter) on 12-in. spacings within the plots, while the seeded entries were broadcast-planted at a seeding rate of 1.0 lb/1000 ft^2. Plots have been maintained under golf course fairway conditions, with a mowing height of 0.5 in., annual nitrogen applications of 5-6 lb N/1000 ft^2, and irrigation was supplied as needed to prevent stress. Plots have been rated for turfgrass quality parameters over the past 4 years and those data have been reported elsewhere (Morris, 2001). Winterkill was assessed using digital image analysis of the amount of green turf present in a plot (Richardson et al., 2001), as observed on 1 May 2001.

FINDINGS

The winter of 2000-2001 was noted to have an extended period of low temperatures and an extended period (~45 days) of snow and ice cover (Richardson et al., 2001). These conditions led to severe winterkill on bermudagrass golf courses, sports fields, and home lawns throughout the region. The turfgrass areas in the region that were most affected were sites that had either experienced shade, drought, or traffic during the prior season. However, it should also be noted that winter injury was also observed in areas where no other stresses were obvious.

In our experiment, there was a wide range of winter injury observed on the bermudagrass genotypes (Table 1). As a general observation, the vegetatively established hybrids experienced less winter injury than the seeded entries, although certain entries within each propagation type were severely injured. Of the vegetative cultivars, Midlawn and Cardinal experienced minimal winterkill, while 'Tifgreen' and 'Mini-verde' both had over 70% winterkill. Three breeding selections, CN2-9, OKC 81-4, and OKC 19-9 also had very good winter tolerance, which indicates that

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additional cold-tolerant cultivars should be available in the near future.

Of the seeded cultivars, ‘Riviera’ was the only cultivar that experienced minimal winter injury (3%), although ‘Blackjack’ and ‘Mirage’ also had acceptable levels of injury (Table 1). All of the remaining seeded cultivars had unacceptable winter injury in this test, with some cultivars experiencing over 80% winter injury. More work remains to be done on seeded bermudagrasses to enhance the winter tolerance of those strains. One cultivar, Yukon, was not in this specific test but showed very high winter survival in another test during the same winter (Richardson et al., 2001, in review).

Genetics remains a key issue relative to bermudagrass winter tolerance in the upper transition zone. Although progress has been made relative to cold tolerance, the number of available cultivars remains low. However, there are now both seeded and vegetative options available to turfgrass managers that produce both a high-quality turf and have excellent cold tolerance.

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Table 1. Percent winterkill of seeded and vegetative bermudagrass cultivars at Fayetteville, Ark. Plots were established under the National Turfgrass Evaluation Program, 1997 bermudagrass trial.

Seeded		Vegetative	
Genotype	Winterkill (%)	Genotype	Winterkill (%)
Majestic	98	Tifgreen	80
Savannah	89	Mini-verde	73
Pyramid	87	Tifway	52
Jackpot	86	Tiftsport	25
Princess	79	Shanghai	20
Shangri La	77	CN2-9	10
J-540	75	Midlawn	8
SW1-7	74	OKC 81-4	8
SW1-11	73	OKC 19-9	7
Arizona Common	70	Cardinal	3
Blue Muda	65	LSD (0.05)	27
PST-R69C	55		
Nu-Mex Sahara	53		
J-1224	53		
Mirage	33		
BlackJack	20		
Riviera	3		
LSD (0.05)[z]	27		

[z] Least significant difference (P=0.05) between means within each column.

EFFECT OF MEDIA TYPE ON THE GROWTH OF CONTAINER-GROWN WOODY ORNAMENTALS

James A. Robbins[1]

IMPACT STATEMENT

Research was conducted to evaluate the effect of media type on the growth of three woody ornamental container-grown shrubs. Significant differences were observed between the physical and chemical properties of the five commercially available container media. Root and shoot growth was significantly affected by media type.

BACKGROUND

Woody ornamental retailers and growers in Arkansas have several options for container media. Container media choices for nursery growers generally include compost, pine bark, wood products, rice hulls, field soil, peatmoss, or combinations of these components. A primary consideration in selecting media components in Arkansas is cost. Most published research has been conducted in other states evaluating the effect of media type on plant growth. This study was conducted to assist Arkansas growers in selecting container media based on media parameters and plant growth.

RESEARCH DESCRIPTION

Research was conducted at a commercial nursery in central Arkansas. Plants used in this study were *Rhododendron* azalea ‘Hershey’s Red’, *Euonymus alatus*, and *Ilex glabra* ‘Shamrock’. Plants were received as liners and potted on 7 Sept. 2000 into 1-gal plastic containers filled with five different media (Table 1). All media evaluated are commercially available except the PSGB+, which was formulated by mixing PSGB with Pioneer Southern coarse pine bark at a ratio of 3:1 (v:v). Media samples were screened for a particle size analysis (Table 2). Dry media samples were screened using U.S. Standard sieves: #40=420 µm, #18=1 mm, #8=2.4 mm, and #4=4.8 mm.

Plants were fertilized at planting with Scotts Pro™ 19-5-9 plus minors 12-month release. Fertilizer was incorporated at a rate of 2 lb N/yd^3. Media was not amended with limestone. Plants were watered as needed using an overhead irrigation system. Containers were placed in a completely randomized design with five single-plant replicates.

Data were collected when roots reached the outside of the media ball. Final data were collected for *Euonymus* on 18 April 2001 and for *Ilex* and azalea on 22 June 2001. Data collection included a final growth index, shoot fresh weight, root dry weight, media shrinkage, and ‘moist’ media/root weight.

FINDINGS

The initial pH of the five media based on a saturated aqueous paste ranged from 4.7 (PSGB+) to 6.8 (HA) (Table 1). Considering that many sources suggest desirable media pH ranges of 5.5 to 6.5 for most crops, three media (J&B, PSGB, and AC) would fit this requirement without further amendment. The PSGB+ (amended with coarse bark) medium is a desirable medium for Ericaceous plants such as azalea and blueberries.

At the end of the study random samples were taken from the center of the media rootballs for the *Ilex* plants. In the case of two media (PSGB and HA), the final pH was significantly more acidic than the initial pH. An increase in media pH was measured for the J&B and AC media. The amended PSGB+ showed no change in pH. It is possible that these results might be different if collected using another plant species.

Guidelines for container media at a large commercial nursery in Oklahoma indicate that desirable media should have over 65% of the particles larger than 2.4 mm. Based on that set of guidelines, none of the media evaluated had 65% of their particles larger than 2.4 mm (Table 2). Both Pioneer Southern (PSGB and PSGB+) products were the closest to this guideline with PSGB and PSGB+ having percentages in this size range of 49 and 52%, respectively. The J&B medium had the lowest percentage of coarse particles (those above 2.4 mm) at 24%. The J&B medium also had the highest percentage (38%) of ‘fine’ particles as measured by the particles collected. While all five media fall within an acceptable range of dry bulk density (Handreck and Black, 1994), the J&B medium approaches the upper limit of 37 lb/ft^3 (Table 1). The grower involved in this study commented on the heavy weight of this medium whether dry or wet. Three (PSGB, PSGB+, and HA) tended to be the lightest-weight media. Significant shrinkage was noted after 9-10 months of production (Table 3). The highest shrinkage was measured for the AC and J&B media and the lowest for PSGB and HA.

Based on the initial measurements and published guidelines for container substrates (Yeager 1995), all media have acceptable air-filled porosities (Table 1). This was surprising based on the particle size analysis showing that the lowest air-filled porosity was not measured on the J&B media sample.

Container media type had a significant effect on the growth of three woody ornamental plants (Table 4). Plants grown in the J&B media had

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the highest shoot and root growth. The lowest root dry weight was measured on plants grown in the AC medium. All plants were considered saleable by the commercial grower at the end of the experiment. Growth index was not a suitable parameter to monitor the effect of media type on plant growth.

Overall results were surprising in that physical parameters considered as negative (weight, porosity, and percent of 'fines') did not appear to decrease the growth of three woody plant species. Results obtained in this study will hopefully be used by growers and retailers to select the proper media for their operation.

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ACKNOWLEDGMENTS

The author acknowledges the financial support of the Arkansas Green Industry Association and Pioneer Southern. Media donations by Green Tree Nursery (Ernie Moix) and Custom Landscapes (Jeb Leggett) are appreciated. The author is extremely appreciative of the donation of production space and labor by Joel Stout at Cricket Hill Farm.

Table 1. Parameters for container media evaluated.

Media[z]	Initial Ea[Y]	Initial dry bulk density (lb/ft^3)	Initial pH	Final pH	Approx cost/1 gal pot[x] ($)
PSGB	39	17	5.7	4.6	0.09
PSGB+	37	16	4.7	4.7	---
HA	43	15	6.8	6.1	0.06
AC	26	26	5.8	6.4	0.036
J&B	30	34	5.9	6.1	0.074

[z] Media are: PSGB = Pioneer Southern Grower's Base; PSGB+ = Pioneer Southern Grower's Base amended w/coarse pine park (3:1); HA = Hope Agri. composted fine bark; AC = American Composting compost; J&B = J&B garden mix.

[Y] Ea = air-filled porosity.

[x] Cost is a delivered price to Little Rock for 40-45 cu. yards.

Table 2. Particle size analysis for container media samples. Values are percent retained in each sieve size.

Media	Pan	#40 sieve	#18 sieve	#8 sieve	#4 sieve
PSGB	11	15	25	25	24
PSGB+	11	13	24	24	28
HA	10	16	36	29	9
AC	25	20	22	16	17
J&B	38	18	20	13	11

Table 3. Final media physical properties.

Media	Mean final media/rootball moist weight (kg)	Mean final media shrinkage (cm)
PSGB	1.67 c[z]	4.5 b
PSGB+	1.56 d	5.0 ab
HA	1.50 d	4.4 b
AC	2.03 b	5.4 a
J&B	2.51 a	5.4 a

[z] Numbers within a column followed by the same letter are not significant ($P \leq 0.05$).

Table 4. Effect of media type on final growth measurements for azalea 'Hershey's Red', *Euonymus alatus*, and *Ilex glabra* 'Shamrock'.

Media	Mean shoot fresh wt. (gm)	Mean Root dry wt. (gm)	Mean growth index (cm^3)
PSGB	47.8 b[z]	19.4 ab	16,230 a
PSGB+	45.9 b	16.7 ab	14,840 a
HA	46.3 b	19.1 ab	17,120 a
AC	50.3 ab	13.8 b	11,670 a
J&B	66.5 a	27.3 a	14,410 a

[z] Numbers within a column followed by the same letter are not significant ($P \leq 0.05$).

SUSCEPTIBILITY OF DAYLILY TO DAYLILY RUST IN ARKANSAS

James A. Robbins[1] and Steve Vann[2]

IMPACT STATEMENT

A new rust disease was confirmed on daylilies (Hemerocallis) growing in Arkansas in August 2001. Evaluation of a large number of daylily cultivars for susceptibility to this new disease would be valuable to breeders, retailers, and consumers. Evaluations indicated that large variation in susceptibly is present in existing cultivars.

BACKGROUND

The documented appearance of daylily rust in Arkansas in 2001 came as no surprise. To date, the rust has been reported in 24 states and is currently confined to the daylily. The disease, which is caused by the fungus *Puccinia hemerocallidis*, was first identified in Florida in the fall of 1999. The rust is native to Asia and may have been introduced into the U.S. from Central America.

Like other rust diseases, the best long-term method to deal with this disease is to select and encourage the planting of resistant cultivars. Daylily cultivars differ in their disease susceptibility. Access to an Arkansas daylily grower with a large selection of daylily cultivars infected with daylily rust enabled us to rate cultivars for disease susceptibility.

RESEARCH DESCRIPTION

A disease severity survey was conducted at a small commercial nursery in central Arkansas. Daylily plants were field-grown in full-sun beds. Plants that were more than 2-years-old were visually rated using a 1-5 scale: 1=very resistant with little or no rust pustules; 2=moderately resistant; 3=moderately susceptible; 4=susceptible; 5=very susceptible with over 50% foliage surface area covered with pustules.

FINDINGS

This is the first reported survey of a large number of daylily cultivars to the new rust disease. Disease severity ratings ranged from very resistant (1) to very susceptible (5) (Table 1). Based on ratings conducted in Arkansas, cultivars with a rating of 2 or less would be recommended for breeders or consumers. Cultivars with a rating of 4 or higher should probably be avoided since disease severity was severe and would require frequent chemical applications to control the disease.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of Joel Stout at Cricket Hill Farm.

Table 1. Daylily rust ratings for daylily cultivars grown in Central Arkansas

Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]	Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]
Abraham	1.0	D	Tet	Barbara Barnett	1.0	D	Dip
Adelia Doretta	1.0	D	Dip	Barbara Mitchell	1.0	S	Dip
Age of Gold	1.0	D	Tet	Betty Warren Woods	1.0	E	Tet
Alabama Jubilee	1.0	D	Tet	Beverly Ann	1.0	S	Dip
All-American Hero	1.0	E	Dip	Beyond Rangoon	1.0	S	Tet
Anita Davis	1.0	D	Tet	Big Green Valley	1.0	D	Dip
Antique Rose	1.0	S	Dip	Bologongo	1.0	D	Dip
Aramis	1.0	D	Tet	Bright Eyed Pink	1.0	S	Dip
Attic Antique	1.0	S	Dip	Brocaded Gown	1.0	S	Dip
Ballerina Elyse	1.0	E	Dip	Broken Heart	1.0	D	Dip
Banned in Boston	1.0	D	Dip	Brookwood Dorado	1.0	S	Dip

[1] Cooperative Extension Service, Little Rock

[2] Extension plant pathologist, Lonoke

Table 1. Daylily rust ratings for daylily cultivars grown in Central Arkansas, continued.

Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]	Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]
Brookwood Ojo Grande	1.0	D	Dip	Huckleberry Candy	1.0		
Cambio	1.0	D	Dip	In Pastures Green	1.0	S	Dip
Cardigan Bay	1.0			Jack May	1.0	S	Dip
Caroline Hunt	1.0	D	Dip	Jason Mark	1.0	D	Dip
Carpenter Shavings	1.0	D	Dip	Jean Barnhart	1.0	D	Dip
Carribean Whipped Cream	1.0	E	Tet	Jeanie Melissa	1.0		
Cat’s Cradle	1.0			Jedi Pink Chiffon	1.0		
Catherine Neal	1.0	D	Dip	Joie de Vivre	1.0	E	Dip
Chestnut Mountain	1.0	E	Tet	Joleyne Nichole	1.0	E	Dip
Chris Salter	1.0	S	Tet	Kate Carpenter	1.0	D	Dip
Christening Gown	1.0	S	Dip	Kindly Light	1.0	D	Dip
Cleopatra	1.0	E	Dip	King Kahuna	1.0	S	Dip
Copernicus	1.0	S	Tet	Lavender Bonnet	1.0	S	Dip
Corduroy Masterpiece	1.0	D	Tet	Lemon Cream Pie	1.0		
Cosmic Pink	1.0	S	Tet	Lemon Lime Radiance	1.0	D	Dip
Creole Blush	1.0	S	Dip	Lilac Lady	1.0	E	Dip
Crystalline Pink	1.0	D	Tet	Lipstick Letter	1.0	S	Dip
Dainty Designer	1.0	S	Dip	Little Print	1.0	S	Dip
Dark of Night	1.0	D	Tet	Mae West	1.0	S	Dip
Debbie Durio	1.0	S	Dip	Majestic Dark Eyes	1.0	D	Dip
Desert Flame	1.0	D	Tet	Mary Kate	1.0	E	Dip
Devil's Footprint	1.0	S	Dip	Masked Phantom	1.0	E	Tet
Devonshire Cream	1.0	D	Dip	Master of Buli	1.0	S	Tet
Ed Brown	1.0	S	Tet	Meadow Sweet	1.0		
Edge of Eternity	1.0	S	Dip	Merle Kent Memorial	1.0	E	Tet
Edna Lankhart Memorial	1.0	D	Dip	Merriness	1.0	D	Dip
Ellen Christine	1.0	S	Dip	Ming Porcelain	1.0	E	Tet
Emperor Butterfly	1.0	E	Tet	Monica Marie	1.0	E	Tet
Enchanted Circle	1.0	S	Dip	Mysterious	1.0	S	Tet
Essence of Pink	1.0	D	Dip	Nagasaki	1.0	E	Dip
Ethel Horne	1.0	S	Dip	Neal Berrey	1.0	S	Dip
Ethereal Beauty	1.0			Neon Pink	1.0	D	Dip
Every Little Thing	1.0	D	Dip	New York Follies	1.0	S	Dip
Fantasy Finish	1.0	D	Tet	Nite Deposit	1.0		
Fashion Design	1.0	D	Dip	Nosferatu	1.0	S	Tet
Femme Fatale row 20 -23	1.0	E	Dip	Ocean Rain	1.0	S	Tet
Follow Your Dreams	1.0	D	Tet	Omomuki	1.0	D	Tet
Freida James	1.0	S	Dip	One Fine Day	1.0	E	Dip
Friend Jack	1.0	D	Tet	Orange Radiance	1.0	E	Dip
Full Moon Magic	1.0	E	Tet	Palladian Pink	1.0	D	Dip
Full Moon Rising	1.0	E	Dip	Pandora’s Box	1.0	E	Dip
Gemstone Warrior	1.0	E	Tet	Pardon Me	1.0	D	Dip
Glebers Top Cream	1.0	S	Dip	Passion for Red	1.0	S	Tet
Golden Mandy	1.0	D	Tet	Pewter Pink	1.0	D	Tet
Grand Masterpiece	1.0	D	Dip	Piney Woods Cardinal	1.0	E	Tet
Great Expression	1.0	S	Tet	Pink Elation	1.0	D	Dip
Happy Returns	1.0	D	Dip	Pink Embrace	1.0	S	Dip
Harem Scarem	1.0			Pink Flirt	1.0	D	Tet
Harlem Nocturne	1.0	D	Dip	Pink Ice Ballet	1.0	S	Dip
Heartfelt	1.0	D	Tet	Pixie Parasol	1.0	S	Dip
Henna Copper	1.0	D	Tet	Pleasingly Pink	1.0	S	Dip
Hidden Rainbow	1.0	S	Dip	Prairie Blue Eyes	1.0	S	Dip
Homer Howard Glidden	1.0	E	Dip	Premier Edition	1.0	S	Dip
Hot Wheels	1.0	D	Dip	Princess Ellen	1.0	E	Dip
Houdini	1.0	D	Dip	Pumpkin Kid	1.0	E	Dip
House of Orange	1.0	D	Dip	Purple Charmer	1.0	D	Dip

Table 1. Daylily rust ratings for daylily cultivars grown in Central Arkansas, continued.

Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]	Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]
Purple Petalloid	1.0	D	Dip	Three Diamonds	1.0	D	Tet
Queen's Memories	1.0	S	Dip	Tiger Kitten	1.0	D	Tet
Queens Castle	1.0	D	Tet	Timeless Fire	1.0	E	Dip
Rachel Billingslea	1.0	E	Dip	Top Show Off	1.0	S	Dip
Rainbow Candy	1.0	S	Tet	Trade Last	1.0	D	Dip
Raspberry Splash	1.0	D	Dip	Twilight Rose	1.0	E	Dip
Red Ribbons	1.0	E	Dip	Walking on Sunshine	1.0	E	Tet
Red Tide	1.0	D	Tet	War March	1.0	S	Tet
Red Volunteer	1.0	D	Tet	Warp Drive	1.0	D	Tet
Regency Dandy	1.0	S	Dip	Warrior Prince	1.0	E	Tet
Rose Frilly Dilly	1.0	E	Dip	Will Return	1.0	E	Dip
Rose Loveliness	1.0			Wings of Chance	1.0	E	Dip
Rose Time	1.0	S	Dip	Winning Hand	1.0	E	Dip
Roswitha	1.0	D	Dip	Winter Olympics	1.0	D	Tet
Ruby Laser	1.0			Witch's Wink	1.0	S	Tet
Ruffled Aristocrat	1.0	S	Dip	Witches Thimble	1.0	S	Dip
Sacred Circle	1.0	E	Dip	Woodside Amethyst	1.0	S	Dip
Savannah Art	1.0	S	Dip	Wynnsom	1.0	D	Dip
Scarlock	1.0	D	Dip	Yellow Exaltation	1.0	D	Dip
Seductor	1.0	E	Tet	Yellow Green Monarch	1.0	D	Dip
Seminole Wind	1.0			Japanese Brocade	1.2	E	Tet
Silk Road	1.0	S	Tet	Angel Rogers	1.2	S	Dip
Siloam Art Work	1.0	D	Dip	Indy Fling	1.2	S	Dip
Siloam Bill Monroe	1.0	D	Dip	Pastilline	1.2	D	Dip
Siloam Double Classic	1.0	D	Dip	Pleasant Edging	1.2	S	Dip
Siloam Edith Scholar	1.0	D	Dip	Siloam Child's Play	1.2	D	Dip
Siloam Elfin Jewell	1.0	S	Dip	Sundy Gloves	1.2	D	Dip
Siloam Grady Lamb	1.0	D	Dip	Alice Mae	1.5		
Siloam Green Diamond	1.0	S	Tet	Attic & Antique	1.5	S	Dip
Siloam Headlight	1.0	D	Dip	August Morn	1.5		
Siloam Irish Prize 4a/1c	1.0	S	Tet	Beautiful Edgings	1.5	S	Dip
Siloam Joels Double	1.0	D	Dip	Bela Logosi	1.5	S	Tet
Siloam Jones Anniversary	1.0	D	Dip	Beyond the Blue	1.5	D	Tet
Siloam Little Girl	1.0	D	Dip	Big Target	1.5	E	Dip
Siloam Meridith Atkinson	1.0	D	Dip	Blue Moon Rising	1.5	S	Dip
Siloam Night Rings	1.0	D	Dip	Bridgeton Bandwagon	1.5	S	Tet
Siloam Paul Watts	1.0	D	Dip	Caribbean WhippedCream	1.5	D	Dip
Siloam Royal Prince	1.0	S	Dip	Carolyn Crisewell	1.5	D	Dip
Siloam Spizz	1.0	D	Dip	Cat's Cradle	1.5	E	Dip
Siloam Ury Winniford	1.0	S	Dip	Chanteuse	1.5	E	Dip
Silver Queen	1.0	S	Tet	Edna Lankart	1.5	D	Dip
Sligo	1.0	D	Tet	Elsie Spaulding	1.5	D	Tet
Smoky Mtn Autumn	1.0	D	Dip	Emeralds and Gold	1.5	S	Dip
Socially Acceptable	1.0	D	Dip	Erin Lea	1.5	D	Tet
Song of Spring	1.0	D	Dip	Exotic Rings	1.5	D	Dip
Soothsayer	1.0	S	Dip	Feel the Heat	1.5	D	Tet
Southern Love	1.0	S	Tet	Glorious Is The Morning	1.5	E	Dip
Spanish Sketch	1.0	E	Tet	In Your Dreams	1.5	D	Dip
Stella De'Oro	1.0	D	Dip	Jedi Sue McCord	1.5	E	Dip
Strange Eyes	1.0	D	Dip	Jedi Tequila Sunset	1.5	S	Dip
Strutters Ball	1.0	D	Tet	Joshua Nathan Allen	1.5	D	Dip
Sue Rothbauer	1.0	S	Dip	Jump Start	1.5	E	Tet
Super Purple	1.0	D	Dip	Kuan Yin (Whatley)	1.5	S	Tet
Surf	1.0			Lady Neva	1.5	S	Dip
Swedish Girl	1.0	S	Dip	Larry Grace	1.5	S	Tet
Taj Mahal	1.0	E	Dip	Little Romance	1.5	E	Dip
Talk About Ruffles	1.0	E	Dip	Lucky Shamrock	1.5	E	Dip

Table 1. Daylily rust ratings for daylily cultivars grown in Central Arkansas, continued.

Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]	Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]
Malaysia Monarch	1.5	S	Dip	CaribbeanMidnightVespers	2.0	D	Dip
Margarets Choice	1.5	E	Dip	Champagne Elegance	2.0	S	Dip
Merle Cravey	1.5	D	Dip	Child of Fortune	2.0	S	Dip
Missouri Memory	1.5	E	Dip	Coral Cay	2.0	E	Tet
Molino Charm	1.5			Daring Deception	2.0	S	Tet
Night Wings	1.5	S	Tet	Dark & Handsome	2.0	S	Dip
One Step Beyond	1.5	S	Tet	Double Red Royal	2.0	S	Dip
Oriental Dancer	1.5	S	Tet	Edge Ahead	2.0	D	Dip
Party Prince	1.5	D	Dip	Edith Ann	2.0	S	Dip
Pastel Classic	1.5	S	Dip	Elizabeth Salter	2.0	E	Tet
Patchwork Puzzle	1.5		Tet	Elizabeth's Magic	2.0	E	Tet
Peach Whisper	1.5	D	Tet	Emerald Splendor	2.0	E	Dip
Phoenix Fire	1.5	S	Tet	Enchanted Empress	2.0	E	Tet
Preppy	1.5	D	Dip	Ever So Ruffled	2.0	S	Tet
Preppy Pink	1.5	D	Dip	Fooled Me	2.0	S	Tet
Radiant Eyes	1.5	S	Dip	Fortunes Dearest	2.0	E	Tet
Robert Lee Batt	1.5	E	Dip	Frank Gladney	2.0	E	Tet
Ruffled Masterpiece	1.5	S	Dip	Gentle Rose	2.0	D	Tet
Rythum in Pink	1.5	D	Dip	Great Northern	2.0	E	Dip
Sabra Salina	1.5	D	Dip	How Sweet	2.0	D	Tet
Siloam Green Stripe	1.5	E	Dip	Idas Magic	2.0	D	Dip
Siloam James Kraft	1.5	E	Dip	Indy Eclipse	2.0	D	Dip
Siloam Louise's Limelight	1.5	D	Dip	Jerusalem	2.0	D	Tet
Siloam New Hope	1.5	D	Dip	John Michael	2.0	D	Dip
Spanish Lemon	1.5	E	Tet	King Creole	2.0	S	Dip
Startle	1.5	D	Tet	La Fenice	2.0	D	Dip
Still Night	1.5	S	Tet	Lambada	2.0	S	Tet
Sunshine Melody	1.5	S	Tet	Lavender Memories	2.0	S	Tet
Sweet Southern Sunshine	1.5	S	Tet	Lilac Morning	2.0	D	Tet
Thinking About Tomorrow	1.5	E	Dip	Lime Frost	2.0	D	Tet
Tiny Tapestry	1.5	S	Dip	Limoges Porcelain	2.0	E	Tet
True Pink Beauty	1.5	E	Dip	Lowenstien	2.0	D	Tet
Tuscawilla Princess	1.5	S	Dip	MacMillan Memorial	2.0	E	Dip
Tuscawilla Tigress	1.5	S	Tet	Mango Mango	2.0	S	Tet
Tuscawilla Tranquility	1.5	S	Dip	Manhattan Mood	2.0		
White Crinoline	1.5	D	Tet	Mariska	2.0	D	Tet
Winds of Tide row 28	1.5	S	Dip	Mary Frances Raigan	2.0	S	Dip
Wine Berry Candy	1.5	D	Tet	Melody Lady	2.0	E	Dip
Siloam Sambo	1.7	D	Dip	Molino Bell	2.0		
Cherry Candy	1.8	S	Tet	My Ways	2.0	D	Tet
Cosmopolitan	1.8	D	Dip	Nicely Dressed	2.0	E	Dip
Joel	1.8	S	Dip	Norma Waybright	2.0	D	Tet
Little Mystic Moon	1.8	S	Tet	Omega Supreme	2.0		
Midsummer Elegance	1.8	D	Dip	Orange Glow	2.0	E	Tet
Precious Beginnings	1.8	D	Dip	Pensive Mood	2.0	E	Dip
Purple Rain Dance	1.8	S	Dip	Pharoah's Treasure	2.0	E	Tet
Sinbad Sailor	1.8	E	Tet	Pink Thistledown	2.0	S	Dip
Sophias Lips	1.8	D	Dip	Prize Picotee Delux	2.0	D	Tet
Tideline	1.8	S	Tet	Quinn Buck	2.0	D	Tet
All Fired Up	2.0	E	Tet	Rocamadour	2.0	E	Tet
Artic Snow	2.0	S	Tet	Rosewitha	2.0	E	Dip
Bahama Ripples	2.0	S	Dip	Roy Odell	2.0	D	Dip
Banana Republic	2.0	D	Tet	Ruffled Ivory	2.0	S	Dip
Be My Valentine	2.0	D	Dip	Sambo Wilder	2.0	D	Dip
Big Target	2.0	E	Dip	Secret Splendor	2.0	E	Tet
Bright Showing	2.0	E	Dip	Siloam Ebony Doll	2.0	D	Dip
Broadway Dancer	2.0	S	Tet	Siloam Jerome Pillow	2.0	D	Dip

Table 1. Daylily rust ratings for daylily cultivars grown in Central Arkansas, continued.

Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]	Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]
Siloam Joan Sr.	2.0			Carillon Bells	3.0	D	Tet
Siloam Little Rascal	2.0	D	Dip	Charlotte Legacy	3.0	E	Tet
Siloam Paul Watts	2.0	Dd	Tet	Cinderellas Blush	3.0	S	Dip
Siloam Preacher Cheyne	2.0			Coyote Moon	3.0	E	Tet
Spode	2.0	E	Tet	Crepe Eyed Ruffles	3.0	E	Dip
Strawberry Candy	2.0	S	Tet	Dark Mosiac	3.0		
Tandy	2.0	D	Tet	Dazzeling Design	3.0	E	Tet
Techney Peace	2.0	E	Dip	Etched Eyes	3.0	D	Tet
True Gertrude Demarest	2.0	E	Dip	Green Forest	3.0	E	Dip
Tune the Harp	2.0	S	Dip	Heaven Can Wait	3.0	S	Dip
Ultimate Destiny	2.0			In the Dark	3.0	S	Tet
Volcanic Explosion	2.0	S	Dip	Indy Maiden Blush	3.0	S	Dip
Wally	2.0	S	Dip	Joan Senior	3.0	S	Tet
Watermelon Time	2.0	D	Dip	Jovial	3.0	S	Tet
Wild Mustang	2.0	D	Tet	July Surprise	3.0	D	Dip
Bonnie Corley	2.2	E	Dip	Lavender Silver Cords	3.0	D	Tet
Light of Heaven	2.2	D	Dop	Leona Esther	3.0	D	Dip
Matt	2.2	D	Tet	Lonesome Dove (Harvey)	3.0	S	Tet
Round Midnight	2.2	D	Tet	New Zealand Red	3.0	E	Dip
Seal of Approval	2.2	S	Dip	Niece Beverly	3.0	E	Dip
Siloam Clary’s Parade	2.2	E	Dip	Passion District	3.0	E	Tet
Edna Shaw	2.3	D	Dip	Phaedra	3.0	D	Tet
All American Baby	2.5	D	Dip	Prince of Midnight	3.0	S	Tet
Annalesia	2.5	S	Tet	Promise Keeper	3.0	D	Tet
Awash with Color	2.5	E	Tet	Reckless	3.0	D	Tet
Baby Blues	2.5	D	Dip	Regency Summer	3.0	S	Tet
Baby Red Eyes	2.5	S	Dip	Respighi	3.0	E	Tet
Big Snowbird	2.5	S	Dip	Scatterbrain	3.0	S	Dip
Crush on You	2.5	E	Tet	Sicilian Summer	3.0	D	Tet
Diane Hidalgo	2.5	S	Dip	Silken Touch	3.0	D	Tet
Enchanter's Spell	2.5	S	Dip	Siloam Grace Stamile	3.0	D	Dip
Golden Hibiscus	2.5	E	Dip	Siloam Lesia Mowery	3.0	D	Dip
Gorden Bigs	2.5	S	Dip	Something Wonderful	3.0	S	Tet
Isosceles	2.5	D	Tet	Start Me Up	3.0	D	Dip
Janice Brown	2.5	S	Dip	Virginia Peck	3.0	E	Tet
Jay Turnman	2.5	E	Tet	Vision of Beauty	3.0	D	Dip
Jeune Tom	2.5	D	Dip	Wendy Glawson	3.0	S	Dip
Little Fat Cat	2.5	S	Dip	Windward Passage	3.0		
Magical Merriment	2.5	S	Dip	Bronze Eye Beauty	3.2	D	Dip
Magnificent Rainbow	2.5	D	Tet	Susan Webber	3.2	S	Dip
Majestic Pink	2.5	D	Tet	Wedding Band	3.2	D	Tet
Mississippi Morning	2.5	E	Dip	Absolute Treasure	3.5	E	Tet
Pink Fanfare	2.5	D	Tet	Capernaum Sin	3.5	D	Tet
Rainbow Radiance	2.5	S	Dip	Charles Johnston	3.5	S	Tet
Royal Saracen	2.5	E	Tet	Creative Edge	3.5	S	Tet
Sepal Streaker	2.5	E	Dip	Double Pink Treasure	3.5	S	Dip
Silent Sentry	2.5	S	Tet	Dragon’s Eye	3.5	S	Dip
Siloam Harold Flickinger	2.5	D	Dip	Flower Shop	3.5	D	Tet
Silver Ice	2.5	S	Tet	Glittering Elegance	3.5	D	Tet
Well of Souls	2.5	S	Tet	Imperial Lemon	3.5	S	Tet
What Wonderous Love	2.5	S	Dip	Jedi Tequila Sunrise	3.5	S	Dip
Stitch in Time	2.8	S	Dip	Judith Weston	3.5	S	Dip
Always Afternoon	3.0	S	Tet	Leonard Bernstein	3.5	E	Tet
Ben Lee	3.0	E	Dip	Magic Lace	3.5	D	Dip
Bountiful Candy	3.0	S	Dip	Obvious Pleasure	3.5		
Brookwood Opelescent	3.0	D	Dip	Orchid Candy	3.5	D	Tet

Table 1. Daylily rust ratings for daylily cultivars grown in Central Arkansas, continued.

Cultivar	Rust rating[z]	Foliage type[y]	Chromosome No.[x]
Pardon Me Boy	3.5	D	Tet
Polynesian Love Song	3.5	S	Tet
Regal Elegance	3.5	D	Dip
Romantic Dreams	3.5	S	Tet
Rosa Grande	3.5	S	Tet
Royal Heiress	3.5	E	Tet
Siloam Hollands Choice	3.5	D	Dip
Siloam New Yoy	3.5	D	Dip
Terza Jane	3.5	E	Dip
Trudy Harris	3.5	E	Tet
Velvet Beads	3.5	S	Tet
Gene Earl	3.8	E	Dip
Big Blue	4.0	S	Tet
David Kirchhoff	4.0	S	Tet
Dena Marie	4.0	D	Dip
Hello Sunshine	4.0	E	Tet
Rosie Pinkerton	4.0	S	Dip
Siloam Doodle Bug	4.0	D	Dip
Siloam Porcelain Doll	4.0		
Solomon's Robes	4.0	E	Dip
Violet Explosion	4.0	D	Dip
White Wow	4.0	D	Dip
Woodland Romance	4.0	D	Dip
Yes Indeed	4.0	D	Tet
Patience Plus	4.5	D	Dip
Pink Beacon	4.5	D	Dip
Royal Ebony	4.5	E	Dip
Siloam Ralph Henry	4.5	D	Dip
Springtime Treasuer	4.5	D	Dip
Splendid Touch	5.0	E	Tet

[z] Daylily rust rating: 1=very resistant; 2=moderately resistant; 3=moderately susceptible; 4=susceptible; 5=very susceptible.

[y] Leaf type: E=evergeen; D=deciduous; S=semi-evergreen.

[x] Chromosome number: Dip=diploid; Tet=tetraploid.

CHEMICAL AND BIOLOGICAL CONTROL OF POWDERY MILDEW ON *Phlox paniculata*

Erin Taylor[1], Richard Cartwright[2], and James Robbins3

IMPACT STATEMENT

Fungicides, bio-rational agents, and biological pesticides were evaluated for their relative efficacy to control powdery mildew (PM) on *Phlox paniculata* 'Miss Pepper' under field conditions. Fungicides that were most effective in controlling PM included: Eagle WSP, Eagle 20, Banner, Daconil, Fungo 50 with and without Capsil, Zyban with and without Capsil, and Terraguard. Treatments that were moderately effective included: Armicarb 100, Heritage, and Camelot. Junction was not effective. The biological treatment, Plant Shield, provided limited control for at least 6 weeks after the initial application. Baking soda cocktail appeared to offer the best control of PM among the bio-rational products, but would not likely replace fungicides for most growers and nurserymen. A solution of garlic also provided significant preventative control of PM relative to the water control.

BACKGROUND

Landscape plants can be affected by numerous infectious diseases. Powdery mildew, caused by the fungus *Erysiphe cichoracearum,* is a major problem among certain cultivars of Phlox. This disease is seldom life-threatening to phlox, but does reduce the aesthetic quality of flowers and leaves (Ball, 1999). Control options for PM include selection of less susceptible cultivars, proper cultural practices, and the use of biological and chemical controls.

Biological (Gill, 1999) or fungicidal sprays (Powell, 1990) have been commonly used to control PM on garden phlox, however, their efficacy and safety have not been well-tested. Growers and researchers continue to look for safer and more effective pesticides to replace more traditional fungicides (McHugh, 1992).

Biological pesticides have often given inconsistent results and work best when used in a well-designed integrated pest management program and early in the season before disease becomes well-established (Gill, 1999). Biological fungicides are products that contain micro-organisms that can control fungal pathogens under certain conditions (Hanson, 1999).

Another control method involves the use of bio-rational products. Bio-rational agents are substances that are considered to be safe to the environment. These include substances such as neem seed oil, horticulture oil, vegetable oil, Sunspray horticulture oil, baking soda, garlic, and compost tea (Bruce and Perry, 1999; Locke, 1993; McHugh, 1992).

The objective of this study was to determine the most effective therapy, or combination of therapies, for PM control on garden phlox. By using biological controls, bio-rational agents and fungicides on a susceptible cultivar, products were evaluated that were suitable for both the home gardener and the nursery industry.

RESEARCH DESCRIPTION

The PM susceptible cultivar of *P. paniculata* 'Miss Pepper', was used in this study, and plants were received in July, 2001. The plants were shipped bare root and planted in 4 L pots using Sungrow Strong-Lite Universal mix (Pine Bluff, Ark.)(pine bark compost, peat, vermiculite, perlite) with an initial pH of 4.5. The plants were fertilized with 4.5 g of Scotts (Marysville, Ohio) Osmocote® 14N-6P-11.6K at planting and placed in a 60% shade structure. Plants were watered using an overhead irrigation system as needed. Treatments were applied to plants when the average shoot height was 10 cm. All treatments were applied as a preventative control and begun on 13 Sept. 2001. The study consisted of 18 treatments and two controls (Table 1). Each plant was sprayed until runoff and average spray volume was 25 mL. The manufacturers' recommended rate and intervals were used unless otherwise specified. The bio-rational agent referred to as baking soda cocktail consisted of baking soda (0.89 g/500 mL water) plus Sunspray horticulture oil (6.7 mL/500 mL water) plus dormant oil (6.7 mL/500 mL water), plus Capsil (0.234 mL/500 mL water). Garlic was applied at 0.9 g of minced garlic per 500 mL water. The study consisted of six single-plant reps. Plants were placed in a randomized complete block. No inoculum plants were used.

Plants were visually rated for percent leaf area covered by the PM fungus at 2, 4, and 6 weeks after initial treatment. This measurement was made by visually estimating total PM coverage on leaf tissue in relation to the total leaf surface area of the plant. Plants were also evaluated for chemical residue on 25 Oct. 2001 using a scale of 1 to 5, with 1 having no chemical residue and 5 having heavy visual residue. The degree of phytotoxic symptoms was rated on 25 Oct. 2001 using a scale of 1 to 5, with 1 representing no phytotoxicity and 5 representing severe phytotoxicity. Data collection was terminated on 25 Oct. 2001 due to cold weather.

FINDINGS

Chemical treatments that were most effective in controlling PM included: Eagle WSP, Eagle 20, Banner, Daconil, Fungo 50 with and without Capsil, Zyban with and without Capsil, and Terraguard (Table

[1] Department of Horticulture, Fayetteville; [2] Department of Plant Pathology, Fayetteville; [3] Cooperative Extension Service, Little Rock

2). Treatments that were moderately effective included: Armicarb 100 at both concentrations, Heritage, and Camelot. Junction was not effective as a chemical control for PM in the field and this result supported the manufacturer's observation (personal communication, Griffin Chemical Company).

The biological treatment Plant Shield provided some control for at least 6 weeks after the initial application. Baking soda cocktail appeared to offer the best control of PM among the bio-rational products but would not likely replace fungicides for most growers and nurserymen. A solution of garlic also provided significant preventative control of PM relative to the water control at all three rating dates. The surfactant Capsil applied alone as a 0.05% solution provided significant control of PM at all three rating dates.

Visual chemical residue was minimal in the study. Only four treatments displayed any type of visual chemical residue. Junction, Zyban plus Capsil, Plant Shield, and Daconil had a residue rating of 2 (low chemical residue). All other chemicals left no visual residue on the plants. No phytotoxic symptoms were observed on any of the plants and plants had good visual quality.

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ACKNOWLEDGMENTS

The authors would like to thank BioSafe and Griffin chemical companies for their donation of products, and Helena, Syngenta, Rohm and Haas, Scotts, and Uniroyal companies for product and financial support.

Table 1. Treatments used in the field chemical study.

Chemical name	Trade name properties	Preventative/curative (% a.i.)	Spray concentration (days)	Spray interval
Myclobutanil	Eagle 20	Both	0.007	7
Myclobutanil	Eagle WSP	Both	0.02	7
Propicanazole	Banner	Both	0.007	21
Chlorothalonil	Daconil	Preventative	0.06	7
Thiophanate-methyl	Fungo 50+Capsil	Both	.03 + .05	14
Thiophanate-methyl	Zyban	Both	0.14	7
Thiophanate-methyl	Zyban+Capsil	Both	.14 + .05	7
Thiophanate-methyl	Fungo 50	Both	0.03	14
Trifluizole	Terraguard	Both	0.02	7
Potassium bicarbonate	Armicarb low	Preventative	0.25	7
Potassium bicarbonate	Armicarb high	Preventative	0.5	7
Azoxystrobin	Heritage	Both	0.002	14
Copper salt (fatty and rosin acids)	Camelot	Preventative	0.3	7
Mancozeb, copper hydroxide	Junction	Preventative	0.1	7
Trichoderma harzianum	Plant Shield	Preventative	0.006	7
Sodium bicarbonate	Baking Soda cocktail[z]	Preventative	-	7
Potassium bicarbonate	Baking soda	-	0.3	7
Garlic	Garlic	-	0.2	7
polyether-polymethylsiloxane-copolymer	Capsil	-	0.05	7
Water	Control	-	-	7

[z]Baking soda cocktail=baking soda, Sunspray horticulture oil, dormant oil, and Capsil.

Table 2. Foliar residue, phytotoxicity and powdery mildew ratings for treatments applied to *Phlox paniculata* 'Miss Pepper' in the field under 60% shade in 2001.

			Powdery mildew rating (% leaf area covered)		
Treatment	Foliar residue rating[z]	Phytotoxicity rating[y]	27 Sept.	11 Oct.	25 Oct.
Eagle 20	1	1	0 c[x]	0 c	0 e
Eagle WSP	1	1	0 c	0 c	0 e
Banner	1	1	0 c	0 c	1 e
Daconil	2	1	0 c	1 c	1 e
Fungo 50+Capsil	1	1	0 c	0 c	1 e
Zyban	1	1	0 c	1 c	1 e
Zyban+Capsil	2	1	0 c	0 c	2 e
Fungo 50	1	1	0 c	1 c	4 e
Terraguard	1	1	0 c	2 c	6 e
Armicarb Low	1	1	1 c	4 bc	13 cde
Armicarb High	1	1	7b	12 bc	18 cde
Heritage	1	1	2 c	10 bc	19 cde
Camelot	1	1	4 bc	11 bc	28 c
Junction	2	1	13 a	32 a	58 a
Plant Shield	2	1	2 c	10 bc	25 cd
Baking soda cocktail[w]	1	1	0 c	1 c	7 de
Baking soda	1	1	1 c	9 bc	18 cde
Garlic	1	1	6 bc	15 b	28 c
Capsil	1	1	1 c	4 bc	15 cde
Control	1	1	15 a	33 a	45 b

[z] Foliar residue rating on 25 Oct. 2001; 1= no residue and 5=heavy residue.

[y] Phytotoxicity rating on 25 Oct. 2001; 1=no toxicity and 5=severe toxicity.

[x] Means within a column followed by same letter are not significantly different (P=.05, Student-Newman-Keuls test).

[w] Baking soda cocktail=baking soda, Sunspray horticulture oil , dormant oil, and Capsil.

EVALUATION OF *Phlox paniculata* CULTIVARS FOR SUSCEPTIBILITY TO POWDERY MILDEW

Erin Taylor[1], Richard Cartwright[2], James Robbins[3], and Gerald Klingaman[1]

IMPACT STATEMENT

Phlox paniculata cultivars were grown under field conditions at Fayetteville, Ark. to evaluate their susceptibility to powdery mildew (PM) caused by *Erysiphe cichoracearum*. Ratings averaged over the entire growing season indicated six groups of relative susceptibility to PM ranging from very susceptible to very resistant. Those cultivars that were very susceptible to PM were ‘Starfire’, ‘Little Princess’, ‘Mt. Fuji’, ‘Miss Universe’, ‘Andre’, and ‘Little Boy’ (De Varoomen source). Cultivars that were resistant or very resistant to PM were ‘ Red Magic’, ‘Blue Boy’, ‘Eden’s Crush’, ‘David’, ‘Darwin’s Joyce’, ‘Robert Poore’, and ‘Delta Snow’. The remaining cultivars were moderately resistant, moderately susceptible, or susceptible to PM.

BACKGROUND

Garden phlox has become an important perennial for both the nursery industry and the home gardener. Powdery mildew is a serious disease of garden phlox. Several studies have been conducted to evaluate phlox cultivar susceptibility to PM. Studies conducted at the University of Vermont (USDA zone 4 and AHS zone 4), Chicago Botanical Gardens (USDA zone 5 and AHS zone 5) and North Carolina State Univ. (USDA zone 6 and AHS zone 7), have concluded that certain cultivars of *P. paniculata* are less susceptible to PM than others, depending on the zone where grown (Bir, 1999; Hawke, 1999; Perry, 1999). The objective of this study was to screen 32 cultivars of *P. paniculata* and determine their susceptibility to PM in USDA cold hardiness zones 6, 7, 8, and 9 and AHS heat zones 7, 8, and 9.

RESEARCH DESCRIPTION

P. paniculata plants were received from five nurseries (VanBloem Nursery, Alpharetta, Ga.; North Creek Nursery, Landenberg, Pa.; De Varoomen Holland Bulb Company, Russell, Ill.; River Bend Nursery, Riner, Va; and Van Hoorn Nursery, Marengo, Ill.) in January through March 2000. Plants were received as rooted cuttings or as bare root plants from the field. Plants were transferred to 4 in. diameter, round containers containing Sungrow Strong-Lite Universal mix (Pine Bluff, Ark.)(pine bark compost, peat, vermiculite, perlite) with an initial pH of 4.5. Plants were then placed in a temperature-controlled greenhouse (60-80º F). Plants were fertilized with Scotts (Marysville, Ohio) Peters® liquid fertilizer 20N-8.8P-16.6K at a rate of 150 ppm of N every 2 weeks.

The field site was at the Arkansas Agricultural Research and Extension Center, Fayetteville. Soil type was a Captina silt loam and was tilled in June 2000 to a depth of 6 in. and 4 ft wide. The rows were oriented north to south. Soil samples were taken 14 June 2000 and analyzed at the University of Arkansas Soil Test Diagnostic Lab and Agricultural Services Laboratory in Fayetteville. Initial soil pH was 6.3.

Garden phlox plants were planted 6 in. from the edge of the 180 ft bed. Each row contained three plants spaced on 18 in. centers. Plants were watered as needed using a drip-tape system. The drip tape provided 1.9 L of water per hour. Beds were mulched with wood chips to a depth of 3 in. On 21 June 2000, each plant was fertilized with 9 g of Osmocote® 14N-6P-11.6K (Scotts, Marysville, Ohio). A second application of the same fertilizer and rate was made on 25 Aug. 2000. Plant stems were cut back to the soil line during Feb. 2001. Plants were fertilized with the same fertilizer and rate on 27 April 2001. The bed was located in full sun and contained 10 reps with 32 cultivars. A randomized complete block design was used. Data collection began on 30 April 2001. Plants were visually rated every 2 weeks for the percent leaf area affected by PM. This measurement was made by visually estimating total PM coverage on leaf tissue in relation to the total leaf surface area of the plant. Data collection was terminated on 24 Sept. 2001 due to plant deterioration.

FINDINGS

A resistance rating was assigned to the garden phlox cultivars based on the maximum percent leaf area affected (Table 1). Based on this rating the 32 garden phlox cultivars evaluated in our trial separated into six resistance categories. These resistance ratings represent ‘resistant’ reactions under trial conditions but do not reflect immunity or complete resistance. Those cultivars that were very susceptible to PM in our trial included: ‘Starfire’, ‘Little Princess’, ‘Mt. Fuji’, ‘Miss Universe’, ‘Andre’, and ‘Little Boy’ (De Varoomen source). Cultivars that were resistant or very resistant included: ‘Red Magic’, ‘Blue Boy’, ‘Eden’s Crush’, ‘David’, ‘Darwin’s Joyce’, ‘Robert Poore’, and ‘Delta Snow’. The remaining cultivars were rated as moderately resistant, moderately susceptible, or susceptible to PM.

Those cultivars that were rated as resistant or very resistant in our trial would likely require no fungicide treatment for PM when grown in Arkansas. It is possible that the PM pathogen may become virulent to these cultivars over time, however. These cultivars included: ‘Delta Snow’, ‘Robert Poore’, ‘Darwin’s Joyce’, ‘David’, ‘Eden’s Crush’, ‘Blue Boy’, and ‘Red Magic’. Cultivars that were rated as moderately susceptible in our trial would likely require moderate to routine use of

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fungicides to control PM. Cultivars that are rated as very susceptible would require regular use of a fungicide to control PM or the cultivars should not be planted. These cultivars included: ‘Starfire’, ‘Little Princess’, ‘Mt. Fuji’, ‘Miss Universe’, and ‘Andre’.

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ACKNOWLEDGMENTS

The authors would like to thank River Bend Nursery, Van Hoorn Nurseries Inc., North Creek Nurseries, VanBloem Nurseries, and De Varoomen Bulb Company for their donations of phlox plants for the research project.

Table 1. Powdery mildew ratings and flower color for *Phlox paniculata* cultivars evaluated at Fayetteville, Ark. in 2001.

Cultivar	% Leaf area affected-season total	Maximum % leaf area affected at any date	Resistance range %	Resistance rating[z]	Flower color
Starfire	600	78	50+	VS	Hot pink
Little Princess	514	62	50+	VS	Med. purple
Mt. Fuji (Mt. Fujiyama)	486	58	50+	VS	White
Andre	466	58	50+	VS	Dark purple/white eye
Miss Universe	482	54	50+	VS	White
Little Boy (De Varoomen)	379	54	50+	VS	Purple
Miss Pepper	362	49	40-49	S	Lt. pink/dark pink eye
Little Boy (VanBloem)	376	46	40-49	S	Purple
Rosalinde	346	46	40-49	S	Lt. pink/med. pink eye
Bright Eyes	264	44	40-49	S	Lt. pink/med. pink eye
Miss Kelly	283	42	40-49	S	White/lt. pink eye
Nicky	263	37	30-39	MS	Dark red-violet
Pink Gown	204	37	30-39	MS	Med. pink/dark pink eye
Fairest One	266	33	30-39	MS	White/med. pink eye
Prime Minister	216	33	30-39	MS	White/dark pink eye
Laura	262	32	30-39	MS	Purple/white eye
Snow White	229	30	30-39	MS	White
Starlight	147	29	20-29	MR	Purple
Eva Cullum	146	25	20-29	MR	Med. pnk/dark pink eye
Miss Ellie	185	24	20-29	MR	Med. pink/dark pink eye
Flamingo	175	24	20-29	MR	Med. pink/dark pink eye
Orange Perfection	137	23	20-29	MR	Bright orange
Red Super	162	21	20-29	MR	Red-violet
Blue Boy	66	18	10-19	R	Lavender/white eye
Red Magic	105	17	10-19	R	Hot pink
David	73	11	10-19	R	White
Eden’s Crush	65	10	10-19	R	Lt. pink/dark pink eye
Darwin’s Joyce	60	10	10-19	R	Med. pink
Robert Poore	48	10	10-19	R	Lavender/white eye
Delta Snow	13	6	0-10	VR	White/med. lavender eye

[z] Ratings are: VS=very susceptible; S=susceptible; MS=moderately susceptible; MR=moderately resistant; R=resistant.

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