2004 National Spinach Conference San Antonio, TX Dec. 15 - 17

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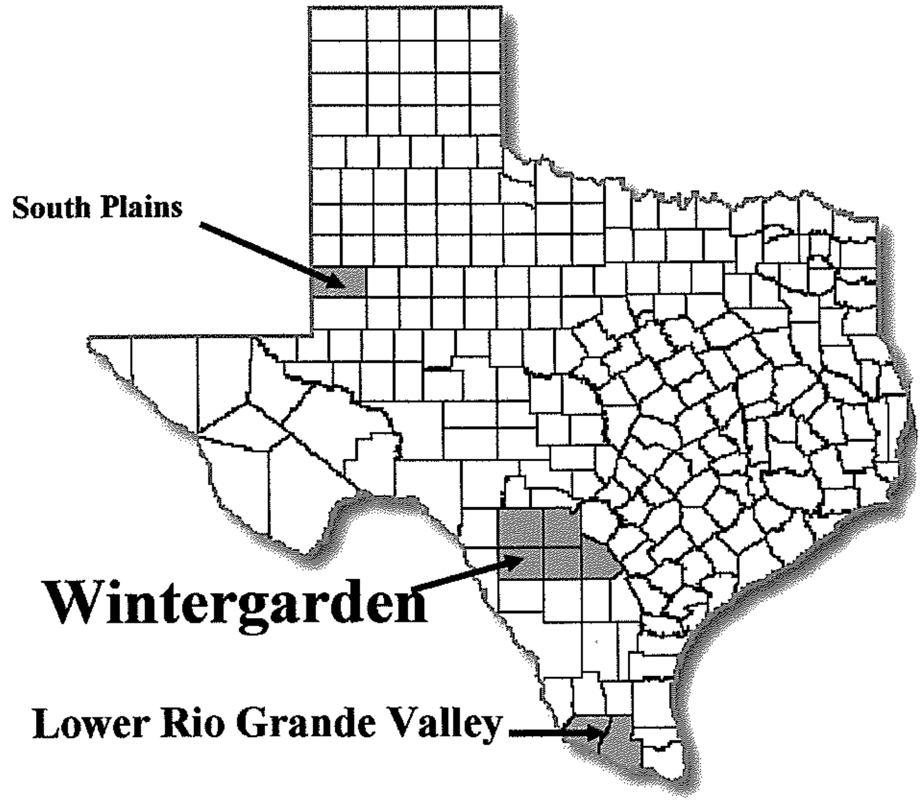
Texas Major Spinach Production Regions



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National Spinach Conference Agenda

December 16, 2004 7:30-8:30 a.m.	Registration and Continental Breakfast	
Moderator:	**Marcel Valdez**	
8:30 a.m.	Welcome	**Al Wagner / Al Wagner**
8:40 a.m.	U.S. Spinach Production, Consumption and Marketing Trends	**Jose G. Peña**
9:00 a.m.	SPINACH...Marketing and Publicity	**Burgundy L. Olivier**
9:20 a.m.	Breeding for White Rust Resistance in Spinach	**Teddy Morelock** and Jim Correll
9:40 a.m.	The Ramifications of Screening Spinach Varieties for Thirty Years	**Frank Dainello**
10:00 a.m.	Break	
Moderator:	**Kenneth White**	
10:30 a.m.	Update on Downy Mildew of Spinach in the U.S. and Europe	**J. C. Correll**, B. M. Irish, S. T. Koike and T. E. Morelock
10:45 a.m.	Molecular Marker Identification for Downy Mildew Resistance	**B. M. Irish**, J. C. Correll and T. E. Morelock
11:05 a.m.	Genetic and Molecular Characterization of Verticillium from Spinach	**A. N. Tomlinson**, J. C. Correll and L. J. du Tort
11:20 a.m.	Validation and Implementation of a Weather-based Spray Advisory Program for White Rust of Spinach	Mbisin Diagne and **Kathryne L. Everts**
11:40 a.m.	Screening Fungicides for Efficacy Against White Rust	**L. Stein**, F. Dainello, E. Cox, M. Valdez, J. Lopez, B. Easterling, A. Phillips A. Mize and K. White
12:00 p.m.	Lunch	
Moderator:	**Jaime Lopez**	
1:00 p.m.	Spinach Curly Top Virus: A New Curtovirus Species Revealing a History of Recombination Among Curtoviruses	S. Baliji, M. C. Black, R. French, D. Stenger and **G. Sunter**
1:20 p.m.	2004 Herbicide Evaluations for Texas Grown Spinach	**Russ Wallace** and Aaron Phillips
1:40 p.m.	Herbicide Carryover Resulting in Injury to Spinach and Fall Greens	**Colleen M. Thomas** and Ronald E. Talbert
2:00 p.m.	Tolerance of Some Spinach Cultivars to Raptor Herbicide	**N. R. Burgos,** T. E. Morelock, D. Motes, S. Eaton and L. Martin
2:20 p.m.	Break	
Moderator:	**Brad Easterling**	
3:00 p.m.	High Density Spinach Variety Trials in Western Oklahoma	**Lynn Brandenberger**
3:20 p.m.	Altering Calcium Bioavailability in Spinach	**Kendal Hirschi**
3:40 p.m.	Flavanoid Content and Antioxidant Capacities of Selected Spinach Genotypes	**Luke Howard**
4:00 p.m.	Tosca Ltd. - Container Pooling in the Spinach Industry	**Charity Schneider** and Mike Fechter
4:20 p.m.	Innovations in Spinach Harvesting by Ramsay Highlander	**Frank Maconachy**
4:40 p.m.	Wrap-up, announcements, Adjourn	

December 17, 2004
7:30 am - 5:30 pm   Tour of the Texas Wingergarden spinach production region

U.S. Spinach Production, Consumption and Marketing Trends

Jose G. Peña, Extension Economist-Management

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While Texas dominated the spinach industry and led in production for the fresh market until the mid-80's, California now leads the nation, producing about 72 percent of the 857.9 million pounds of spinach produced in the U.S. in 2003. Texas now produces about 13% of total U.S. production compared to the mid-80's, when it produced close to 40%. In addition, production for the fresh market has decreased substantially in Texas. Texas ranks a very distant 3rd in production for the fresh market, behind California and New Jersey, producing only 3.9% of the 597.8 million pounds produced in 2003. Texas ranks 2nd in production for the processed market behind California, producing about 30 percent of the about 260 million pounds of spinach produced for the processed market in 2003. U.S. fresh-market spinach consumption has been increasing with consumption greatest in the Northeast and West. According to recent studies by USDA-ERS, per capita spinach use is strongest among Asians, highest among women 40 and older, and weakest among teenage girls.. While processed spinach consumption has increased slightly, most of the increase per capita spinach consumption has been for the fresh market to an average of 1.5 pounds during the last two years compared to an average of 0.8 pounds during 1992-1999. Fresh spinach consumption, however, remains just a small blip in relation to total lettuce per capita consumption of about 31.0 pounds in 2003. This means that there appears opportunities for further growth in the industry. This paper presents the trends in U.S. spinach production based on a review of USDA's annual spinach production

SPINACH ----Marketing and Publicity: Taking the world's most unpopular vegetable and making it famous

"The Spinach Lady" Burgundy L. Olivier

During much of the 1900's, spinach was often thought of as a much-dreaded vegetable on the plates of many children. Its popularity received a boost in the arm when a cartoon character became well known as the "sailor who ate spinach to make him strong." Despite the marketing efforts of spinach growers and producers across the nation, spinach still struggled in popularity in both the canned and frozen varieties. As fresh spinach became readily available year round, [especially in pre-washed packages], spinach started to carve a niche all its own.

The marketing of spinach and spinach products is a virtual "clean slate" with which to cultivate innovative ideas, with the end result being increased production and end-consumer sales. One such approach is to educate people on the versatility of spinach, its nutritional values, and what to do with it once you get it home.

Restaurants, TV chefs, food writers, cookbook authors and even home cooks have taken a sincere interest in this leafy green, putting it on the map as well as on the road to becoming America's darling of vegetables.

As an added bonus feature, eye health professionals are encouraging their patients to consume more spinach as part of their daily food intake, due to the high lutein content in spinach.

With a join effort on the part of growers, processors, shippers, retailers, nutritionists, etc., spinach will find its way to millions of dinner tables, creating an industry that will no doubt struggle to meet the increasing demands on production.

Breeding for White Rust Resistance in Spinach

T.E. Morelock and J.C. Correll

Department of Horticulture and Plant Pathology, University of Arkansas

The spinach breeding program at the University of Arkansas was initiated about 35 years to address the need for white rust resistant varieties when the USDA ended its white rust breeding efforts, as well as its overall spinach breeding program. Since its beginning the program has emphasized field screening for white rust resistance and at the present time two breeding nurseries exist at the Vegetable Substation at Kibler, Arkansas. They have been in continuous spinach since 1975 when the station moved to its current location from Van Buren, Arkansas. These two nurseries have developed into excellent disease screening sites which make it possible to routinely screen for white rust and fusarium, as well as several other soil borne and foliar diseases. In 1985 a nursery site was added at the Texas A&M Research and Extension Center at Uvalde, Texas because of the more consistent white rust pressure in that area. In recent years the nursery was expanded and moved to the Del Monte Research farm near Crystal City, Texas. Field selections have been made at all these locations, dug and transported to the spinach breeding greenhouse in Fayetteville, Arkansas where they are caged and seed is produced for the next field screening cycle.

These excellent field screening sites and greenhouse isolation facility with its 80 cages has allowed the Arkansas breeding program to develop varieties with good levels of resistance to white rust and other diseases. Varieties developed by this program include 'Ozarka', 'Green Valley', 'Fallgreen', 'F380', 'WinterGreen', 'F415' and 'Evergreen' (88-212). Arkansas genetics is also utilized by industry in the development of white rust resistant hybrids.

Recently we have begun to look at breeding lines to determine if differences in antioxidant levels existed in our breeding program. It appears that white rust resistant material has higher levels of phenolics which should account for higher antioxidant levels. Early results are very encouraging and significant variation has been found between varieties and breeding lines for lutein and flavonoids with Arkansas material being the highest that we tested for these traits. We are presently looking at the effect of age and plant to plant variation for these traits. When these studies are completed we plan to incorporate screening for these characteristics into our overall breeding program.

The Ramifications of Screening Spinach Varieites for Thirty Years

Frank J. Dainello, Extension Horticulturist- Commercial Vegetable Crops,

Department of Horticultural Sciences, Texas A&M University.

Spinach production in Texas has undergone significant changes over the past 30 years. The greatest change has been the decline in acreage. Although there is many causes for the decline one of the most important has been the effect of the disease white rust, *Albugo occidentalis* G. W. Wilson. Although this disease has always been a major problem to the Texas spinach industry it reached epidemic proportions in the 80's due in part to the use of varieties without adequate resistance. The establishment of world class resistance screening nurserises by the Texas Spinach Improvement Team, in cooperation with Del Monte Foods, the University of Arkansas and Alf Christianson Seed Company, resulted in the identification and release of several varieties that have been credited with enabling spinach to continue to be a viable crop in the Texas Wintergarden. The major fresh market variety releases that played a major role in keeping spinach production alive were; Ozarka, Green Valley, Fall Green and Samish. The major processing releases having an impact were; F380, 5044, and 3633.

Molecular marker identification for downy mildew resistance

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Downy mildew, caused by *Peronospora farinosa* f. sp. *spinaciae*, is a destructive disease of spinach worldwide. An effective management tool for the control of downy mildew is the use of major resistance genes. Frequently, new races of the pathogen can overcome resistance mediated by major genes. Identification of races of the downy mildew pathogen is based on disease reactions on a set or sets of host differential spinach lines. These lines have typically included both hybrid and open pollinated commercial cultivars. However, a major problem associated with this approach is that over time, the availability of seed of open pollinated lines diminishes, hybrid lines become unavailable, and even inbred parents can change. In addition, there is evidence that minor or quantitative resistance can confound reactions of some cultivars with certain major genes. Thus it would be valuable if a set of open-pollinated isogenic spinach lines, which only differ in their major resistance genes to individual races of the pathogen were available.

In an effort to establish one such differential, crosses were made between a line with resistance to race 6 and to the highly susceptible cv 'Viroflay' as the recurrent parent. Progeny from this cross were evaluated for their disease reaction to race 6, and resistant progenies were then backcrossed to the recurrent parent 'Viroflay'. Evidence from four backcross generations showed that the gene for disease resistance to race 6 of the pathogen segregated as a single dominant gene. An open-pollinated line from this material with fixed homozygous resistance to race 6 can now be generated.

An AFLP marker linked to resistance to race 6 was identified from the segregating population. The AFLP marker was converted into a sequence characterized amplified region (SCAR) marker. This marker can be used in breeding efforts to expedite identification of race 6 resistant material. However, the marker linked to resistance to race 6 was only identified in certain commercial cultivars known to be resistant to race 6. It is hypothesized that race 6 resistant material that did not have the marker and had an allele different from that of the original resistant line used to develop the marker; alternatively, additional backcrossing among some race 6 resistant lines during cultivar development may have broken the linkage between the marker and the resistant locus.

Genetic and Molecular Characterization of *Verticillium dahliae* from Spinach

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Departments of Plant Pathology, [1]University of Arkansas, Fayetteville, AR 72701 and

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Verticillium dahliae is an important vascular wilt pathogen that affects many plant species. Recently, *V. dahliae* has been reported to be pathogenic to spinach (*Spinaceae oleraceae*) (3,4). In 2002, several spinach seed production fields in Washington exhibited late-season wilt symptoms. Plants and seed harvested from these crops were initially assayed for *Fusarium oxysporum* f. sp. *spinaceae,* but *V. dahliae* was recovered. This caused concern as the Pacific Northwest region produces approximately 75% of the U.S. and 50% of the global supply of spinach seed. Pathogenicity tests verified that the isolates were pathogenic on spinach (3,4).

The purpose of the current research was to characterize 5 pathogenic reference isolates of *V. dahliae* for genetic vegetative compatibility group (VCG) diversity and molecular mitochondrial DNA (mtDNA) RFLPs (1,2). In addition, a VCG analysis of 50 additional isolates of *V. dahliae* recovered from seed produced in the U.S., the Netherlands, and Denmark was conducted. Nitrate-nonutilizing (*nit*) mutants were generated from all five isolates and tester *nits* were generated and identified. Two types of modified chlorate media were evaluated for *nit* mutant production; water agar chlorate (WAC) and corn meal agar chlorate (CMC) at concentrations of 0%, 2.5%, and 5% chlorate (5). The most efficient medium for the generation of *nit* mutants was WAC amended with 5% chlorate. Molecular fingerprinting (mtDNA RFLPs) was performed by digesting the five reference isolates with four restriction enzymes and hybridizing the fragments with two mtDNA probes.

Complementation tests indicated that there were two distinct groups, or VCGs, among the five reference isolates. The two VCGs were designated VCG-2B and VCG-4B. A total of 17 isolates (30.9%) from Washington and Denmark belong to VCG-2B and a total of 36 isolates (65.5%) from Washington, the Netherlands, and Denmark belonged to VCG-4B; nits were not recovered from 2 isolates (3.6%). Thus, the two groups recovered from spinach apparently have a worldwide distribution. Molecular analysis of the 5 reference isolates revealed no RFLPs and thus isolates from both VCGs belonged to a single mtDNA RFLP haplotype.

Validation and Implementation of a Weather-based Spray Advisory Program for White Rust of Spinach.

Diagne, Mbisin, and Everts, Kathryne L.

Former Graduate Student and Associate Professor, University of Maryland, College Park and Salisbury, Maryland, U.S.A.

Spinach is grown for fresh market and processing in Maryland and Delaware, which comprise the fourth leading spinach producing area in the U.S.A. White rust, caused by *Albugo occidentalis*, is the most prevalent yield-limiting disease within the region. Favorable environmental conditions are required for the initiation and development of white rust. The ability to schedule fungicide applications for white rust management to coincide with these disease-favorable periods would reduce application frequency and/or increase the efficacy of each application. A weather-based fungicide advisory program that related leaf wetness and temperature conditions to white rust was developed in Oklahoma in 1999. A modified version of the advisory program was evaluated in Maryland and Delaware. Experiments were conducted over three cropping seasons within 2002 and 2003. Spinach was treated with the broad-spectrum fungicide pyraclostrobin, acibenzolar-S-methyl, a plant activator and Naiad, a surfactant. For pyraclostrobin and Naiad, fungicide applications were initiated by scouting for white rust; subsequent applications were applied weekly or scheduled according to the weather-based fungicide advisory program. (Scouting is the predominant method used to initiate fungicide applications in commercial spinach production in Maryland and Delaware.) Acibenzolar-S-methyl application was initiated by scouting and also at the second true leaf stage, with subsequent applications weekly or according to the advisory program. Both acibenzolar-S-methyl initiated at the second true leaf stage and pyraclostrobin applied weekly and according to the advisory program, reduced disease incidence compared to untreated plots. Pyraclostrobin did not always reduce the percent weight of infected leaves compared to the control, but maintained processing white rust grade below the threshold levels of 5% or 12%. Acibenzolar-S-methyl initiated at the second true leaf stage and applied weekly or according to the weather-based spray advisory program reduced the percent weight of infected leaves compared to the control and maintained the grade below the 12% level. Identical experiments also were conducted in side-by-side fields in the fall of 2002. One field had not been previously planted to spinach for three years and one field was double-cropped within one year. White rust incidence was unacceptably high in the double-cropped field whether sprays were applied weekly or according to the advisory program. Evaluation of the weather-based spray advisory program in Maryland and Delaware has demonstrated that the program often results in better fungicide timing. These experiments however, did not compare white rust progress when initiation of fungicide applications was based on scouting vs. spinach growth stage. Trials initiated in the fall of 2004 will examine the *i*) presence and extent of over-wintering oospore inoculum, *ii*) the optimum time to initiate fungicide applications, and *iii*) fungicides or bio-fungicides that can be successfully used with a weather-based fungicide application program.

Screening Fungicide for Efficacy Against White Rust

L. Stein, F. Dainello, E. Cox, M. Valdez, K. White, J. Lopez, B. Easterling,
A. Phillips and A. Mize
Texas Cooperative Extension and Del Monte

White rust of spinach *(Albugo occidentalis)* historically has been the limiting factor to profitable spinach production in Texas. Currently, economic control of this disease is being achieved with the implementation of a systems approach including the use of resistant varieties in-seed furrow application of metalaxyl at planting, and the use of alternating foliar applications of the strobilurin fungicide Amstar (formerly Quadris), with a fungicide of dissimilar chemistry, generally a copper based fungicide. The rotation of Amstar with a fungicide of dissimilar chemistry is necessary to prevent resistance buildup to this product. However, the copper fungicides have proven to offer only marginal efficacy against white rust. Therefore, the objective of this study was to find an effective fungicide of dissimilar chemistry to rotate with Amstar.

Over the past six years, some 20+ compounds were evaluated at various rates and application schedules, either alone or in combination for efficacy against white rust. In addition five different surfactants were also evaluated either in combination with various fungicides or alone.

Promising results have been shown with several products including Cabrio and Zoxium. The most effective combination in the 2003 study was two applications of Amstar at 4 oz/A followed by Zoxium at 6 oz/A. To date, Zoxium has been the most effective product with different chemistry. However, neither product currently has a spinach label.

We are continuing to screen new compounds in 2004, including many of the "green" or bio pesticide products in hopes of finding "new chemistry" to keep white rust in check.

Spinach Curly Top Virus: a new *Curtovirus* species revealing a history of recombination among curtoviruses

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A curtovirus of spinach was isolated in southwest Texas during 1996. Disease symptoms included severe stunting and chlorosis, with younger leaves curled, distorted, and dwarfed. Symptoms produced in spinach agroinoculated with cloned viral DNA were similar to those observed in the field. Viral single-stranded and double-stranded DNA forms typical of curtovirus infection were detected in both field-collected and experimental host plants by Southern blot hybridization. The complete nucleotide sequence of the infectious clone comprised 2925 nucleotides, with seven open reading frames encoding proteins homologous to those of other curtoviruses. Complete genome comparisons revealed that the spinach curtovirus shared 64.2-83.9% nucleotide sequence identity relative to four previously characterized curtovirus species: *Beet curly top virus, Beet severe curly top virus, Beet mild curly top virus*, and *Horseradish curly top virus*. Phylogenetic analysis of individual open reading frames indicated that the evolutionary history of the three virion sense genes was different from that of the four complementary sense genes, suggesting that recombination among curtoviruses may have occurred. Collectively, these results indicate that the spinach curtovirus characterized here represents a new species of the genus *Curtovirus*, for which we propose the name Spinach curly top virus.

2004 Herbicide Evaluation Results for Texas-Grown Spinach

Russell W. Wallace[1], Aaron Phillips[2] and John C. Hodges[1]

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& [2]Del Monte Foods, Crystal City, TX

Introduction. Three trials were conducted in 2003 and 2004 to evaluate the effects of preemergence (PRE) and postemergence (POST) herbicides applied alone or in combination for crop injury, weed control and yields in processing spinach (*Spinacea oleracea*) grown in the Texas Wintergarden. Trials were established at the Del Monte Ag Research Farm located near Crystal City on a clay loam soil with a pH of 8.1 and less than 2% organic matter. Pre-plant incorporated (PPI) treatments were applied using a CO_2-pressurized backpack sprayer and hand-held boom equipped with four flat fan nozzles that delivered 20 GPA at 30 PSI. Following incorporation and bed shaping, spinach varieties DMC66-07, DMC66-09, DMC66-16 and FO18 (depending on trial) were planted in mid-to-late October. Percent weed control and crop injury ratings were recorded throughout the season.

Major weeds present in the 2003 trial included henbit (*Lamium amplexicaule*) and London Rocket (*Sisymbrium irio*). Weed control was generally good to excellent for all PRE-applied herbicides including Dual Magnum 7.62E (*s*-metolachlor at 0.65 lbs a.i./A, grower standard), Ro-Neet 6-E (cycloate at 2.25 lbs a.i./A), Outlook 6E (dimethenamid-p at 0.65 lbs a.i./A), and Nortron 4SC (ethofumesate at 1.0 and 2.0 lbs a.i./A). PRE-applied Bolero 8EC (thiobencarb at 1.0 and 2.0 lbs a.i./A) generally failed to give good weed control in this study. Crop injury observed 42 days after treatment (DAT) from PRE-applied herbicides was greatest with Outlook and Nortron (high rate), but was non-existent by harvest. Yields were statistically equivalent for all treatments with the exception of Nortron (high rate) applied to DMC 66-07. The results indicate that Outlook 6E and Nortron 4SC (low rate) are excellent candidates for preemegence use in processing spinach. In 2004, Outlook (PRE at 0.5 lbs a.i./A), Eptam 7-E (EPTC at 2.63 and 3.06 lbs a.i./A) applied PPI, Ro-Neet (PPI at 2.25 lbs a.i./A) and Prefar 4E (bensulide, applied at 2.0 lbs a.i./A double applications PPI + PRE after seeding) resulted in less than 10% crop injury 25 DAT. However, Prefar applied twice at 3.0 lbs a.i. (PPI + PRE after seeding) resulted in significant injury when compared to all other treatments. POST-applied treatments of Everest 70WG (flucarbazone-sodium at 0.025 lbs a.i./A) or UpBeet 50DF (triflusulfuron-methyl at 0.032 lbs a.i./A) caused greater than 95% injury and were dropped from future herbicide screens. All other treatments will continue to be evaluated for mid- and late-season crop injury, weed control and yield, though trial results will not be available until early 2005. Finally, in a third trial, PRE- and POST-applied Nortron (0.5 to 2.0 lbs a.i./A) was evaluated for crop injury on four processing spinach varieties. Early season results (25 DAT) indicate that as the rate of Nortron increases, stunting also increased from 1.6% to 35.3%. These results are similar to those of 2003. While the early injury is significant in the 2004 trial, it is expected that spinach yields would not decrease in those plots treated with Nortron at rates of 1.0 lb a.i./A or less. Potential future herbicide candidates for registration in processing spinach include Eptam, Nortron, Outlook and Prefar. More research is needed with these and other herbicides to improve and augment weed control strategies in processing spinach.

Herbicide Carryover Resulting in Injury to Spinach and Fall Greens.

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Identifying herbicides that are safe for use in vegetable crops as well as identifying herbicides that do not carryover and cause injury to vegetable crops in rotation is important to create more options for the vegetable grower.

Field studies with cool-season crops (spinach 'F380', cabbage 'Blue Dynasty', collard 'Champion', kale 'Dwarf Siberian, mustard 'Savannah' and turnip 'Alamo') were conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville, Arkansas in 2004 to evaluate the persistence of seven herbicides at 1 and 2X rates. Herbicides included imazamox at 0.03125 and 0.0625 lb ai/A, halosulfuron at 0.047 and 0.094 lb ai/A, sulfentrazone at 0.375 and 0.75 lb ai/A, imazethapyr at 0.0625 and 0.125 lb ai/A, clomazone at 0.75 and 1.5 lb ai/A and rimsulfuron at 0.0625 and 0.125 lb ai/A. The experimental design is a randomized complete split-split block with four replications with herbicide as the main plot, herbicide rate as sub plots and a single row of each crop as the sub-sub plots. The herbicides were applied to the soil surface on soil July 15 and the crops planted into a freshly rotary-tilled seedbed August 15, September15 and October 18. Crops were visually rated for injury 3 to 4 weeks after planting.

Herbicide activity persisted at one month with all the herbicides except clomazone. All crops tolerated clomazone when planted one month after application. Sulfentrazone was very damaging to spinach, 100% injury at 3 months after application. However, the other fall-planted crucifera greens were more tolerant than spinach to sulfentrazone carryover. At one month, cabbage injury from sulfentrazone carryover was 75%, kale was 50% collards, turnip and mustard was approximately 25%. Fomesafen residues were very injurious to all crops, decreasing form 100% injury at one month after application to 50% or more injury at 3 months after application. Rimsulfuron, halosulfuron and imazethapyr were very injurious to all crops when planted one month after application. By two months injury to all crops was moderate (below 50%) and by three months after application these herbicides had dissipated to below phytotoxic levels on all crops. Imazamox was tolerated by mustard and turnip at one month. Cabbage was injured by imazamox carryover to near 100% at one month with injury dropping to moderate (25%) at two months and dissipating by 3 months. Spinach, kale and collards suffered moderate injury from imazamox at 1 month, with injurious levels dissipating below phytotoxic levels at two months.

Tolerance of some spinach cultivars to Raptor® herbicide

N. R. Burgos, T. E. Morelock, D. Motes, S. Eaton, and L. Martin

University of Arkansas, Fayetteville

Raptor® (imazamox) is one of the acetolactate synthase (ALS) inhibitor herbicides labeled for use in cowpeaLike its analogue herbicide, Pursuit® (imazethapyr), Raptor® controls some broadleaf and grass weeds when applied pre- or postemergence. This herbicide has shorter residual activity in the soil than Pursuit® and, therefore, may make a cowpea-spinach rotation possible. This study was conducted to determine the sensitivity of some spinach cultivars to Raptor®. Four spinach cultivars including AR415, Avon, F380, and 17047 were planted in 6- by 1.8-m beds on October 16, 2003 at the University of Arkansas Vegetable Substation in Kibler. Raptor® was applied right after planting (preemergence) or on November 4, 2003 (posteemergence) when spinach had about 3 to 4 leaves. The herbicide rates were 0, 0.015, and 0.034 kg ai/ha. The experimental units were arranged in a split plot design with four replications, with cultivar as mainplot and herbicide treatment as subplot. Stand loss, crop injury, and yield were recorded. The emergence and establishment of spinach cultivars were similarly affected by Raptor® rate. Averaged over rate, the stand of F380 was reduced 25% compared to the untreated check, but stand of other cultivars were not affected. All cultivars showed some growth inhibition in response to Raptor® treatment. The 1/2X rate (0.015 kg ai/ha) caused significant injury when applied preemergence. In general, the preemergence treatment was more injurious (65 to 85% stunting) than postemergence application (5 to 10% stunting). At the 1X rate, injury from preemergence application ranged from 85 to 95%. There was no rate response to postemergence application of Raptor®, at least within the range used, with injury ranging from 5 to 20% regardless of application timing. The least injury from postemergence application was observed with AR415. Avon had the highest yield potential (800 g fresh leaves/m^2) of the cultivars tested, but AR415 incurred the least yield reduction (5%) from posteemergence herbicide treatment at 1/2X rate. We conclude that spinach is more sensitive to preemergence application of Raptor® than postemergence. The full rate of Raptor® could not be commercially used on these cultivars regardless of application timing. These spinach cultivars could not tolerate residual soil activity of Raptor® equivalent to 1/2X rate. Such level of residual activity generally does not exist in fields three months after normal use of this herbicide. Raptor® can be applied, postemergence, to AR415 at 1/2X rate without incurring significant injury or yield reduction.

High Density Spinach Variety Trials in Western Oklahoma

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The objectives of these trials were to evaluate spring planted spinach varieties for use in successive high density plantings for both yield and quality attributes. Five spinach varieties including Avon, F-380, F-415, Samish, and Tyee, and four experimental lines from Alf Christianson Seed including XSPC402, XSPC403, XSPC404, XSPC405 were planted on 3/18/04, 3/31/04, 4/15/04, and 5/10/04. Each plot was 20 feet long and consisted of 9 rows planted on 5 inch row centers. Seeding rates were approximately, 2.1 million seeds per acre. The experimental area received 11-52-30-2 pounds of N-P-K-Zn pre-plant. Supplemental fertilizer was applied on 4/15/04 as 82.5-0-90 pounds of N-P-K. No herbicide was used. Supplemental water was supplied through an overhead pivot sprinkler system. Plots were arranged in a RBD with 4 replications. Spinach was harvested on 4 different dates ranging from 35 to 40 days after planting (4/26/04, 5/10/04, 5/20/04, 6/14/04). Data recorded at each harvest included subjective ratings for leaf color, bolting, and fresh yields. Objective color evaluations were conducted on intact spinach leaf samples using a Minolta CM-3500d reflectance spectrophotometer using a 5.0 mm aperture (Minolta Corp., Ramsey, NJ). Five random leaves from each plot were analyzed for each of the four harvests. Each leaf was evaluated four times and rotated 90 degrees between readings to compensate for surface irregularities. Color readings were taken as C.I.E. L* a* b* values using the °65 Standard Illuminant.

Subjective field color ratings were highest for Avon, Tyee, and XSPC403 for the first two harvests, indicating a more intense green color in these cultivars for those harvests. For the objective color values a higher L value indicates a lighter leaf color. We might assume that within the range of values observed, a lower L value would correspond to increased consumer preference for spinach leaves. This would have to be confirmed by consumer sensory testing however. For the subjective field color values, a lower number corresponds to a lighter leaf color. Higher L values did tend to correspond to lower subjective color ratings. Significant differences were seen in L value for the first and third planting dates. Looking at the effect of planting date there was a clear trend in all varieties for the spinach to become lighter in color (higher L value) after the first planting date. Comparing objective spinach color values for each variety averaged over all planting dates shows that significant differences were seen in L values. No bolting was observed at harvest time (35-40 days after planting) for any of the cultivars in the trials, even late in the season. Bolting 48 to 63 days after planting was significant with the highest percentage of bolting recorded at 63 days after planting for the first harvest. Only Avon and Tyee had bolting of 20% or less for this rating. Yields were relatively stable for the first three harvests during April and May (10,723 to 23,290 lbs/acre). Spinach yield for the last harvest on June 14 was considerably lower than the other three harvests, yield averaged 5,839 lbs/acre for this harvest compared to 15,592 lbs/acre for the preceding three harvests.

Altering Calcium Bioavailability in spinach

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Low levels of dietary calcium contribute to osteoporosis and other significant health risks for millions of people worldwide. For many consumers, current methods of increasing dietary calcium are inconvenient, costly, or unpalatable. This talk will focus on ways to EVENTUALLY develop novel methods of increasing calcium levels in spinach. Two different methods will be discussed by which genetically enhanced plants could be manipulated to contain higher levels of calcium. The approaches outline may provide the basis for a cost-effective, grower-based technology that increases the nutritional value of vegetables already comprising a significant part of the U.S. diet.

Flavonoids and Antioxidant Capacities of Selected Spinach Genotypes

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Flavonoids in different spinach genotypes were separated, identified, and quantified by a high performance liquid chromatographic (HPLC) method with photodiode array (PDA) and mass spectrometric (MS) detection. The antioxidant capacities of the genotypes were also measured using two antioxidant assays; oxygen radical absorbance capacity ($ORAC_{FL}$) and photochemiluminescence (PCL), which measure the response to the peroxyl and superoxide anion radicals, respectively. Eighteen flavonoids representing glucuronides and acylated di- and triglycosides of methylated and methylene dioxide derivatives of 6-oxygenated flavonols were identified (patuletin, spinacetin, spinatoside, jaceidin). The total flavonoids ranged from 1,804.9-3,702.6 mg/kg indicating 2.0-fold variation among genotypes. The $ORAC_{FL}$ and PCL values ranged from 48.7-84.4 mmol/kg and 9.0-14.0 mmol/kg, respectively, representing as much as 1.7-fold variation. The $ORAC_{FL}$ and PCL values were highly correlated with total flavonoid content (r_{xy}= 0.96), indicating that flavonoids possess excellent peroxyl and superoxide scavenging properties.

Container Pooling in the Spinach Industry

Charity Schneider

Tosca Ltd.

Tosca Ltd is a container management company head quartered in Green Bay, Wisconsin. The company was founded in 1956 as a privately held group to rewax cheese barrels for Kraft Foods. Since then it has branched into other container related areas including beer keg sales and refurbishing, and, returnable plastic container(RPCs) management.

Tosca became involved in the savoy spinach industry in 1996 to address sanitation and food safety issues associated with the conventionally used wooden bushel baskets for spinach shippment. As a result, Tosca developed a plastic crate having a 16 " x 24" footprint that provides proper ventilation for spinach, readily maintained ice load and enable sanitation of a reusable stackable container. The use of RPCs offers spinach producers and repackers many advantages: reduced container inventory and storage needs; container tacking system; optimized fleet usage; container repair and sanitation; and generally a better freight rate. Tosca Ltd. Container management operates as a Third-Party Partnering operation. This allows its partners quality assurance, container expertise as well as coordination of empty container return.

Innovations in Spinach Harvesting

Frank Maconachy

Ramsey Highlander Manufacturing

Mechanically harvesting of spinach has been around for a long time. The most dominate spinach harvester over the past 30 years has been the Porterway harvester. Although this machine provides a fairly efficient way to harvest spinach, its sickle bar cutting mechanism and its belt conveying system does not meet the quality demands of today's fresh market spinach consumer.

Ramsey Highlander has adapted band saw cutting technology to a self propelled all stainless steel harvester designed to operate on an 80 " plant bed. With this machine and estimated 18 % increase in yield has been reported. The increase in yield can be attributed in part to the extremely uniform cut across the bed surface and the effective conveying system. The conveying system allows for tote loading or conventional bulk loading. The product quality achieved with the band saw cutting technology has greatly enhanced the productivity of the baby leaf spinach industry. In addition to the self propelled machine Ramsey Highlander also manufactures a pull type version with the band saw cutting system.

Deficit Irrigation and Plant Population Interaction for Processing Spinach Cultivars

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Water conservation and cultural strategies are being investigated in spinach grown under a center pivot system used in a rotation with corn and fallow. Our objectives are to determine yield, water use efficiency, and leaf quality responses to deficit irrigation rate, plant population and cultivar on processing spinach. A previous 2-year project focused on three irrigation regimes, 100%, 75%, and 50% crop evapotranspiration rates (ETc) and three cultivars, DMC 09, ASR 157 and CXF 3665. Leaf quality and water use efficiency was significantly affected by deficit irrigation and cultivar. In general, leaf yellowness was higher at 50% ETc, while the percentage of excess stem (longer than 4 inches) was higher at 100% ETc. That project demonstrated that deficit irrigation (75% ETc) in combination with fast growing spinach genotypes was efficient to produce high marketable yields and to reach at least 25% water savings in one season.

During 2003 season, we investigated how deficit irrigation affected spinach leaf quality and yield at three plant populations. Spinach seeds were planted with a vacuum planter with four lines per bed on 11 Nov. 2003. Raised (6-in high) beds spaced 40 inches apart were used. Spacing between the seeds along each line was 3.25, 2.50 and 2.0 inches [equivalent to a theoretical plant density of 300,000 (P3); 250,000 (P2) and 200,000 (P1) seeds/acre]. Three irrigation regimes, 100%, 75%, and 50% ETc and cultivars DMC 16 and ASR 157 were used. The ETc value applied was the actual evapotranspiration lost by a spinach crop (cv. DMC 16) planted in the in-ground lysimeter on the same date. The cumulative water received per treatment (rainfall + irrigation applied) was 7.94" for 100% ETc, 7.03 inches for the 75% ETc and 6.14" for the 50% ETc. Plots were harvested on 3 March 2004 with a spinach harvester provided by Del Monte canning company. Net marketable yields were not reduced by deficit irrigation at the range of 200-300,000 seeds/acre, but water use efficiency (lb/inch received) was significantly higher for 50% ETc compared to 100% ETc. Leaf quality (stem weight) was significantly affected by cultivar and ETc irrigation rate. DMC 16 had lower stem weight than ASR 157 (8.3 vs. 16.4%). The significant plant population-ETc rate-cultivar interaction for stem weight indicated that ASR 157 had an excess of stem weight at 100% and 75% ETc compared to 50% ETc at 200,000 (P1) seeds/acre. The first year of this study showed that deficit irrigation (50% ETc, 6.14 inches water applied + rainfall) did not reduce leaf quality and yield at the three plant populations tested. Deficit irrigation allowed a 23% water savings compared to 100% ETc.

During the field day at the TAMU Uvalde Research and Extension Center (2004 season) we are going to discuss and visit a 12-ac field plot where deficit irrigation is being evaluated in combination with high population rates (265,000 through 465,000 seeds/acre) on cv. DMC 16.

CONTACTING SPEAKERS

SPEAKER	PRESENTATION	e-mail ADDRESS
Jose G. Peña	U.S. Spinach Production, Consumption and Marketing Trends	<Jpena@tamu.edu>
Burgundy L. Olivier	SPINACH...Marketing and Publicity	<email@ilovespinach.com>
Teddy Morelock	Breeding for White Rust Resistance in Spinach	<morelock@uark.edu>
Frank Dainello	The Ramifications of Screening Spinach Varieties for Thirty Years	<f-dainello@tamu.edu>
J. C. Correll	Update on Downy Mildew of Spinach in the U.S. and Europe	<jcorrell@uark.edu>
B. M. Irish	Molecular Marker Identification for Downy Mildew Resistance	<maybi@ars-grin.gov>
A. N. Tomlinson	Genetic and Molecular Characterization of Verticillium from Spinach	<atomlin@uark.edu>
Kathryne L. Everts	Validation and Implementation of a Weather-based Spray Advisory Program for White Rust of Spinach	<Ke35@umail.umd.edu>
L. Stein	Screening Fungicides for Efficacy Against White Rust	<LStein@tamu.edu>
G. Sunter	Spinach Curly Top Virus: A New Curtovirus Species Revealing a History of Recombination Among Curtoviruses	<Garry.Sunter@utsa.edu>
Russ Wallace	2004 Herbicide Evaluations for Texas Grown Spinach	<RWWallace@tamu.edu>
Colleen M. Thomas	Herbicide Carryover Resulting in Injury to Spinach and Fall Greens	<cxm07@uark.edu>
N. R. Burgos	Tolerance of Some Spinach Cultivars to Raptor Herbicide	<nburgos@uark.edu>
Lynn Brandenberger	High Density Spinach Variety Trials in Western Oklahoma	<lynn.brandenberger@okstate.edu>
Kendal Hirschi	Altering Calcium Bioavailability in Spinach	<kendalh@bcm.tmc.edu>
Luke Howard	Flavanoid Content and Antioxidant Capacities of Selected Spinach Genotypes	<lukeh@uark.edu>
Charity Schneider	Tosca Ltd. - Container Pooling in the Spinach Industry	
Frank Maconachy	Innovations in Spinach Harvesting by Ramsay Highlander	<Frank@harvestingaid.com>
Daniel Leskovar	Deficit Irrigation and Plant Population Interaction for Processing Spinach Cultivars	<DLeskovar@tamu.edu>

Update on Downy mildew of spinach in the U.S. and Europe

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Spinach downy mildew, caused by *Peronospora farinosa* f. sp. *spinaciae*, is the most economically important disease on spinach worldwide. Recent field observations suggested that spinach cultivars that were resistant to the seven previously described races (race 1-7) of the spinach downy mildew pathogen were becoming heavily infected. Several isolates of the downy mildew pathogen were collected from California and the Netherlands and characterized for race identity based on disease reactions on two modified sets of differentials and on a set of commercial germplasm. Three new races (8, 9 and 10) of the downy mildew pathogen are identified based on the reactions on the differentials. Several cultivars with disease resistance to downy mildew races 1-7 were used to distinguish the three new races. 'Dolphin' was susceptible to races 8 and 10 but not to race 9; 'Califlay' was susceptible to race 10, but was not susceptible to races 8 and 9. The cultivar 'Lazio' was resistant to all three new races. Disease reactions of over 200 commercial cultivars also were evaluated. Race 10 has been recovered from 13 different commercial cultivars in the Salinas Valley and surrounding production areas (Monterey, Santa Cruz, San Luis Obispo, and San Benito Counties) and apparently is now widespread in this production area and represents a significant economic concern. Only 5 commercial cultivars have been identified thus far with resistance to race 10; the five cultivars are El Dorado, El Palmer, Emilia, Lazio, and Lombardia.