AgriLIFE EXTENSION
Texas A&M System

Abstracts of the

International Spinach Conference

November 30 – December 2, 2008
Holiday Inn-Market Square Downtown
San Antonio, Texas

2008 INTERNATIONAL SPINACH CONFERENCE

Planning Committee

Larry Stein, Coordinator

Jimmy Crawford

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Aaron Phillips

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Wintergarden Spinach Producer's Board

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REGISTRATION

5:30 - 7:00 p.m.	November 30, 2008	Informal Social - Holiday Inn 6:00 - 8:00 p.m.
8:00 - 9:00 a.m.	December 1, 2008	

PROGRAM

December 1, 2008

8:55 a.m.	Welcome Marcel Valdez, Program Moderator
9:00 – 9:20 a.m.	U.S. Spinach Production, Consumption and Marketing Trend *Jose G. Peña*
9:20 – 9:40 a.m.	A Brief History of the Texas Winter Garden Spinach Industry; 1915-2008 *Frank J. Dainello and Teddy E. Morelock*
9:40 – 10:00 a.m.	History of the Del Monte Corporation in Texas *Aaron Phillips, Allen Mize, and Ray Dabney*
10:00 – 10:20	From Breeding To Bag - Spinach Supply Chain and Methods Of Working In the U.K. and Iberian Peninsula *Graham Clarkson and Steven Winterbottom*
Break	
10:40 – 11:00 a.m.	The Effects of Pre-Plant Nitrogen and Plant Population on Processing and Fresh Market Spinach Yield and Quality *Larry Stein, Aaron Phillips, and Marcel Valdez*
11:00 – 11:20 a.m.	Deficit Irrigation and Plant Population Impact on Yield, Quality and Phytochemicals in Spinach *Daniel L. Leskovar, Giovanni Piccinni, Shinsuke Agehara, and Kil Sun Yoo*
11:20 – 11:40 a.m.	Herbicide Choice and Tank-Mix Combinations Affect Crop Injury, Yield and Grower Revenues in Spinach *Russ Wallace, Alisa K. Petty, and Aaron Phillips*
11:40 – 12:00 p.m.	Efficacy of Soil and Foliar Applied Pesticides on White Rust *Aaron Phillips, Larry Stein, and Marcel Valdez*
Lunch	
1:00 – 1:20 p.m.	Food Safety Gaps Initiative for the Spinach Industry *Marcel Valdez, Juan Anciso, Jaime Lopez, Omar Gonzales, Larry Stein, Joe Taylor, Richard Griffin, Rolando Zamora, Omar Montemayor, and Barbara Storz*
1:20 – 1:40 p.m.	Preharvest Management of Spinach: Potential Implications on Microbial Food Safety *Eduardo Gutierrez-Rodriguez, Heiner Lieth, Marita Cantwell, and Trevor Suslow*
1:40 – 2:00 p.m.	Food Safety Research on Fresh Greens Crops in Oklahoma *Lynn Brandenberger, William McGlynn, Emilia Cuesta-Alonso, Jessica Ong, and Lynda Carrier*
2:00 – 2:20 p.m.	Electronic Pasteurization of Lettuce and Spinach to Eliminate Pathogens *Suresh D. Pillai and Alejandro "Alex" Castillo*
2:20 – 2:40 p.m.	The Use of Lactic Acid Bacteria as A Post-Harvest Intervention to Control *Escherichia coli* 0157:H7 in Fresh Spinach *Sara Gragg*
Break	
3:00 – 3:20 p.m.	In Vitro Iron Bioavailability of Selected Spinach Genotypes *H.G. Dodson and T.E. Morelock*
3:20 – 3:40 p.m.	Verticillium Wilt on Spinach and Seed Transmission *Jim Correll, Lindsey J. du Toit, Maria Villarroel Zeballos, and Chunda Feng*
3:40 – 4:00 p.m.	Efficacy of Organic and Conventional Fungicides for Management of *Verticillium dahliae* on Spinach Seed *Lindsey J. du Toit, Emily Gatch, Mike L. Derie, Louise M. Brissey, and Barbara J. Holmes*
4:00 – 4:20 p.m.	A New Treatment for Spinach Seed with Efficacy Against Seed and Soil-Borne Fungal Pathogens, in Particular *Verticillium dahliae* *Graham Kinsey*
4:20 – 4:40 p.m.	New Uses for Oversized Spinach Leaves as a Fresh Product *H.G. Dodson, M.E. Fitch-Hilgenberg, and T.E. Morelock*
4:40 – 5:00 p.m.	Update on Spinach Downy Mildew Efforts in Arkansas and California *Jim Correll, Steve Koike, Chunda Feng, and Teddy Morelock*
Adjourn	

TENTATIVE TOUR AGENDA

December 2, 2008

8:00 a.m.	Board Buses
8:30 a.m.	Depart Holiday Inn
10:00 a.m.	Arrive Crawford Farm - Carnes - View Fresh Market Spinach Plant Population Study - View Processing Field - DMC - 07
10:30 a.m.	Travel to Barn - View Elevator - View Port-A-Way Harvester - View Ramsay Highlander Harvester - View Meyer Weigh Wagon - View Pivot Wheel Closer
11:00 a.m.	Travel by Ehler - No Stop - Arrive Processing Plant Population Study - Home Farm DMC 09 and 16 Processing Fields
11:30 a.m.	Lunch
12:30 p.m.	Depart for La Pryor - View Fresh Market Plant Population Study
1:30 p.m.	Depart for Del Monte Research Farm
2:00 p.m.	View Nurseries - Teddy Morelock, University of Arkansas - Margaret Savage, Alf Christianson - Jan de Visser, Pop Vriend - Russ Wallace, Herbicide Trial - Aaron Phillips, Fungicide Test
3:30 p.m.	Depart for Zavala County Show Barn - View Popeye Statue
4:00 p.m.	Pachanga
5:00 p.m.	Dinner
6:30 p.m.	Depart for San Antonio

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U.S. Spinach Production, Consumption and Marketing Trends

Jose G. Peña[1]

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 78 percent of the 831 million pounds of spinach produced in the U.S. in 2007. Texas produces about 9% of total U.S. production, compared to the mid-80's, when it produced close to 40%. Texas ranks a very distant 3rd in production for the fresh market, behind California and Arizona, producing only about 2.0% of the 635.4 million pounds produced in 2007. Texas ranks 2nd in production for the processed market behind California, producing about 32 percent of the about 195.6 million pounds of spinach produced in 2007. Demand is growing for fresh vegetables, after a slight decline during 2005-06, which was probably influenced by the spinach E-coli crisis. While processed spinach consumption has increased slightly, most of the increased per capita spinach consumption has been for the fresh market to an average of 2.0 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 (about 6%) in relation to total lettuce per capita consumption (romaine and head lettuce) of about 34.4 pounds in 2007. This means that there appears an opportunity for further growth in the industry. These trends in U.S. spinach production are based on a review of USDA's annual spinach production statistics.

[1] Professor and Extension Economist-Management, Texas AgriLife Research and Extension Center, Uvalde, Texas

A Brief History of the Texas Winter Garden Spinach Industry; 1915–2008

Frank J. Dainello[1] and Teddy Morelock[2]

The mild climate that predominates in the Texas Winter Garden during the fall and winter months provides favorable conditions for the successful production of spinach. The region's favorable climate coupled with the presence of an abundance of high quality water, fertile soils, and a large labor supply, enabled successful production of high quality spinach continuously from late fall through early spring. As a result, consistent market windows were established enabling Texas to become the nation's leading spinach producing state for nearly 60 years. Texas' reputation for producing high quality spinach was based on the use of savoy or semi savoy varieties rather than the smooth leaf types grown in most other spinach producing regions today. To date, the farm gate value of spinach to the state's economy has exceeded 387 million dollars with an annual contribution of 4.7 million dollars. This has represented nearly 1 billion dollars in economic impact to the state over the life of the spinach industry. As a result, spinach historically has been one of the backbone vegetable crops produced in the region.

Winter Garden region in South Texas. The Winter Garden is roughly the area formed by a triangle drawn from San Antonio on the northeast down to Laredo at the south and to Del Rio at the northwest. This area is also blessed with a long growing season. As a result the Winter Garden is an ideal spinach production region. However, around the turn of the 20th century, livestock was the major agricultural enterprise in the region. Crop production was limited to dry land production of a few agronomic crops. Proximity to the Senorian Desert in Mexico caused rainfall to be sparse and erratic. Consequently, crops such as spinach could not be produced reliably due to the limited rainfall. It wasn't until several non environmental occurrences presented themselves that enabled the Winter Garden to become the premier spinach production region in the United States. According to personal conversations with longtime spinach industry producers (Les Laffere, Lawrence Wilde, Don Lindenborne) it is speculated that the major impetus were: the clearing of brush land and the development of irrigation potential; the construction of railroads; the importation of an adequate labor supply; and the construction of large capacity electricity generating plants which allowed the production of a local ice supply.

The Winter Garden spinach industry arguably had its beginning in the Crystal City area when the first of four acres of spinach were planted in 1917 in an experiment to determine if this crop had potential in the area. It's apparent success led to the establishment of 100 A in 1918 – 1919 which increased each year with about 5000 A planted in 1926-1927. It is not known exactly where the experiment or by whom the experiment was conducted. However, in an account of the history of the City of Asherton, it suggests that the industry had it beginning when six carloads of spinach rolled out of Asherton in 1918. The spinach was purchased by Lee

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[1] Emeritus Professor and Extension Horticulturist, Department of Horticultural Science, Texas A & M University, College Station, Texas.
[2] University Professor, Department of Horticulture, University of Arkansas, Fayetteville, Arkansas

Steward, pioneer independent buyer in Asherton, and shipped to a northern market via railroad. As a result, he is credited with being the father of the Winter Garden / Texas spinach industry. Data presented in the *Texas Historical Crop Statistics: 1866* – 1989**,** confirms that 1918 was the first documented shipment of Texas spinach. Consequently it is believed that 1918 was the year that large scale commercial planting of spinach began in Texas.

A rapid proliferation of the spinach acreage occurred over the next 20 years following the first shipment of spinach in 1918. From 1924 to 1927, a doubling of the acreage resulted (8,700 A to 19,450 A). In 1929 the area southwest of San Antonio and north of Laredo, Texas produced 12,932 acres of spinach. Zavala County alone produced 8,226 acres. A total of 10,317 car load lots of spinach were shipped in the United Stated during 1929 with 6007 car lots shipped from Texas while Zavala County shipped 3775 cars. These numbers show that during 1929 Texas shipped 63 per cent and Zavala county shipped 36 per cent of the spinach shipped in the United States.

Acreage nearly doubled again from 1930 to 1936 (25,260 A to 48,000 A, respectively)**.** The reported price received for this initial crop was $ 5.02/cwt which resulted in a gross return of $271/A, an outstanding return /A for that period of time! The return/A and crop of $ 577,000 was the impetus which started the "Spinach Boom". Spinach acreage peaked in the Winter Garden at 48,000 A in 1936**.** The down turn in acreage was incited by problems with blue mold (downy mildew) and were compounded by the influence of the Great Depression that hit the country. Adverse impacts of blue mold and the Great Depression were soon magnified by the emergence of an even more devastating disease, white rust. White rust diseased spinach was first found in a carload lot of spinach shipped to New York City in 1937. The next season, white rust could be found in most spinach fields in the Winter Garden. No effective control measures were available. When coupled with the drought of the 50's these events marked the end of the Winter Garden "Spinach Boom"!!

A combination of hard freezes, severe infestations of the white rust disease, lack of adequate weed control, the emerging bagged baby spinach industry in California, and the failure of local producers to rapidly adapt emerging technology resulted in Texas dropping it's lead.

History of the Del Monte Corporation in Texas

Aaron L. Phillips, Allen L. Mize and Ray A. Dabney[1]

The Del Monte Corporation has a long and distinguished history in south Texas from it's early research initiatives in the late 1930's to the construction of the cannery in Crystal City, Texas in 1945 to it's current status as a leader and innovator of Texas Vegetable Production. This presentation takes a closer look at the events and people that made up that process.

Highlights of the discussion pertaining to spinach are as follows:

- 1916: J.K. Armsby of the Central California Canneries, California Fruit Canners Assoication along with Griffin & Shelley form the California Packing Corporation (later to change their name to Del Monte). The Del Monte Corporation is born.
- 1939: Ed Delwiche starts selecting spinach for better canning color. He also crosses and selects Viroflay types.
- 1945: The Crystal City cannery is constructed. Plant #250 produces it's first pack of finished product beginning with the 1945 – 1946 spinach pack.
- 1946: A report produced by Delwiche refers to "Selection B" as the principle California Packing Corporation spinach variety of the time.
- 1947: H.A. Jones, ARS, USDA, Beltsville, Md. begins a breeding program to develop improved spinach cultivars and F_1 hybrids with adaptation to the fall, winter, and early spring production areas of Texas, Arkansas, and Oklahoma
    - Jones organizes a team consisting of personnel from both public and private agencies to participate in the spinach improvement program.
    - Included in those involved in the spinach improvement program are Bruce Perry, Horticulture, Texas Agricultural Experiment Station – Crystal City, E.D. Delwiche, Del Monte Corporation, and Robert MacDonald, Alf Christianson Seed Company – Mt. Vernon
    - All play highly significant roles in the various program elements needed to achieve the progress accomplished in spinach improvement during the succeeding 10 years.
- 1950: Ed Delwiche works on the production of all-female lines to eliminate need for heavy rogueing in hybrid seed production fields. He also partners with Ray Webb of the USDA in the development of disease resistant lines for use in Texas.
- 1967: Jim Hooks continues the work on white rust (*Albugo occidentalis*) and blue mold (*Peronospora effusa*) resistance for Texas-grown Del Monte spinach. He also works to develop longer standing (slower bolting) varieties. He will be responsible for the breeding work that produces the commercial varieties still in use today.
- 1974-75: Del Monte 66-07 is field tested for the first time. It is classified as an "Early midseason" variety and is said to have much better frost tolerance than 66-133, the current commercial check of the time. Of interest at the time the report is written:

[1] Del Monte Foods, Crystal City, TX

"Hybrid 66-07 may require a modified nutritional label. The nutritional values are being retested during the 1976-77 production season."

  - It contained statistically significantly less Vitamin A than the other varieties of it's time. This was later to be proven as unreliable information as the variety's nutrient quality ranged by year.

- 1976: Del Monte begins to contract with local farmers in the Wintergarden area, the first two being D.C. Carnes and Les Laffere of Batesville.
- Del Monte moves to a cropping system on a raised 40" bed in an effort to mitigate the effects of white rust on stand quality, health and yield
- September 1995: Under the guidance and urgency of Dr. Frank Dainello, Professor and Extension Horticulturist of the Texas Agricultural Extension Service – the Winter Garden Spinach Producers Board is created as a checkoff program to support spinach research and extension efforts. The referendum passes by a 90% vote in favor of the Board. It is the first commodity advocacy group to be established in the history of the Texas Vegetable Industry. This board will appropriate monies to be used for spinach variety, pesticide and cultural research.
- June 2004: Del Monte continues its position as a leader in innovative agricultural practices – moving spinach field production to a high-density cropping system. Trial work in commercial fields as well as the Del Monte research farm begins in the fall of 2004 to lay the ground work for current commercial practices.

From Breeding to Bag – Spinach Supply Chain and Methods of Working in the U.K. and Iberian Peninsula

Graham Clarkson[1] *and Steven Winterbottom*[2]

The paper looks at the spinach production practices of one of Europe's largest prepared salad producers and how a close relationship with the plant breeder delivers a consistently high quality product to the supermarket shelf. The paper will stress the importance of planning and close liaison between the various departments in both companies. We will explore how product is developed from single row trials to commercial production; how the needs of the consumer, supermarket and grower are balanced and the complexities of delivering a continuity of supply year round from production facilities in the U.K., Portugal and Spain.

[1] Vitacress Salads Limited
[2] Tozer Seeds Ltd.

The Effects of Pre-Plant Nitrogen and Plant Population on Processing and Fresh Market Spinach Yield and Quality

Larry A. Stein[1], Aaron Phillips[2] and Marcel Valdez[3]

Plots were established at the Jimmy Crawford Home Farm. Pre-plant nitrogen levels of 50,100 and 150 pounds per acre were banded into 80 inch beds using N-32. Four plant populations, 700,000 (7), 580,000 (6), 470,000 (5) and 360,000 (3.5) seed per acre were used on 12 and 18 lines per 80 inch bed. Plots were planted using Ed Ritchie's Stanahay air planter on 17 October 2007. Siena was the processing and Sanish, the fresh market variety. Dual at the rate of 6 oz/A was applied and set prior to irrigation. Plots were watered on 18 October. The first harvest was made with Ed Ritchie's Ramsay Highlander Harvester on 3 December 2007; second and third cuts were made with Del Monte's Port-A-Way Harvester with a band saw on 1/23 and 2/18/08

Processing spinach plant population was significant with 12 lines and 700,000 and 580,000 seed/A were better than 470,000. The increased cost of seed was offset by the increased yield for 700,000 and 580,000. Pre-plant fertilizer was not significant with 12 lines meaning that 100 pounds of N/A pre-plant was sufficient; 150 pounds N/A yielded the same amount as 100 and 50 lbs N/A yielded less. Plant population was significant with 18 lines as with 12 lines and again pre-plant fertilizer was not significant. When analyzing the combined data for 12 and 18 lines, number of lines was not significant. On the other hand, plant population was significant as 700,000 seed per acre yielded 26 tons/A as opposed to 22 for 580,000. Combined data for 12 and 18 lines also showed that pre-plant fertilizer was not significant and 50 to 100 pounds of N per acre pre-plant was sufficient.

There was no difference in plant population with 12 lines for fresh market spinach; 470,000 yielded as much as the higher plant populations. There was also no difference in pre-plant nitrogen with 12 lines. However, there was a difference in plant population with 18 lines, but again no difference in pre-plant N with 18 lines. A combination of the data for 12 and 18 lines showed that there was a difference in the number of lines for fresh market spinach and 18 lines were better than 12 lines. On the other hand, there was no difference in the three plant population levels of 700,000, 580,000 and 470,000 meaning that the lower population should be used. Lastly, pre-plant nitrogen fertilizer did not matter meaning that less should be used.

[1] Professor and Extension Horticulturist, Texas AgriLife Research and Extension Center, Uvalde.
[2] Field Supervisor/Ag Research, Del Monte Foods, Crystal City, TX
[3] County Extension Agent-Ag, Zavala County

Deficit Irrigation and Plant Population Impact on Yield, Quality and Phytochemicals in Spinach

Daniel I. Leskovar, Giovanni Piccinni, Shinsuke Agehara, and Kil Sun Yoo[1]

Field studies were conducted to determine yield, leaf quality, vitamin C and carotenoid contents in response to deficit irrigation and plant population of processing spinach (*Spinacia oleracea* L. cv. DMC 66-16). Spinach seeds were planted at various plant populations, ranging from 497,000 to 1,307,000 seeds/ha (201,000 to 528,000 seeds/ac) Three irrigation regimes were imposed with either a Center pivot or low pressure drip system (LPS); 100, 75, and 50% crop evapotranspiration rates (ETc). Harvests were done on February 28 and March 1, 2006 in the Center pivot and the LPS, respectively. Total rainfall and irrigation received were 213, 170, and 132 mm in the Center pivot, and 295, 244, and 198 mm in the LPS, for 100, 75 and 50% ETc, respectively. Overall, seedling emergence was higher in the LPS compared to the Center pivot system. Under both systems, irrigation rate significantly affected marketable yield, yield components ($P \leq 0.05$) and phytochemical contents ($P \leq 0.10$). Conversely, plant population and its interaction with irrigation rate were not significant for most measured parameters.

Marketable yields increased with higher water inputs ($R^2=0.954$). Deficit irrigation at 50% ETc significantly reduced marketable yield by 53% and 17% in the Center pivot and LPS, respectively. However, water use efficiency was highest at 75% and 50% ETc in the Center pivot and the LPS, respectively. Excess petiole growth, a negative quality component for the processing canning industry, was significantly reduced at 50% ETc under both irrigation systems. Ascorbic acid, and the carotenoids β-carotene, lutein, and neoxanthin, consistently increased at 50% compared to 100% ETc rate under both irrigation systems. The overall increase in phytochemical contents in the Center pivot as compared to the LPS was probably a response to a greater water stress since this system received an average of 43% less water (rainfall+irrigation) with less irrigation frequency. In the LPS, 51 mm of water was saved by deficit irrigation at 75% ETc without a significant yield reduction. Regulated deficit irrigation is a strategy that may save water and improve phytochemicals in spinach.

[1] Texas AgriLife Research, Vegetable and Fruit Improvement Center, Department of Horticultural Sciences, Texas A&M University, 1619 Garner Field Rd., Uvalde, TX 78801, USA

Herbicide Choice and Tank-Mix Combinations Affect Crop Injury, Yield and Grower Revenues in Spinach

Russell W. Wallace[1], Alisa K. Petty[2] and Aaron L. Phillips[3]

Objective: To evaluate the effects of PRE and POST-applied herbicides on processing spinach (*Spinacia oleracea*) for weed control, crop injury and potential grower profitability.

Materials & Methods: The trial was conducted at the Del Monte Research Farm located in Crystal City on an Bookout clay loam soil with a pH of 7.6 and 1.1% organic matter. Spinach (var. "DMC 66-09") was planted November 5, 2007 on 80" beds in plots measuring 6.7' x 25'. Preemergence (PPI or PRE) and postemergence (POST) herbicides were applied using a CO_2-pressurized backpack sprayer. POST herbicides were applied at the spinach 2-leaf and 5-leaf stages. Crop injury, yield and herbicide costs were evaluated for each treatment. The test site was irrigated, using a linear system and insects and diseases controlled as needed. Spinach was harvested on January 17 and weighed for yield. The trial was conducted as a RCBD with 4 replications and all data were subjected to analysis of variance and means separated using Fisher's Protected LSD at the 0.05 level.

Results and Discussion: Weeds were generally not present within the trial site, and as a result observations could not be recorded. Spinach injury was defined as both overall crop stunting and leaf twisting in this trial (Table 2). Leaf twisting and malformation was apparent from applications of Stinger herbicide, while leaf burning was observed only with Spin-Aid. In this study, when applied alone, both Ro-Neet (Trt . 3) and Dual Magnum (Trt. 4) caused 15 – 19% early injury (stunting) on November 27. When applied together PPI or separately (Trt. 7 & 8), spinach injury increased slightly, but not significantly. Injury from Dual Magnum was reduced slightly when applied at half rates PRE and again at the 2-leaf stage (Trt. 5 & 6).

When Dual Magnum was applied in combination with Stinger (Trt. 9), injury was significantly greater than when either product was applied alone (Trt. 5 & 11). The greatest injury was observed when Spin-Aid was applied at the 2-leaf stage, regardless of whether it was applied alone or tank-mixed (Trt. 10, 13, 14, 19, 20). Injury was reduced significantly when Spin-Aid applications were delayed until the 5-leaf stage (Trt. 15 & 21), showing enhanced tolerance for older spinach. Combining SelectMax with Stinger for a single application generally did not increase crop stunting (Trt. 16, 17 & 18). When tank-mixed with Spin-Aid, crop injury was equivalent to similar treatments where Spin-Aid was applied alone (Trt. 14 & 19). Injury ratings on January 9 showed that the spinach crop in general was outgrowing the initial crop injury, though it was still apparent in treatments showing greater than 15% stunting (Table 2). Leaf twisting from applications of Stinger was significantly higher only when Stinger was tank-mixed with Dual Magnum (Trt. 9), SelectMax (Trt. 18), or Spin-Aid (Trt. 20 & 21), and growers would be advised not to tank-mix Stinger with any other products. Applications of Stinger applied at both the 2-leaf and 5-leaf stages also increased leaf twisting (Trt. 12).

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[1] Extension Vegetable & Weed Specialist and Research Technician, Texas AgriLife Research & Extension Center, Lubbock
[2] Production Manager, Del Monte Foods, Crystal City, TX
[3] Field Supervisor/Ag Research, Del Monte Foods, Crystal City, TX

Spinach yields (Table 2) ranged from 4.6 tons/A (Trt. 14) to 9.7 tons/A (Trt. 2). In general, where Dual Magnum was applied PRE at the 10.9 oz rate (not including any Spin-Aid treatments), there was a minimum of an 8% yield reduction, similar to previous years. However, when Spin-Aid was included POST, yields were reduced an average 38% compared to the handweeded control (Trt. 2). Overall assessment indicates that Stinger is safe to spinach, though leaf twisting may occur as times. Caution should be used with Spin-Aid applications. Stinger applied alone may reduce overall yield, and it should not be tank-mixed with any other herbicide for POST applications in processing spinach.

Total costs of individual weed control and herbicide programs (including an estimated spraying cost of \$6/A) indicate that treatments cost anywhere from \$0/A up to \$177/A based on individual herbicides selected and number of applications (Table 2). As mentioned previously, there were very few weeds present within the test site during 2007, and weeds did not compete with the spinach crop. As a result, the cheapest program was the untreated control, and revenue after subtracting seed expenses was \$599/A. It is unlikely that growers would go without herbicides in conventional plantings; therefore these results are not typical. Additionally, handweeding costs were estimated at \$85/A, and based on overall yield, revenues in that treatment were \$523/A.

Where herbicides were applied, preemergence programs cost anywhere from \$23/A (Dual Magnum alone) to \$64/A (Ro-Neet PPI + Dual Magnum PRE). In addition to the \$23 cost of application, Dual Magnum also caused a 2 ton yield loss further reducing revenues by \$170 (compare Trt. 2 and Trt. 4). While Ro-Neet alone cost \$41/A to apply (Trt. 3) and there was no yield loss, experience with this product indicates that weed control is considerably less than that of Dual Magnum and therefore, there is a higher potential for additional handweeding costs with Ro-Neet alone. Applying Dual Magnum as a split application of 5.5 oz/A PRE followed by an application at the spinach 2-leaf stage increased costs from \$23 to \$32/A; however, there was no yield drag or loss when compared to the handweed control. Additionally, when only Dual Magnum was applied, splitting the treatment reduced yield drag by %16 and resulted in a net increase of revenues by \$125/A (compare Trt. 4 and Trt. 5). Combining Ro-Neet with Dual Magnum (Trts. 7 & 8) did not result in further yield drag compared to Dual Magnum alone (Trt. 4), but increased costs up to \$64/A. The combined applications may be somewhat more expensive, but may also improve control of selected weeds (including fumitory) resulting in less handweeding costs.

Applying POST treatments of Stinger added \$37/A for each full rate (0.5 pint) application, or \$22/A for each half rate (0.25 pint). In addition to herbicide and application costs, Stinger applied once at the full rate (0.5 pint) resulted in a 20% yield reduction (compare Trt. 4 and Trt. 11), causing a further revenue loss of \$173/A based on spinach tonnage. However, when Stinger was applied twice at the low rate (0.25 pint) at a cost of \$44/A, there was no yield loss (compare Trt. 4 and Trt. 12). This indicates that splitting the rate of Stinger and applying it twice (even though it cost up front an additional \$6/A for the extra application) resulted in less crop stunting and revenue savings.

Where Spin-Aid was applied POST following Dual Magnum PRE applications, there was an additional weed control cost of $65/A (at the 3.0 pint rate). Spin-Aid caused significant leaf burn in this test and resulted in an average 1.9 ton yield loss, decreasing revenue by $274/A (compare Trt. 4 to the average of Trts. 13, 14, 15 and 19). Not only is it an expensive treatment to apply, the risk of significant crop injury and yield loss suggests using extreme caution when applying this product in processing spinach. Applying SelectMax ($26/A total cost) POST alone for grass control did not reduce spinach yield, nor did it further reduce yields in any treatment where it was tank-mixed with either Stinger or Spin-Aid.

Overall, there was a negative cost to using both PRE and POST herbicides in processing spinach. This indicates that spinach crops are very sensitive to herbicide applications, thus making research, development and registration of new products extremely difficult. Negative costs were not only attributed to the actual cost of the chemical and application, but to the reduced yields where herbicides were applied. Compared to the handweeded control, using Dual Magnum alone reduced revenues by 19%, and using Ro-Neet had no revenue losses. But again, under grower field conditions Ro-Neet may not provide sufficient and long-term control with high handweeding costs a possibility. In addition to Dual Magnum, applying Stinger with or without SelectMax further reduced revenues an additional 11%. Spin-Aid reduced revenues even further, an additional 40%. Further research will continue to evaluate the effects of Dual Magnum as a split application when combined with other POST or PRE applied herbicides.

Table 2. Effect of herbicide treatments and timings on crop injury, leaf twisting, yield, herbicide program costs and final profit/A in processing spinach in the Texas Wintergarden.

Trt. #	Treatment *	Product Rate/A	Timing	Injury 11/27	Injury 01/09	Leaf Twisting	Yield	Total cost of the individual herbicide program*	Revenue/A following herbicide & seed expenses
				-------- % ---------		12/20	Tons/A	---- $/A ----	--- $/A ---
1	Untreated			0 h	0 k	0 d	9.1 abc	0	599 a
2	Handweed			0 h	0 k	0 d	9.7 a	85	523 a-c
3	Ro-Neet 6E	4.5 pints	PPI	19 def	4 ijk	0 d	9.3 ab	41	582 ab
4	Dual Magnum 7.62E	10.9 oz	PRE	15 d-g	5 h-k	0.3 d	7.7 b-e	23	457 a-d
5	Dual Magnum + Dual Magnum + NIS ($3/A)	5.5 oz 5.5 oz 0.25% v/v	PRE 2-leaf 2-leaf	13 fg	4 ijk	0 d	9.2 abc	32	582 ab
6	Dual Magnum + Dual Magnum + SelectMax 0.97EC + NIS	5.5 oz 5.5 oz 16.0 oz 0.25% v/v	PRE 2-leaf 2-leaf 2-leaf	8 gh	3 jk	0 d	8.8 abc	49	525 a-c
7	Ro-Neet + Dual Magnum	4.5 pints 10.9 oz	PPI PPI	23 de	1 jk	0 d	7.5 c-f	58	410 c-f
8	Ro-Neet + Dual Magnum	4.5 pints 10.9 oz	PPI PRE	24 d	8 g-j	0.3 d	7.7 bcd	64	421 c-f
9	Ro-Neet + Dual Magnum + Stinger 3EC	4.5 pints 10.9 oz 0.5 pint	PPI 2-leaf 2-leaf	43 a-c	24 abc	1.9 a	5.3 gh	95	181 gh
10	Ro-Neet + Dual Magnum + Spin-Aid 1.3EC	4.5 pints 10.9 oz 3.0 pints	PPI 2-leaf 2-leaf	50 a	26 a	0 d	5.9 e-h	123	211 gh
11	Dual Magnum + Stinger	10.9 oz 0.5 pint	PRE 2-leaf	19 def	14 d-g	1 c	6.1 d-h	60	284 e-g
12	Dual Magnum + Stinger + Stinger	10.9 oz 0.25 pint 0.25 pint	PRE 2-leaf 5-leaf	14 efg	11 fgh	1.1 bc	7.6 c-f	66	433 b-e
13	Dual Magnum + Spin-Aid	10.9 oz 3.0 pints	PRE 2-leaf	45 ab	13 efg	0.1 d	5.7 gh	88	224 gh
14	Dual Magnum + Spin-Aid + Spin-Aid	10.9 oz 3.0 pints 3.0 pints	PRE 2-leaf 5-leaf	43 a-c	26 a	0 d	4.6 h	153	94 h
15	Dual Magnum + Spin-Aid	10.9 oz 6.0 pints	PRE 5-leaf	13 fg	19 b-e	0.1 d	6.9 d-g	147	265 fg
16	Dual Magnum + SelectMax + NIS	10.9 oz 16.0 oz 0.25% v/v	PRE 5-leaf 5-leaf	15 d-g	3 jk	0 d	9.5 a	49	584 ab
17	Dual Magnum + Stinger + SelectMax + NIS	10.9 oz 0.25 pint 9.0 oz 0.25% v/v	PRE 2-leaf 2-leaf 2-leaf	9 gh	4 ijk	0.3 d	8.7 abc	58	509 a-c

Table 2. Effect of herbicide treatments and timings on crop injury, leaf twisting, yield, herbicide program costs and final profit/A in processing spinach in the Texas Wintergarden (continued).

Trt. #	Treatment	Product Rate/A	Timing	Injury 11/27	Injury 01/09	Leaf Twisting	Yield	Total cost of the individual herbicide program*	Revenue/A following herbicide & seed expenses
				-------- %	---------	12/20	Tons/A	---- $/A-----	--- $/A ---
18	Dual Magnum +	10.9 oz	PRE						
	Stinger +	0.5 pint	2-leaf						
	SelectMax +	16.0 oz	2-leaf						
	NIS	0.25% v/v	2-leaf	19 def	10 ghi	1.5 ab	7.6 b-e	80	396 c-f
19	Dual Magnum +	10.9 oz	PRE						
	Spin-Aid +	3.0 pints	2-leaf						
	SelectMax +	0.25 pint	2-leaf						
	NIS	0.25% v/v	2-leaf						
	Spin-Aid +	3.0 pints	5-leaf						
	SelectMax +	0.25 pint	5-leaf						
	NIS	0.25% v/v	5-leaf	34 c	20 a-d	0.3 d	5.9 fgh	177	150 gh
20	Dual Magnum +	10.9 oz	PRE						
	Spin-Aid +	3.0 pints	2-leaf						
	Stinger	0.25 pint	2-leaf	40 bc	18 c-f	1.1 bc	6.8 d-g	104	306 d-g
21	Dual Magnum +	10.9 oz	PRE						
	Spin-Aid +	6.0 pints	5-leaf						
	Stinger	0.5 pint	5-leaf	11 fg	25 ab	1.8 a	6.1 d-h	166	185 gh

* Note: Weed control program costs based on the following estimates: Ro-Neet ($35/A); Dual Magnum ($17/A); SelectMax ($17/A); Stinger ($31/A at 0.5 pint); Spin-Aid ($59/A at 3 pints); NIS ($3/A); Handweeding ($85/A); Sprayer costs ($6/A for each application); Seed costs at $0.31/1000 for 550,000 seeds/A ($170/A); Spinach price ($85/ton). All other production variables are considered to be equal among all treatments and were not deducted; therefore overall profits are expected to be lower than those estimated.

Efficacy of Soil and Foliar Applied Pesticides on White Rust

Aaron Phillips[1], Larry Stein[2], and Marcel Valdez[3]

Objective: To evaluate the effects of fungicides and endogenous defense products applied alone or as part of a rotational disease management program for control of white rust (*Albugo occidentalis*).

Materials & Methods: The trial was conducted at the Del Monte Ag Research Farm located northeast of Crystal City, TX on FM 1025. The soil was a clay loam (35% clay) with an average pH of 7.7 and 3.9% organic matter. Fertilizer was applied and disked in prior to planting at 80, 100, 0, 5, 7, 4 and 25 lbs./A for nitrogen, phosphorus, potassium, magnesium, zinc, manganese, and sulfur, respectively. Nitrogen was applied a second time at 50 lbs/A in early December.

A white rust susceptible variety was planted October 21, 2007 using a standard gravity-feed spinach seeder at commercial spacing (1.2" for a finished stand of 263,000 per acre) and depth. Spinach seed was double-row planted onto previously formed beds centered at 40-inches with a 15-inch distance between seeded rows.

Each plot measured 13.33 ft x 40 ft with four beds for a total of 8 rows of spinach. All plots received 10 lb/ac of Ridomil Gold (Mefenoxam) in furrow at planting with the exception of Treatment Number(s): 1,3,4,6, & 19. Immediately following planting, Dual Herbicide (s-Metolachlor) was applied at a rate of .67 pt/ac to provide weed control during the duration of the study.

Plots were planted utilizing a randomized complete block design (RCBD) with 20 treatments replicated 4 times. All standard crop management and pest control measures were utilized as needed during the growing season. Immediately following planting and herbicide application the trial area was irrigated with 1' of water.

Applications were made on 7 day intervals beginning with the first application made on December 7, 2007. Alternating chemistries were applied the following week, on December 14. This pattern was maintained throughout the course of the study with treatments applied on the 21st and 28th of December, 2007. The crop was cut and dumped on January 13, 2008. Following a period of crop re-growth, applications were resumed on February 8, followed by February 13, 20, and 27, 2008. Ratings were conducted independently by L. Stein and A. Phillips on February 29 and March 5, 2008. Each plot was indexed for severity of infection by white rust.

Results and Discussion: White rust control was good to excellent with Reason at 8 fl oz + Induce (Trt. 17) and also with Cabrio at 12 oz alternated with Kocide 3000 at 1 lb/ac (Trt 16). Presidio fungicide performed well in several of the total nine entries that it was a part of; the best being 4 fl oz of Presidio at planting plus the commercial standard of 12 oz Quadris alternated

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with Kocide 3000 at 1lb (Trt. 6). Presidio at 4 oz alternated with 1lb of Kocide 3000 (Trt. 8) did not perform statistically better than Presidio at 3 oz alternated with Kocide 3000 at 1 lb (Trt. 7). Similarly 10 lb of Ridomil Gold only applied at planting (Trt. 2) and 4 fl oz of Presidio only applied at planting (Trt. 3) were not significantly better than the untreated check (Trt. 1). This reinforces the need for a well constructed rotational program. Endogenous defense products such as Kendal at 1 pt/ac (Trt. 20) were added to this year's study to evaluate the effectiveness of natural plant immune system materials against an aggressive disease such as *Albugo occidentalis*. Kendal plus 10 lb of Ridomil Gold at planting was in the top 50% of all treatments evaluated. Oxidate (Trt. 19), an organically approved fungicide at 10% v/v, performed poorly.

Rating results are listed in the two tables below.

First Rating Taken 2/29/08

Treatment	Rep I	Rep II	Rep III	Rep IV	Average
1. Check	9	7	8	8	8
2. Ridomil Gold only	7	7	8	8	7.5
3. Presidio only	7	8	8	7	7.5
4. Presidio only	6	6	7	8	6.75
5. Standard - Quadris 12 oz/A alt. w/Kocide 3000 1 lb/A	5	6	5	6	5.5
6. Presidio plus Std. - Quadris 12 oz/A alt. w/Kocide 3000 1 lb/A	3	4	4	3	3.5
7. Presidio 3 oz/A alt. w/Kocide 3000 1 lb/A	3	4	4	3	3.5
8. Presidio 4 oz/A alt. w/Kocide 3000 1 lb/A	2	3	4	3	3
9. Presidio 3 oz/A alt. w/Quadris 12 oz/A	4	5	4	5	4.5
10. Presidio 4 oz/A alt. w/Quadris 12 oz/A	3	3	5	5	4
11. Presidio 3 oz/A + Kocide 3000 1 lb/A alt. w/Kocide 3000 1 lb/A	5	3	5	7	5
12. Presidio 4 oz/A + Kocide 3000 1 lb/A alt. w/Kocide 3000 1 lb/A	6	4	6	7	5.75
13. Presidio 3 oz/A + Kocide 3000 1 lb/A alt. w/Quadris 12 oz/A	6	5	5	6	5.5
14. Presidio 4 oz/A + Kocide 3000 1 lb/A alt. w/Quadris 12 oz/A	4	5	5	3	4.25
15. Quadris 12 oz/A alt. Ridomil Gold Copper 2.5 lbs/A	4	6	6	4	5
16. Cabrio 12 oz/A alt. Kocide 3000 1 lb/A	3	3	3	2	2.75
17. Reason 8 fl oz/A + Induce 8 fl oz/A	2	3	3	2	2.5
18. Ridomil Gold Copper 2.5 lbs/A alt. w/Quadris 12 oz/A	5	4	5	7	5.25
19. Oxidate 10% volume solution	8	7	8	8	7.75
20. Kendal 1 pt/Ac	5	3	5	6	4.75

Second Rating Taken 3/5/08

Treatment	Rep I	Rep II	Rep III	Rep IV	Average
1. Check	8	8	8	8	8
2. Ridomil Gold only	8	8	8	8	8
3. Presidio only	7	8	8	7	7.5
4. Presidio only	7	8	8	8	7.75
5. Standard - Quadris 12 oz/A alt. w/Kocide 3000 1 lb/A	6	7	5	5	5.75
6. Presidio plus Std. - Quadris 12 oz/A alt. w/Kocide 3000 1 lb/A	6	5	5	3	4.75
7. Presidio 3 oz/A alt. w/Kocide 3000 1 lb/A	5	4	6	4	4.75
8. Presidio 4 oz/A alt. w/Kocide 3000 1 lb/A	4	5	7	4	5
9. Presidio 3 oz/A alt. w/Quadris 12 oz/A	6	6	4	6	5.5
10. Presidio 4 oz/A alt. w/Quadris 12 oz/A	6	6	6	6	6
11. Presidio 3 oz/A + Kocide 3000 1 lb/A alt. w/Kocide 3000 1 lb/A	7	4	7	7	6.25
12. Presidio 4 oz/A + Kocide 3000 1 lb/A alt. w/Kocide 3000 1 lb/A	8	6	7	8	7.25
13. Presidio 3 oz/A + Kocide 3000 1 lb/A alt. w/Quadris 12 oz/A	7	6	6	6	6.25
14. Presidio 4 oz/A + Kocide 3000 1 lb/A alt. w/Quadris 12 oz/A	7	7	7	4	6.25
15. Quadris 12 oz/A alt. Ridomil Gold Copper 2.5 lbs/A	7	7	7	5	6.5
16. Cabrio 12 oz/A alt. Kocide 3000 1 lb/A	3	7	4	3	4.25
17. Reason 8 fl oz/A + Induce 8 fl oz/A	2	5	4	2	3.25
18. Ridomil Gold Copper 2.5 lbs/A alt. w/Quadris 12 oz/A	5	6	6	7	6
19. Oxidate 10% volume solution	8	8	8	8	8
20. Kendal 1 pt/Ac	7	5	7	7	6.5

Food Safety Gaps Initiative for the Spinach Industry

Marcel Valdez[1], Juan Anciso[2], Jaime Lopez[3], Omar Gonzales[4], Larry Stein[5], Joe Taylor[6], Richard Griffin[7], Rolando Zamora[8], Omar Montemayor[9], and Barbara Storz[10]

With the California e-coli tainted spinach outbreak in September of 2006, the California leafy greens industry has initiated a Good Agricultural Practices (GAPs) requirement for the industry to regain consumer confidence in leafy greens. This document has been used by the retail industry as a standard for all growers in the United States growing these high risk crops. These crops include leafy greens (all lettuce, spinach, arrugala, dandelion), green onions, herbs (parsley, cilantro, basil), tomatoes, and cantaloupes. While GAPs practices have existed for years, this document has added documentation and thresholds (metrics) for water quality, documentation/land metrics for animal encroachment (cattle, hogs, goats, sheep, and deer) and manure based amendments and sprays. Water data was collected from 30 fields in District 12 to develop a data base and provide documentation for 3rd party GAPs certification. The goal is for those producers participating in the water testing demonstrations to become 3rd party GAPs certified producers. Currently, very few producers are GAPs certified and this effort would increase this adoption and they in turn can convey their experience to other producers so they can also become GAPs certified. This program is intended to create a behavior change in the producer and adaptation and implementation of a new practice which is the U.S.D.A. Best Management Practice (GAPS).

County Extension Agents in 8 counties in the Winter Garden and Rio Grande Valley areas of Texas have identified 30 fields to conduct water quality demonstrations. These fields produce high contamination risk commodities such as spinach, green onions, herbs, tomatoes, cantaloupes and a variety of leafy greens. Irrigation water applied to these crops comes from wells in the Edwards and Carrizo Wilcox aquifers as well as the Rio Grande and Nueces Rivers. Water Samples collected consisted of 3 samples per field from surface water irrigation applications (first irrigation, mid-season, and close to harvest). For deep wells the sample size was 1 sample per field (before planting) unless the threshold levels exceed 575 generic E. coli/100mls from drip irrigation water applications or 235 generic E. coli/100mls if furrow or sprinkler applications. The results of these water sources has been entered and a data base of irrigation water quality has been started and will continue to expand as more water samples are collected analyzed and entered in the data base.

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Another big part of the GAP's certification process is food safety. Eating fresh produce has contributed to a $36.2 billion increase in food sales from 1987 to 1997. Despite these benefits, the Center for Disease Control (CDC) reported that the proportion of food borne disease outbreaks in produce has doubled from 1973-1987 and again from 1988-1991. Many factors can contribute to microbial contamination throughout the fresh produce process but water quality and unsafe handling of fresh fruits and vegetables have been identified as two (2) important steps where implementation of educational practices would impact and help decrease the risk of contamination of these products.

Preharvest Management of Spinach: Potential Implications for Microbial Food Safety

Eduardo Gutierrez-Rodriguez, Heiner Lieth, Marita Cantwell, and Trevor Suslow[1]

The environmental conditions, edaphic factors, adjacent landscape influences, and specific crop management practices may significantly impact rhizosphere and phyllosphere populations, quantitatively and qualitatively. Similarly, these factors will influence plant growth and development as well as aspects of cellular, tissue, and organ morphology. Current agronomic practices in California spinach cultivation, particularly for the dominant acreage devoted to 'baby-leaf' salads, depend on precise and consistent pest management practices, irrigation management and nutrient supply. There is a tendency towards excess nitrogen fertilization and frequent watering during the summer months. Inorganic forms of nitrogen and nitrogen availability determine the nutritional composition and overall quality of crops, including spinach. We have been characterizing the impact of these practices under different production conditions on leaf morphology and nutritional quality. In addition, studies have been initiated to evaluate the interaction of these differential morphological traits and qualities on *E. coli* O157:H7 survival and colonization on spinach leaves, following transfer from a contamination source. Hydroponically grown spinach (cv Whale, Bolero, Shasta and Avenger) were cultivated with three different nitrogen regimes and harvested before dawn after 30-35 days of cultivation. In addition, field grown spinach from the Salinas valley from these cultivars and cv Emilia and Blackhawk were subjected to similar evaluations. A summary of results from research conducted to date follows.

Plant Growth and Development

Greenhouse grown spinach cultivated under three different nitrogen regimes under normal PAR (1250 $\mu mol/m^2 s$) were observed to have reproducible and significant morphological differences among nitrogen treatments. Spinach leaf morphology was evaluated after harvest on leaves 6 and 12. Excess nitrogen fertilization at both leaf stages produces thicker leaves with increased intercellular spaces which could be measurably contrasted as spongy mesophyll thickness, larger and fewer numbers of cells in the palisade and increase in total leaf area. With decreasing PAR (up to 80% of normal light conditions), leaf thickness (palisade and mesophyll thickness for both leaf stages) was reduced. The interaction of PAR and nitrogen fertilization had marginal influence on leaf morphology. Differences associated with cultivars were also observed. Significant differences in leaf thickness, palisade thickness and number of cells in the palisade were observed between cultivars Whale, Shasta and Bolero when cultivated with identical nitrogen regimes (125ppm Total nitrogen (80:20 ratio nitrate to ammonium). Significant differences were also observed in the total cell wall content and cell wall composition between nitrogen treatments. Higher cell wall content was observed for low nitrogen regimes and these cell walls posses higher concentrations of pectins than hemicellulose when compared to the excess nitrogen treatment.

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Field grown spinach presented similar morphological characteristics to those observed for the highest nitrogen regime under greenhouse conditions. However, differences in thickness between the palisade and spongy mesophyll were not observed. Spinach cultivated in the greenhouse and in conventional spinach fields were determined to have a very similar stomata incidence per unit leaf area. As expected, younger leaves had significantly higher number of stomates per 100µm than older leaves. Leaf thickness, spongy mesophyll and palisade thickness decrease and number of cells in the palisade increased with younger leaves for greenhouse and field grown spinach.

The leaf texture profile of spinach expressed as leaf toughness was measured using a punch test with a texture analyzer. Comparative values were calculated from the force displacement curve generated. Excess nitrogen fertilization for greenhouse grown spinach reduces leaf toughness at both leaf stages. Younger leaves were tougher than older leaves. Between cultivars, leaf toughness was significantly influenced by nitrogen fertilization and PAR intensity. All cultivars at similar nitrogen concentrations presented identical leaf texture profiles and differences were only observed between leaf 6 and 12. Spinach plants cultivated at low PAR intensities were less tough than those plants cultivated under normal PAR intensities. Leaf toughness was also significantly influenced by the total cell wall content. Leaves with higher cell wall content were tougher than leaves with lower cell wall content.

Nutritional Quality and Safety

The nutritional composition and agronomic traits of these plants at harvest were significantly impacted by the soilless culture conditions of the study. The overall N rate affected the concentration of nitrate and oxalate in the leaves, resulting in levels unsafe for human consumption at the highest N rates. Nitrate and oxalate concentrations were as high as 8500 ppm and 40 mg/g DW, respectively. Oxalic acid concentrations increased as total nitrogen supply increased. High nitrogen nutrition produced yields of over 50 g per plant while plants from low N treatment were limited to an average of 24 g/plant. High nitrogen supply did not significantly increase iron and vitamin C concentrations in spinach leaves, under test conditions, but total chlorophyll and carotenoids marginally increased with increased N supply. Total sugars were higher for low nitrogen regimes and sucrose, the principal sugar present in spinach leaves at different leaf stages. Overall no net improvement in spinach nutritional quality was obtained by increasing nitrogen fertilization in hydroponic culture despite increasing yields almost two fold.

Microbial Food Safety

Postharvest inoculations: The potential for *E. coli* O157:H7 to survive, grow, and internalize on postharvest inoculated leaves was evaluated. Leaves from greenhouse and field cultivated spinach were used in the evaluations. Inoculations of *E. coli* O157:H7 were carried out on leaves 6 and 12 after harvest from greenhouse grown spinach and for leaves 1-2 and 3-4 for field grown. These leaves were kept fully turgid for no more than three days before inoculations were performed. Initial inoculum concentration was Log 2-2.4 CFU/leaf. Leaves were inoculated up to ¾ in length from the tip by immersion for 30s. Careful attention was placed to prevent single drop accumulation of the inoculum before placing the leaves in storage for 6 days at 15C and 95% relative humidity. Spot inoculations were also used in our evaluations. Spinach leaves from greenhouse trials under three different nitrogen regimes (as described above) presented significantly different morphological characteristics and nutritional composition. Our observations, to date, indicate no significant difference in total *E. coli* O157:H7 colonization and survival between nitrogen regimes. Populations in these leaves reached concentrations of up to log 5 CFU/leaf. No significant differences in *E. coli* O157:H7 colonization and survival were observed between cultivars. There was on average a 1.5 log CFU/leaf lower level of bacterial recovery between plants cultivated at low PAR intensities than those cultivated under normal light conditions. With regard to leaf stage, cultivar Whale and Bolero followed similar trends under normal light conditions. Higher concentrations of *E. coli* O157:H7 were recovered from leaf stage 6 than from leaf stage 12. No significant differences were observed between leaf stages with the Shasta cultivar. From our experimental results it is evident that irrespective of nitrogen fertilization, light intensity and cultivar *E. coli* O157:H7 is able to proliferate potentially when they are present in the surface at low initial inoculum concentrations. At this time, no evidence for a correlation between leaf morphological differences due to nitrogen fertilization and significant internalization by *E. coli* O157:H7 has been observed. Detailed analysis of spatial distribution and internalization potential by *E. coli* O157:H7 during preharvest stages remains to be completed.

Food Safety Research on Fresh Greens Crops in Oklahoma

Lynn Brandenberger, William McGlynn, Emilia Cuesta-Alonso, Jessica Ong, Lynda Carrier[1]

All studies were conducted at the Oklahoma State University Vegetable Research station in Bixby, Oklahoma. Studies during spring 2007 showed some promise regarding successful inoculation of test plots with generic E. coli and the subsequent contamination of leaf tissue of a leafy brassica greens crop. As with many field studies, a number of confounding issues arose that gave mixed results. First, record rainfall resulted in flooding between plots and the movement of soil and bacteria from inoculated plots to non-inoculated plots in the study. Second, the spent mushroom compost that was utilized as a carrier for plot inoculations carried a fairly large population of background microorganisms, which may have made it more difficult for the inoculated E. coli to survive. It's also possible that the compost possessed other anti-bacterial properties. A follow-up study completed in the fall of 2007 utilized fresh, unused livestock bedding as the carrier for plot inoculations. Results from that study indicated a successful transfer of E. coli from the livestock bedding to the soil, but the bedding which was comprised of wood shavings appeared to cause serious stand losses of spinach seedlings in all plots. Studies during the spring and fall of 2008 were carried out to determine if indeed the livestock bedding was the cause of stand loss in the spinach and to determine if different inoculation methods could be used to simplify research methods and improve conditions for the growth of crops under investigation. Results from the spring 2008 study indicated that while livestock bedding was effective as an inoculation media, there were again serious crop stand reductions as a result of using it. The fall 2008 studies are focused on exploring different means of inoculating plots with E. coli. In the fall 2008 study, plots were arranged in a randomized block design with four replications, each plot consisting of 8 rows of spinach on 6 inch row centers, rows being 20 feet long. The study included three treatments inoculated with generic E. coli and a non-inoculated control. Treatments are described in Table 1 and consisted of plots treated with inoculated livestock bedding-tilled-planted, plots sprayed with inoculum-tilled-planted, and plots tilled-planted-sprayed with inoculum. The study was initiated on 10/02/08 with treatment applications and seeding of spinach. Plots were direct seeded to the spinach variety Padre at a seeding rate of approximately 1.1 million seeds/acre (non-inoculated plots first followed by inoculated plots). Following planting and inoculation with E. coli the entire test area received 0.65 lb ai/acre of Dual Magnum (S-metolachlor) followed by approximately 0.5 inch of irrigation from overhead irrigation. Soil samples were collected and tested for levels of E. coli on 10/02/08, 10/07/08, and 10/13/08. Field samples were collected then transferred to the laboratory in an ice-chest with ice. Samples were processed the following day with coliform counts recorded on each of the four sample dates.

Results and discussion: Coliform counts from soil samples on the first sampling date were negligible for the non-inoculated control and 18,836, 86,099, and 2,455, respectively, for the livestock bedding-tilled-plant, spray-tilled-plant, and the tilled-plant-spray treatments (Table 2). The non-inoculated control and the tilled-plant-spray treatment had negligible soil coliforms on 10/7/08 and 10/13/08. Counts of soil samples for the livestock bedding-tilled-plant and

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spray-tilled-plant treatments, respectively, were 91,201 and 45,446 on 10/7/08 and 17,783 and 218,776 CFU/gram on 10/14/08. Although the study is still ongoing, there are three outcomes that are becoming evident. First, inoculating plots by spraying inoculum on the soil surface after planting (tilled-plant-spray treatment) is not an effective inoculation procedure. Second, inoculating plots by spraying inoculum on the soil surface and immediately tilling appears to be as effective as using livestock bedding as the inoculation media. The ability to directly apply inoculum as a spray to study plots will provide a more efficient means of conducting studies and will simplify the inoculation procedures. Third, crop stands of spinach appear less affected by the current treatment that includes livestock bedding than previous studies and other treatments without it are unaffected. This is likely due to a reduced amount of bedding being used (spring utilized 50 lbs. of livestock bedding/plot vs. 18 lbs. in fall). These studies will continue into the fall-early winter with soil sampling and additional sampling of spinach leaf tissue as the crop becomes established.

Table 1. Food safety study on spinach, Treatment descriptions, fall 2008.

Application method for field plots	**Inoculum media**	**Original inoculum[z] diluted in**
Non-inoculated	NA	NA
Livestock bedding-tilled[x]-plant	Wood shavings sprayed[y] with inoculum & mixed in cement mixer	1 gal H_2O
Sprayed- tilled-plant	Water	1 gal H_2O
Tilled-plant-sprayed	Water	1 gal H_2O

[z]Original inoculum consisted of 250 ml of liquid culture at ~ 10^9 cfu/ml of generic E. coli
[y]Spray method included use of 2 gal. hand-pump sprayer with one flat-fan spray nozzle
[x]Soil was tilled with 4.5 ft. wide tractor mounted rototiller at a depth of 3-4 inches

Table 2. Food safety study on spinach, Number of Coliform Bacteria Detected on soil, Bixby, OK, fall 2008

	Soil CFU/gram soil					
Treatment	**10/2/08**		**10/7/08**		**10/13/08**	
Non inoculated Control	10	c[z]	10	b	10	c
Livestock bedding-tilled-plant	18,836	ab	91,201	a	17,783	b
Spray-tilled-plant	86,099	a	45,446	a	218,776	a
Tilled-plant-spray	2,455	b	10	b	10	c

[z] Numbers in a column followed by the same letter exhibited no significant differences based on Duncan's Multiple Range Test where P=0.05.

Electronic Pasteurization of Lettuce and Spinach to Eliminate Pathogens

Suresh D. Pillai, Ph.D.[1]

Agricultural exports from the US to Mexico increased from approximately $ 2.5 billion in 1991 to approximately $8.5 billion in 2004. Similarly, agricultural imports from Mexico to the United States increased from around $2.8 billion to $7.25 billion in 2004. The microbiological safety of produce grown in the United States and Mexico are a concern in both countries. The food borne outbreaks in the United States associated with imported vegetable produce from Mexico are a concern to the USDA, FDA and the CDC. Similarly, the exposure of microbial pathogens in foods in Mexico is a concern to the Mexican public health agencies. Agricultural produce can get contaminated in the field, during packing, during transportation, and or at retail. Whether the agricultural produce is consumed in the United States or Mexico, it is imperative that efforts should be made to improve the microbiological quality. Though there have been overall improvements in the microbiological quality of produce due to the adoption of Good Agricultural Practices (GAP) in the US and Mexico, disease outbreaks associated with fresh produce is a serious issue. New technologies need to be developed to address this issue. Electronic pasteurization using E-Beam and X-ray technologies are commercially available technologies. Studies have shown that harmful pathogens such as *Salmonella* and *E.coli* O157:H7 can be eliminated from fresh produce by using ionizing irradiation. The Food and Drug Administration (FDA) has recently approved the use of ionizing irradiation up to 4 kGy to eliminate harmful pathogens from spinach and fresh iceberg lettuce. This presentation will discuss the underlying technology, the current state of the science and associated technologies, and the commercial feasibility of adopting this technology by the fresh produce industry.

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The Use of Lactic Acid Bacteria as A Post – Harvest Intervention to Control *Escherichia coli* O157:H7 in Fresh Spinach

Sara Gragg[1]

In recent years, fresh spinach has been identified as a vehicle for *Escherichia coli* (*E. coli*) O157:H7 transmission. Multiple studies have demonstrated the ability of lactic acid producing bacteria (LAB) to reduce the presence of *Escherichia coli* O157:H7 in food products and the efficacy of LAB cultures as a post – harvest intervention in fresh spinach production were evaluated. To determine the effect of spinach inoculated with *Escherichia coli* O157:H7, spinach samples were rinsed with sterile distilled water and a four – strain LAB cocktail at a target concentration of 2.0×10^8 CFU/mL. Both treatments were compared to an inoculated control over a 24 – hour time period at 7^{o}C. According to composite LS means data obtained for each treatment, water and LAB resulted in significant reductions of 0.88 logs ($p<0.0001$) and 1.03 logs ($p<0.0001$) in comparison to the control, respectively. The improved reduction of LAB was significantly better than that of water ($p=0.0363$), making it the most effective treatment.

A triangle test was conducted to determine if a statistically significant difference in sensory characteristics exists when LAB is applied to fresh spinach. Two samples were rinsed with tap water and considered to be identical. The remaining sample was rinsed with LAB at a concentration of 2.0×10^8 CFU/mL. 40 panelists participated in the test and 16 correctly identified the LAB – treated spinach as being the one unique sample. These results indicate that a statistically significant difference does not exist ($\alpha=0.05$, 0.01) when LAB is applied to fresh spinach and that the use of LAB may be acceptable from a consumer acceptance standpoint.

The ability of LAB to control *E. coli* O157:H7 populations in combination with the industry standard chlorine rinse was determined in a 12 day shelf – life study at 7^{o}C. The multi – hurdle intervention was evaluated in comparison to water, LAB and chlorine rinses. LAB cultures were applied at a concentration of 2.0×10^8 CFU/mL, while chlorine was utilized at the 200 ppm level. As indicated by composite LS means data, significant reductions in comparison to control populations were achieved by the LAB ($p=0.0215$), chlorine ($p=0.0002$) and multi – hurdle treatments ($p<0.0001$). However, the multi – hurdle treatment produced the greatest reductions with 1.35 logs. This reduction was significantly improved upon LAB ($p=0.0012$) and chlorine ($p=0.0815$), indicating that the application of chlorine and LAB is most effective as a combination treatment.

[1] Texas Tech University

In Vitro Iron Bioavailability of Selected Spinach Genotypes

H.G. Dodson[1] and T.E. Morelock[2]

In order to improve iron levels and iron bioavailability of spinach (*Spinacia olerace*) by classical breeding methods, total iron levels and iron bioavailability must be determined in common genotypes. The 15 genotypes of spinach selected for study were from the University of Arkansas breeding program and commercial sources. The spinach samples were grown at the University of Arkansas Vegetable Substation, Kibler, AR and the Del Monte research farm near Crystal City, Texas. The University of Arkansas Soil Testing Laboratory performed total iron analysis on spinach samples using an emission spectrophotometric method. The *in vitro* iron bioavailability protocol used was modified from a study by Rangarajan and Kelly (1998). There was significant variation between spinach genotypes based on percent dialyzable ferrous iron (D-Fe (II)), which is considered the most comparable value to bioavailable iron. The spinach genotype 'F415' had a dialyzable ferrous iron (D- Fe (II)) content that was significantly higher than the other genotypes. The results from this study need to be confirmed by measuring bioavailable iron of these genotypes of spinach using other methods.

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Verticillium Wilt On Spinach And Seed Transmission

Jim Correll, Lindsey du Toit, Maria Villarroel-Zeballos and Chunda Feng[1]

Verticillium dahliae has recently been demonstrated to be a pathogen of spinach during seed production as plants remain symptomless until bolting has been initiated (conversion from vegetative to reproductive growth). Efforts over the past 4 years have focused on several objectives including (1) characterizing Verticillium recovered from commercial spinach seed lots and USDA germplasm; (2) developing a greenhouse disease screening procedure; (3) evaluating a set of USDA spinach germplasm for Verticillium resistance; (4) examining the impact of spinach seed infested with *V. dahliae* on the infection process; and (5) the impact of infested seed on inoculum potential in soils. Examination of the vegetative compatibility groups (VCGs) of 159 isolates of *V. dahliae* obtained from symptomatic spinach plants or from spinach seed produced in the U.S. or the E.U. indicated that the isolates belonged to two distinct VCGs, VCG 2B and 4B. Isolates of both VCG 2B and 4B obtained from spinach were pathogenic when inoculated onto spinach plants. A subset of isolates was examined for ITS and IGS sequence variation, and a *Verticillium dahliae* specific sequence (DB). There was little variation in ITS sequences among the isolates in both VCG 2B and VCG 4B; however, several atypical isolates from spinach were identified as either *V. nigrescens* or *V. tricorpus* based on ITS sequences. Variation was observed in both IGS and DB sequences and distinct haplotypes could be discriminated. The resistance screening results showed that plants inoculated with *V. dahliae* typically senesced faster and had significantly reduced biomass compared to non-inoculated plants of the same genotype. No qualitative resistance was identified among the germplasm tested but some genotypes showed higher levels of quantitative resistance than other lines, as measured by severity of Verticillium wilt symptoms and biomass of inoculated vs. non-inoculated plants. However, screening for resistance to Verticillium wilt was confounded by the fact that some seed lots of the USDA germplasm lines proved to be infected/infested with *V. dahliae*, *V. tricorpus*, and *V. nigrescens*. Examination of the infection process has indicated that seed infested with *V. dahliae* can result in root tip infections and root mortality.

Recent publications:

Tomlinson, A., Correll, J. C., and du Toit, L. J. 2004. Genetic and molecular characterization of Verticillium from spinach. Texas A&M National Spinach Conference (December15-18). San Antonio, TX.

Villarroel-Zeballos, M. I., Tomlinson, A. N., Correll, J. C., and du Toit, L. J. 2005. Genetic characterization of Verticillium from spinach. National Spinach Conference. (November 16-17) Fayetteville, AR.

Villarroel, M. I., du Toit, L. J., and Correll, J. C. 2006. Genetic and molecular characterization of *Verticillium dahliae*. International Spinach Meeting (August). Mt. Vernon, WA.

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[1] University of Arkansas and Washington State University

Villarroel, M. I., du Toit, L. J., and Correll, J. C. 2006. Genetic and molecular characterization of *Verticillium dahliae* from spinach and screening for disease resistance. Phytopathology 96: S118.

Villarroel-Zeballos, M. I., du Toit, L. J., and Correll, J. C. 2008. Screening for disease resistance to *Verticillium dahliae* in spinach. Phytopathology 98 :S163.

Efficacy of Organic and Conventional Fungicides for Management of *Verticillium dahliae* and *Stemphylium botryosum* on Spinach Seed

Lindsey J. du Toit, Emily Gatch, Mike L. Derie, Louise M. Brissey, and Barbara J. Holmes[1]

A seed lot of a proprietary spinach hybrid naturally infected with *Verticillium dahliae* and *Stemphylium botryosum* (causal agents of Verticillium wilt and Stemphylium leaf spot of spinach, respectively), was used to evaluate 9 conventional and 11 organic seed treatments for control of these seedborne pathogens. Seed treated with colorant served as the control treatment. A seed germination assay and a freeze-blotter seed health assay were each completed using four replications of 100 seeds per treatment. In the germination assay, 70% of non-treated seeds had germinated by 7 days vs. 74% by 14 days. None of the seed treatments significantly reduced or increased germination at 7 days or 14 days compared to non-treated seed, except Experimental II, a proprietary organic treatment that reduced germination by an average of 12% (to 58% at 7 days and 62% at 14 days).

In the freeze-blotter seed health assay, *V. dahliae* was observed on 63.5% of non-treated seed. Seven treatments reduced the incidence of *V. dahliae* to <10%, the current threshold for exporting spinach seed to Mexico. The most effective treatments were the conventional fungicides Topsin M 70 WP (thiophanate-methyl) (0% *V. dahliae*), Mertect 340F (thiabendazole) applied alone (0.3%) or with Farmore D300 (mefenoxam + fludioxonil + azoxystrobin) (0%), and BAS 595 XG F (triticonazole) (2.0%). Three proprietary organic treatments not currently registered for spinach seed treatment in the U.S. were also highly effective against *V. dahliae*: Seedgard (a steam treatment from ThermoGard in the E.U.) (2.8%), Seed Support II (3.3%), and Seed Support I (7.0%). Seed treatments with intermediate efficacy against *V. dahliae* included Thiram 42-S (thiram) (17.8%), Captan 400C (captan) (25.0%), Experimental II (organic disinfectant + *Trichoderma harzianum* T22) (25.3%), Incotec II (proprietary organic treatment) (30.3%), ACX803 (proprietary organic treatment) (30.8%), Incotec I (proprietary organic treatment) (32.5%), Experimental I (organic disinfectant) (32.5%), ACX804 (proprietary organic treatment) (37.0%), and Coronet (boscalid + pyraclostrobin) (41.5%). Some treatments effectively limited *V. dahliae* and/or *S. botryosum* from developing on the outer pericarp of spinach seed, but the fungi were observed developing on the embryo at the split end of the pericarp (where the radicle emerges) or the funiculus (original site of attachment of the seed to the plant), illustrating the systemic nature of infection of spinach seed from the mother plant via the vascular system.

S. botryosum was observed on 35.5% of non-treated seed, and 10 treatments reduced this to <10%. The most effective organic treatments were Seed Support I and II (0 and 0.3%, respectively), SeedGard (0.5%), Incotec I and II (4.3 and 5.0%, respectively), and ACX804 (5.5%). The most effective conventional fungicides against *S. botryosum* were Coronet (0.8%), Farmore D300 + Mertect 340F (1.8%), Thiram 42-S (2.8%), and Captan 400C (9.0%). Mertect

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340F alone and Topsin M 70 WP had no effect on *S. botryosum* (35.5 and 50.3%, respectively), but were two of the most effective treatments against *V. dahliae*. This highlights the need to combine modes of action in spinach seed treatments for management of both *V. dahliae* and *S. botryosum*. In addition, the ideal spinach seed treatment should protect against downy mildew (*Peronospora farinosa* f. sp. *spinaciae*) and soilborne inoculum of damping-off pathogens such as *Pythium* spp., *Rhizoctonia* spp., and *Fusarium* spp.

Research is in progress to assess the extent to which these seed treatments reduce seed transmission of *V. dahliae* as well as the level of soil infestation by this vascular wilt pathogen. The latter is increasingly significant given recent research that suggests the potential for strains of *V. dahliae* from spinach seed to infect some crops commonly grown in rotation with spinach (e.g., lettuce). Overall, the results demonstrate the very strong efficacy of several conventional and organic seed treatments against seedborne *V. dahliae* and/or *S. botryosum*. However, few of these treatments are currently registered for use on spinach seed in the U.S. Seedgard could be approved for registration very rapidly because this steam treatment produces no chemical residues, but should be combined with conventional and/or organic fungicide(s) to protect emerging spinach seedlings against soilborne pathogens.

A Treatment for Spinach Seed With Efficacy Against Seed And Soil-Borne Fungal Pathogens, In Particular *Verticillium dahliae*

Graham Kinsey[1]

Abstract

A development program has been conducted to generate a new commercial treatment for spinach seed. The focus has been to address the occurrence of *Verticillium dahliae* on spinach seed as well as other seed-borne fungal pathogens. The treatment is suitable for organic use. Diagnostic test data is presented for a range of seedlots. The data shows that levels of fungal infection differ widely between seedlots, and that several pathogens may be present on individual seeds. The efficacy of a new treatment is evaluated in terms of reduction of on-seed *V. dahliae*. The new process has been designed to be effective against even the highest levels of *V. dahliae* infection. Excellent efficacy against other pathogens such as *Cladosporium variabile* and *Fusarium oxysporum* is also demonstrated. The treatment is also effective against soil-borne pathogens such as *Pythium ultimum* as well as pathogens which are both seed and soil-borne such as *F. oxysporum*. Seed safety has been a primary consideration. Data is presented which shows that treated seed retains germination and moreover, shows an enhanced speed of emergence.

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[1] Germains Technology Group

New Uses for Oversized Spinach Leaves as a Fresh Product

H.G. Dodson[1], M.E. Fitch-Hilgenberg[2] and T.E. Morelock[3]

Consumers have become accustom to spinach leaves becoming smaller in almost all spinach products that are eaten as the fresh product. Some spinach genotypes can produce very large individual leaves when allowed to grow to a more mature stage and some individual leaves can reach lengths of 18 inches or more. These large leaves offer many options for use with various specialty food products whether as wraps with the large flat leaves or as individual bowls from the large savoy and semi savoy leaves. This could also create a demand for new specialty products that could be provided by smaller growers. This would be very high value products because of the need to hand harvest and to handle the spinach leaves individually. This presentation will discuss, in detail, possible food products and some of the cultivation practices of large leaf spinach

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Update On Spinach Downy Mildew Efforts In Arkansas And California

Jim Correll[1], Steve Koike[2], Chunda Feng[2], and Teddy Morelock[1]

Downy mildew, caused by the pathogen *Peronospora farinosa* f. sp. *spinaciae,* continues to be a major disease problem on commercial fresh market spinach production throughout the world. Ten races of the downy mildew pathogen have been described. To distinguish downy mildew races, a set of 10 international differential spinach cultivars are inoculated and the race is identified based on which cultivars are susceptible. The prevalence of races, and the appearance of new strains are monitored by collecting field isolates throughout the year and examining the disease reactions of these when inoculated onto the differential spinach lines. Novel isolates are examined in more detail to determine which resistance sources are being overcome by the novel strain.

To more effectively communicate global information about downy mildew on spinach and facilitate screening and characterization of resistance, the International Working Group Peronospora committee on spinach (IWGP) was formed several years ago to establish criteria for determining if it was justified to give novel strains of the pathogen a formal race designation. These criteria help promote a sound scientific understanding of the variation in the pathogen as well as prevent the somewhat arbitrary designation of strains that may not persist or significantly impact the spinach industry.

Surveys of downy mildew isolates were conducted in California in 2008 to determine which races predominate. In July-August of 2008, outbreaks of downy mildew appeared in California on several cultivars that previously had been resistant. Because of this development, efforts were initiated in California and Arkansas to characterize the new strains of the downy mildew pathogen. The data indicated that initial isolates received were either novel or a mixture of novel and previously described races. A new strain of the downy mildew pathogen, designated UA2708PL, was unique and represents a strain which can overcome several sources of resistance. A number of lines, particularly older lines such as Lion (which contains the resistance locus *Pfs-1* and is resistant to races 1-7, 9) and Califlay (which contains the resistance locus *Pfs-3* and is resistant to races 1, 3, 5, 8, 9) were resistant to strain UA2708PL. Field observations of downy mildew were similar to those results observed in greenhouse tests among the spinach genotypes evaluated.

The general consensus of the committee as of November 2008 is that strain UA2708PL should not be given a formal race designation at the current time. However, the committee will revisit this issue in the near future for further discussion and consideration.

Comments or questions can be addressed to Jim Correll (jcorrell@uark.edu) or Steve Koike (stkoike@ucdavis.edu).

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[1] University of Arkansas
[2] University of California Cooperative Extension

Recent Publications:

Irish, B, Correll, J. C., Koike, S. T., Morelock, T. E. 2007. Identification and cultivar reactions to races 8, 9, and 10 of the spinach downy mildew pathogen (Peronospora farinosa. f. sp. spinaciae) in the United States and Europe. Plant Disease 91:1392-1396.

Tomlinson, A. N., Correll, J. C., Koike, S. T., Kammeijer, K. 2007. First report of race 8 of downy mildew, caused by Peronospora farinosa f. sp. spinaciae, of spinach in the United States. Plant Disease 91:1205.

Irish, B. M., Correll, J. C., Feng, C., Bentley, T., and de los Reyes, B. G. 2008. Characterization of a resistance locus (Pfs-1) to the spinach downy mildew pathogen (Peronospora farinose f. sp. spinaciae) and the development of a molecular marker linked to Pfs-1. Phytopathology 98:98:894-900.

Recent Book Chapters:

Correll, J. C., Feng, C., Irish, B. M., Koike, S. T., Morelock, T. E. and Bentley, T. C. 2007. Spinach downy mildew: overview of races and the development of molecular markers linked to major resistance genes. Advances in downy mildew research: 3:135-142. A. Lebeda and P.T.N. Spencer-Phillips (Eds). Palacky University Press.Czech Republic

Morelock, T. E., and Correll, J. C. 2008. Spinach Breeding. Pp. 183-212. In:J Prohens and F. Nuez (eds.), Vegetables I, Springer, New York.

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Fresh Market Spinach Plant Population Study

Janco Farm - Jimmy Crawford

Planted 10/01/08, Dual 10 oz/A set with 0.25" on 10/01/08, 1 1/2 inches applied 10/02/08

Field planted to Viceroy

752,000 seed/A; Gaspardo planter (20-30) 21 16 setting
746,000 final plant population on
12 lines per bed

Pivot

3	3	3
2	2	2
1	1	1
3	3	3
2	2	2
1	1	1
3	3	3
2	2	2
1	1	1
3	3	3
2	2	2
1	1	1 {100 feet per rep}
Samish	Viceroy	P.V. 7131

3 plant populations:

1 = 537,654 seed/A	Gaspardo planter (20-30)	21	21 setting
2 = 752,000 seed/A	Gaspardo planter (20-30)	21	16 setting
3 = 940,896 seed/A	Gaspardo planter (15-15)	15	19 setting

Processing Spinach Plant Population Study

Home Farm - Jimmy Crawford

Planted 10/09/08, Dual 10 oz/A set with 0.25" on 10/09/08, 1 1/2 inches applied on 10/10/08.

Field planted to DMC 16; 12 lines/bed

6 plant populations
1 = 470,448 Gaspardo planter (20-30) 15 17 setting
2 = 537,600 Gaspardo planter (20-30) 21 21 setting
3 = 625,000 Gaspardo planter (20-30 or 10-20) 21 20 setting
4 = 684,288 Gaspardo planer (20-30) 21 17 setting
5 = 855,360 Gaspardo planter (20-20) 15 19 setting
6 = 940,896 Gaspardo planter (20-20) 15 17 setting

6	6	6												
5	5	5												
4	4	4												
3	3	3												
2	2	2												
1	1	1												
6	6	6												
5	5	5												
4	4	4												
3	3	3												
2	2	2												
1	1	1												
6	6	6												
5	5	5												
4	4	4												
3	3	3												
2	2	2												
1 DMC 07	1 DMC 16	1 88-154												
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Pivot

FM 140

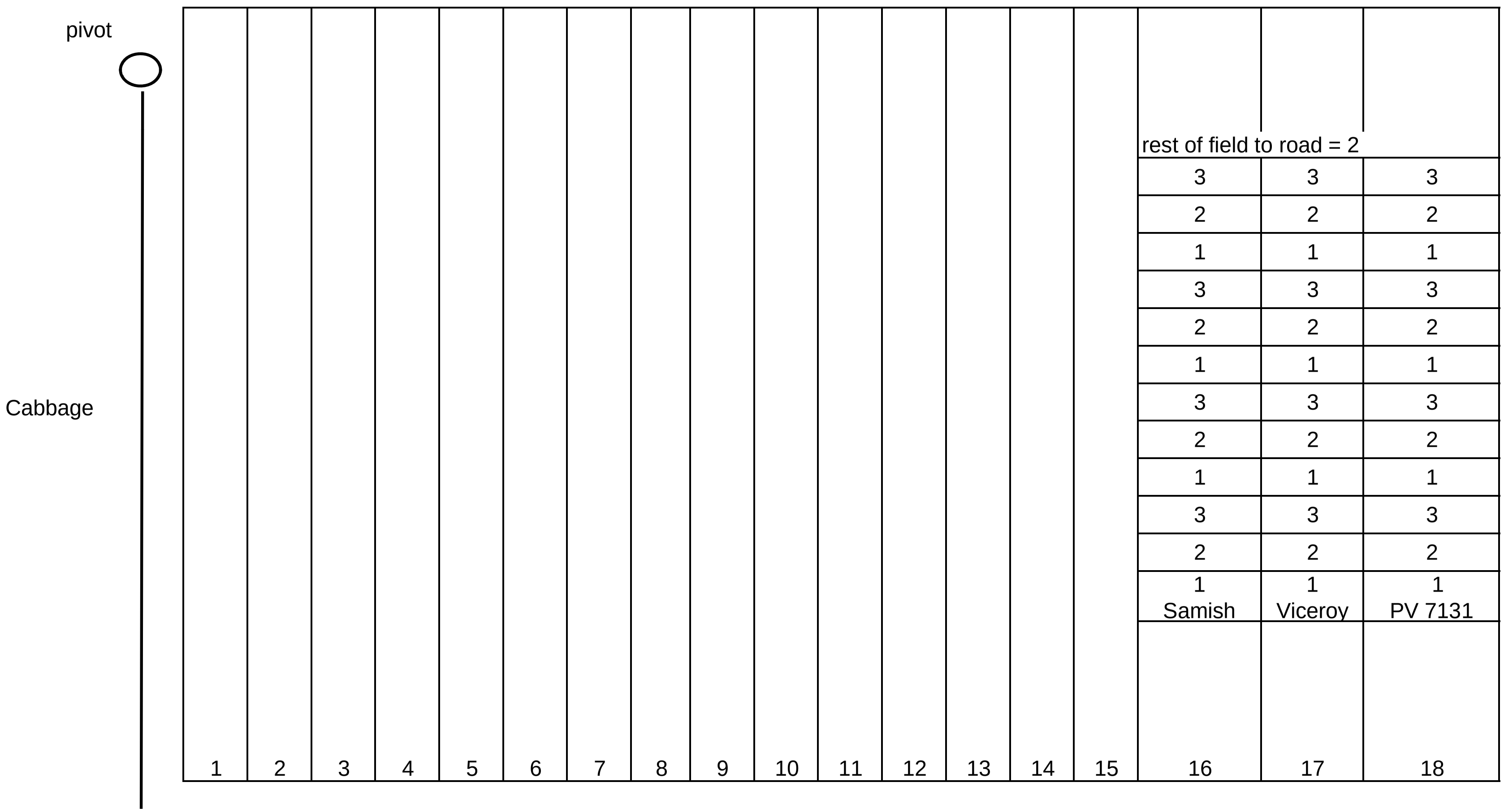
Fresh Market Spinach Plant Population

Carnes Farm - Jimmy Crawford

Planted 10/09/08, Dual 10 oz/A set with 0.25" on 10/09/08, 1 ½ inches applied 10/10/08.

Field planted to Viceroy, Gaspardo planter (20-30) 21 20 setting = 588,060 seed/A
Final plant population = 647,000 plants/A
12 lines/bed

3 plant populations
1 = 537,654
2 = 752,000
3 = 940,896



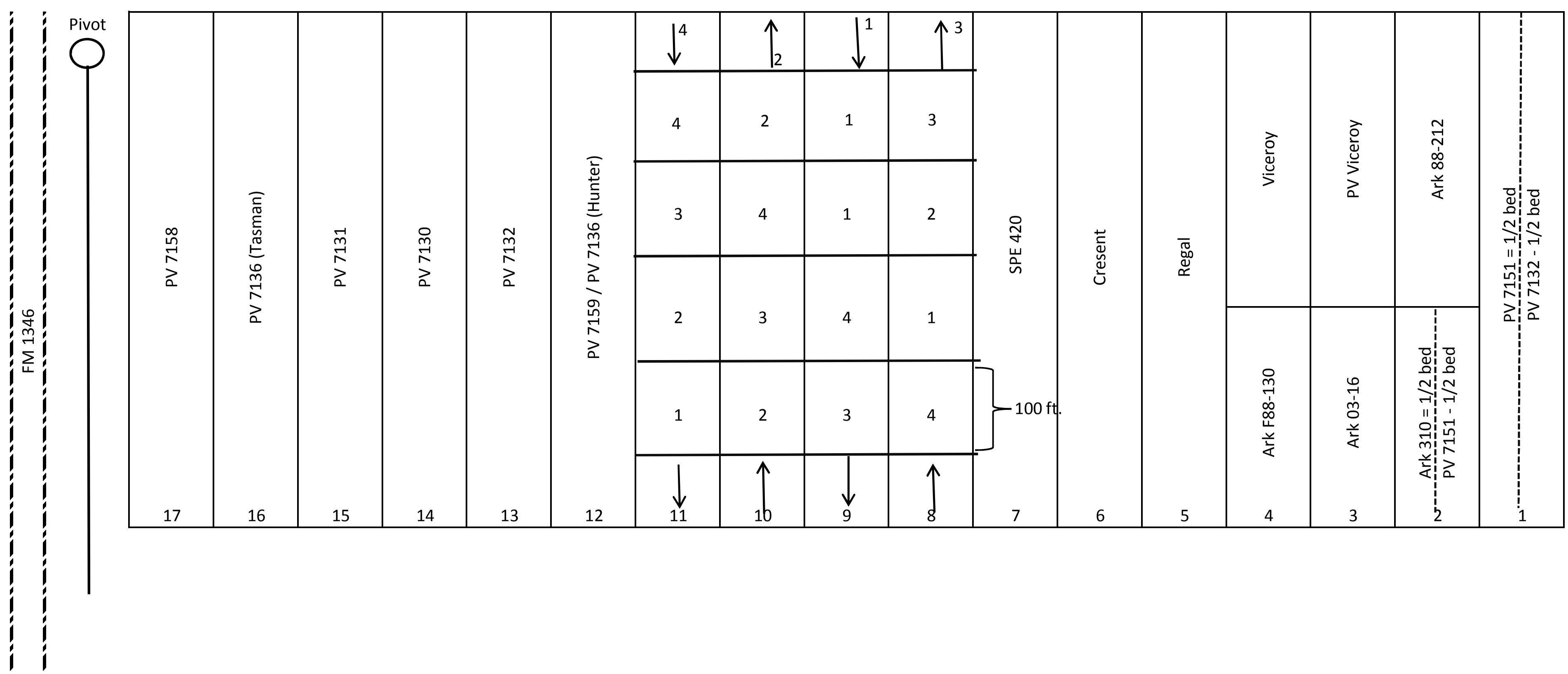
Fresh Market Spinach Plant Population and Variety Trial

Tiro Tres Farms – La Pryor

Planted 10/27/08, 8 oz Dual, watered 10/27/08.
Field planted the Viceroy, 18 lines bed, 717,433 seed/A
Stanahay Air planter

Beds 8 – 11 = Plant Population study (Viceroy)
1 = 470,448 seed/A
2 = 588,060 seed/A
3 = 717,433 seed/A
4 = 846,806 seed/A

La Pryor



Fresh Market Spinach Plant Population

Ehler Farm - Jimmy Crawford

Planted 10/28/08, Variety = Viceroy, Dual 8 oz/A set with 0.25" on 10/29/08, field watered on 10/30/08.
Gaspardo planter (20-30) 21 16 setting = 752,000 seed/A.

3 plant populations
1 = 537,654
2 = 752,000
3 = 940,896

pivot

rest of field = 3

3	3	3	3	3	3
2	2	2	2	2	2
1	1	1	1	1	1
3	3	3	3	3	3
2	2	2	2	2	2
1	1	1	1	1	1
3	3	3	3	3	3
2	2	2	2	2	2
1	1	1	1	1	1
3	3	3	3	3	3
2	2	2	2	2	2
1 PV 7130	1 Samish	1 PV 7131	1 PV 7136	1 PV Viceroy	1 PV 7158

100 feet per rep

trial = 60 beds from pivot center

Kennedy Gravel Road

	2008-2009 Spinach Fungicide Trial	
	Treatment	**In Furrow Treatment Prior to Planting**
1	Untreated Check	None
2	Serenade ASO 1 qt + Quadris 6 oz/A	
3	Serenade ASO 2 qt + Quadris 6 oz/A	
4	Quadris 12 oz/A	
5	Prophyt 2 qts + Serenade ASO 2 qts/A	
6	Presidio 4 oz + Kocide 3000 1 lb/A alt. with Quadris 12 oz/A	
7	Presidio 3 oz alt. with Quadris 12 oz/A	
8	Presidio 4 oz alt. with Quadris 12 oz/A	
9	Presidio 3 oz alt. with Kocide 3000 1 lb/A	
10	Presidio 4 oz alt. with Kocide 3000 1 lb/A	
11	Ranman 2.75 fl. oz. + 2 oz. Silwet-77 alt. with Quadris 12 oz/A	
12	Ridomil Gold 10 lbs/A at planting only	
13	Quadris 12 oz/A alt. with Ridomil Gold Copper 2.5 lbs/A	
14	Cabrio 12 oz/A alt. with Kocide 3000 1 lb/A	
15	Reason 8 fl. oz/A + Induce 8 fl. oz/A	
16	Ridomil Gold Copper 2.5 lbs/A alt. with Quadris 12 oz/A	
17	Picoxystrobin	
18	Ranman 2.75 fl. oz. + 2 oz Silwet-77	
19	Ranman 5.5 fl oz. + 5 oz Silwet-77	
20	Polyoxin-D 6.2 oz/A	

Herbicide Evaluations for Weed Control, Crop Injury and Yield in Processing Spinach

Russell W. Wallace & Alisa K. Petty

Texas AgriLife Extension & Texas AgriLife Research - Lubbock

The trial is being conducted at the Del Monte Research Farm located in Crystal City on a Bookout clay loam soil with a pH of 7.6 and 1.1% organic matter. Spinach (var. "DMC 66-09") was planted November 4, 2008 on 80" beds in plots measuring 6.7' x 25'. Preemergence (PPI or PRE) and postemergence (POST) herbicides were applied using a CO_2-pressurized backpack sprayer. POST herbicides were applied at the spinach 1 to 2-leaf and 5-leaf stages. Crop injury, yield and herbicide costs will be evaluated for each treatment. The test site was irrigated, using a linear system and insects and diseases controlled as needed. Spinach will be harvested and weighed for yield.

Spinach Herbicide Screen Trial

Trt #	Treatment	Product Rate/A	Timing	Notes
1	*Untreated*			
2	*Handweed*			
3	*Ro-Neet 6E*	4.5 pints	PPI	
4	*Dual Magnum 7.62E*	10.9 oz	PRE	
5	*Dual Magnum +* *Dual Magnum +* *NIS*	5.5 oz 5.5 oz 0.25% v/v	PRE 2-leaf 2-leaf	
6	*Dual Magnum +* *Dual Magnum +* *SelectMax +* *NIS*	5.5 oz 5.5 oz 16.0 oz 0.25% v/v	PRE 2-leaf 2-leaf 2-leaf	
7	*Ro-Neet +* *Dual Magnum*	4.5 pints 10.9 oz	PPI PPI	
8	*Ro-Neet +* *Dual Magnum*	4.5 pints 10.9 oz	PPI PRE	
9	*Ro-Neet +* *Dual Magnum +* *Stinger 3EC*	4.5 pints 10.9 oz 0.5 pint	PPI 2-leaf 2-leaf	
10	*Ro-Neet +* *Dual Magnum +* *Spin-Aid*	4.5 pints 10.9 oz 3.0 pints	PPI 2-leaf 2-leaf	
11	*Dual Magnum +* *Stinger*	10.9 oz 0.5 pint	PRE 2-leaf	
12	*Dual Magnum +* *Stinger +* *Stinger*	10.9 oz 0.25 pint 0.25 pint	PRE 2-leaf 5-leaf	
13	*Dual Magnum +* *Spin-Aid 1.3EC*	10.9 oz 3.0 pints	PRE 2-leaf	
14	*Dual Magnum +* *Spin-Aid 1.3EC +* *Spin-Aid*	10.9 oz 3.0 pints 3.0 pints	PRE 2-leaf 5-leaf	
15	*Dual Magnum +* *Spin-Aid 1.3EC*	10.9 oz 6.0 pints	PRE 5-leaf	

16	*Dual Magnum +*	10.9 oz	PRE
	SelectMax +	16.0 oz	5-leaf
	NIS	0.25% v/v	5-leaf
17	*Dual Magnum +*	10.9 oz	PRE
	Stinger +	0.25 pint	2-leaf
	SelectMax 0.97EC +	9.0 oz	2-leaf
	NIS	0.25% v/v	2-leaf
18	*Dual Magnum +*	10.9 oz	PRE
	Stinger +	0.5 pint	2-leaf
	SelectMax +	16.0 oz	2-leaf
	NIS	0.25% v/v	2-leaf
19	*Dual Magnum +*	10.9 oz	PRE
	Spin-Aid 1.3EC +	3.0 pints	2-leaf
	SelectMax +	0.25 pint	2-leaf
	NIS	0.25% v/v	2-leaf
	Spin-Aid +	3.0 pints	5-leaf
	SelectMax +	0.25 pint	5-leaf
	NIS	0.25% v/v	5-leaf
20	*Dual Magnum +*	10.9 oz	PRE
	Spin-Aid +	3.0 pints	2-leaf
	Stinger	0.25 pint	2-leaf
21	*Dual Magnum +*	10.9 oz	PRE
	Spin-Aid +	6.0 pints	5-leaf
	Stinger	0.5 pint	5-leaf

Linuron Herbicide Screen

Trt #	Treatment	Product Rate/A	Timing	Notes
1	*Untreated*			
2	*Handweed*			
3	*Ro-Neet 6E*	4.5 pints	PPI	
4	*Dual Magnum 7.62E*	10.9 oz	PRE	
5	*Lorox 50DF*	0.2 lbs	PRE	
6	*Lorox*	0.4 lbs	PRE	
7	*Lorox*	0.8 lbs	PRE	
8	*Ro-Neet +*	4.5 pints	PPI	
	Lorox	0.2 lbs	PRE	
9	*Ro-Neet +*	4.5 pints	PPI	
	Lorox	0.4 lbs	PRE	
10	*Ro-Neet +*	4.5 pints	PPI	
	Lorox	0.8 lbs	PRE	
11	*Dual-Magnum +*	10.9 oz	PRE	
	Lorox	0.2 lbs	PRE	
12	*Dual-Magnum +*	10.9 oz	PRE	
	Lorox	0.4 lbs	PRE	
13	*Dual-Magnum +*	10.9 oz	PRE	
	Lorox	0.8 lbs	PRE	
14	*Ro-Neet +*	4.5 pints	PPI	
	Dual Magnum +	10.9 oz	PRE	
	Lorox	0.4 lbs	PRE	

UNIVERSITY OF ARK. WHITE RUST NURSERY

PLANTED 10/11/2008

EMERGED 10/18/08

P	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	A
O	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	13	B	14	L
P	127	B	128	B	173	B	174	B	215	B	216	B	136	B	138	B	180	B	181	B	226	B	228	B	146	B	147	B	187	B	188	B	B	B	1	B	6	B	7	B	12	B	15	F
	126	B	129	B	172	B	175	B	213	B	219	B	135	B	139	B	179	B	182	B	225	B	229	B	145	B	148	B	186	B	189	B	234	B	2	B	5	B	8	B	11	B	16	
V	125	B	130	B	171	B	176	B	212	B	221	B	133	B	140	B	178	B	183	B	224	B	230	B	143	B	149	B	185	B	190	B	232	B	3	B	4	B	9	B	10	B	17	L
R	123	B	131	B	170	B	177	B	210	B	223	B	131	B	141	B	177	B	184	B	223	B	231	B	141	B	150	B	184	B	191	B	231	B	4	B	3	B	10	B	9	B	18	A
I	120	B	133	B	169	B	178	B	209	B	224	B	130	B	143	B	176	B	185	B	221	B	232	B	140	B	151	B	183	B	192	B	230	B	5	B	2	B	11	B	8	B	19	T
E	119	B	135	B	168	B	179	B	208	B	225	B	129	B	145	B	175	B	186	B	219	B	234	B	139	B	152	B	182	B	193	B	229	B	6	B	1	B	12	B	7	B	20	E
N	117	B	136	B	167	B	180	B	207	B	226	B	128	B	146	B	174	B	187	B	216	B	101	B	138	B	153	B	181	B	194	B	228	B	7	B	34	B	13	B	6	B	21	
D	116	B	138	B	166	B	181	B	206	B	228	B	127	B	147	B	173	B	188	B	215	B	102	B	136	B	154	B	180	B	195	B	226	B	8	B	33	B	14	B	5	B	22	
	115	B	139	B	165	B	182	B	205	B	229	B	126	B	148	B	172	B	189	B	213	B	103	B	135	B	156	B	179	B	196	B	225	B	9	B	32	B	15	B	4	B	23	R
R	114	B	140	B	164	B	183	B	204	B	230	B	125	B	149	B	171	B	190	B	212	B	104	B	133	B	157	B	178	B	197	B	224	B	10	B	31	B	16	B	3	B	24	U
U	112	B	141	B	163	B	184	B	203	B	231	B	123	B	150	B	170	B	191	B	210	B	107	B	131	B	158	B	177	B	198	B	223	B	11	B	30	B	17	B	2	B	25	S
S	111	B	143	B	162	B	185	B	202	B	232	B	120	B	151	B	169	B	192	B	209	B	108	B	130	B	159	B	176	B	199	B	221	B	12	B	29	B	18	B	1	B	26	T
T	110	B	145	B	161	B	186	B	201	B	234	B	119	B	152	B	168	B	193	B	208	B	109	B	129	B	160	B	175	B	200	B	219	B	13	B	28	B	19	B	34	B	27	
	109	B	146	B	160	B	187	B	200	B	101	B	117	B	153	B	167	B	194	B	207	B	110	B	128	B	161	B	174	B	201	B	216	B	14	B	27	B	20	B	33	B	28	N
N	108	B	147	B	159	B	188	B	199	B	102	B	116	B	154	B	166	B	195	B	206	B	111	B	127	B	162	B	173	B	202	B	215	B	15	B	26	B	21	B	32	B	29	U
U	107	B	148	B	158	B	189	B	198	B	103	B	115	B	156	B	165	B	196	B	205	B	112	B	126	B	163	B	172	B	203	B	213	B	16	B	25	B	22	B	31	B	30	R
R	104	B	149	B	157	B	190	B	197	B	104	B	114	B	157	B	164	B	197	B	204	B	114	B	125	B	164	B	171	B	204	B	212	B	17	B	24	B	23	B	30	B	31	S
S	103	B	150	B	156	B	191	B	196	B	107	B	112	B	158	B	163	B	198	B	203	B	115	B	123	B	165	B	170	B	205	B	210	B	18	B	23	B	24	B	29	B	32	E
E	102	B	151	B	154	B	192	B	195	B	108	B	111	B	159	B	162	B	199	B	202	B	116	B	120	B	166	B	169	B	206	B	209	B	19	B	22	B	25	B	28	B	33	R
R	101	B	152	B	153	B	193	B	194	B	109	B	110	B	160	B	161	B	200	B	201	B	117	B	119	B	167	B	168	B	207	B	208	B	20	B	21	B	26	B	27	B	34	Y
Y	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	

CENTER ROAD

→ North

UNIV. OF ARK / DMC OPEN NURSERY

2008-2009

PLANTED 10-11-2008

			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
Arkansas 101	101								
Arkansas 102	102								
Arkansas 103	103								
Arkansas 104	104								
Arkansas 107	107								
Arkansas 108	108								
Arkansas 109	109								
Arkansas 110	110								
Arkansas 111	111								
Arkansas 112	112								
Arkansas 114	114								
Arkansas 115	115								
Arkansas 116	116								
Arkansas 117	117								
Arkansas 119	119								
Arkansas 120	120								
Arkansas 123	123								
Arkansas 124	124								
Arkansas 125	125								
Arkansas 126	126								
Arkansas 127	127								
Arkansas 128	128								
Arkansas 129	129								
Arkansas 130	130								
Arkansas 131	131								
Arkansas 133	133								
Arkansas 135	135								
Arkansas 136	136								
Arkansas 138	138								
Arkansas 139	139								
Arkansas 140	140								
Arkansas 141	141								
Arkansas 143	143								
Arkansas 145	145								
Arkansas 146	146								
Arkansas 147	147								
Arkansas 148	148								
Arkansas 149	149								
Arkansas 150	150								
Arkansas 151	151								
Arkansas 152	152								
Arkansas 153	153								
Arkansas 154	154								
Arkansas 156	156								
Arkansas 157	157								

		UNIV. OF ARK / DMC OPEN NURSERY						
			2008-2009					
			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
Arkansas 158	158								
Arkansas 159	159								
Arkansas 160	160								
Arkansas 161	161								
Arkansas 162	162								
Arkansas 163	163								
Arkansas 164	164								
Arkansas 165	165								
Arkansas 166	166								
Arkansas 167	167								
Arkansas 168	168								
Arkansas 169	169								
Arkansas 170	170								
Arkansas 171	171								
Arkansas 172	172								
Arkansas 173	173								
Arkansas 174	174								
Arkansas 175	175								
Arkansas 176	176								
Arkansas 177	177								
Arkansas 178	178								
Arkansas 179	179								
Arkansas 180	180								
Arkansas 181	181								
Arkansas 182	182								
Arkansas 183	183								
Arkansas 184	184								
Arkansas 185	185								
Arkansas 186	186								
Arkansas 187	187								
Arkansas 188	188								
Arkansas 189	189								
Arkansas 190	190								
Arkansas 191	191								
Arkansas 192	192								
Arkansas 193	193								
Arkansas 194	194								
Arkansas 195	195								
Arkansas 196	196								
Arkansas 197	197								
Arkansas 198	198								
Arkansas 199	199								
Arkansas 200	200								
Arkansas 201	201								
Arkansas 202	202								
Arkansas 203	203								
Arkansas 204	204								

		UNIV. OF ARK / DMC OPEN NURSERY							
			2008-2009						
			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
Arkansas 205	205								
Arkansas 206	206								
Arkansas 207	207								
Arkansas 208	208								
Arkansas 209	209								
Arkansas 210	210								
Arkansas 212	212								
Arkansas 213	213								
Arkansas 215	215								
Arkansas 216	216								
Arkansas 219	219								
Arkansas 221	221								
Arkansas 223	223								
Arkansas 224	224								
Arkansas 225	225								
Arkansas 226	226								
Arkansas 228	228								
Arkansas 229	229								
Arkansas 230	230								
Arkansas 231	231								
Arkansas 232	232								
Arkansas 234	234								
Arkansas 101	101								
Arkansas 102	102								
Arkansas 103	103								
Arkansas 104	104								
Arkansas 107	107								
Arkansas 108	108								
Arkansas 109	109								
Arkansas 110	110								
Arkansas 111	111								
Arkansas 112	112								
Arkansas 114	114								
Arkansas 115	115								
Arkansas 116	116								
Arkansas 117	117								
Arkansas 119	119								
Arkansas 120	120								
Arkansas 123	123								
Arkansas 124	124								
Arkansas 125	125								
Arkansas 126	126								
Arkansas 127	127								
Arkansas 128	128								
Arkansas 129	129								
Arkansas 130	130								
Arkansas 131	131								

UNIV. OF ARK / DMC OPEN NURSERY

2008-2009

			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
Arkansas 133	133								
Arkansas 135	135								
Arkansas 136	136								
Arkansas 138	138								
Arkansas 139	139								
Arkansas 140	140								
Arkansas 141	141								
Arkansas 143	143								
Arkansas 145	145								
Arkansas 146	146								
Arkansas 147	147								
Arkansas 148	148								
Arkansas 149	149								
Arkansas 150	150								
Arkansas 151	151								
Arkansas 152	152								
Arkansas 153	153								
Arkansas 154	154								
Arkansas 156	156								
Arkansas 157	157								
Arkansas 158	158								
Arkansas 159	159								
Arkansas 160	160								
Arkansas 161	161								
Arkansas 162	162								
Arkansas 163	163								
Arkansas 164	164								
Arkansas 165	165								
Arkansas 166	166								
Arkansas 167	167								
Arkansas 168	168								
Arkansas 169	169								
Arkansas 170	170								
Arkansas 171	171								
Arkansas 172	172								
Arkansas 173	173								
Arkansas 174	174								
Arkansas 175	175								
Arkansas 176	176								
Arkansas 177	177								
Arkansas 178	178								
Arkansas 179	179								
Arkansas 180	180								
Arkansas 181	181								
Arkansas 182	182								
Arkansas 183	183								
Arkansas 184	184								

		UNIV. OF ARK / DMC OPEN NURSERY							
			2008-2009						
			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
Arkansas 185	185								
Arkansas 186	186								
Arkansas 187	187								
Arkansas 188	188								
Arkansas 189	189								
Arkansas 190	190								
Arkansas 191	191								
Arkansas 192	192								
Arkansas 193	193								
Arkansas 194	194								
Arkansas 195	195								
Arkansas 196	196								
Arkansas 197	197								
Arkansas 198	198								
Arkansas 199	199								
Arkansas 200	200								
Arkansas 201	201								
Arkansas 202	202								
Arkansas 203	203								
Arkansas 204	204								
Arkansas 205	205								
Arkansas 206	206								
Arkansas 207	207								
Arkansas 208	208								
Arkansas 209	209								
Arkansas 210	210								
Arkansas 212	212								
Arkansas 213	213								
Arkansas 215	215								
Arkansas 216	216								
Arkansas 219	219								
Arkansas 221	221								
Arkansas 223	223								
Arkansas 224	224								
Arkansas 225	225								
Arkansas 226	226								
Arkansas 228	228								
Arkansas 229	229								
Arkansas 230	230								
Arkansas 231	231								
Arkansas 232	232								
Arkansas 234	234								
Arkansas 101	101								
Arkansas 102	102								
Arkansas 103	103								
Arkansas 104	104								
Arkansas 107	107								

		UNIV. OF ARK / DMC OPEN NURSERY						
		2008-2009						
			FROST	WHITE RUST RATING DATES			10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE				STALK	STALK
Arkansas 108	108							
Arkansas 109	109							
Arkansas 110	110							
Arkansas 111	111							
Arkansas 112	112							
Arkansas 114	114							
Arkansas 115	115							
Arkansas 116	116							
Arkansas 117	117							
Arkansas 119	119							
Arkansas 120	120							
Arkansas 123	123							
Arkansas 124	124							
Arkansas 125	125							
Arkansas 126	126							
Arkansas 127	127							
Arkansas 128	128							
Arkansas 129	129							
Arkansas 130	130							
Arkansas 131	131							
Arkansas 133	133							
Arkansas 135	135							
Arkansas 136	136							
Arkansas 138	138							
Arkansas 139	139							
Arkansas 140	140							
Arkansas 141	141							
Arkansas 143	143							
Arkansas 145	145							
Arkansas 146	146							
Arkansas 147	147							
Arkansas 148	148							
Arkansas 149	149							
Arkansas 150	150							
Arkansas 151	151							
Arkansas 152	152							
Arkansas 153	153							
Arkansas 154	154							
Arkansas 156	156							
Arkansas 157	157							
Arkansas 158	158							
Arkansas 159	159							
Arkansas 160	160							
Arkansas 161	161							
Arkansas 162	162							
Arkansas 163	163							
Arkansas 164	164							

		UNIV. OF ARK / DMC OPEN NURSERY							
			2008-2009						
			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
Arkansas 165	165								
Arkansas 166	166								
Arkansas 167	167								
Arkansas 168	168								
Arkansas 169	169								
Arkansas 170	170								
Arkansas 171	171								
Arkansas 172	172								
Arkansas 173	173								
Arkansas 174	174								
Arkansas 175	175								
Arkansas 176	176								
Arkansas 177	177								
Arkansas 178	178								
Arkansas 179	179								
Arkansas 180	180								
Arkansas 181	181								
Arkansas 182	182								
Arkansas 183	183								
Arkansas 184	184								
Arkansas 185	185								
Arkansas 186	186								
Arkansas 187	187								
Arkansas 188	188								
Arkansas 189	189								
Arkansas 190	190								
Arkansas 191	191								
Arkansas 192	192								
Arkansas 193	193								
Arkansas 194	194								
Arkansas 195	195								
Arkansas 196	196								
Arkansas 197	197								
Arkansas 198	198								
Arkansas 199	199								
Arkansas 200	200								
Arkansas 201	201								
Arkansas 202	202								
Arkansas 203	203								
Arkansas 204	204								
Arkansas 205	205								
Arkansas 206	206								
Arkansas 207	207								
Arkansas 208	208								
Arkansas 209	209								
Arkansas 210	210								
Arkansas 212	212								

		UNIV. OF ARK / DMC OPEN NURSERY						
			2008-2009					
			FROST	WHITE RUST RATING DATES			10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE				STALK	STALK
Arkansas 213	213							
Arkansas 215	215							
Arkansas 216	216							
Arkansas 219	219							
Arkansas 221	221							
Arkansas 223	223							
Arkansas 224	224							
Arkansas 225	225							
Arkansas 226	226							
Arkansas 228	228							
Arkansas 229	229							
Arkansas 230	230							
Arkansas 231	231							
Arkansas 232	232							
Arkansas 234	234							
Unipak 12	1							
Unipak 151	2							
Falcon	3							
Vancouver	4							
Bossanova	5							
Fidalgo	6							
Cypress	7							
Ventor	8							
Mig	9							
Emilia	10							
Skookum	11							
Tyee	12							
Avon	13							
Samish	14							
Regal	15							
Crescent	16							
Viceroy	17							
88-212 (U of A)	18							
88-212 (Alf)	19							
88-310	20							
88-130	21							
03-316	22							
04-054	23							
F380	24							
F415	25							
F154	26							
91-227	27							
Fallgreen	28							
Ozarka II	29							
04-103	30							
05-191	31							
97-139	32							

		UNIV. OF ARK / DMC OPEN NURSERY							
			2008-2009						
			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
90-198	33								
Bordeaux	34								
Unipak 12	1								
Unipak 151	2								
Falcon	3								
Vancouver	4								
Bossanova	5								
Fidalgo	6								
Cypress	7								
Ventor	8								
Mig	9								
Emilia	10								
Skookum	11								
Tyee	12								
Avon	13								
Samish	14								
Regal	15								
Crescent	16								
Viceroy	17								
88-212 (U of A)	18								
88-212 (Alf)	19								
88-310	20								
88-130	21								
03-316	22								
04-054	23								
F380	24								
F415	25								
F154	26								
91-227	27								
Fallgreen	28								
Ozarka II	29								
04-103	30								
05-191	31								
97-139	32								
90-198	33								
Bordeaux	34								
Unipak 12	1								
Unipak 151	2								
Falcon	3								
Vancouver	4								
Bossanova	5								
Fidalgo	6								
Cypress	7								
Ventor	8								
Mig	9								
Emilia	10								
Skookum	11								

		UNIV. OF ARK / DMC OPEN NURSERY							
			2008-2009						
			FROST	WHITE RUST RATING DATES				10% SEED	50% SEED
VARIETY	PLOT	1ST WR	DAMAGE					STALK	STALK
Tyee	12								
Avon	13								
Samish	14								
Regal	15								
Crescent	16								
Viceroy	17								
88-212 (U of A)	18								
88-212 (Alf)	19								
88-310	20								
88-130	21								
03-316	22								
04-054	23								
F380	24								
F415	25								
F154	26								
91-227	27								
Fallgreen	28								
Ozarka II	29								
04-103	30								
05-191	31								
97-139	32								
90-198	33								
Bordeaux	34								