Texas A&M AgriLife Extension

International Spinach Conference

La Quinta Inn & Suites-Market Square Downtown
November 29 & 30, 2012
San Antonio, Texas

Welcome to the 2012

International Spinach Conference
San Antonio, Texas

November 29-30, 2012

La Quinta Inn & Suites San Antonio Downtown
Place of meeting: Blue Star Brewing Company

And

Field Tour of the
Texas Wintergarden
Spinach Growing Areas

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2012 International Spinach Conference
November 29-30, 2012
San Antonio, TX

PROGRAM
(Updated November 26, 2012)

Thursday, November 29, 2012
Blue Star Brewing Company

8:00 - 8:30 am	On-Site registration and light refreshments
8:30 - 8:50 am	U.S. Spinach Production and Consumption Trends **Luis Ribera and Marco Palma**
8:50 - 9:10 am	Current European Spinach Planting and Consumption Trends **Jan De Visser**
9:10 - 9:30 am	Gardening Can Be Fun For Kids, How About Growing Some Spinach **David Rodriguez**
9:30 - 9:50 am	Growing Fresh Market and Processing Spinach in Texas **Larry Stein**
BREAK	
10:30 - 10:50 am	Changing the Popeye Image of Spinach – Strategies for Teaching Spinach Nutrition to Chefs **Homer Emery**
10:50 - 11:10 am	Strategies for Implementing a Food Safety Program on the Farm **Marcel Valdez**
11:10 - 11:30 am	*Escherichia coli* in Spinach at the Pre-Harvest Level as Affected by the Farm Management and Environmental Factors **Renata Ivanek-Miojevic, Sang Shin Park, Sarah Navratil, Ashley Gregory, Indumathi Srinath, Mikyoung Jun, Barbara Szonyi, Kendra Nightingale and Juan Anciso**
11:30 - 11:50 am	Can We Decrease Water Use in Spinach Without Compromising Crop Yield or Quality? **Graham Clarkson, Hazel Smith and Gail Taylor**

Thursday, November 29, 2012

LUNCH ON SITE

1:00 - 1:20 pm	Deficit Irrigation and Planting Systems for Spinach in Southwest Texas **Daniel Leskovar, Chenping Xu, Shinsuke Agehara, Sat Pal Sharma, and Carrie Hensarling**
1:20 - 1:40 pm	Past, Current and Future Prospects Regarding Weed Control in Processing Spinach **Russ Wallace and C. Joel Webb**
1:40 - 2:00 pm	Development of a Muliplex Real-Time PCR Assay for Multiple Seedborne Spinach Pathogens **Jim Correll, Chunda Feng, L. J. Du Toit, B. H. Bluhm**
2:00 - 2:20 pm	Systematic review: What do we really know about risk factors for produce contamination at the pre-harvest level? **Renata Ivanek-Miojevic, Sang Shin Park, Barbara Szonyi, Raju Gautam, Kendra Nightingale and Juan Anciso**

BREAK

2:40 - 3:00 pm	Downy Mildew of Spinach – An Overview of Resistance **Jim Correll, Chunda Feng, Katherine E. Kammeijer and Steven Koike**
3:00 – 3:20 pm	Spinach Disease Trends in Southwest Texas **Mark Black and Larry Stein**
3:20 – 3:40 pm	2011 – 2012 Screening Fungicides for Control of White Rust on Spinach **Larry Stein, Marcel Valdez and Devin Kerstetter**
3:40 – 4:00 pm	
4:00 - 4:30 pm	**Questions and Answers**

TENTATIVE TOUR AGENDA

Friday, November 30, 2012

7:30 am	Board Buses
8:00 am	Depart La Quinta
9:00 am	Martin Farm – Hondo -Del Monte Strip Trial -Plant Population Study
10:15 am	Uvalde Library - Bracero exhibit
11:00 am	Crawford Home Farm -Equipment -Baby -Teen -Curly
12:15 pm	Lunch -Crawford Barn-sponsored by Del Monte
1:00 pm	Spinach trials – La Pryor
1:45 pm	Tiro Tres Farms, Espinaca packing Facility
3:00 pm	Del Monte Research Farm -Disease Screening Nurseries -Fungicide Trial -Herbicide Trial
4:00 pm	Popeye Statue – Crystal City
4:30 pm	Pachanga
5:30 pm	Dinner
6:30 pm	Return to San Antonio

U.S. Spinach Production and Consumption Trends

Luis A. Ribera[1] and Marco A. Palma[2]

[1]Associate Professor and Extension Economist – Management,
Texas A&M AgriLife Extension Service, Weslaco, TX 78596
[2]Associate Professor and Extension Economist – Marketing,
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Spinach production in the U.S., fresh and processed has increased in the last 10 years from 300,000 tons in 2001 to 454,150 tons in 2011. Most of the increase in production is for the fresh market going from 172,900 tons to 308,950 tons (79 percent increase) while the processed market increased by 14 percent. Area harvested has remained fairly constant ranging from a low of 40,390 to a high as 52,100. Average yield has increased from 8 tons/ac in 2001 to 12 tons/ac in 2011. Imports increased by 429 percent from 8,800 tons in 2000 to 46,555 tons in 2010. About 84 percent of the imports go to the frozen market.

Prices have increased for both the fresh and processed markets. Fresh spinach went from $648/ton in 2001 to $810/ton in 2011, while processed spinach went from $116/ton to $138/ton in the same time period. Moreover, per capita spinach consumption in the U.S. has increased 16.7 percent over the last 10 years from 1.8 lbs. to 2.1 lbs. This increase is in contrast to overall per capita reduction in fruit and vegetable consumption. The 2010 Dietary Guidelines for Americans calls for a 113 percent increase on vegetable consumption and for a 151 percent increase in the dark greens subcategory under the vegetable category. If U.S. consumers comply with the guidelines, the vegetable industry will be impacted tremendously.

Current European Spinach Planting and Consumption Trends

Jan de Visser[1]

[1]Pop Vriend Seeds B.V., Middenweg 52, 1619 BN Andijk, The Netherlands

In the world of spinach, Europe is behind Asia – China in particular – and with the USA, one of the top three production regions globally.

The spinach market can roughly be divided in two:

- Fresh spinach: minimally processed (field product or washed spinach);
- Processing spinach: washed, blanched, canned or frozen spinach.

The traditional way of growing, packing and even consumption of fresh spinach in Europe changed dramatically the past twenty years. From 'romantic' hand labor to high tech equipment, from loose spinach to packed convenience food, from cooked spinach to salads.

The development of the fresh spinach market in Europe and the related trends, will be discussed in this presentation based on the evolution of the UK spinach market.

Initially, processing spinach was synonymous for canned spinach. France was the number one production area for processing spinach in Europe till the eighties of the last century. Nowadays Belgium is on top.

How Belgium became an important player in processing spinach worldwide, will be presented as well.

Gardening Can Be Fun for Kids, How About Growing Some Spinach?

David Rodriguez[1]

[1]County Extension Agent-Horticulture,
Texas A&M AgriLife Extension Service, San Antonio, TX 78230

When it comes to gardening, children are naturals. They aren't afraid of getting dirty; in fact, most kids love playing in the soil, and they're genuinely inquisitive and learn best by doing things for themselves. Gardening with little ones at an early age is a great way to teach them about the cycle of life, while giving them the chance to care and cultivate for something over time, in return this teaches important life skills of hard-work and patience. Children also experience great gratification with the finale results of caring for their very own plot of land. We can also capitalize on this, as an opportunity to initiate the mentoring of future stewards of the environment.

There are many easy-to-grow vegetables and fruits that children can care for in their very own garden. One of these choices can and should be spinach. Spinach as a health food is well deserved and would be a great contribution to anyone's garden. Spinach has the highest amount of vitamins A and B2 of any common vegetable and is loaded with iron, calcium, and protein. It's excellent as a cooking green or can stand alone in any salad. The benefits of our youth exposed at a young age to healthy foods and understanding where it comes from as well as how it's grown, can possibly carry-over as adults that practice moderate physical activity and engage in positive social interactions as healthy lifelong individuals.

Growing Fresh Market and Processing Spinach in Texas

Larry Stein[1]

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Both fresh market and processing spinach production has shifted to 80 inch beds. Since this spinach is now mechanically harvested, field rotation is critical to minimize former crop field stubble from ending up in the harvested product which means in most cases spinach crops follow wheat, green beans, onions and in some cases corn. If following a high residue crop, like corn it is critical to bury the trash with deep plowing. Prior to bedding, pre-plant fertilizer is broadcast and incorporated; in most cases 110-80-0 per acre. Prior to planting the beds are either rotovated or lightly worked and leveled with a small field cultivator. It is ultra-critical that the beds are properly built so as to have a flat-bed top on which to plant and harvest spinach. Spinach is seeded on these beds in either 8, 12, 18, 30 or 42 lines per bed with an average plant population of 550,000 up to 3 million depending on the crop being grown. Ridomil is applied in furrow as a liquid. Dual herbicide is applied to control the weeds. Typically Diazinon is applied along with the herbicide application for grub control. Most growers "set" their herbicide with about three tents of an inch of water and allow the field to set for another 12 hours before applying sufficient water to germinate the crop. If weather conditions are warm and wet 30 days after planting, then a fungicide application will be needed to keep potential disease in check. In the early season when warm conditions prevail, worm pressure can be high and must be monitored carefully so appropriate control measures can be made as needed. The crop is also side dressed with a nitrogen application of either urea (broadcast) or N – 32 through the irrigation water, at the rate of 60 to 80 pounds of actual nitrogen per acre. Curly and processing spinach fields may be harvested one to three times, whereas baby leaf is a one cut operation.

Changing the Popeye Image of Spinach –
Strategies for Teaching Spinach Nutrition to Chefs

Homer C. Emery[1], Ph.D.

[1] Registered Sanitarian; Diplomate American Academy of Sanitarians;
Instructor of Food Science, Culinary Institute of America, San Antonio, Texas, 78215

In a Vegetable Nutrition Fact Sheet published by the U.S. Food and Drug Administration (FDA) spinach is not even mentioned. Instead of hiding spinach, the FDA should be highlighting it as what some experts have described as being the "World's Healthiest Food." While spinach is an excellent source for a number of vitamins and minerals and provides more than 100% of the daily value (DV) recommended for vitamin K, it just doesn't get much respect.

This presentation will focus on strategies used for teaching spinach nutrition to first semester students enrolled in a two-year degree culinary arts program. Practical exercises involving recipe modification were found to generate and maintain better student interest, while at the same time transferring nutritional facts on spinach, than other approaches used in the classroom. Students were also exposed to new cartoon personalities (Sammy Spinach and Mitch Spinach) that have been used for promoting nutritional values of spinach, but none were able to challenge Popeye's worldwide image recognition.

Strategies for Implementing a Food Safety Program on The Farm

Marcel Valdez[1]

[1]County Extension Agent-ANR,
Texas A&M AgriLife Extension Service-Zavala County

With the California spinach *E. coli* outbreak in September of 2006 and the outbreak of *Salmonella sp.* in 2008 in peppers/tomatoes, food safety concerns continue to be on the forefront of Texas spinach and vegetable production now and for years to come. In response to consumer concerns, many retailers have recently announced programs requiring growers to have independent third-party inspections of farms to certify that fruits and vegetables are being grown, harvested, and packaged using good agricultural and management practices. These programs are developing rapidly and many growing and packing operations are already being inspected by companies, organizations, and agencies approved by retailers. Effective farm strategies focus on prevention of contamination. Research clearly demonstrates that it is very difficult to completely sanitize produce once contamination has occurred. The key to reducing risks is preventing contamination before it happens.

Many pathogens can be transferred to fresh fruits and vegetables by workers who pick, package, or handle the produce. The failure of people working with food to wash their hands after using the toilet has been the cause of many foodborne illness outbreaks. Frequent, proper hand washing is an effective strategy for helping to prevent foodborne illness; however, few people do it properly.

With financial support from the Winter Garden Spinach Producers board an effective food safety training program is in place in the Winter Garden Spinach Producing Area of Texas. Since 2006 over 750 agricultural workers that harvest, package and handle spinach and other vegetables have been trained in both English and Spanish. Key to these efforts is to know strategies to implement a food safety program on the farm as a key in reducing the risks of contamination before it happens. Prevention is key and by starting at the farm level it is truly a Good Agricultural Practice.

Escherichia coli In Spinach At The Pre-Harvest Level As Affected By Farm Management And Environmental Factors

Sang Shin Park[1], Sarah Navratil[2], Ashley Gregory[3], Indumathi Srinath[1], Mikyoung Jun[4], Barbara Szonyi[1], Kendra Nightingale[2], Juan Anciso[3], Renata Ivanek[1]

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[2] Department of Animal and Food Sciences, Texas Tech University, Lubbock, TX 79409
[3] Department of Horticultural Sciences, Texas AgriLife Extension Service, Weslaco, TX 78596
[4]Department of Statistics, Texas A&M University, College Station, TX 77843

There is a great need to improve produce safety. This study was conducted to determine the effect of farm management and environmental factors on generic *Escherichia coli* contamination in spinach at the pre-harvest level. We conducted a repeated cross-sectional study by visiting spinach farms up to three times per season over a period of 2 years (2010 and 2011). A total of 955 samples of spinach were collected on 13 spinach farms in West and South West regions of the United States. During each sample collection, farmers were surveyed about farm-related management and environmental factors using a questionnaire. Associations between the prevalence of *E. coli* in spinach and farm-related factors were assessed using a multivariable logistic regression model including random effects for farm and farm visit. Approximately 7% of spinach samples were positive for generic *E. coli*. Significant risk factors for spinach contamination with generic *E. coli* were: proximity (within 10 miles) of a poultry farm, use of pond water for irrigation, planting-sampling interval greater than 66 days, farming on fields previously used for grazing, the hay condition of fields before planting, and the farm location in the South West. The presence of generic *E. coli* was significantly reduced by irrigating-sampling interval greater than 5 days, use of portable toilets, training to use portable toilets, and use of hand-washing stations. To our knowledge, this is the first report of an association between field workers' personal hygiene and produce contamination with generic *E. coli* at the pre-harvest level. Collectively, our findings support that practicing good personal hygiene and other good farm management practices may help prevent produce contamination with *E. coli* at the pre-harvest level.

Can We Decrease Water Use in Spinach Without Compromising Crop Yield or Quality?

Hazel Smith[1], Graham Clarkson[2], and Gail Taylor[1]

[1]Centre for Biological Sciences, University of Southampton, Hampshire, SO17 1BJ, UK
[2]Vitacress Salads Ltd., Lower Link Farm, St Mary Bourne, Andover, Hampshire, SP11 6DB, UK

Eighteen percent of the world's cropped land is irrigated and, as this area produces 40-45% of food globally (FAO, 2007), reducing irrigation could have major impacts on food security. When irrigation is applied in excess to the crop's needs, water is lost through evaporation, run-off or deep-percolation. Improving the efficiency with which water is applied is of critical importance if we are to continue to feed our growing population without irreversibly damaging our environment.

When irrigation management practices have been compared with respect to baby leaf salads it has been shown that irrigation is often applied in excess to the crop's needs so as to prevent stress, or even death, of the crop (Smith, 1997). It is therefore critical that the actual water requirements of baby leaf salads are quantified and linked to remote measures of crop water status, as in this study, so that irrigation can be targeted more precisely. Furthermore, the impact of altering irrigation on crop yield and quality must be determined so as to optimize the system. Consequently, we have applied irrigation to a commercial spinach crop at a number of levels of deficit and excess so as to establish links with thermal imagery for future automation of the system, as well as elucidating the effects these alterations will have on crop quality and yield.

We have been able to manipulate a spinach crop with improved quality through the use of deficit irrigation, with a reduced cell size and stomatal index when compared to a crop grown under commercial or excess irrigation. The challenge this approach faces in the future is that of balancing quality improvements with the yield penalties incurred when irrigation is applied in deficit. However, this trial finds good evidence for the possibility of using thermal imagery to minimize the water required for spinach production, while reducing waste due to poor quality product.

Deficit Irrigation and Planting System for Spinach in Southwest Texas

[1]Daniel I. Leskovar, Chenping Xu, Shinsuke Agehara, Sat Pal Sharma, and Carrie Hensarling

[1]Texas A&M AgriLife Research, Vegetable and Fruit Improvement Center, Department of Horticultural Sciences, Texas A&M System, Uvalde, TX 78801

Irrigation water is becoming increasingly limited in southwest Texas. One approach to water conservation and sustainable production systems is the adoption of deficit irrigation strategies in combination with best plant population rates. Field experiments were conducted over three seasons (2005-06, 2008-09 and 2009-10) in the Wintergarden of Texas to investigate plant growth, yield, and quality of spinach (*Spinacia oleracea* L. cv. DMC 66-16) in response to deficit irrigation (based on % of crop evapotranspiration or ETc) and plant population. In 2005-06 season, deficit irrigation with 50% ETc reduced photosynthetic rate temporarily and significantly reduced marketable yield as compared to 100% ETc, from 16.1 to 13.4 t ha^{-1}. Conversely, 50% ETc irrigation increased water use efficiency from 54.7 to 67.8 kg ha^{-1} mm^{-1}. Leaf ascorbic acid and carotenoids (β-carotene, lutein, and neoxanthin) content significantly increased for plants grown under 50% ETc irrigation. The intermediate deficit irrigation rate of 75% ETc did not significantly affect marketable yield, water use efficiency, ascorbic acid and caroteniod content. Plant population (497,000 to 1,307,000 seed ha^{-1}) had no significant effect on these parameters. Similarly in 2008-09 season, 50% ETc irrigation significantly reduced photosynthetic rate and marketable yield, and had no effects on chlorophyll and carotenoid content. High plant population (660,000 vs. 400,000 seed ha^{-1}) slightly ($p = 0.099$) increased water use efficiency and did not affect other parameters. In 2009-10 season, 50% ETc irrigation slightly ($p = 0.074$) reduced marketable yield. Similarly, little effects were detected for plant population. The lack of plant responses to irrigation in 2009-10 season was related to the high amount of rainfall (175 mm) as compared to the previous two dry seasons 2005-06 (6 mm) and 2008-09 (11 mm). These results suggest that 75% ETc irrigation could be considered as an efficient strategy during drought seasons without causing significant yield reduction. For rainy winter seasons, 50% ETc irrigation could be considered sufficient to compensate for the crop evapotranspiration needs for a single or double harvest.

Past, Current and Future Prospects Regarding Weed Control in Processing Spinach

Russell W. Wallace and C. Joel Webb[1]

[1]Extension Vegetable Specialist and Research Technician,
Texas A&M AgriLife Research & Extension Center at Lubbock

In the 1990s, many chemical companies shifted emphasis from new herbicide discovery to the development of herbicide-resistant crops. An unintended result was a significant reduction in new herbicide chemistries for potential use in vegetables, including spinach. Currently, there are only two preemergence and three postemergence herbicides registered for spinach.

A review of spinach research at Texas A&M AgriLife Research and Extension during the past decade indicates that twenty-five herbicide trials were conducted in the Wintergarden area. The majority of research was supported by the Wintergarden Spinach Producers Board, with additional support from Del Monte and the USDA Minor Crops IR-4 program. Research included eight overall weed management goals that evaluated pre- and postemergence herbicides, herbicide use rates and timing, spinach seeding density and variety evaluations, herbicide residual/crop plant back, off-site herbicide drift and injury, and herbicide rate plus handweeding combinations. Economics of weed management were included where possible in the results summary. Over 480 individual weed control treatments (replicated 3 or 4 times) and thirty-seven herbicides were evaluated during this period. Spinach weed control collaborators included researchers at universities in Arkansas, California, Georgia, Michigan, New York, North Carolina, Ohio, Oklahoma, Oregon, Texas, and Washington.

Currently, preemergence applications of Dual Magnum (s-metolachlor) continue to be the number one choice for growers in the Texas Wintergarden. While several non-registered herbicides evaluated gave excellent efficacy and low crop injury, manufacturers have shown little interest in expanding their uses to spinach, especially where perceived risks and potential revenues did not justify the added registration expense. As a result, growers continue their dependence on Dual Magnum plus handweeding.

What does the future hold for weed control in processing spinach? First, it is unlikely that herbicide-resistant spinach or other vegetable seeds will be developed in the near future. Second, the continued reliance on only one herbicide may lead to a shift in higher populations of non-controlled weeds, or possibly even weed resistance; thereby only adding to the current weed control costs. Third, with the upcoming marketing of dicamba- and 2,4-D-resistant row crops, off-site drift to non-target food crops like spinach requires strict attention. Collaborative research with groups like the Wintergarden Spinach Producers Board, the IR-4 Minor Crops Program, other land grant universities, and with important input from growers must continue forward to improve the potential future of weed control in spinach.

Development Of A Multiplex Real-Time PCR Assay For Multiple Seedborne Spinach Pathogens

C. Feng[1], J. C. Correll[1], L. J. du Toit[2], B. H. Bluhm[1]

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Fresh market spinach is a highly nutritious vegetable, and dramatic increases in both production and consumption have occurred in the USA over the last two decades. The increase in production has resulted in an increase in disease pressure by a number of seedborne pathogens. Downy mildew, caused by the obligate pathogen *Peronospora farinosa* f. sp. *spinaciae* (Pfs) is the most important and destructive disease of spinach. *Verticillium dahliae* (Vd), although not a pathogen of the vegetative production crop, is an important disease during seed production and represents a potential concern if planted in non-infested soils. In addition, Stemphylium leaf spot, caused by *Stemphylium botryosum* (Sb), and Cladosporium leaf spot, caused by *Cladosporium variabile* (Cv), are important foliar diseases of spinach that can be seedborne. Multiple seed detection assays for individual pathogens is less economically feasible than a multiplexed assay for several seedborne pathogens. DNA primers and probes targeting these four spinach pathogens were designed, and proved highly specific in TaqMan real-time PCR assays tested against 12 Pfs isolates, 20 Vd isolates, 6 Sb isolates, and 4 Cv isolates. The assays were very sensitive based on testing a range of concentrations of pathogen DNA. A rapid DNA extraction protocol from single seed was developed which enables individual and batches of seed to be examined for multiple pathogens. Optimization of the multiplex real-time PCR seed assay is in progress.

Systematic review: What do we really know about risk factors for produce contamination at the pre-harvest level?

Sang Shin Park[1], Barbara Szonyi[1], Raju Gautam[1], Kendra Nightingale[2], Juan Anciso[3], Renata Ivanek[1]

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The public health and economic consequences of produce contamination with *Listeria monocytogenes*, *Salmonella*, and *Escherichia coli* O157:H7 provide a strong incentive to prevent contamination of fresh produce with these pathogens. In that regard, it is important to summarize the existing knowledge so as to provide comprehensive guidelines for decision making and future research. The objective of this study was to perform a systematic review of risk factors for contamination of fruits and vegetables with *L. monocytogenes*, *Salmonella*, and *E. coli* O157:H7 at the pre-harvest level. Relevant studies were identified by searching 6 electronic databases: MEDLINE, EMBASE, CAB Abstracts, AGRIS, AGRICOLA, and FSTA, using the following thesaurus terms: *L. monocytogenes*, *Salmonella*, *E. coli* O157 AND *fruit*, *vegetable*. All searching terms were exploded to find all related subheadings. To be eligible, studies had to be prospective controlled trials or observational studies at the pre-harvest level and had to show clear and sufficient information on the process in which the produce was contaminated. Out of 3,463 identified citations, 68 studies fulfilled the eligibility criteria. Most of these studies were on leafy greens and tomatoes. Six studies assessed produce contamination with respect to animal host related risk factors and 20 studies assessed contamination with respect to pathogen characteristics. Sixty-two studies assessed the association between produce contamination and factors related to produce, water and soil, as well as local ecological conditions of the production location. While evaluation of many risk factors for pre-harvest level produce contamination have been reported, the quality assessment of the reviewed studies confirmed existence of solid evidence for only some of them, including growing produce on clay-type soil, application of contaminated or non-pH-stabilized manure and usage of spray irrigation with contaminated water, with a particular risk of contamination on the lower leaf surface. In conclusion, synthesis of the reviewed studies suggests that reducing microbial contamination of irrigation water and soil are the most effective targets for prevention and control of produce contamination. Furthermore, this review provides an inventory of the evaluated risk factors, including those requiring more research.

Reference: *Park, S., Szonyi, B., Gautam, R., Nightingale, K., Anciso, J., Ivanek, R.: Risk factors for microbial contamination in fruits and vegetables at the pre-harvest level: A systematic review. Journal of Food Protection, 2012, 75(11):2055-2081.*

Downy Mildew Of Spinach – An Overview Of Resistance

Chunda Feng[1], James C. Correll[1], Katherine E. Kammeijer[2], Steven Koike[2]

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Spinach downy mildew disease, caused by the oomycete pathogen Peronospora farinosa f. sp. spinaciae (Pfs), continues to be a major production constraint for commercial spinach (Spinacia oleracea). However, based on cooperation through the International Working Group on Peronospora (IWGP), spinach seed companies, and various researchers, a considerable amount of information has been learned about the genetics of resistance, the race diversity of the pathogen, and how to breed for more durable resistance to the downy mildew pathogen. Based on the disease reactions of a diverse group of open pollinated spinach cultivars and hybrid spinach cultivars, six downy mildew resistance loci, designated RPF1 to RPF6, have been hypothesized. In order to determine the genetics of resistance to Pfs, a consortium project, involving a number of spinach seed companies, was initiated to introgress each of the hypothesized loci into a common susceptible genetic background (Viroflay) to develop Near Isogenic Lines or NILs. Although this work is still underway, efforts with RPF1 and RPF2 have shown that each segregates as a single locus and the resistance is dominant. Interestingly, each of the six hypothesized loci controls resistance to multiple races including some of the newest races identified. Fortunately, no races have been found in recent years that defeat all six of the hypothesized resistance loci. Almost certainly, additional resistance loci will be identified in spinach as a wider set of spinach accessions and collections are evaluated.

Spinach Disease Trends in Southwest Texas

Mark Black and Larry Stein[1]

[1]Extension Plant Pathologist and Extension Horticulturist,
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Beet western yellows virus epidemics last occurred in the mid-1980s during high aphid populations in spinach thought to be associated with widespread synthetic pyrethroid insecticide use in vegetables and field crops.

Spinach curly top virus occurs at low to nondetectable levels every season and is most noticeable at edges of fields with poor stands. The trend is down due to increased spinach plant populations. Recent long term droughts have limited range and weed vegetation for leafhopper vectors.

Incidence of white rust caused by *Albugo occidentalis* (class Oomycota, order Peronosporales), is low because of widespread use of cultivars with partial resistance, long rotations, field spatial separation, and options for soil and foliar fungicide use. White rust caused severe losses into the 1990s. Demotion to minor disease status in southwest Texas is a true success story made possible by collaborations among university scientists, public and private plant breeders, agricultural chemical companies, food processors, and growers.

Blue mold caused by *Peronospora farinosa* f. sp. *spinaciae* (class Oomycota, order Peronosporales) is now seldom seen. Reasons include reduced acreage, field spatial separation, local use of white rust-resistant cultivars that apparently also have race-nonspecific blue mold partial resistance (Brandenberger et al. 1994 Phytopathology 84:431-437) and fungicide options. If use of white rust-susceptible cultivars increases, blue mold will increase in importance.

Incidence of anthracnose caused by *Colletotrichum dematium* is increasing. The fungus is apparently introduced repeatedly on seed. Factors favoring disease include multiple cuts per planting, double cropping, lack of crop rotation, high plant populations, poor drying conditions, and no highly effective fungicide options.

Incidence is up for Stemphylium leaf spot caused by *Stemphylium botryosum*. It is probably often introduced on seed. Risk factors are double cropping, lack of crop rotation, increased plant populations, and use of susceptible cultivars. Foliar fungicides reduce risk of loss.

Fusarium wilt caused by *Fusarium oxysporum* f. sp. *spinaciae* is not a recognized problem. Local calcareous high pH soils apparently suppress this seed borne fungus.

Verticillium wilt caused by *Verticillium dahlia* may be repeatedly introduced on seed but is not recognized as a problem. The probable limiting factor is high summer temperature that limits survival.

A fungus tentatively identified as *Humicola* species was associated with large white leaf spots late in spring 2012 after a period of high temperature, rains, and poor drying conditions. Disease distribution was limited to a few fields.

2011 – 2012 Screening of Fungicides for Control of White Rust on Spinach

Larry Stein[1], Marcel Valdez[2], and Devin Kerstetter[3]

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[2]County Extension Agent, Texas AgriLife Extension Service, Crystal City, TX 78839-3503
[3]Field Supervisor, Del Monte Corporation, Crystal City, TX 78839-3503

White rust of spinach (*Albugo occidentalis*) historically has been the limiting factor to profitable spinach production in Texas. Currently, economic control of this disease is being achieved with the implementation of a systems approach including the use of resistant varieties, in-seed furrow application of metalaxyl at planting and the use of fungicides. Screening of new generation fungicides has resulted in the identification of promising white rust control compounds and subsequent spinach labels for products like Quadris and Cabrio. As a result the two main fungicides used for white rust control are Quadris and Cabrio. However, the key to the longevity of these two products is to rotate them with products of different chemistry as both Quadris and Cabrio are in the same fungicide group or group 11.

Over the last couple of years the products which have given good white rust control in rotation with either Quadris or Cabrio have been Ranman (Group 21 fungicide), Presidio (Group 43 fungicide) and Kocide and Ridomil Gold Copper; however the copper residue is not acceptable on fresh market spinach.

This fungicide trial was planted 13 October 2011 and emerged on 19 October at the Del Monte Research Farm near Crystal City. It was a fairly wet fall so initial white rust pressure was high. The first spray was put out on 11/21/2011. White rust was found in the plots on 12/14/2011 when the second application was made. The field was very wet so the second application was made with backpack sprayers. Spinach was wet and it was cloudy and damp. Third application was made on 12/23/2011 and again it was very wet so the application had to be walked on with backpacks. Spinach was wet but the day was sunny with a slight North wind. Fourth application went out on 1/3/2012; again spinach was wet with bright sunshine, but it was cold; about 45 □F. The next application was made on 1/13/2012 with similar conditions as on 1/3. The last spray application was made on 1/20/2012; initially wet spinach with fog, but later, warm with sunshine. Spray applications were designed to simulate a commercial application of about 15 gallons/acre. Plots were rated on 1/3, 1/13, 1/20, 1/30 and 2/13.

Wet conditions at the beginning and continuing through the season stimulated early season white rust infection; found in early December 2011 as opposed to February of the next year as in 2011. Our goal is to have a fungicide application in place 30 days after planting if weather conditions are favorable for white rust. Several products and product alterations resulted in clean spinach even when a susceptible variety was used, namely Cabrio alt. w/Ranman, Cabrio alt. w/Presidio, Cabrio alt. w/Prophyt, DPX QGU42 alternated w/Cabrio and Merivon on 3 January 2012. All treatments were better than the untreated check on January 3rd as well. These same trends held up for about six weeks. The cleanest treatments 26 days post application were Merivon, and Cabrio alt. w/Presidio. Note also that fungicide applications were made when the spinach was extremely wet and at times under foggy and cool conditions and other times bright sunshine. In most cases, a surfactant was used with the spray applications as well. However, fungicide applications under these wet spinach conditions did not result in any foliar burn. Ranman, Presidio, Prophyt and possibly DPX-QGU42 are good rotational products with different chemistry. Merivon is a combination strobilurin fungicide with two different fungicides which could be potentially used as well.