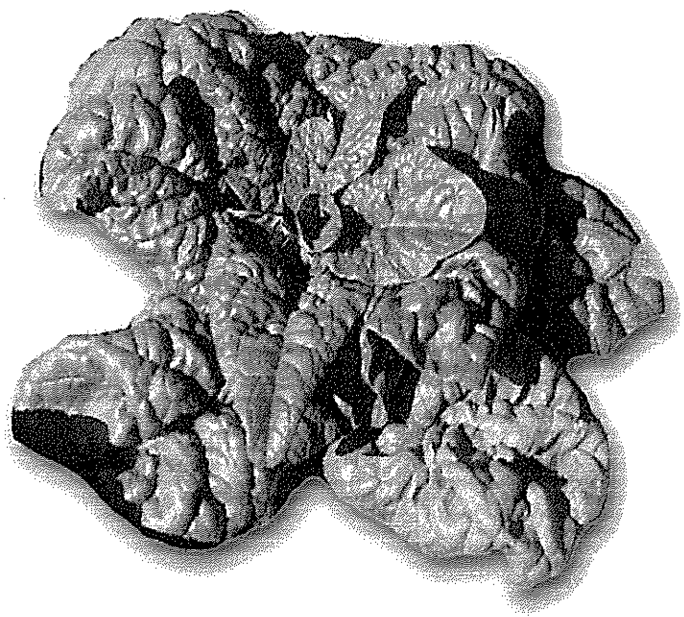
Abstracts
of the
NATIONAL SPINACH CONFERENCE
December 14 – 16, 2000
San Antonio, Texas



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ADGENDA

Thrusday December 14, 200

5:30 PM Registration and informal reception/bar-be-que

Friday December 15, 2000

7:00 AM Continental breadfast and registration

8:00 Welcome - ***Sam Cotner, Head*** - Department of Horticulture, Texas A&M Univeristy

8:15 Breeding white rust resistant spinach - ***T. E. Morelock and J. C. Correll*** - University of Arkansas

8:35 Quantitative and qualitive resistance to downy mildew of spinach - ***J. C. Correll, T. E. Morelock, and B. M.Irish*** - University of Arkansas

8:55 Biochemical mechanisms of aphid resistance in spinach - ***R. Musser, G. Felton and T. E. Morelock*** - University of Arkansas

9:15 Zoxium a new fungicide - ***Kenneth Burchert*** - Rohm & Haas

9:35 The effect of surfactants on white rust disease of spinach - ***B. M. Irish, J. C. Correll, and T. E. Morelock*** - University of Arkansas

9:55 Break

10:20 New chemistry from Norvartis - ***Brad Minton*** - Novartis

10:40 Spinach production and pest management in California - ***S. T. Koike*** - University of California

11:00 Benefits of fungicides and host resistance in reducing yield and quality loss due to foliar diseases in spinach - ***K. L. Everts, M. T. McGrath and S. A. Johnson*** - Rutgers University Agricultural Research and Extension Center, Bridgeton

11:20 Spinach Viruses in Southwest Texas - ***M. C. Black.*** - Texas A&M University

11:40 Lunch

1:00	Herbicide evaluations for Texas spinach - ***Lynn Brandenberger*** - Texas A&M University
1:20	Spinach production and marketing trends - ***Jose G. Pena*** - Texas A&M University
1:40	Growth and quality of spinach are affected by planting systems - ***D. I. Leskovar, L. A. Stein, and F. J. Dainello*** - Texas A&M University
2:00	Packaging design for fresh-cut spinach leaves - ***Julio Loiaza, F. J. Dainello, and Luis Cisneros Zevallos*** - Texas A&M University
2:20	Handling spinach from a re-packer's standpoint - ***Dave Schwartz*** - Cutter's Edge, Hamburg, NY
2:40	Break
3.:00	Health benefits of spinach - ***Luke Howard*** - University of Arkansas
3:20	Consumer acceptance of spinach as a replacement for iceberg lettuce on sandwiches - ***M. E. Fitch-Hilgenberg*** - University of Arkansas
3:40	Lutein and beta carotene content of selected spinach genotypes - ***J. A. Kirkpatrick, R. A. Gard, J. B. Murphy and T. E. Morelock*** - University of Arkansas
4:00	Growing awareness for lutein and opportunities for the spinach industry - ***Zoraida De Freitas*** - Kemin Foods, Des Moines, IA
4:20	Development of a CEA Greenhouse production system for spinach - ***R. W. Langhans, C. F. Johnson, L.S. Katzman and L. D. Albright*** -Cornell University
4:40	Wrap up, announcements

Saturday, December 16, 2000

7:15 PM 9:30	Bus loading for tour of Texas Wintergarden Spinach Production Region
5:30	Arrive back at Omni Hotel

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BREEDING WHITE RUST RESISTANCT SPINACH

T.E. Morelock[1] and J.C. Correll[2]

[1]Department of Horticulture and [2]Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701

White rust (*Albugo occidentalis*) is a common disease in mid-south and eastern seaboard of the United States. The disease is the most serious disease in the Arkansas-Oklahoma production area (the Arkansas River Valley from Alma, Ark., to Tulsa, Okla.) and in the Texas Winter Garden. Because of the seriousness of the disease and the limited number of chemicals available for control, a breeding program was initiated by the Arkansas Agricultural Experiment Station in 1970. During this time period five white rust resistant varieties have been developed: 'Ozarka', 'Greenvalley', 'Fallgreen', 'F380', and 'Wintergreen'. 'Fallgreen' (semi-savoy) and 'F380' (flat) have the highest levels of white rust resistance. Additional advance breeding lines are presently being evaluated in Arkansas, Texas and Oklahoma for possible release. The flat line 91-415 is the closest to release and is being tested in Commercial size trials.

A disease nursery was developed at the University of Arkansas Vegetable Substation in 1974 and has been in continuous spinach (two crops per year) since that time. Excellent disease pressure for white rust as well as other diseases common to the region is present at this location. White rust nurseries are also grown at the Texas A & M Research and Extension Center at Uvalde, Texas, and at the Del Monte Research Farm near Crystal City, Texas. These Texas sites consistently produce heavy white rust pressure and are a valuable portion of the evaluation process and make it possible to select plants under extreme pressure.

White rust resistant varieties and breeding lines developed by this program also exhibit some resistance or tolerance to downy mildew. This resistance appears to be race nonspecific; it appears to hold up equally well to all races of downy mildew and may prove to be useful when single gene immunity to downy mildew is not readily available.

QUANTITATIVE AND QUALITATIVE RESISTANCE TO DOWNY MILDEW (*Peronospora farinosa* f. sp. *spinaciae*) OF SPINACH.

J. C. Correll[1], B. M. Irish[1], S. T. Koike[2], and T. E. Morelock[1]

[1]Department of Plant Pathology, University of Arkansas, Fayetteville, AR 72701 and [2]University of California Cooperative Extension, Salinas, CA93901.

Downy mildew (*Peronospora farinosa* f. sp. *spinaciae*) is a serious disease of spinach in most spinach growing areas of the world including the U. S. (Correll et al, 1994). Since 1996, three new races (races 5, 6, and 7) of the pathogen have been identified (Correll et al, 1998; 2000; Nali, 1998). Race 5 and 6 occur commonly in California whereas race 7 has not yet been identified in the United States. Race 5 and 6 have not been identified in Texas. Races 5 and 7 occur in parts of Europe, but race 6 has not been reported. Characterizing resistance to downy mildew has traditionally relied on screening for major single gene resistance at the cotyledon stage; however, partial, or field resistance to races 3 and 4 of *P. farinosa* f. sp. *spinaciae* (Brandenberger et al, 1992) and *Albugo occidentalis* (Brandenberber et al, 1994) under greenhouse and field conditions has previously been documented Although most commercial cultivars were considered susceptible to race 6 based on the more traditional cotyledon inoculation assay, field observations indicated that certain cultivars appeared tolerant under field conditions. Consequently, a modified greenhouse cotyledon and true-leaf test was developed to evaluate partial resistance to race 6 by inoculating 2-wk-old seedlings. Seven days after inoculation, the cotyledons and the first set of true leaves was scored (0 = no symptoms; 1= 25% chlorosis; 2= 26-50%; 3= 51-75%; 4= >75%). A wide range of partial resistance was observed among the 80 commercial genotypes evaluated. The assay is a quick and reliable means of evaluating partial resistance in spinach. Field tests are currently being evaluated to determine if the partial resistance observed under greenhouse conditions is correlated with field performance.. Interestingly, the partial resistance observed in greenhouse tests was evident with race 6 but not with race 5 for most of the cultivars evaluated indicating some race specificity to the partial resistance.

References

Brandenberger, L. P., Correll, J. C., Morelock, T. E., and McNew, R. W. 1991. Identification of and cultivar reactions to a new race (race 4) of *Peronospora farinosa* f. sp. *spnaciae* on spinach in the United States.

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BIOCHEMICALMECHANISMS OF GREEN PEACH APHID RESISTANCE IN SELECTED SPINACH CULTIVARS

R.O. Musser, C. Doan, G.N. Ervin, and T. Morelock

Depts. Of Entomology and Horticulture, University of Arkansas, Fayetteville

Several breeding lines of University of Arkansas spinach were noted in 1986 to suffer substantially lower green peach aphid (GPA, *Mysus persicae*) damage while growing in a Texas A&M nursery. Of these lines, one (line F86-70) has been screened through several generations, with persistent, significant resistance when compared to other breeding lines and GPA-susceptible commercial varieties. In addition, a selection from this line (MX2) also demonstrates significant resistance to GPA feeding. These two breeding lines of spinach have been investigated for chemical feeding deterrents in order to determine chemical markers that may be of utility in future screening programs aimed at selecting for aphid-resistant spinach varieties. Chemical anti-herbivore defenses currently under investigation are: oxidative enzymes, insect herbivore protease inhibitors, phenolic plant defenses, plant sterols, and low-molecular weight volatile compounds that may serve as direct toxins or signicals for other plant defenses. Results to date indicate that these spinach breeding lines display a host of chemical components that are characteristic of the aphid resistance syndrome in spinach and other aphid hosts. Among these are decreased oxidative enzyme activity, increased production of phenolic compounds and trypsin inhibitors, and heightened activity of enzymes involved in production of volatile defensive compounds. Further work will be necessary to determine quantitatively which of these defenses is most important in reducing GPA feeding on spinach lines F86-70 and MX2.

ZOXIUM™ FUNGICIDE

Kenneth P. Buchert

Research and Development,Rohm and Haas Company
Waller, Texas

The Oomycetes class of fungi which includes economically important genera such as: *Albugo, Bremia, Phytophthora, Plasmopora,* and *Pseudoperonospora* has always been a challenging group of fungi pest to manage. Rohm and Haas Company has developed **ZOXIUM™** fungicide (RH-7281, common name zoxamide) which provides effective control of diseases caused by these organisms. **ZOXIUM™** is currently under-going the first ever trilateral registration review among US, Canada, and Mexico. The mode-of-action of **ZOXIUM™** is unique and unlike any other fungicide. **ZOXIUM™** controls diseases by covalently binding to the cytoskeleton and arrest cell division. The mechanism is unique among Oomycete fungi. **ZOXIUM™** has excellent rain fastness and residual activity. This reduced risk fungicide has demonstrated excellent mammalian, environmental and crop safety. A Mancozeb/ Zoxamide (8:1) blend will be marketed as **GAVEL™** fungicide in potatoes.

THE EFFECT OF SURFACTANTS ON WHITE RUST (*Albugo occidentalis*) OF SPINACH.

*Brian M. Irish, James C. Correll, and Teddy E. Morelock**

Departments of Plant Pathology and *Horticulture
University of Arkansas, Fayetteville, AR 72701

White rust, caused by *Albugo occidentalis,* is an economically important disease of spinach (*Spinacia oleraceae*) (Correll et al., 1994). Although cultural practices and horizontal resistance are used for disease management of white rust (Brandenberger et al., 1994), control strategies often rely on fungicides (Dainello et al., 1990). Due to environmental concerns, residue on food products, and pathogen resistance, there has been a shift away from pesticides and towards research on alternative methods for disease control. Previous work has shown that synthetic surfactants can have a lytic effect on several types of zoosporic plant pathogens and thereby reduce disease (Stanghellini and Miller, 1997).

In the current study, synthetic surfactants were tested for their efficacy in controlling white rust of spinach under greenhouse and field conditions. Greenhouse plants were treated once with several different surfactants followed by inoculation with sporangia of *A. occidentalis.* Field plants received several applications of the surfactants. Disease incidence and severity were rated by scoring leaves for infection after 10 days in the greenhouse tests and at the end of the growing season for field trials. Most surfactant treatments caused a significant reduction in white rust disease incidence and severity compared to water controls and several surfactants were not significantly different from the highly efficacious azoxystrobin fungicide, Quadris.

Direct examination of zoospores at 400 X magnification showed that the synthetic surfactants, as well as *P. aeruginosa* caused rapid (< 2 min.) zoospore lysis. Use of surfactants to manage white rust of spinach may be an economical alternative to fungicides.

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NEW CHEMISTRY FROM NOVARTIS

Brad Minton

Novartis Crop Protection, Cypress, Texas

Acibenzolar-S-methyl is a novel plant health product that recently received registration for use in tomatoes, tobacco, and spinach. It is rapidly absorbed and translocated throughout treated plants, but does not have direct activity against pathogens. Acibenzolar-S-methyl exhibits a unique mode of action that mimics the natural Systemic Activated Resistance (SAR) response found in most plants. SAR is an intrinsic resistance which occurs in response to invading pathogens. Acibenzolar-S-methyl mimics SAR which results in the accumulation of pathogenesis related proteins. Pathogenesis related proteins are enzymes that may have growth inhibiting activity on the advancing pathogen. These proteins are theorized to also play a major role in the systemic response since they accumulate during the onset of resistance.

Acibenzolar-S-methyl is available under the trade name of Actigard™ and is formulated as a 50 WG. Actigard is registered for control of white rust and downy mildew on spinach grown in the following Texas counties: Atascosa, Dimmit, Frio, Kinney, LaSalle, Medina, Uvalde, Zavala, Maverick, Hidalgo, Cameron, Willacy, Starr, Webb, and Zapata. Registration will be expanded to other spinach production areas as additional data are generated. Actigard™ at 0.023 lb ai/A applied on a 7-10 day schedule provides excellent control of both spinach white rust and downy mildew.

Pymetrozine represents a new and novel class of chemistry for control of insects with sucking mouth parts. Registration under the trade name of Fulfill™ was received earlier this year for use in potatoes and tobacco. Additional registrations, including spinach, are expected in the next 12-18 months. The mode of action of pymetrozine is different from other registered insecticides and no cross resistance has been identified. Pymetrozine causes affected insects to stop feeding as a result of influence on the salivary pump. Pymetrozine at 0.085 lb ai/A provides control of many important aphid species as well as suppression of whiteflies, and has a wide margin of safety for most beneficial insects and honeybees. Pymetrozine is ideally suited for IPM programs due to the narrow spectrum of activity, unique mode of action, and safety to beneficial insects.

Thiamethoxam is a second generation neonicotinoid insecticide under development by Novartis Crop Protection for use in vegetable, row, and tree crops. Thiamethoxam is systemic within plants and can be applied as a soil or foliar treatment. It has activity against aphids, whiteflies, thrips, leafhoppers and certain beetle species. The mode of action of thiamethoxam involves interference with the nicotinic acetylcholine receptor in the nervous system of the affected insect. Initial registration of thiamethoxam on cucurbits, fruiting vegetables, and leafy vegetables (including spinach) is expected in 2-3 months. Thiamethoxam will be sold under the trade names of Platinum™ 2 SC for soil applications and Actara™ 25 WG for foliar applications. Soil use rates will range from 0.078-0.17 lb ai/A and foliar use rates will be 0.03-0.06 lb ai/A.

SPINACH PRODUCTION AND PEST MANAGEMENT IN CALIFORNIA

S. T. Koike

University of California Cooperative Extension, Monterey County

In California, spinach is a vegetable commodity that has steadily increased in acreage and value over the past decades. In 1960, the spinach crop consisted of 8,150 acres that produced 58,700 tons of spinach valued at $1.5 million. In 1999, spinach was grown on 23,700 acres that produced 147,000 tons valued at $104 million. In coastal California, spinach is grown all year. The southern desert area has spinach from November through March, and the central valley has spinach from February to April. The Salinas Valley, located in the coastal Monterey County, is the largest spinach producing region and grows approximately 60% of the state's crop. Spinach is grown for several products, including frozen spinach, traditional fresh bunched spinach, fresh packaged spinach that is pre-washed, bagged and ready to eat, and baby leaf spinach that is also a value-added fresh product.

California spinach production is characterized by dense seeding rates that are set depending upon the nature of the final product. On standard 40-inch beds, spinach is generally planted at the following rates (million seed/acre): frozen spinach at 0.3 to 0.6; standard fresh at 1.0 to 1.5; baby leaf at 1.5 to 3.0. Recently, Salinas Valley farmers are growing spinach and other crops on 80-inch beds so as to increase the amount of crop per acre. On 80-inch beds, baby leaf spinach is planted at 3.7 to 4.0 million seed/acre.

California spinach products are noted for their high quality. Hence, pest management is a critical, challenging aspect of production. The main arthropod pests are leafminers and crown mites. Other periodic pests are aphids, lepidopteran worms, and wireworms. While a few cultural practices (timely disking of harvested fields, delaying planting until crop residue breaks down) help manage pests, control is mostly achieved through the application of insecticides.

Some key weed pests are the following: burning nettle, shepherdspurse, little mallow, chickweed, and London rocket. Standard cultural (crop rotation, sanitation, land preparation steps, pre-irrigation, cultivation, hand weeding) and herbicide (metam sodium, Roundup, Ro-Neet, Spin-Aid, Poast) controls are used to manage weeds.

The main soilborne disease is damping-off caused by the complex of *Rhizoctonia*, *Fusarium*, and *Pythium*. Cyst nematode is the only nematode pest of spinach in California. Foliar diseases are downy mildew (*Peronospora farinosa* f. sp. *spinaciae*), Cladosporium leaf spot (*C. variabile*), anthracnose (*Colletotrichum dematium*), and Stemphylium leaf spot (*S. botryosum*). Recently, two new races (5 and 6) of the downy mildew pathogen have occurred in the state.

Stemphylium leaf spot is a new disease that was first reported in 1997. Symptoms are small (2 to 5 mm diameter), circular, gray green spots that enlarge and become tan. Older spots are dry, papery, and resemble burn from chemicals.

S. botryosum was isolated from these spots and caused identical symptoms when inoculated onto ten spinach cultivars. However, this pathogen did not cause disease when inoculated onto 22 other crop plants. The host range of this pathogen appears restricted to spinach and the pathogen could possibly be a distinct *forma specialis* of *S. botryosum*.

BENEFIT OF FUNGICIDES AND HOST RESISTANCE IN REDUCING YIELD AND QUALITY LOSS DUE TO FOLIAR DISEASES IN SPINACH.

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White rust, anthracnose and leaf spots can cause severe yield and quality losses in spinach (*Spinacia oleracea*) in the mid-Atlantic and northeastern United States. Foliar fungicides are an important component of disease management systems available to growers. Experiments were conducted in 1996, 1997 and 1998 in New York, Maryland and New Jersey to determine the economic benefit of five foliar disease management programs on three spinach cultivars. Presently registered fungicides (copper hydroxide and fosetyl-Al), as well as maneb and dodine were examined. White rust susceptible 'Seven R', and moderately resistant 'Fall Green', 'Vancouver' or 'Coho' cultivars were examined. In environments where white rust was severe, dodine (unregistered) was the most effective fungicide and one of the least expensive fungicides. The previously registered EBDC fungicide maneb was as effective as dodine when white rust disease pressure was low and only maneb reduced anthracnose severity. Some treatments, were phytotoxic, especially copper hydroxide applied full season. Marginal economic returns indicate that the benefit of fungicide application to a susceptible cultivar could be as high as $18,532/A for fresh market spinach and $1,803/A for processing spinach. Host resistance was as effective as fungicide application in two environments where white rust was severe. Nontreated Vancouver and Fall Green produced a yield of A Grade fresh market spinach similar to Seven R treated with copper hydroxide and fosetyl-Al. In one environment where white rust onset was late, resistance was more effective than fungicide treatment in preventing a reduction in grade.

SPI NACH VIRUSES IN SOUTHWEST TEXAS

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Viruses diseases have occurred annually in commercial spinach in the Texas Winter Garden. Yield and quality losses have varied. Significant losses in the 1987-88 and 1988-89 seasons were mostly attributed to *Beet western yellows virus* (BWYV), but *Tomato spotted wilt virus* (TSWV) was also detected at a high incidence in those seasons. This peak of TSWV incidence followed 1987 and 1988 spotted wilt epidemics in area peanut fields. In the 1998-99 season, *Beet curly top virus* (BCTV) caused the greatest loss. Overall, *Cucumber mosaic virus* (CMV) occurs most consistently. *Tobacco ringspot virus* (TobRSV) occurs sporadically at very low levels.

CMV (Cucumovirus) is non-persistent in >60 aphid vector species (primarily *Myzus persicae* and *Aphis fabae*), explaining a clustered disease distribution, usually at the field edge. Cultivars have a level of resistance to severe CMV strains. Seed transmission has been reported in spinach and other plants. A common symptom is yellowing of lower leaves, stunting, and dark green rugose new leaves. Host range is extensive (800 species, monocots and dicots) including pepper, tomato, cucurbits, celery, and numerous weeds. Control suggestions are use of resistant cultivars, broadleaf weed control near fields before and after planting, high plant populations, and good growing conditions for rapid plant growth.

BCTV (Geminivirus) in Southwest Texas spinach may represent a fourth BCTV group (Drake Stenger, Univ. Nebraska, *personal communication*). BCTV is persistent in the vector, beet leafhopper (*Circulifer tennelus*), which may fly >100 km. Incidence is often higher near the field edge. Resistance could probably be developed in spinach. Early fall seeding has higher incidence than late fall or early winter seeding. Risk is higher with low plant populations. Prolonged summer drought may indicate greater risk. Symptoms are yellow older leaves with asymmetrical younger leaves dwarfed, crinkled, and rolled upward and inward. Host range is moderate (>300 species in 44 families) including pepper, tomato, sugar beet, table beet, cucurbits, broadleaf weeds, and native shrubs. Control suggestions are high plant populations, broadleaf weed control near fields before and after planting and delayed fall planting dates.

BWYV (Luteovirus) is persistent in >eight aphid vector species (primarily *Myzus persicae*). Incidence is nearly uniform across fields. Resistance could probably be developed in spinach. High light intensity after several days of cloudy weather may trigger rapid symptom development and rapid quality loss. Symptoms are mild chlorotic spotting on interveinal areas, most often on the leaf tips of older and middle-aged leaves. From a distance, the canopy may have a bronze cast. *Alternaria* invades yellowed leaf tissue, resulting in black lesions with red-orange halos. Host range is moderate (>146 species in 23 families) including spinach, table beet, sugar beet, lettuce, crucifers, and broadleaf weeds. Control suggestions are to avoid high aphid populations, broadleaf weed control near fields before and after planting, and early harvest when symptoms develop.

TSWV (Tospovirus) is persistent in two thrips vectors (tobacco thrips, *Frankliniella fusca* and western flower thrips, *F. occidentalis*). Resistance may be difficult to develop. Symptoms are not known. Spinach may be a significant TSWV winter reservoir for spring and summer crops. Host range is extensive (>600 species, monocots and dicots) including peanut, tomato, pepper, tobacco, numerous ornamentals; and tobacco. Control suggestions are high plant populations and avoiding early fall plantings near mature infected peanuts.

TobRSV (Nepovirus) is vectored by dagger nematodes (*Xiphinema americanum*) and close relatives and apparently at low rates by several insects. TobRSV is seedborne in several plants. Resistance may be difficult to develop. Symptoms include chlorotic mottling and mosaic and tan necrotic lesions. Host range is moderate (many species in 20 families) including cucurbits, tobacco, pepper, bean, tomato, pea, apple, blackberry, blueberry, grape, ornamentals, and broadleaf weeds. Control suggestions are crop weed control and avoid planting after weedy fallow.

HERBICIDE EVALUATIONS FOR SPINACH

L. Brandenberger, R. Wiedenfeld, M. Matocha[1] and R. Talbert[2]

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Currently preemergent and postemergent herbicides available for use in commercial spinach production are limited, but screening and rate studies during the past several years have identified some new materials that have potential. Studies carried out during 1999 which are being repeated in 2000 indicate that Diuron, Metolachlor, S-Metolachlor, Dimethenamid and S-Dimethenamid provided adequate preemergence weed control with reasonable levels of crop damage. Postemergent materials in the same studies generally resulted in higher levels of crop damage, but also provided an increase in overall control of weed species and horse purslane. Postemergent materials Phenmedipham and Lactofen and a tank mix of Phenmedipham and Metolachlor provided between 66 to 87 percent overall control of weed species.

SPINACH PRODUCTION AND MARKETING TRENDS

Jose G. Peña, Extension Economist-Management

Texas Agricultural Extension Service Uvalde, TX 78802

Texas led the nation in spinach production for the fresh market and total annual production until the mid-80's. In the 50's, for example, Texas annually harvested 30-40,000 acres of both fresh and processing spinach. The 1952 edition of USDA's Agricultural Statistics indicates that Texas harvested 30,000 acres (25,000 fresh; 5,000 processed) on page 307 of this reference book. Since the mid-80's production has decreased substantially. Disease problems, antiquated postharvest handling techniques and lower yields than competitive states caused plantings to be reduced substantially. Since 1992 Texas has annually harvested an average of 9,125 acres (2,612 acres fresh; 6,513 processed) and Texas now produces about 20% of total U.S. production compared to the mid-80's, when it produced close to 40% of total production. California now leads the nation in total production and dominates production for the fresh market. A severe infestation of blue mold and white rust in Texas in the mid-80's contributed to the decrease in spinach production. In addition, fresh and processed market shares have reversed in Texas with California leading the nation in production for the fresh market since the late 80's and Texas leading the nation in spinach production for processing. In 1999, for example, Texas produced 42.2 percent of the 229.4 million pounds of spinach produced in the U.S. for processing.

GROWTH AND QUALITY OF SPINACH ARE AFFECTED BY PLANTING SYSTEMS

Daniel I. Leskovar[1], Larry A. Stein[2], and Frank J. Dainello[3]

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Plant population have pronounced effects on growth and yield of many vegetable crops. However, few studies on plant spacings have been conducted in spinach (*Spinacea oleracea* L.). Advantages of using plastic mulch as a component of intensive production systems also has been documented in cucurbits and solanaceous crops but less in leafy vegetables. The aim of this study was to determine if plant density and mulching affect plant growth dynamics, product cleanliness, quality, and yield of an experimental semi-savoy spinach genotype 'Ark-310' established by transplanting. Within-row spacings were 15 and 25 cm, and mulching treatments were bare-soil and black polyethylene mulch. Plants were destructively sampled weekly (first year) or bi-weekly (second year) for leaf area (LA), leaf number, leaf dry weight (LDW) and root dry weight (RDW) measurements. Plants grown on plastic mulch at 25- cm spacing had greater LA, LDW, and RDW than when grown at 15-cm spacing on mulch or bare-soil. Leaf number and specific leaf area (LA/LDW) were less affected by either spacing or mulching. The amount of soil on harvested leaves was lower on plants grown on plastic mulch in both years. In one year, total yields (MT ha^{-1}) were 42% higher at 15-cm than at 25-cm plant spacing, while mulch increased yields by 20 %, independently of plant spacing. These effects were not evident in the second year with higher rainfall.

PACKAGING DESIGN FOR FRESH-CUT SPINACH LEAVES

Julio Loiaza, Frank Dainello and Luis Cisneros-Zevallos

Department of Horticultural Sciences, Texas A&M University, College Station TX77843.

A packaging system for spinach leaves is proposed for keeping aerobic conditions within the package and extending the spinach shelf life based on external quality attributes such as appearance, color and aroma.

Spinach leaves cultivars Bossanova and 3-10 were used in this study. Respiration of spinach leaves was determined using closed jars under different temperature conditions ranging from 2 to 20∞C and under different partial pressures of O2 and CO2. A respiration enzyme kinetics model was applied to the closed jars allowing to determine respiration of spinach under different conditions of O2 and temperature, as well as the lower oxygen limit (*LOL*) under which fermentation takes place.

Quality attributes of overall appearance, color, decay and aroma were evaluated using low-density polyethylene (LDPE) plastic bags. The film permeability of the packaging material, the amount of spinach tissue per bag, and different storage temperatures allowed a broad range of O2 partial pressures within the bags. The obtained Quality attributes were related to these O2 partial pressures. Results indicate that respiration ranges from ~ 10 to 110 mL/Kg h for a temperature range of 5 to 20∞C , while the *LOL* for spinach ranges from 1 to 2% O2 under the same temperature conditions. Parameters of the enzyme kinetics respiration model were characterized for spinach leaves for each temperature. Additionally, we observed that quality attributes decrease with temperature, however, it seems not to be influenced by O2 concentration at lower temperatures.

The results of this study can be used as the basis to design a packaging system for fresh-cut spinach leaves. The packaging design would be based on the enzyme kinetics respiration parameters obtained for fresh spinach and the gas transfer properties of the selected plastic film.

HANDLING SPINACH FROM A RE-PACKER'S STANDPOINT

Dave Schwartz

Cutter's Edge, Hamburg, New Yok

HEALTH BENEFITS OF SPINACH

L.R. Howard

Food Science Department, University of Arkansas, Fayetteville, AR 72704

Fruits, vegetables, nuts and whole grains contain an abundance of phytonutrients that have been associated with protection from and/or treatment of chronic diseases including coronary heart disease, various types of cancer, eye disorders, diabetes, stroke and hypertension. Plant phytonutrient protection against degenerative diseases has primarily been attributed to antioxidant constituents. Free radical species cause oxidative damage to lipids, proteins and nucleic acids and play a role in numerous degenerative conditions. Antioxidants contributed by the diet effectively scavenge free radicals, and protect tissues against free radical mediated diseases. Spinach is reported to be an excellent source of antioxidants, ranking third behind garlic and kale among 20 vegetables tested, with an oxygen radical absorbance capacity (ORAC) value of 12.6 (mol of trolox equivalents/gram fresh weight. This past year we analyzed 26 advanced breeding lines and/or commercial spinach cultivars for ORAC, total soluble phenolics, cinnamic acid and flavonol contents to determine if genetic variation for antioxidant capacity and phenolics exists among breeding materials. Spinach germplasm varied over two-fold for all of the attributes measured indicating that genetic variation exists for genetic enhancement. ORAC values ranged from 10.1 to 25.0 (mol of trolox equivalents/gram fresh weight, and correlated well with total phenolics ($r = 0.50$), water soluble cinnamic acids ($r = 0.57$), and flavonols ($r = 0.58$). Further research is needed to identify the specific compounds responsible for antioxidant capacity, and to determine the effects of maturation, cultural practices and environmental growing conditions on antioxidant capacity.

Table 1. Antioxidant capacity and phenolic content of spinach breeding lines and varieties.

Variety/ Breeding Line	ORAC[1] (µmol TE[5]/g FW)	Total Phenolics[2] (mg/kg FW)	Cinnamic Acids[3] (mg/kg)	Flavonols[4] (mg/kg)
380	25.0a[6]	3832.6def	1190.2cd	1594.2e
97-139	22.4b	4282.9c	1085.2def	1320.9fgh
90-276	21.9bc	4057.2cd	1903.8a	2227.3a
88-354	21.3bcd	4669.3ab	1450.4b	1872.3c
Fallgreen	20.8bcde	3608.9fgh	817.9hijk	1013.2ij
91-227	20.5bcdef	3945.5cde	1489.4b	1997.4b
09	20.4bcdef	3388.7ghij	919.6fgh	1066.0ij
88-130	20.2bcdef	4835.3a	1168.4cde	1443.4f
90-252	19.9cdef	3682.7efg	1092.9de	1382.8fg
97-152	19.9cdef	3668.9efgh	897.7ghi	1073.8i
97-173	19.2def	3332.3ghij	814.3hijk	1070.9i
97-154	17.3g	4281.5c	1270.3c	1719.2d
San Juan	16.4gh	3026.8kl	855.7ghi	970.9ijkl
91-248	16.3ghi	3561.9fghi	835.6ghij	1070.9I
Variety/ Breeding Line	**ORAC[1] (µmol TE[5]/g FW)**	**Total Phenolics[2] (mg/kg FW)**	**Cinnamic Acids[3] (mg/kg)**	**Flavonols[4] (mg/kg)**

310	15.8ghi	4090.9cd	845.8ghij	1011.5ij
St. Helens	15.0ghij	3102.7k	755.1hijk	845.2klm
88-212	14.4ijk	2586.8m	1082.7def	1434.8f
Ozarka II	14.4ijk	4544.4ab	1127.9cde	1422.4f
Bolero	13.4jkl	2291.8n	815.6hijk	874.4jklm
97-165	13.3jkl	3489.0fghij	735.1ijk	823.6klm
90-198	13.3jkl	3637.8efgh	732.9ijk	896.4ijklm
Avon	13.2jkl	2864.9kl	592.1l	676.5n
91-415	13.1jkl	3351.1ghij	916.1fgh	1041.3ij
86-70	13.0kl	3468.3fghij	1000.3efg	1275.3gh
Coho	12.2kl	2904.6kl	767.5hijk	978.1ijk
Samish	10.7m	3609.6fgh	862.9ghi	1073.7i

[1] Oxygen radical absorbance capacity.

[2] Total soluble phenolics = sum of water and acetone soluble phenolics detected by the Folin-Ciocalteu assay.

[3] Total water-soluble cinnamic acids detected by absorbance at 320 nm and expressed as mg of caffeic acid/kg.

[4] Total water-soluble flavonols detected by absorbance at 360 nm and expressed as mg of quercetin/kg.

[5] Trolox equivalents.

[6] Mean separation by Tukey-Kramer test. Values within columns with similar letters not significantly different (P>0.05).

CONSUMER ACCEPTABILITY OF SPINACH AS A REPLACEMENT FOR ICEBERG LETTUCE ON HOT AND COLD SANDWICHES

Fitch-Hilgenberg, M. E. and Morelock, T.

University of Arkansas-Fayetteville.

Americans purchase over 10.5 billion sandwiches each year with hamburgers and cheeseburgers accounting for more that 50 percent of those purchased. In an effort to increase the nutrient density of sandwiches, sensory evaluation was conducted to determine consumer acceptance of spinach as a replacement for iceberg lettuce on hot and cold sandwiches. Hamburger and club submarine sandwich ingredients were purchased from nationally recognized fast food restaurants. Fresh, curly leafed spinach was purchased locally, washed, central vein removed and shredded to resemble the shape of the iceberg lettuce supplied by the restaurant. Sandwiches were assembled with either iceberg lettuce or spinach as an ingredient. Hamburgers (n=43) and sub sandwiches (n=112) were evaluated on different days at 5 different sites. Untrained taste panelists received either two samples with lettuce and one with spinach or two samples with spinach and one with lettuce. Panelists rated each sample using a Hedonic scale of 1 (like extremely) to 5 (dislike extremely). Statistical analysis of data was conducted using ANOVA for comparing group ratings and Chi square analysis for comparing percentages. Data indicated that order of presentation (2 lettuce, 1 spinach or 2 spinach, 1 lettuce) had no significant effect on acceptability. No significant differences were found when spinach replaced lettuce on either the hamburger or submarine sandwich. When data from hot and cold sandwiched were combined, the Hedonic rating for all spinach samples and all lettuce samples was 2.19 ± 0.07 (mean ± SE) and 2.21 ± 0.07, respectively. The results indicate that the likeability of sandwiches made with spinach was equal to those made with lettuce.

LUTEIN AND BETA-CAROTENE CONTENT OF SELECTED SPINACH GENOTYPES

J.A. Kirkpatrick, R. A. Gard, J.B. Murphy and T.E. Morelock

University of Arkansas, Department of Horticulture,Fayetteville, Arkansas

Public awareness of nutrition is rising due to more information concerning cancer prevention, antioxidants, and neutraceuticals. Antioxidant has become a household word that implies good health. Carotenoids are a group of yellow to orange pigments found in plants that have the ability to act as antioxidants in the human body. Spinach is high in the carotenoids lutein and beta-carotene in comparison to other fruits and vegetables. Lutein is a strong antioxidant that has been found to slow or prevent the onset of age-related macular degeneration (AMD) and prostate cancer. Beta-carotene, a pigment also found in carrots, and often associated with a possible decrease in occurrence of lung and breast cancer, appears in levels near those of lutein in spinach.

University of Arkansas researchers have conducted analyses of spinach leaf tissue for lutein and beta-carotene using HPLC. These studies examined the differences of lutein and beta-carotene content found in current market varieties and experimental breeding lines as well as differences based on leaf maturity. As expected, significant differences were found among varieties and leaf maturities. A quantification of that expectation is now available. Information found here is useful to the plant breeder for increasing levels of such substances but it is also useful to the consumer in order to eat the healthiest product available.

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

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LUTEIN ROLE IN EYE HEALTH

Dr. Zoraida DeFreitas

Kemin Foods, Des Moines, IA

Lutein is a natural antioxidant, primarily found in green leafy vegetables, such as kale and spinach. It may not be metabolized "*de novo*" by humans, therefore it must be ingested from the diet. Dietary lutein deposits in the eye, skin and fat tissues. The benefits of lutein in humans were first associated with healthy vision. Lutein and zeaxanthin, another carotenoid found in green vegetables, deposit in the macular region, other areas of the retina and the lens. In the eye, lutein filters blue light and acts as an antioxidant, protecting tissues and molecules from photoxidation. Low levels of lutein and zeaxanthin in the macular region and the lens have been associated with higher risk of developing age-related macula degeneration (AMD), the leading cause for blindness in the Western civilizations, and cataracts. Today, there is new evidence that suggest that lutein may have other important roles in the body. Recent animal and "*in vitro*" studies show that lutein may also protect the skin against photo-oxidation damage induced UV-A and UV-B. More animal and human studies are underway to determine the role of these carotenoids as antioxidants in the skin.

DEVELOPMENT OF A CEA GREENHOUSE PRODUCTION SYSTEM FOR SPINACH

R. W. Langhans, C.F. Johnson, L.S. Katzman and L.D. Albright

Cornell University, Ithaca, NY

Goals of the system include:

1. Prevent disease in the hydroponic system without use of chemical pesticide.
2. Develop germination system to produce consistent uniform seedlings.
3. Develop production system for head and/or cut leaf spinach.
4. Select cultivars for head and/or leaf spinach production.
5. Quantify nutritional value of CEA grown spinach.
6. Quantify energy requirements for CEA production of spinach.
7. Evaluate best marketing opportunities for CEA spinach.
8. Demonstrate economic viability of the CEA Spinach Production System.
9. Determine spinach production system for NASA base Lunar, Mars and Space Station.

This project is part of the CEA (Controlled Environment Agriculture) program at Cornell, which includes 12 faculty (Horticulture, Agriculture Engineering, Economics, Marketing, Food Safety, Seed Technology, Plant Breeding, Entomology and Plant Pathology), 2 Senior Research Associates, and 8 graduate students. Over 10 years of research on a CEA production system for leaf lettuce led to the construction of a demonstration commercial production system. The 8,000 square foot greenhouse produces one thousand 5-ounce heads of lettuce every day of the year. The prototype greenhouse serves as a research tool to identify real-world challenges of transition from research scale to commercial scale production. First year start up problems (mechanical equipment, computer control and aphids) were identified and innovative solutions including biological-control of insect pests have presently been put in place for our second year of production. The transition phase is expected to last 3 to 5 years.

Spinach will be a more difficult production system to develop, because of its susceptibility to disease (Pythium), lack of seed uniformity (as compared to lettuce), and it's quick bolting due to the long days used in the CEA system. Our research program will focus on solving these major problems.

If this spinach production program is successful, we feel the market will be attracted to this product, because it will be fresh, safe, pesticide free and nutritious. The CEA program involves small greenhouse units, located close to the market (fresh). The CEA system is HACCP (Hazardous Analysis Critical Control Point) approved, ie. the spinach can be produced and packaged without water or humans contacting the leaves. If the spinach is sealed in a bag at the greenhouse, the product can be used without washing. We use IPM practices, ie. no chemical pesticides for insect or disease control. Biological control methods are the mode of control for insects. Since the growing conditions are consistent every day, the nutritional value of the plants will be the same year-round. We are also evaluating the opportunity to change the environment to improve the nutrition.

TASP = Texas /Arkansas Spinach Program

PROGRAM COORDINATORS

10. Arkansas - Dr. Teddy Morelock
11. Texas - Dr. Frank Dainello

PROGRAM GOALS:

1. Development of a world class spinach research and extension program
2. Enhance and expand the teaching, research and extension efforts of the cooperating Departments
3. Increase the potential for successful procurement of grant funding to support the research and extension efforts of the cooperating departments

PROGRAM OBJECTIVES:

1. Maintain and enhance the processing spinach industry of the region
2 Revitalize the regions' fresh market industry
3 Organize a research and extension rapid response team to react to the regions' spinach industries problems

FACILITIES AVAILABLE TO COOPERATIVE PROGRAM:

1. ARKANSAS:
   - A. Campus
     - a) Tissue culture lab with 2 isolation flow hoods
     - b) 2 culture rooms
     - c) 4 molecular labs (Gene gun, HLPC)
       - Pathology
       - Entomology
       - Physiology
       - Weeds
     - d) Isolation facility for transgenic material(HPLC)
     - e) Access to Food Science Institute
   - B. Kibler Station
     - f) Amble field plot area
     - g) Good field plot equipment
     - h) Excellent disease screening nursery
2. TEXAS:
   - A. Campus
     - a) Food processing lab
     - b) Access to the Vegetable & Fruit Improvement Center ????
   - B. Uvalde AREC
     - a) 1 multi-purpose lab
     - b) 1 greenhouse
     - c) 1 grow room
     - d) 4 growth chambers
     - e) 1 rough processing lab
     - f) Adequate field plot area
     - g) Excellent white rust screening nursery
     - h) Adequate field plot equipment

i) 4 walk-in refrigeration units
j) Access to Del Monte Foods Research Farm and white rust nursery

COOPERATIVE EFFORTS CURRENTLY INITIATED:

1. Joint white rust screening nurseries
   a) TAMU AREC @ Uvalde
   b) TAEX / DMF Nursery @ Crystal City
2. Production and packaging techniques for the breeding line ARK 88-310
3. Joint membership on MS graduate committee for student investigating the above
4. Influence of field fertilization practices on phyto-chemical content of processing spinach
5. Evaluation of surfactants on spinach white rust disease development

SPINACH RESEARCH NEEDS TO BE ADDRESSED:

1. Enhance breeding efforts to produce adaptable varieties with high levels of disease and insect resistance
2. Identification of aphid resistance gene(s) of Arkansas germplasm and transfer to an horticulturally acceptable variety
3. Roundup resistance transformation in spinach
4. An effective IPM program for both fresh market and processing spinach
5. An effective white rust predictive model
6. Investigation of the basic biology and etiology of the white rust fungus
7. Development of a semi heading semi savoy spinach variety
8. Maintenance of Blue mold race identification project and a race repository
9. High yielding fresh market spinach production systems
10. Redefine technology for development of transgenic spinach
11. Virus identification and control strategies
12. Enhanced flavor, nutritive values and health benefits of spinach
13. Development of flavor profile for spinach

ADDITIONAL POTENTIAL COOPERATIVE PROJECTS:

1. Joint publication of journal articles, extension publications, webpages
2. CD rom technology
3 Shared graduate students

FACULTY TASP FORCE:

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Extension Horticulturist
Department of Horticulture
Fayetteville

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Texas Agricultural Extension Service

Vegetable Production & Marketing NEWS

VOLUME 10, NUMBER 11 NOVEMBER 2000

NATIONAL SPINACH CONFERENCE

The Cooperative Texas A&M University and The University of Arkansas Spinach Program will host the National Spinach Conference in San Antonio, Texas, on December 14, 15, and 16, 2000.

Participants are invited to an informal evening reception on Thursday, December 14. A full-day program on spinach production and marketing is planned for Friday, and there will be a tour of the Winter Garden spinach production area on Saturday. *See page 2 for program agenda and tentative agenda and tour schedule.*

A registration fee of $50 will be charged to help cover costs of meals and tours. This fee is payable to the National Spinach Meeting and is due by November 1st. Late registration will be $75. *See registration form on page 3.*

Conference headquarters will be the spacious Omni Hotel in San Antonio. We have secured a special room rate of $70 for a single, and $89 for a double for this event. Reservations are due by November 14, 2000, to insure you receive the conference rate. Call 1-800-THE OMNI (800-843-6664) to reserve your room today.

Looking forward to meeting and visiting with you in San Antonio.

Appearing Within...

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2000 NATIONAL SPINACH CONFERENCE AGENDA
December 14, 15, and 16, 2000 - Omni Hotel, San Antonio, Texas

THURSDAY, DECEMBER 14:
Informal reception - Omni Hotel - 6:30 p.m.

FRIDAY, DECEMBER 15:
Paper presentations (topics)

Breeding and Genetics

- **Breeding white rust-resistant spinach.** T. E. Morelock and J. C. Correll, University of Arkansas
- **Quantitative and qualitative resistance to downy mildew of spinach.** J. C. Correll, T. E. Morelock, and B. M. Irish, University of Arkansas
- **Biochemical mechanisms of aphid resistance in spinach.** R. Musser, G. Felton, and T. E. Morelock, University of Arkansas

Pest Control

- **Zoxium, a new fungicide.** Kenneth Burchert, Rohm and Haas.
- **Herbicide evaluations for Texas spinach.** Lynn Brandenberger, Texas A&M University
- **The effect of surfactants on white-rust disease of spinach.** B. M. Irish, J. C. Correll, and T. E. Morelock, University of Arkansas.
- **New chemistry from Novartis.** Brad Minton, Novartis
- **Spinach production and pest management in California.** S. T. Koike, University of California
- **Benefits of fungicides and host resistance in reducing yield and quality loss due to foliar diseases in spinach.** K. L. Everts, M. T. McGrath, and S. A. Johnston, Rutgers Agricultural Research and Extension Center
- **Spinach viruses in Southwest Texas.** M. C. Black, Texas A&M University

Production and Culture

- **Spinach production and marketing trends.** Jose G. Pena, Texas A&M University
- **Growth and quality of spinach are affected by planting systems.** D. I. Leskovar, L. A. Stein, and F. J. Dainello, Texas A&M University
- **Packaging design for fresh-cut spinach leaves.** Julio Loiaza, F. J. Dainello, and Luis Cisneros-Zevallos, Texas A&M University

Nutrition and Consumer Acceptance

- **Health benefits of spinach.** Luke Howard, University of Arkansas
- **Lutein and beta carotene content of selected spinach genotypes.** J. A. Kirkpatrick, R. A. Gard, J. B. Murphy, and T. E. Morelock, University of Arkansas
- **Consumer acceptance of spinach as a replacement for iceberg lettuce on sandwiches.** M. E. Fitch-Hilgenberg, University of Arkansas

SATURDAY, DECEMBER 16:
Winter Garden Spinach Production Tour
Tentative Tour Agenda

7:30-8:30 a.m.	Board buses. Depart at 8:00 a.m. sharp. Travel highway 90-west to Uvalde; possible stop at spinach field in D'Hanis
9:45 a.m.	Agri Link Foods - tour of freezing plant
10:45 a.m.	Board buses to leave for Crystal City
11:00 a.m.	View fresh-market spinach harvest - Ed Ritchie
11:30 a.m.	View processing spinach harvest and strip-trial plots - Del Monte
12:30 p.m.	Lunch - grower farm or Del Monte Research Farm. Winter Garden history and background: Kenneth White
1:30 p.m.	Del Monte Research Farm Screening nursery Fungicide trial Fertility trial Herbicide trial Yield trial
3:00 p.m.	Load buses for return trip to Omni Hotel

(Registration Form on Page 3)

National Spinach Conference December 14-16, 2000
Omni Hotel, San Antonio, TX
Registration Form

Name:

Organization:

Mailing Address:

City, State & Zip Code:

Phone:

FAX:

E-mail:

Registration fee includes lunch on December 15 and bus tour and lunch on December 16

	Conference registration fee before November 1, 2000 $50.00
	Conference registration fee after November 1, 2000 $75.00
	Spouse or other guests who will attend meals and tours, but not meetings registration fee $25.00 per person
	Total

Mail this registration form along with a check or money order to payable to:

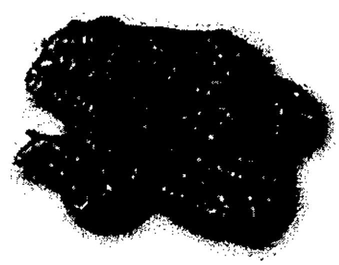
STAR - National Spinach Meeting
c/o Larry Stein
TAMU Research and Extension Center
P.O. Box 1849
Uvalde, TX 78802-1849
Phone: 830/278-9151

Enjoying Texas-Grown Spinach

By Dr. Jerry Parsons
Texas Agricultural Extension Service - San Antonio, Texas

To be aware of and concerned about one's health, fitness, and life is the latest "fad" in America. A strong part of this "new" awareness is the understanding that in order for the body to thrive and perform, it must be well nourished, rather than just well fed.

But what exactly does nutrition mean? The dictionary defines it as the process by which the food material taken into an organism is converted into living tissue. The USDA simplifies this by saying that food is essential for the energy we need to move, breathe, think, and grow. The nutrients in food maintain the building, the upkeep, and the repair of the body tissue as well as the basic functions of the body.



The nutrients which the USDA finds valuable for good health are: food energy, expressed in calories; protein, fat and fiber; calcium, phosphorus, iron, sodium, potassium, thiamin (Vitamin B-1), riboflavin (Vitamin B-2), niacin, ascorbic acid (Vitamin C), and beta-carotene (Vitamin A).

America is in love with salads. The fast food restaurants have salad bars now which makes it easy to enjoy a quick lunch of fresh, tasty vegetables. Whether you're creating that salad at a restaurant or in your own kitchen, it is good to know what is nutritional.

The main ingredient of a salad is obviously the leafy stuff. Most of us are proficient at growing the salad additives such as tomatoes, broccoli and carrots but I will bet my hat that few of us have grown an acceptable lettuce crop. By "acceptable" I mean crunchy and sweet - - anyone can grow leaf lettuce and it tastes as its name implies, like leaves. Most of us want crunch and sweet when we eat lettuce. The best way to get both is not to grow lettuce but to grow spinach.

Nutritionally speaking, spinach is a super-champ of the vegetable garden. Spinach has twice as much protein, calcium, iron, potassium, Vitamin A, Vitamin B, and B-2, niacin and Vitamin C as any other of the leafy greens.

Spinach is easy to grow especially in this area of Texas. Commercial growers in this area produce 90 percent of all the spinach consumed in the United States and almost 50 percent of the entire world's supply.

Spinach is an unusual vegetable. It shares the honor with asparagus of being a dioecious plant. That is, unisexual with pollen-producing male flowers on one plant and seed-bearing female flowers on a separate plant. Spinach is classified as a "very hardy cool season crop." Although it can be grown almost anywhere in the Unites States, it does best at a mean temperature of 50 to 60 degrees F. If planted in late spring, when hot weather is approaching, the plant will quickly form a flower stalk, going to seed after the development of only a few leaves.

Spinach varieties are available in flat-leaved, semi- crinkle-leaved (semi-savoy) and crinkle-leaved (savoy) types. The flat-leaved types are best suited for canning and the crinkle-leaved types are best for fresh use. Because of the fungus diseases which damage spinach growth and leaf appearance, only certain varieties should be used. Spinach is a cool-season crop which should be planted from seed in September. Spinach seed germinates very poorly in warm soils. Therefore, to avoid a poor stand, the first planting should occur when soil temperatures are 75 degrees F. or below which is now the case. Soil temperatures in this range will occur about 8 weeks prior to the first anticipated fall frost.

(Continued on Page 5)

Additional plantings can be made up until about 6 to 8 weeks before temperatures are expected to drop near 20 degrees F. at which temperature spinach is often damaged or even killed. Gardeners in this area can continue planting right through winter and into early spring. Spinach should always be seeded directly in your garden. Ideally, there should be sufficient moisture in the soil at planting time to result in germination and emergence of the seedling without having to apply additional water. If soil is too dry when it's time to plant, consider watering several days or so before planting to supply the needed moisture. Applying water after planting to supply the moisture needed for germination often causes seedling diseases and is best avoided.

The seed can be scattered or broadcast over the top of the bed, or it can be planted in rows. Generally, planting in rows is preferable since weeds which emerge near the spinach seedlings can be more easily removed. If your planting bed is about 20 inches wide, 4 rows of spinach can be seeded across the top, leaving plenty of room for the plants to develop. Regardless of your planting system, the seed should be covered to a depth of one-half inch. Always use more seed than needed to ensure a good stand. Depending upon conditions, the seedlings should be up in about 7 to 10 days. About 2 weeks after emergence, thin the seedlings to a spacing of 4 to 6 inches apart.

About 10 days to 2 weeks after thinning, you should stimulate the growth of your spinach with a light application of nitrogen fertilizer. Use about one-half pound of ammonium sulfate (21-0-0) for each 30 feet of row planted in spinach. Apply the fertilizer to the side of the plants and then water it in lightly. As your crop of spinach grows, its important that you provide sufficient soil moisture. Remember that spinach has a rather shallow and limited root system, with most of the feeder roots in the top 8 to 10 inches of soil. Therefore, frequent watering is necessary.

Approximately 6 to 10 weeks after planting, depending upon the variety and the weather, it's harvest time . You'll note that as the weather cools down your spinach will take a little longer to fully mature and will grow more upright. Generally, spinach that matures when temperatures average between 50 degrees and 60 degrees F. will be fuller-bodied and of higher quality. Harvesting is usually done either by removing the older, outer leaves, or by pulling up the whole plant. A third method that works quite well is to harvest foliage with a sharp knife, leaving the crown or growing point of the plant and roots in place so that a second crop can be produced by the same plant. A light application of fertilizer (ammonium sulfate) and watering should follow this type of harvest to encourage new leaf growth.

Europeans and Americans eat the leaves which are dark green with rounded leaf edges. However, entire plants with red roots and dandelion-like leaves are preferred in Japan. The simplest and most nutritious way to eat spinach is raw in salad substituted for, or with, lettuce. When cooking spinach, care should be taken not to overcook it, boiling away flavor and nutrients. To cook it successfully, wash and put it in a covered pan with only the water clinging to the leaves. Steam over a medium flame for 3 to 5 minutes. Butter, bacon bits, or sauteed onions can be added for complementary flavoring. More elaborate spinach dishes include Eggs Florentine (poached eggs placed in spinach and hollandaise sauce), spinach-stuffed tomatoes, spinach quiche and spinach fondue. Other interesting dishes are spinach potato soup, spinach cheese balls deep fat fried, spinach-shrimp omelet ring, spinach and chicken or ham - - Chinese style, spinach and shredded beet ring, and spinach-tuna salad.

So, if you're not already growing some, plant and start eating nutritious spinach - - insure a sweet crunch.

A New Spin On Spinach

Texas and Arkansas growers are not about to let California rule the lucrative fresh market spinach boom.

This article by Lisa Heacox appeared in the AMERICAN VEGETABLE GROWER, MAY, 2000

Who says California growers should lay sole claim to America's new love affair with spinach? Certainly not Texas And Arkansas producers who are out to reclaim their presence in a market valued at more than $50 million.

Until the 1950s, Texas was a spinach mecca, with some 44,000 acres of both fresh and processing spinach. In fact, the center of the Wintergarden production region, Crystal City, boasts a monument to the legendary spinach-guzzler, Popeye. But decades of disease problems and antiquated post-harvest handling techniques have reduced Texas acreage nearly 80 percent. The state now produces about 2,700 acres for fresh market and 7500 acres for processing. Its neighbor to the east, Arkansas, has exited the fresh market completely, but still claims about 2,000 to 4,000 acres for processing.

"We basically ship spinach out of Texas the same way we did in the '40s," explains Frank Dainello, Texas A&M University professor and extension specialist. Unfortunately, due to a high respiration rate, spinach is highly perishable -- and the grade-out is considerable by the time the crop reaches the packer. "Consequently, we're just not putting a quality product in the marketplace. It's a quality product in the field, but we're just not geared up to handle it," admits Dainello.

BANDING TOGETHER

Texas growers have watched the startling rise of California's 'baby leaf' spinach industry with a touch of envy. They've seen California growers meet consumers' preferences for an attractive, bagged product so successfully that the state now commands 70 percent of the country's fresh spinach market, with some 12,000 acres in production.

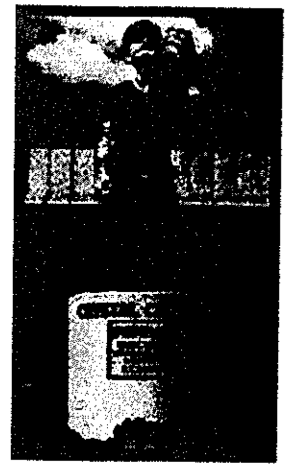
The need for a concerted effort to save the spinach industry in Texas really came to a head about four years ago when growers faced major weed problems, and called upon Texas A&M to assist in securing a Section 18 for Dual herbicide. Dainello says he agreed to help -- but drove home the need for ongoing grower funding for spinach research.

Nearly 60 growers banded together to form the Texas Wintergarden Spinach Producers Association, whose goal is to first fund production research, and then fund promotional efforts for the state's spinach. Third-generation grower Ed Ritchie serves as its president. Ritchie explains that the Board collects check-off funds from growers on a per-bushel basis for fresh market product and a per-ton cost for processing spinach. So far, the program has raised nearly $105,000 through assessments and contributions (about $30,000 annually) for work at Texas A&M University and The University of Arkansas. The two institutions have signed a cooperative spinach research agreement, and university officials there have even agreed to kick in some of their funds for the work.

BUILDING A BETTER SPINACH

The first priority of the research is to address "the disease that essentially wrecked us: white rust," says Dainello. "Because spinach is such a minor crop, we're losing chemicals all the time -- so we need new crop-protection products," says Ritchie.

(Continued on Page 7)



Dainello is testing various chemistries, including some of the new-generation fungicides. He is trialing both Quadris (azoxystrobin, Zeneca) and Acti-Guard (CGA-245704, Novartis), and says they both look good, though neither are currently labeled for spinach in Texas.

Researchers are also addressing variety development. In fact, The University of Arkansas runs the only public spinach breeding program left in the country. Its efforts, led by Teddy Morelock, have been fruitful. Arkansas has released a number of cultivars with resistance to white rust. The program has even identified a strain that possesses some aphid resistance.

Ritchie has been thrilled with the breeding results thus far. He reports few problems with white rust in his spinach over the last four to five years, thanks to the Arkansas variety 'Fall Green' and the Alf Christianson variety 'Samish', which contains Arkansas genetics. He's also trialed Morelock's newest introduction 'AR310', and believes it "shows promise."

POST-HARVEST DEFICIENCIES

But disease resistance won't solve Texas' post-harvest problems, and many growers don't have enough spinach acreage to justify the cost for high-tech packing sheds. He also believes research will have to come up with a new type of packaging material that can preserve this highly perishable crop. It's another project on the universities' to-do lists.

Courting the Customer

Down the road, check-off funding will be aimed at marketing Texas spinach to U.S. consumers. Dainello and the Board are not short on ideas.

Create a brand. The group would like to develop a trademark for the Wintergarden region spinach, much as the Vidalia onion growers have. The Texas Department of Agriculture has already expressed an interest in promoting the concept, once it's developed.

Create a new mix. Dainello says the group wants to do something different than the premium 'yuppie' salad mixes coming out of California. "We want to come up with something more Southern -- maybe take spinach, some of our mustards, and some onion tops to create a spice flavor," he explains. Getting the mixes into grocery stores will pose a challenge, he admits, as Texas producers don't have the extensive buyer connections that huge California vegetable growers have developed.

Tout the nutrition. Nutritionally, spinach is head and shoulders above many lettuces on the market today, particularly iceberg, which Dainello calls "a green container for water." Morelock says breeding efforts could even tweak nutrient levels in spinach, which already possesses high levels of vitamin A, lutein (an antioxidant), and folic acid. Morelock also has items in his test plots with varied flavors and shapes that could be tapped into. For instance, one spinach variety has a fuller habit, and could be coaxed into a head, to compete with the butterhead and premium lettuces.

Year-round presence. Texas' spinach season runs from late November into mid-March. By teaming with Arkansas and other states, such as Arizona and Colorado, growers can come close to making the tasty savoys available to stores all year.

A Comparison of the Nutrient Content of Spinach and Lettuce Types						
		Spinach	Lettuce, iceberg	Lettuce, looseleaf	Lettuce, romaine	Lettuce, butterhead
Nutrient	Units	Value per 100 grams of edible portion				
Water	g	91.580	95.890	94.000	94.910	95.580
Energy	kcal	22.000	12.000	18.000	14.000	13.000
Energy	kj	92.000	50.000	75.000	59.000	54.000
Protein	g	2.860	1.010	1.300	1.620	1.290
Total lipid (fat)	g	0.350	0.190	0.300	0.200	0.220
Carbohydrates, by difference	g	3.500	2.090	3.500	2.370	2.320
Fiber, total dietary	g	2.700	1.400	1.900	1.700	1.000
Ash	g	1.720	0.480	0.900	0.900	0.590
Minerals						
Calcium, Ca	mg	99.000	19.000	68.000	36.000	32.000
Iron, Fe	mg	2.710	0.500	1.400	1.100	0.300
Magnesium, Mg	mg	79.000	9.000	11.000	6.000	13.000
Phosphorus, P	mg	49.000	20.000	25.000	45.000	23.000
Potassium, K	mg	558.000	158.000	264.000	290.000	257.000
Sodium, Na	mg	79.000	9.000	9.000	8.000	5.000
Zinc, Zn	mg	0.530	0.220	0.290	0.250	0.170
Copper, Cu	mg	0.130	0.028	0.044	0.037	0.023
Manganese, Mn	mg	0.897	0.151	0.750	0.636	0.133
Selenium, Se	mg	1.000	0.200	0.200	0.200	0.200
Vitamins						
Vitamin C, ascorbic acid	mg	28.100	3.900	18.000	24.000	8.000
Thiamin	mg	0.078	0.046	0.050	0.100	0.060
Riboflavin	mg	0.189	0.030	0.080	0.100	0.060
Niacin	mg	0.724	0.187	0.400	0.500	0.300
Pantothenic acid	mg	0.065	0.046	0.200	0.170	0.180
Vitamin B-6	mg	0.195	0.040	0.055	0.047	0.050
Folate	mcg	194.400	56.000	49.800	135.700	73.300
Vitamin B-12	mcg	0.000	0.000	0.000	0.000	0.000
Vitamin A, IU	IU	6715.000	330.000	1900.000	2600.000	970.000
Vitamin A, RE	mcg_RE	672.000	33.000	190.000	260.000	97.000
Vitamin E	mg_ATE	1.890	0.280	0.440	0.440	0.440
Lipids						

Fatty acids, saturated	g	0.056	0.025	0.039	0.026	0.029
Fatty acids, monounsaturated	g	0.010	0.007	0.012	0.008	0.008
Fatty acids, polyunsaturated	g	0.146	0.100	0.159	0.106	0.117
Cholesterol	mg	0.000	0.000	0.000	0.000	0.000
Phytosterols	mg	9.000	10.000	38.000		
Amino Acids						
Tryptophan	g	0.039	0.008	0.009	0.012	0.009
Threonine	g	0.122	0.053	0.059	0.074	0.059
Isoleucine	g	0.147	0.075	0.084	0.105	0.083
Leucine	g	0.223	0.070	0.079	0.098	0.078
Lysine	g	0.174	0.075	0.084	0.105	0.084
Methionine	g	0.053	0.014	0.016	0.020	0.016
Cystine	g	0.035	0.014	0.016	0.019	0.015
Phenylalanine	g	0.129	0.049	0.055	0.068	0.054
Tyrosine	g	0.108	0.029	0.032	0.040	0.032
Valine	g	0.161	0.062	0.070	0.087	0.069
Arginine	g	0.162	0.063	0.071	0.088	0.070
Histidine	g	0.064	0.020	0.022	0.028	0.022
Alanine	g	0.142	0.050	0.056	0.070	0.055
Aspartic acid	g	0.240	0.127	0.142	0.177	0.141
Glutamic acid	g	0.343	0.162	0.182	0.227	0.180
Glycine	g	0.134	0.051	0.057	0.071	0.057
Proline	g	0.112	0.043	0.048	0.060	0.048
Serine	g	0.104	0.035	0.039	0.049	0.039
USDA Nutrient Database for Standard Reference, Release 12 (March 1998)						

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