Our group of agricultural economists, engineers and plants scientists collaborates works on projects that will utilize technology to improve sustainability of greenhouse production. We are specifically interested in reducing energy use in greenhouses, improving water conservation, and utilizing technology such as sensors to improve the ability of growers to control environments without wasting resources. Our multistate project encompasses collaborators at twelve experiment stations throughout the United States. We feel that it is vital to continue to look for collaborators for our project so that our group can grow, not only in size, but we also wish to gain fresh ideas with new members. Also, we wish to ensure that our project does not overlap with other, ongoing multi-state, hatch, or grant projects.

To meet these goals, we conducted a CRIS review on 19 August, 2013 to search for potential collaborators for our multi-state project. We conducted five separate searches using search terms. The results are described below. For the sake of brevity, the approach, impact, publications, and progress have been removed from these reports. However, that information is available upon request.

1. Our first search used the terms: 'greenhouse' and 'energy'. This search resulted in 50 records, 5 of which were relevant. Of the relevant results, 3 relate to efforts from our past multi-state efforts (NE-1017 or NE-1035). Reports from NE-1017 and NE-1035 are not shown. The other two projects are specifically not looking at engineering approaches to reducing energy usage in greenhouses, such as utilizing alternative fuels. Thus, these individuals would not be likely collaborators, and these projects are not overlapping with the work we have proposed for the next five years.

2. Our next search combined the terms 'greenhouse' and 'irrigation', which provided no results. The search combinations 'greenhouse' and 'water' as well as 'hydroponics' or 'ebb-and-flow' also provided no results. Finally, searching for 'sensor' and 'irrigation', but not 'field' provided 84 search results. 23 of these were related to our work. Out of these 23 related results, members of our multi-state group conducted 10 projects individually or as a part of NE-1017 or NE-1035. These projects are not presented. One additional project is presented, but it expired in 2005 (Kluepfel and Lieth).

Three of the 23 related projects represent the work of collaborators or contributors to our group who are not formally members of this multi-state project. For example, Dr. Martin Gent has worked closely with Geremia, who received a small business grant for a project they worked on together. We have also collaborated with Dr. Marc van Iersel, a former member of this group. Dr. van Iersel has two hatch projects in the search results.

Two search results were for another multi-state group (NCERA-101) multi-state group that works in controlled environments, including greenhouses. Our group works closely with this information exchange multi-state group. Several members of our multi-state project work are members of NCERA-101 and vice versa. To save travel funds and encourage collaboration between our two groups, we regularly host joint meetings. We plan to continue to work closely with NCERA-101. However, we feel that we are distinct from this group as their goal is primarily information exchange, while our goal is

to collaborate on research projects. Further, our group is strongly dedicated to the collaboration between plant scientists and engineers.

The work of Dr. Jonathan Frantz represents 3 publications from this search. Before joining private industry, Dr. Frantz collaborated informally with our group and was a co-author on some NE-1035 and NE-1017 publications. Dr. Frantz' collaborators on these projects include some researchers who are not members of our multi-state project. Dr. Paul Fisher was formerly a member of our group, but is no longer able to contribute due to newly defined job responsibilities now that he is at the University of Florida, not the University of New Hampshire. His other collaborators, including Dr. Jim Faust and John Dole would be good individuals to invite to participate in this multi-state project due to similar research interests. An additional project in the search results represents a separate project of Dr. Faust's.

Drs. Cameron, Runkle, and Warner's project also represents work that would be a good contribution to our group. Dr. Runkle was formerly a member of our group, but was unable to continue to find travel funds to attend our annual meetings to represent Michigan State.

Dr. Roberto Lopez' project on sustainable and low input floriculture production would be a valuable contribution to the work of our multi-state project. We have invited Dr. Lopez to join our group, and we hope that he will consider collaborating with us in the future.

Finally, the last project in the search (White et al.), is work to be conducted in commercial nurseries, not greenhouses. Hence, there would not be significant overlap between our groups.

3. Finally, we searched for 'greenhouse' and 'sensor', but not 'field'. This resulted in 89 results; 37 of these results were relevant. Results from members of our group and those that would repeat projects from searches above are not shown.

One of the three relevant, new results was a small business grant. This project was likely initiated by a member of the industry who could be approached to attend meetings, but would not likely be a member of the group. The second result, from Dr. Cary Mitchell from Purdue, represents work from a member of our collaborating group, NCERA-101. Dr. Mitchell would be an excellent contributor to our group and could be approached about joining this multi-state project. However, considering his long-standing contributions to NCERA-101, we feel that it may be best to collaborate informally through our connection to him via this group. Finally, the last project was an additional project from Dr. Jonathan Frantz. As mentioned above for search #2, when Dr. Frantz was with the USDA, he worked with many members of this group and those collaborations were reported in our refereed journal articles and at our annual business meetings. However, since Dr. Frantz no longer has a formal research appointment with the USDA, it is unlikely that his contribution to this group will continue.

4. Next, we conducted a search with the terms 'SCRI' and 'Greenhouse', but not 'climate' to include any Specialty Crops Research Initiative Grants that could overlap with our project. This search provided 51 results, and 23 of these results were relevant. Of the relevant results, 8 were projects by members of our multistate group or were projects that were discussed previously. These projects are not presented. Of the remaining fifteen projects, two of these projects expired and will not be discussed. Nine of these remaining projects refer to the same multi-state project (NC-1186), 'Water Management and Quality for Ornamental Crop Production and Health'. We do not currently collaborate with this multi-state group as we do with NCERA-101. However, we will reach out to the leaders of this multi-state group and see if they would like to connect in order to prevent overlapping efforts. Two projects were by Dr. Hong from Virginia Tech. These two projects relate more to plant pathology in greenhouse production and are only slightly related to our work. One project lead by Dr. White appears to focus more on nursery production than greenhouse production and would not overlap with our work. Finally, a SCRI grant lead by Dr. John Lea-Cox, 'Precision Irrigation and Nutrient Management for Nursery, Greenhouse and Green Roof Systems: Wireless Sensor Networks for Feedback and Feedforward Control' appears to be related to the irrigation work that our group is conducting. We have collaborated with some members of this group, however, it would be beneficial for us to reach out to the contributors to this grant and determine whether they would be interested in joining our multi-state project.

5. Our last search included the terms, 'greenhouse' and 'lighting'. This final search provided 124 results; 44 of which were relevant. As with the above searches, results for members' projects and repeated results will not be discussed. Of the fourteen remaining projects, seven expired and will not be discussed. Three are for small business grants; the individuals from the businesses that wrote these grants (R.C. Morrow from Orbital Technologies Corporation and R. Tuck from Cycloptics Technologies LLAC) would not be likely members of our multi-state project. However, we should contact them to determine if they would be interested in attending our meetings to advise us on the direction of future research. Two of the four remaining projects are hatch projects from Michigan State. As mentioned above, we formerly had a representative from Michigan State, but funds are no longer available for a representative from their Experiment Station to participate in our project. However, a member of our multi-state project, A.J. Both, is collaborating on one of the projects from Michigan State (Runkle et al.), so we are maintaining our connections with Michigan State. The Specialty Crop Research Initiative grant, 'Developing LED Lighting Technologies and Practices for Sustainable Specialty-Crop Production', lead by Dr. Cary Mitchell represents work that would be a good fit for our group. In the future, we plan to invite members of this grant to collaborate on our multistate project. However, some members, including Dr. Mitchell, may be members of NCERA-101, so as mentioned above, it may be easier to interact with some individuals from this group at our joint meetings with NCERA-101. The contributors to Surbrook et al.'s hatch project, 'Energy Efficiency and Alternative Management in Production Agriculture' would provide valuable contributions to our work. Finally, Lopez and Mitchell's Hatch project, 'Increasing the Energy Efficiency of Commercial Greenhouses' represents work that would contribute greatly to our project.

In conclusion, we feel that after a thorough search, a large number of the search results were projects related to sustainable greenhouse production were from members of our group. For example, ten out of twenty-three relevant search results were for projects from members of our multi-state project. We still found potential new members to invite to join our multistate project. Specifically, we would like to invite Drs. Jim Faust, John Dole, Roberto Lopez, John Lea-Cox, and Dr. Surbrook to consider working with our group. We also would like to invite Orbital Technologies Corporation and Cycloptics Technologies LLAC to join us at a meeting to provide input on the direction of our research. We plan to reach out to the leaders of the multi-state project, NC-1186 'Water Management and Quality for Ornamental Crop Production and Health' to determine if we may collaborate informally with them as we do with NCERA-101.

Search Results for #1

Item No. 2 of 5

ACCESSION NO: 0209955 **SUBFILE:** CRIS
PROJ NO: ARX05035 **AGENCY:** NIFA AR.X
PROJ TYPE: EVANS-ALLEN **PROJ STATUS:** EXTENDED
START: 01 OCT 2007 **TERM:** 30 SEP 2013 **FY:** 2012

INVESTIGATOR: Islam, S.

PERFORMING INSTITUTION:
AGRICULTURE
UNIV OF ARKANSAS
PINE BLUFF, ARKANSAS 71601

COLLECTION AND EVALUATION OF ORNAMENTAL, FLOWERING AND NURSERY PLANTS FOR ADAPTATION IN THE LOWER MISSISSIPPI DELTA REGION

NON-TECHNICAL SUMMARY: The horticulture industry is one of the largest segments of commercial agriculture in Arkansas. However, Arkansas is not a major producer in the USA. Production in Arkansas has not kept pace with that in many other states. There are smaller growers in Arkansas producing **greenhouse** and nursery crops for local and regional markets. These growers do not have the economics of scale available to the large national producers and thus must compete on the basis of crop quality, value added, new or minor crops not economical to produce or ship in large quantities. Many flowering plants are fast growing crops, thus two or more crops can be grown in one season. Crop sequence, species selection and marketing plan influences net returns. The goals of this research are focused on developing new and innovative approaches to the production of ornamental and floriculture crops that improve efficiency, increase productivity, and maximize profitability of local growers. Furthermore, the aim of the project is also to develop improved methodology and production package for the Delta area growers to minimize the cost of production and secure ultimate good returns. The purpose of this project are focused on developing new and innovative approaches to the production of ornamentals and floriculture crops that will improve production efficiency, increase productivity, and maximize profitability of the mid-south and Mississippi Delta region growers.

PROJECT CONTACT:

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Item No. 4 of 5

ACCESSION NO: 0209485 **SUBFILE:** CRIS
PROJ NO: MIS-149090 **AGENCY:** NIFA MIS
PROJ TYPE: HATCH **PROJ STATUS:** EXTENDED
START: 01 OCT 2006 **TERM:** 30 SEP 2012 **FY:** 2012

INVESTIGATOR: Evans, W. B.; Snyder, R. G.; Ingram, D. M.

PERFORMING INSTITUTION:
TRUCK CROPS BRANCH EXPERIMENT STATION
MISSISSIPPI STATE UNIV
MISSISSIPPI STATE, MISSISSIPPI 39762

IMPROVEMENT OF COMMERCIAL FIELD AND GREENHOUSE CROP PRODUCTION USING INTEGRATED MANAGEMENT STRATEGIES.

NON-TECHNICAL SUMMARY: Mississippi vegetable growers face challanges unique to their sub-tropical climate, southern soils, and markets. Pest pressures are great. Production seasons are long, with periods of excessive heat, drought, and moisture. Changing markets are reducing some opportunities while increasing those for direct marketers, niche growers, organic producers, and certain wholesale crops. The purpose of this project is to provide Mississippi vegetable growers with applicable information on vegetable production practices for field and **greenhouse** production.

PROJECT CONTACT:

Name: Evans, W. B.
Phone: 601-892-3731
Fax: 601-892-2056
Email: wbe@ra.msstate.edu
URL: http://www.msstate.edu/dept/cmrec/truckcrops.htm

Search Results for #2

Item No. 2 of 23

ACCESSION NO: 0403451 **SUBFILE:** CRIS
PROJ NO: 5306-13210-001-01S **AGENCY:** ARS 5306
PROJ TYPE: USDA COOPERATIVE AGREEMENT **PROJ STATUS:** TERMINATED
CONTRACT/GRANT/AGREEMENT NO: 58-5310-0-213
START: 28 SEP 2000 **TERM:** 27 SEP 2005 **FY:** 2004 **GRANT YR:** 2000
GRANT AMT: $30,000

INVESTIGATOR: KLUEPFEL D A; LIETH H

PERFORMING INSTITUTION:
UNIV OF CALIFORNIA
DAVIS, CALIFORNIA 95616

DEVELOP MATHEMATICAL MODELS TO MANAGE IRRIGATION, FERTILIZATION, RUN-OFF IN GREENHOUSES

OBJECTIVES: Develop mathematical models that describe the fate of specific ions in greenhouse and nursery production systems. Such models are needed to improve our understanding of how greenhouse crops use fertilizer nutrients. They are also needed in optimization of fertilization, **irrigation**, and run-off management.

Item No. 3 of 23

ACCESSION NO: 0207488 **SUBFILE:** CRIS
PROJ NO: CONK-2006-03060 **AGENCY:** NIFA CONK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** EXTENDED
CONTRACT/GRANT/AGREEMENT NO: 2006-33610-17175 **PROPOSAL NO:** 2006-03060
START: 01 SEP 2006 **TERM:** 31 AUG 2009 **FY:** 2008 **GRANT YR:** 2006
GRANT AMT: $296,000

INVESTIGATOR: Geremia, J.

PERFORMING INSTITUTION:
Geremia Greenhouse
Wallingford, CONNECTICUT 06492

PARTIAL SATURATION EBB AND FLOW WATERING SYSTEM FOR A FLOODED FLOOR GREENHOUSE

NON-TECHNICAL SUMMARY: Sub **irrigation** combats the waste of water and fertilizer in traditional overhead watering systems used in greenhouses for production of potted ornamental plants. However, current ebb and flow watering systems achieve nearly complete saturation of the root medium for each watering cycle. There is no ability to restrict the water provided to the plants. This may decrease plant quality and facilitate spread of disease. Geremia Greenhouse has developed a method to achieve partial saturation with ebb and flow watering of the root medium for production of potted ornamental plants. The water or fertilizer solution is delivered and removed rapidly, resulting in less water absorbed by the pots, and little leaked back out of the pots. This research will determine the benefits of partial saturation ebb and flow watering when applied on flooded floors, in terms of improved quality and shelf life of potted flowering plants, and reduced spread of disease. In-line filtration and sterilization methods will be tested to prevent spread of disease. Once the system is optimized, Geremia Greenhouse will apply this method on a scale of several acres. The improved plant quality and shelf life will benefit growers and consumers, and this watering system will protect natural resources and the environment.

PROJECT CONTACT:

Name: Geremia, J.
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Email: Martin.Gent@po.state.ct.us

Item No. 4 of 23

ACCESSION NO: 0414608 **SUBFILE:** CRIS
PROJ NO: 3607-21000-015-24S **AGENCY:** ARS 3607
PROJ TYPE: USDA COOPERATIVE AGREEMENT **PROJ STATUS:** NEW
START: 22 SEP 2008 **TERM:** 31 JUL 2011 **FY:** 2012

INVESTIGATOR: FRANTZ J; FISHER P

PERFORMING INSTITUTION:
UNIVERSITY OF FLORIDA
118 NEWINS-ZEIGLER HALL
GAINESVILLE, FLORIDA 32611

IMPROVED PRODUCTION METHODS: NORTH SOUTH INITIATIVE (UNIVERSITY OF FLORIDA)

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ACCESSION NO: 0202693 **SUBFILE:** CRIS
PROJ NO: GEO00548 **AGENCY:** NIFA GEO
PROJ TYPE: HATCH **PROJ STATUS:** TERMINATED **MULTISTATE PROJ NO:** NCERA-101
START: 26 MAR 2008 **TERM:** 30 SEP 2011 **FY:** 2011

INVESTIGATOR: van Iersel, M. W.

PERFORMING INSTITUTION:
HORTICULTURE
UNIVERSITY OF GEORGIA
110 RIVERBEND ROAD
ATHENS, GEORGIA 30602

COMMITTEE ON CONTROLLED ENVIRONMENT TECHNOLOGY AND USE

NON-TECHNICAL SUMMARY: Growth chambers are commonly used in plant sciences. However, there are no clear standards on how to use growth chambers, or how to report environmental conditions in growth chambers. This projects develops guidelines for use of growth chambers, and standards for measuring and reporting environmental conditions in controlled environment research.

PROJECT CONTACT:

Name: van Iersel, M. W.
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Email: mvanier@uga.edu
URL: http://nimss.umd.edu/homepages/home.cfm?trackID=7936

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ACCESSION NO: 0203661 **SUBFILE:** CRIS
PROJ NO: GEO00564 **AGENCY:** NIFA GEO
PROJ TYPE: HATCH **PROJ STATUS:** EXTENDED
START: 01 JUN 2005 **TERM:** 30 MAY 2014 **FY:** 2012

INVESTIGATOR: van Iersel, M. W.

PERFORMING INSTITUTION:
HORTICULTURE
UNIVERSITY OF GEORGIA

110 RIVERBEND ROAD
ATHENS, GEORGIA 30602

OPTIMIZING IRRIGATION EFFICIENCY FOR ORNAMENTAL PLANTS

NON-TECHNICAL SUMMARY: Greenhouses and nureseries often apply excess water to prevent drought stress. The goal of this research is to develop **irrigation** controllers that can apply water in the correct amount and only when the plants really need it.

PROJECT CONTACT:

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ACCESSION NO: 0229260 **SUBFILE:** CRIS
PROJ NO: GEO00704 **AGENCY:** NIFA GEO
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NCERA-101
START: 01 MAY 2012 **TERM:** 30 SEP 2016

INVESTIGATOR: van Iersel, M. W.

PERFORMING INSTITUTION:
Horticulture
UNIVERSITY OF GEORGIA
110 RIVERBEND ROAD
ATHENS, GEORGIA 30602

CONTROLLED ENVIRONMENT TECHNOLOGY AND USE

NON-TECHNICAL SUMMARY: Growth chambers and greenhouses are commonly used in plant sciences and commercial production. New **sensor** technology, including the use of wireless networks (which use radio technology to transmit data to a computer), can provide users with real-time information about the environmental conditions inside their growth chambers and greenhouses. In addition, these wireless **sensor** networks can be used to adjust and control environmental conditions based on the crop's requirements. This technology can help users use resources more efficiently and economically, resulting in improved sustainability.

PROJECT CONTACT:

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Email: mvanier@uga.edu
URL: www.controlledenvironments.org

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ACCESSION NO: 0192118 **SUBFILE:** CRIS
PROJ NO: GEO01640 **AGENCY:** NIFA GEO
PROJ TYPE: HATCH **PROJ STATUS:** TERMINATED
START: 01 MAY 2002 **TERM:** 30 APR 2005 **FY:** 2005

INVESTIGATOR: van Iersel, M. W.

PERFORMING INSTITUTION:
HORTICULTURE
UNIVERSITY OF GEORGIA
110 RIVERBEND ROAD
ATHENS, GEORGIA 30602

WATER REQUIREMENTS OF GREENHOUSE CROPS

NON-TECHNICAL SUMMARY: Reduced water availability in Georgia may decrease amount of water available to the greenhouse industry. When water restrictions are in effect, consumers are hesitant to buy plants, thus reducing overall volume of plants sold. Drought conditions also change type of plants that are popular, creating a need for drought-resistant plants. The purpose of this research is to develop an accurate and reliable method of measuring the moisture content of soilless media and use this technique to determine responses of greenhouse crops to drought.

PROJECT CONTACT:

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ACCESSION NO: 0214086 **SUBFILE:** CRIS
PROJ NO: IND011815 **AGENCY:** NIFA IND
PROJ TYPE: HATCH **PROJ STATUS:** TERMINATED
START: 01 MAR 2008 **TERM:** 30 SEP 2012 **FY:** 2012

INVESTIGATOR: Lopez, R. G.

PERFORMING INSTITUTION:
HORTICULTURE
PURDUE UNIVERSITY
WEST LAFAYETTE, INDIANA 47907

SUSTAINABLE AND LOW INPUT FLORICULTURE CROP PRODUCTION

NON-TECHNICAL SUMMARY: In 2005, it was estimated that the commercial floriculture industry in the U.S. produced over 900 billion potted-plants in plastic pots, trays, and cell packs. The vast majority of the plastic containers, trays, greenhouse coverings, packaging, and labels used by the industry are not recycled due to a variety of economic reasons. In 2005 alone, 31.1 million tons of plastic containers and packages were generated in the U.S. and only 14% were recycled. In addition, greenhouses use tremendous amounts of resources to fertilize, heat, cool, light, protect, and transport their crops throughout propagation, production and marketing. In recent years, these practices have become the focus of media outlets across the U.S. and Europe. As consumers become more environmentally conscious and environmental regulations increase, growers that show environmental stewardship by producing sustainable crops will gain a competitive advantage. To a commercial greenhouse grower, sustainably, locally, and efficiently produced flowers can be a new high-value niche or specialty market for crops that will lead to increased profits, environmental stewardship and survival in a competitive market.

PROJECT CONTACT:

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ACCESSION NO: 0196468 **SUBFILE:** CRIS
PROJ NO: MICL02057 **AGENCY:** NIFA MICL
PROJ TYPE: HATCH **PROJ STATUS:** TERMINATED
START: 01 FEB 2008 **TERM:** 31 JAN 2013 **FY:** 2012

INVESTIGATOR: Cameron, A.; Runkle, E.; Warner, R.

PERFORMING INSTITUTION:
HORTICULTURE
MICHIGAN STATE UNIV
EAST LANSING, MICHIGAN 48824

NEW FLORICULTURE CROPS: SELECTION AND DEVELOPMENT OF PRODUCTION PROTOCOLS

NON-TECHNICAL SUMMARY: Over the past decade, floriculture and nursery crops have been one of the fastest growing U.S. and Michigan agricultural sectors. The development of new floriculture crops is a critical component for the continued success of the Michigan greenhouse industry and continues to be a primary goal of our MSU floriculture research program. One focus of our studies has been the selection of new and existing crops not traditionally produced as floriculture crops. Continued investigation of "new" floriculture crops and a fundamental understanding of growth and development patterns will benefit the entire Floriculture Industry - in and out of Michigan.

PROJECT CONTACT:

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Email: cameron@msu.edu

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ACCESSION NO: 0414609 **SUBFILE:** CRIS
PROJ NO: 3607-21000-015-25S **AGENCY:** ARS 3607
PROJ TYPE: USDA COOPERATIVE AGREEMENT **PROJ STATUS:** NEW
START: 26 SEP 2008 **TERM:** 31 JUL 2011 **FY:** 2012

INVESTIGATOR: FRANTZ J; DOLE J

PERFORMING INSTITUTION:
NORTH CAROLINA STATE UNIV
RALEIGH, NORTH CAROLINA 27695

IMPROVED PRODUCTION METHODS: NORTH SOUTH INITIATIVE (NORTH CAROLINA STATE UNIVERSITY)

OBJECTIVES: The objective of this research will focus on research to optimize nutrition and **irrigation** rates during different stages in floriculture crop development taking into account stock plant, propagation, and finishing environments.

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ACCESSION NO: 0414604 **SUBFILE:** CRIS
PROJ NO: 3607-21000-015-21S **AGENCY:** ARS 3607
PROJ TYPE: USDA COOPERATIVE AGREEMENT **PROJ STATUS:** NEW
START: 16 SEP 2008 **TERM:** 31 JUL 2011 **FY:** 2012

INVESTIGATOR: FRANTZ J; FAUST J

PERFORMING INSTITUTION:
CLEMSON UNIVERSITY
CLEMSON, SOUTH CAROLINA 29634

IMPROVED PRODUCTION METHODS: NORTH SOUTH INITIATIVE (CLEMSON UNIVERSITY)

OBJECTIVES: The objective of this unified research effort is to improve the efficiency of plant production through a multi-disciplinary team approach that focuses on scheduling, the environment, energy, nutrient, water, and chemical growth regulator resources.

Item No. 22 of 23

ACCESSION NO: 0227100 **SUBFILE:** CRIS
PROJ NO: SC-1700428 **AGENCY:** NIFA SC.
PROJ TYPE: HATCH **PROJ STATUS:** EXTENDED
START: 01 JUL 2011 **TERM:** 30 SEP 2016 **FY:** 2012

INVESTIGATOR: Faust, J. E.

PERFORMING INSTITUTION:
School of Agricultural, Forest, & Environmental Sciences
CLEMSON UNIVERSITY
CLEMSON, SOUTH CAROLINA 29634

OPTIMIZING WATER USE DURING PROPAGATION OF UNROOTED CUTTINGS

NON-TECHNICAL SUMMARY: This project will explore the efficient use of water to propagate floriculture crops through the implementation of a dynamic mist control system. Current commercial production practices often use static control systems that apply excess water during propagation. These practices are not sustainable and often create additional production problems, such as an increase in disease incidence which results in additional chemical fungicide applications. Currently, most large commercial growers have computer control systems that can dynamically manage mist **irrigation**, however they often fail to use them due to a lack of specific knowledge needed to actually implement the existing technology. Our goal is to accurately determine the proper strategies and models for managing mist **irrigation** so that commercial growers can take advantage of current computer control technologies. The end result will be more

sustainable use of water and plant nutrients, reduced fungicide application and an improvement in propagation performance of vegetatively-propagated floricultural crops.

PROJECT CONTACT:

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Item No. 23 of 23

ACCESSION NO: 0225797 **SUBFILE:** CRIS
PROJ NO: SC-2098634 **AGENCY:** NIFA SC.
PROJ TYPE: OTHER GRANTS **PROJ STATUS:** EXTENDED
CONTRACT/GRANT/AGREEMENT NO: 2011-51181-30633 **PROPOSAL NO:** 2011-01382
START: 01 SEP 2011 **TERM:** 31 AUG 2013 **GRANT YR:** 2011
GRANT AMT: $50,000

INVESTIGATOR: White, S.; Fernandez, R. T.; Fisher, P.; Hall, C. R.; Irani, T.; Kong, P.; Lea-Cox, J. D.; Newman, J. P.; Oki, L. R.

PERFORMING INSTITUTION:
School of Agricultural, Forest, & Environmental Sciences
CLEMSON UNIVERSITY
CLEMSON, SOUTH CAROLINA 29634

CONTAINMENT, REMEDIATION, AND RECYCLIG OF IRRIGATION WATER FOR SUSTAINABLE ORNAMENTAL CROP PRODUCTION

PROJECT CONTACT:

Name: White,Sarah
Phone: 864-656-7433
Email: swhite4@clemson.edu

ACCESSION NO: 0213548 **SUBFILE:** CRIS
PROJ NO: CALK-2008-00133 **AGENCY:** NIFA CALK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** TERMINATED
CONTRACT/GRANT/AGREEMENT NO: 2008-33610-18909 **PROPOSAL NO:** 2008-00133
START: 01 MAY 2008 **TERM:** 31 DEC 2009 **GRANT YR:** 2008
GRANT AMT: $79,998

INVESTIGATOR: egalon, C. O.

PERFORMING INSTITUTION:
SCIENCE AND SENSORS TECHNOLOGIES
EL SEGUNDO, CALIFORNIA 90245

OPTICAL FIBER SENSOR FOR PLANT NUTRIENTS

NON-TECHNICAL SUMMARY: Nutrient concentrations in **greenhouse** crops have a direct effect on the yield and quality of flowering plants. Nutrients are often applied on a rule of thumb basis and the level of nutrients and salinity "in the bag" is controlled by leaching with the salinity level measured with a salinity **sensor** in the leachate water. However, specific nutrient measurement is expensive and often requires wet chemistry. Two different approaches have been used so far: Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) and Ion Selective Electrodes (ISE). The ICP method is very sensitive and selective however, it is also expensive: on the order of tens of thousands of dollars. The ISE method is portable and cost effective but suffers from interference from other species, is subjected to electromagnetic interference and requires constant maintenance. It is the purpose of this project to develop a unique, low cost multi point/multi parameter optical fiber **sensor** to monitor the primary nutrients (nitrate, phosphate and potassium ions), in hydroponics solution. This is a real time single strand optical fiber that has an active cladding sensitive to the targeted species.

PROJECT CONTACT:

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Email: coegalon@aol.com

ACCESSION NO: 0063971 **SUBFILE:** CRIS
PROJ NO: IND011837 **AGENCY:** NIFA IND
PROJ TYPE: HATCH **PROJ STATUS:** REVISED
START: 01 OCT 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: Mitchell, C. A.

PERFORMING INSTITUTION:
Horticulture
PURDUE UNIVERSITY
WEST LAFAYETTE, INDIANA 47907

ENVIRONMENTAL STRESSES AND CROP PRODUCTIVITY

NON-TECHNICAL SUMMARY: Northern specialty-crop production is seasonal, and protected off-season production is not economically viable because traditional sources of energy for heating and supplemental lighting are too costly. As costs of transportation from milder climates rise, as the environment suffers, as the quality of transported produce deteriorates, and as local agriculture languishes for lack of jobs and revenue during the off-season, innovation is needed to correct such societal burdens. Leveraging sources of waste energy has great potential to empower local, off-season specialty-crop production that also is economically viable. Sources of waste energy include power plants, landfills, dairies, concentrated animal-feeding operations, food-process plants, sawmills, waste-treatment plants, foundries, and biofuel plants. Waste energy occurs as thermal and/or as biomass that can be converted to generate heat, electricity, and carbon dioxide that can be used to stimulate photosynthesis in protected culture. Low-grade waste heat can be converted to high-grade heat as well as electricity by heat pumps and heat engines. Once proof of concept is demonstrated that waste energy can empower off-season agriculture, education will be needed to encourage partnerships between growers, entrepreneurs, investors, and waste-energy enterprises. Lack of sunlight severely limits crop production in protected cultivation during the off-season in northern climates. Traditional lamps used for supplemental lighting in horticulture are electrically inefficient, blisteringly hot, are spectrally challenged, have limited lifetimes, are fragile, and have disposal restrictions due to their mercury content. Light-emitting diodes (LEDs) hold great promise as a future source of plant-growth lighting: they have extremely long lifetimes, are robust due to their solid-state nature, have color emissions that can be custom selected for specific crop requirements, can be placed close to leaf surfaces because they are cool, and do not require high electrical power. The latter feature also makes LEDs amenable to using electrical energy generated from local thermal and/or biomass wastes. Using optimum combinations of environmental factors for highly efficient growth of crops in controlled environments are largely unknown because there are too many variables that are highly interactive in terms of crop response, and cropping cycles are too long to test all the combinations needed. On the other hand, identifying combinations that give the best instantaneous photosynthetic rates for the least expensive resource inputs can be done quickly and easily with the right kind of equipment, and can be re-established each day of a cropping cycle as they change.

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ACCESSION NO: 0414991 **SUBFILE:** CRIS
PROJ NO: 3607-21000-015-00D **AGENCY:** ARS 3607
PROJ TYPE: USDA INHOUSE **PROJ STATUS:** NEW
START: 10 DEC 2008 **TERM:** 09 DEC 2013 **FY:** 2012

INVESTIGATOR: FRANTZ J; LOCKE J C; KRAUSE C R

PERFORMING INSTITUTION:
AGRICULTURAL RESEARCH SERVICE
WOOSTER, OHIO 44691

DEVELOP MANAGEMENT TOOLS FOR EARLY STRESS DETECTION AND EFFICIENT AGROCHEMICAL UTILIZATION FOR PROTECTED HORTICULTURE CROPS

Search Results for #4

ACCESSION NO: 0226091 **SUBFILE:** CRIS
PROJ NO: COL00218 **AGENCY:** NIFA COL
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 MAY 2011 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: Bauerle, W.

PERFORMING INSTITUTION:
Horticulture and Landscape Architecture
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO 80523

WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Regardless of the area of the United States in which an operation is located, challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. Most field producers of nursery stock use irrigation at some point during the growing season. Many field producers use low-volume irrigation and some use such systems to deliver soluble fertilizers. While supplemental irrigation is beneficial in field production it is essential for container production. Container substrates need to be well drained and container volume limits the amount of available water, resulting in frequent irrigation and high water use. Almost all **greenhouse** crops are produced in containers. Over 75% of nursery crops in 17 of the major nursery producing states were grown in containers (USDA, 2007) and thus require irrigation. In Florida, container nurseries annually apply 56 to 120 inches per year in addition to the 40 to 50 inches of average annual rainfall. Container nurseries in Alabama were estimated to have used 30,000 to 40,000 acre-feet of water in 1985 (Fare et al., 1992) and container nursery production in Alabama has almost tripled since 1987 (USDA 1994, 2004). Amount of water applied, method of application, and irrigation frequency for Georgia nurseries has been summarized (Garber et al., 2002). Frequent irrigation along with high fertilizer and pesticide use can lead to significant losses of agricultural chemicals in runoff water that transports them to containment ponds and/or off-site into groundwater or surface water (Briggs et al., 1998, 2002; Cabrera, 2003; Camper et al., 1994). Irrigation water management is a key component in the nutrient management of ornamental crop production and in reducing the impact of runoff water on local water (Tyler et al., 1996; Lea-Cox et al., 2001; Ross et al., 2002). Recycling water includes another set of issues for growers, primarily in the form of disease and salinity management. Emerging constraints on water use and quality

means that the ornamental industry needs to find ways to manage water without detracting from production schedules and crop quality. Water conservation and quality are top priority issues in agriculture. Research and extension projects that are designed to address these issues are needed in ornamental production (Ogg and Keith, 2002). Precision water management and resource efficiency were rated at the top of the issue/need/concern list developed at the joint USDA, ARS, NASA and NSF workshop "Engineering Solutions for Specialty Crop Challenges" (USDA, 2007).

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Item No. 5 of 23

ACCESSION NO: 0224879 **SUBFILE:** CRIS
PROJ NO: IND011860R **AGENCY:** NIFA IND
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 DEC 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: Mickelbart, M. V.

PERFORMING INSTITUTION:
Horticulture
PURDUE UNIVERSITY
WEST LAFAYETTE, INDIANA 47907

WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: The ornamental plant industry ranks 5th (>$14.6 billion) in US agriculture commodities and is in the top 5 commodities for 26 states. Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Regardless of the area of the United States in which an operation is located, challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. Most field producers of nursery stock use irrigation at some point during the growing season. Many field producers use low-volume irrigation and some use such systems to deliver soluble fertilizers. While supplemental irrigation is beneficial in field production it is essential for container production. Container substrates

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ACCESSION NO: 0223968 **SUBFILE:** CRIS
PROJ NO: KY011034 **AGENCY:** NIFA KY.
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 OCT 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: Dunwell, W.

PERFORMING INSTITUTION:
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WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: The ornamental plant industry ranks 5th ($14.6 billion) in US agriculture commodities and is in the top 5 commodities for 26 states (USDA, 2004). Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Regardless of the area of the United States in which an operation is located, challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. Most field producers of nursery stock use irrigation at some point during the growing season. Many field producers use low-volume irrigation and some use such systems to deliver soluble fertilizers. While supplemental irrigation is beneficial in field production it is essential for container production. Container substrates need to be well drained and container volume limits the amount of available water, resulting in frequent irrigation and high water use. Almost all greenhouse crops are produced in containers. Over 75 pecent of nursery crops in 17 of the major nursery producing states were grown in containers (USDA, 2007) and thus require irrigation. Amount of water applied, method of application, and irrigation frequency for Georgia nurseries has been summarized (Garber et al., 2002). Frequent irrigation along with high fertilizer and pesticide use can lead to significant losses of agricultural chemicals in runoff water that transports them to containment ponds and/or off-site into groundwater or surface water (Briggs et al., 1998, 2002; Cabrera, 2003; Camper et al., 1994). Irrigation water management is a key component in the nutrient management of ornamental crop production and in reducing the impact of runoff water on local water (Tyler et al., 1996; Lea-Cox et al., 2001; Ross et al., 2002). Recycling water includes another set of issues for growers, primarily in the form of disease and salinity management. Emerging constraints on water use and quality means that the ornamental industry needs to find ways to manage water without detracting from production schedules and crop quality. Water conservation and quality are top priority issues in agriculture. Research and extension projects that are designed to address these issues are needed in ornamental production (Ogg and Keith, 2002). Precision water management and resource efficiency were rated at the top of the issue/need/concern list developed at the joint USDA, ARS, NASA and NSF workshop Engineering Solutions for Specialty Crop Challenges(USDA, 2007). There are five interrelated areas relevant to this project: 1. Source water management and quality, 2. Irrigation management, 3. Runoff water management and quality, 4. Substrate and nutrition management, and 5. Pathogens and crop health management.

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ACCESSION NO: 0219581 **SUBFILE:** CRIS
PROJ NO: MD-PSLA-0805 **AGENCY:** NIFA MD.
PROJ TYPE: OTHER GRANTS **PROJ STATUS:** NEW
CONTRACT/GRANT/AGREEMENT NO: 2009-51181-05768 **PROPOSAL NO:** 2009-02561
START: 01 SEP 2009 **TERM:** 31 AUG 2014 **GRANT YR:** 2009
GRANT AMT: $5,161,495

INVESTIGATOR: Lea-Cox, J. D.; Kantor, G. A.; Bauerle, W. L.; van Iersel, M.; Campbell, C.; Bauerle, T. L.; Ristvey, A. G.; Ross, D. S.; Parker, D.; King, D.; Bauers, R.

PERFORMING INSTITUTION:
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PRECISION IRRIGATION AND NUTRIENT MANAGEMENT FOR NURSERY, GREENHOUSE AND GREEN ROOF SYSTEMS: WIRELESS SENSOR NETWORKS FOR FEEDBACK AND FEEDFORWARD CONTROL

NON-TECHNICAL SUMMARY: The overarching objective of this proposal is to make better use of increasingly scarce fresh water resources for specialty crops which are usually irrigated. This project aims to solve and deliver the science that industry leaders and representatives have identified as vital to the sustainability of specialty crop production systems and our natural resources at the local level. We intend to build upon our systems-based, transdisciplinary approach that spans more than three years of prior work in implementing wireless sensor networks in field (orchard-type) environments, in `open' (i.e. open to the environment) nursery container-production and green roof systems, and `closed' **greenhouse** environments which are more environmentally controlled. We will advance our knowledge of plant and soil science at both the micro- and macro-scale, to provide a means to automatically assess and schedule precision irrigation using wireless hardware and software technology. The result will be a commercially available product for irrigation water management that is specifically designed for diverse and intensive production environments, but that has broad applications for all high-value specialty crops, including ornamental, fruit and vegetable production. Precision irrigation and production management will benefit **greenhouse** and nursery producers, while a better understanding of the water dynamics of green roofs will

benefit green roof managers. In addition to these private benefits, limited to individual growers or companies, there also are public benefits: reductions in water use and runoff from these facilities will result in environmental benefits for the public at large. In addition, reductions in energy use will result in both private and public benefits. We will work with specialty crop growers to capture needs-based issues during development. The integration of commercial partners into this project is critical for its success: it assures that the software and hardware that will be developed meets the needs of the industry, rather than our perception of those needs. In addition to our direct involvement with our commercial partners, we shall provide educational outreach on the economics and viability of sensor networks to producers throughout the United States, by (1) developing appropriate new learning modules in our existing online knowledge center (http://www.waternut.org/moodle) for the nursery and **greenhouse** industries, and (2) use sensor networks as a pedagogical tool for undergraduate problem-based learning at the undergraduate level (see later example). In addition, we shall further develop the project website (http://www.sensornet.umd.edu) and offer traditional outreach efforts through field days, trade magazine articles and trade show talks. All research will be fully documented through peer-reviewed papers, published dissertations and theses.

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ACCESSION NO: 0224412 **SUBFILE:** CRIS
PROJ NO: MICL04074 **AGENCY:** NIFA MICL
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 OCT 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: Fernandez, R. T.

PERFORMING INSTITUTION:
Horticulture
MICHIGAN STATE UNIV
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WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: The ornamental plant industry ranks 5th (>$14.6 billion) in US agriculture commodities and is in the top 5 commodities for 26 states.

Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Regardless of the area of the United States in which an operation is located, challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. Most field producers of nursery stock use irrigation at some point during the growing season. Many field producers use low-volume irrigation and some use such systems to deliver soluble fertilizers. While supplemental irrigation is beneficial in field production it is essential for container production. Container substrates need to be well drained and container volume limits the amount of available water, resulting in frequent irrigation and high water use. Almost all greenhouse crops are produced in containers. Over 75% of nursery crops in 17 of the major nursery producing states were grown in containers and thus require irrigation. In Florida, container nurseries annually apply 56 to 120 inches per year in addition to the 40 to 50 inches of average annual rainfall. Container nurseries in Alabama were estimated to have used 30,000 to 40,000 acre-feet of water in 1985 and container nursery production in Alabama has almost tripled since 1987. Amount of water applied, method of application, and irrigation frequency for Georgia nurseries has been summarized. Frequent irrigation along with high fertilizer and pesticide use can lead to significant losses of agricultural chemicals in runoff water that transports them to containment ponds and/or off-site into groundwater or surface water. Irrigation water management is a key component in the nutrient management of ornamental crop production and in reducing the impact of runoff water on local water. Recycling water includes another set of issues for growers, primarily in the form of disease and salinity management. Emerging constraints on water use and quality means that the ornamental industry needs to find ways to manage water without detracting from production schedules and crop quality. Water conservation and quality are top priority issues in agriculture. Research and extension projects that are designed to address these issues are needed in ornamental production. Precision water management and resource efficiency were rated at the top of the issue/need/concern list developed at the joint USDA, ARS, NASA and NSF workshop Engineering Solutions for Specialty Crop Challenges. Furthermore, the United States Environmental Protection Agency (EPA) is enforcing federal legislation requiring states to implement Total Maximum Daily Load (TMDL) programs for watersheds.

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ACCESSION NO: 0225014 **SUBFILE:** CRIS
PROJ NO: MIS-211100 **AGENCY:** NIFA MIS
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 OCT 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: Blythe, E. K.

PERFORMING INSTITUTION:
South Mississippi Branch Experiment Sta
MISSISSIPPI STATE UNIV
MISSISSIPPI STATE, MISSISSIPPI 39762

WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: The ornamental plant industry ranks 5th (>$14.6 billion) in US agriculture commodities and is in the top 5 commodities for 26 states. Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Regardless of the area of the United States in which an operation is located, challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. Most field producers of nursery stock use irrigation at some point during the growing season. While supplemental irrigation is beneficial in field production it is essential for container production. Container substrates need to be well drained and container volume limits the amount of available water, resulting in frequent irrigation and high water use. Over 75% of nursery crops in 17 of the major nursery producing states were grown in containers and thus require irrigation. Frequent irrigation along with high fertilizer and pesticide use can lead to significant losses of agricultural chemicals in runoff water that transports them to containment ponds and/or off-site into groundwater or surface water. Irrigation water management is a key component in the nutrient management of ornamental crop production and in reducing the impact of runoff water on local water. Recycling water includes another set of issues for growers, primarily in the form of disease and salinity management. Emerging constraints on water use and quality means that the ornamental industry needs to find ways to manage water without detracting from production schedules and crop quality. Water conservation and quality are top priority issues in agriculture. Research and extension projects that are designed to address these issues are needed in ornamental production. Precision water management and resource efficiency were rated at the top of the issue/need/concern list developed at the joint USDA, ARS, NASA, and NSF workshop 'Engineering Solutions for Specialty Crop Challenges'. Furthermore, the United States Environmental Protection Agency (EPA) is enforcing federal legislation requiring states to implement Total Maximum Daily Load (TMDL) programs for watersheds. Since few states have the expertise to integrate all these issues we need a national

multidisciplinary approach to water management. There are five interrelated areas relevant to this project: 1. Source water management and quality, 2. Irrigation management, 3. Runoff water management and quality, 4. Substrate and nutrition management, and 5. Pathogens and crop health management.

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ACCESSION NO: 0204654 **SUBFILE:** CRIS
PROJ NO: MOX-HYDROPONICS-05 **AGENCY:** NIFA MO.X
PROJ TYPE: EVANS-ALLEN **PROJ STATUS:** TERMINATED
START: 01 JUL 2005 **TERM:** 30 SEP 2009 **FY:** 2009

INVESTIGATOR: Egilla, J. N.; Jones, R. J.; Wollo, W.

PERFORMING INSTITUTION:
AGRICULTURE
LINCOLN UNIVERSITY
JEFFERSON CITY, MISSOURI 65101

SUSTAINABLE SMALL-SCALE HYDROPONIC CROPPING OF SPECIALTY VEGETABLES AND HERBS FOR LIMITED RESOURCE GROWERS IN MISSOURI

NON-TECHNICAL SUMMARY: Production of specialty crops under hydroponic greenhouse conditions can provide an alternative approach to field production for limited resource farmers. This project focuses on evaluating alternative crops for hydroponic production and its associated costs. The ultimate goal is to establish a small-scale market for hydroponic grown alternative crops. This project will focus on developing basic and applied research capable of providing simplified hydroponic technologies and services to limited resource farmers,the horticultural industry, amateur horticulturists and hobbyists. The goal is sustainable production of alternative vegetables, spices and various culinary and medicinal herb species for the expanding niche market for these crops. The purpose of this project is to also develop the hydroponic research facility into a center for novel scientifically based and simplified hydroponic technologies capable of leading innovative research that will assist limited resource/small-scale growers to: 1) become educatied about sustainable horticultural practices at the grass roots level; 2) recognize what is neeeded to get started on a new crop or business of crop production; and 3) to help experienced growers to become more successful through continuous updates about

modern production methods and marketing strategies. The ultimate goal is to facilitate the establishment of a successful small-scale hydroponic industry for alternative crops in Missouri, through collaborative efforts with LU Coooperative Extension Program and ther Missouri State Department of Agriculture.

PROJECT CONTACT:

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Item No. 14 of 23

ACCESSION NO: 0224031 **SUBFILE:** CRIS
PROJ NO: NJ60204 **AGENCY:** NIFA NJ.
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 OCT 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: Mangiafico, S. S.

PERFORMING INSTITUTION:
Agricultural Resource Management
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WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: Ornamental plant production is an important agricultural industry in the U.S., both in terms of the value of the products and, in some parts of the nation, the land devoted to the task. The proper use of irrigation, fertilizers, and recycled water is critical in these operations to ensure successful crops, but also to promote water conservation and prevent inadvertent pollution of water resources with agricultural runoff. This multistate workgroup fosters communication among scientists and extension educators who work in this field in order to determine what gaps there are in our knowledge of these issues, and then conduct research to fill those gaps. Information is disseminated to plant producers and other stakeholders through an outreach program utilizing appropriate publications, extension education, and multi-media methods.

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ACCESSION NO: 0226084 **SUBFILE:** CRIS
PROJ NO: NC00086 **AGENCY:** NIFA NC.
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 OCT 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: LeBude, A. V.

PERFORMING INSTITUTION:
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WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: The ornamental plant industry ranks 5th (>$14.6 billion) in US agriculture commodities and is in the top 5 commodities for 26 states (USDA, 2004). Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. While supplemental irrigation is beneficial in field production it is essential for container production. Container substrates need to be well drained resulting in frequent irrigation and high water use. Almost all greenhouse crops are produced in containers. Over 75% of nursery crops in 17 of the major nursery producing states were grown in containers (USDA, 2007) and thus require irrigation. Frequent irrigation along with high fertilizer and pesticide use can lead to significant losses of agricultural chemicals in runoff water that transports them to containment ponds and/or off-site into groundwater or surface water (Briggs et al., 1998, 2002; Cabrera, 2003; Camper et al., 1994). Irrigation water management is a key component in the nutrient management of ornamental crop production and in reducing the impact of runoff water on local water (Tyler et al., 1996; Lea-Cox et al., 2001; Ross et al., 2002). Recycling water includes another set of issues for growers, primarily in the form of disease and salinity management. Emerging constraints on water use and quality means that the ornamental industry needs to find

ways to manage water without detracting from production schedules and crop quality. Water conservation and quality are top priority issues in agriculture. Research and extension projects that are designed to address these issues are needed in ornamental production (Ogg and Keith, 2002). Precision water management and resource efficiency were rated at the top of the issue/need/concern list developed at the joint USDA, ARS, NASA and NSF workshop engineering solutions for Specialty Crop Challenges (USDA, 2007). Furthermore, the United States Environmental Protection Agency (EPA) is enforcing federal legislation requiring states to implement Total Maximum Daily Load (TMDL) programs for watersheds (Lea-Cox and Ross, 2001). Since few states have the expertise to integrate all these issues we need a national multi-disciplinary approach to water management. There are five interrelated areas relevant to this project: 1. Source water management and quality, 2. Irrigation management, 3. Runoff water management and quality, 4. Substrate and nutrition management, and 5. Pathogens and crop health management.

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Item No. 16 of 23

ACCESSION NO: 0194179 **SUBFILE:** CRIS
PROJ NO: NCX-178-5-03-130-1 **AGENCY:** NIFA NC.X
PROJ TYPE: EVANS-ALLEN **PROJ STATUS:** TERMINATED
START: 01 OCT 2002 **TERM:** 30 SEP 2006 **FY:** 2006

INVESTIGATOR: NIEDZIELA, C.

PERFORMING INSTITUTION:
NATURAL RESOURCES & ENVIRONMENTAL DESIGN
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GREENSBORO, NORTH CAROLINA 27411

USE OF TOBACCO TRANSPLANT GREENHOUSES FOR SPECIALTY CUT FLOWER PRODUCTION

NON-TECHNICAL SUMMARY: Limited research on alternatives for tobacco transplant greenhouses has been conducted and the need for further research has never been greater. Additional and alternative uses for this farm resource would increase diversification and provide an additional source of income for tobacco farmers.

OBJECTIVES: 1) Evaluate the suitability and feasibility of several cut flower species for production in a tobacco transplant greenhouse. 2) Determine the suitability and feasibility of several cut flower production systems for each species. 3) Develop production budgets for selected species and systems.

PROJECT CONTACT:

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Item No. 18 of 23

ACCESSION NO: 0224469 **SUBFILE:** CRIS
PROJ NO: ORE00176 **AGENCY:** NIFA ORE
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 OCT 2010 **TERM:** 30 SEP 2015

INVESTIGATOR: Owen, Jr., J. S.

PERFORMING INSTITUTION:
North Willamette Research & Extension Center
OREGON STATE UNIVERSITY
CORVALLIS, OREGON 97331

WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: The ornamental plant industry ranks 5th (>$14.6 billion) in US agriculture commodities and is in the top 5 commodities for 26 states (USDA, 2004). Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Regardless of the area of the United States in which an operation is located, challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. Most field producers of nursery stock use irrigation at some point during the growing season. While supplemental irrigation is beneficial in field production it is essential for container production. Container substrates need to be well drained and container volume limits the amount of available water, resulting in frequent irrigation and high water use. Over 75% of nursery crops in 17 of the major nursery producing states were grown in containers and thus require irrigation. Frequent irrigation along with high fertilizer and pesticide use can lead

to significant losses of agricultural chemicals in runoff water that transports them to containment ponds and/or off-site into groundwater or surface water. Furthermore, irrigation water management is a key component in the nutrient management of ornamental crop production and in reducing the impact of runoff water on local water. Recycling water includes another set of issues for growers, primarily in the form of disease and salinity management. Emerging constraints on water use and quality means that the ornamental industry needs to find ways to manage water without detracting from production schedules and crop quality. Water conservation and quality are top priority issues in agriculture. Research and extension projects that are designed to address these issues are needed in ornamental production. Precision water management and resource efficiency were rated at the top of the issue/need/concern list developed at the joint USDA, ARS, NASA and NSF workshop ?Engineering Solutions for Specialty Crop Challenges?. Furthermore, the United States Environmental Protection Agency (EPA) is enforcing federal legislation requiring states to implement Total Maximum Daily Load (TMDL) programs for watersheds. Since few states have the expertise to integrate all these issues we need a national multi-disciplinary approach to water management. There are five interrelated areas relevant to this project: 1. Source water management and quality, 2. Irrigation management, 3. Runoff water management and quality, 4. Substrate and nutrition management, and 5. Pathogens and crop health management

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ACCESSION NO: 0223897 **SUBFILE:** CRIS
PROJ NO: SC-1700421 **AGENCY:** NIFA SC.
PROJ TYPE: HATCH **PROJ STATUS:** NEW **MULTISTATE PROJ NO:** NC-1186
START: 01 OCT 2010 **TERM:** 30 SEP 2015 **FY:** 2012

INVESTIGATOR: White, S. A.

PERFORMING INSTITUTION:
School of Agricultural, Forest, & Environmental Sciences
CLEMSON UNIVERSITY
CLEMSON, SOUTH CAROLINA 29634

WATER MANAGEMENT AND QUALITY FOR ORNAMENTAL CROP PRODUCTION AND HEALTH

NON-TECHNICAL SUMMARY: The ornamental plant industry ranks 5th (>$14.6 billion) in US agriculture. Water issues, specifically irrigation scheduling, surface water management, salinity and runoff water quality are topics of major concern to ornamental producers. Drought, urban competition for water resources, and increasing legislation at state and county levels increase the need for ornamental producers to manage water more effectively and/or use alternative water sources that are often of inferior quality. Regardless of the area of the United States in which an operation is located, challenges exist regarding sufficient quantities of quality water sources. Legislation regarding water use and/or quality has been implemented in at least 8 states. Most field producers of nursery stock use irrigation at some point during the growing season. Many field producers use low-volume irrigation and some use such systems to deliver soluble fertilizers. While supplemental irrigation is beneficial in field production it is essential for container production. Frequent irrigation along with high fertilizer and pesticide use can lead to significant losses of agricultural chemicals in runoff water that transports them to containment ponds and/or off-site into groundwater or surface water. Irrigation water management is a key component in the nutrient management of ornamental crop production and in reducing the impact of runoff water on local water. Recycling water includes another set of issues for growers, primarily in the form of disease and salinity management. Emerging constraints on water use and quality means that the ornamental industry needs to find ways to manage water without detracting from production schedules and crop quality. Water conservation and quality are top priority issues in agriculture. Research and extension projects that are designed to address these issues are needed in ornamental production. Precision water management and resource efficiency were rated at the top of the issue/need/concern list developed at the joint USDA, ARS, NASA and NSF workshop 'Engineering Solutions for Specialty Crop Challenges.' Furthermore, the United States Environmental Protection Agency (EPA) is enforcing federal legislation requiring states to implement Total Maximum Daily Load (TMDL) programs for watersheds. Since few states have the expertise to integrate all these issues we need a national multi-disciplinary approach to water management. There are five interrelated areas relevant to this project: 1) Source water management and quality, 2) Irrigation management, 3) Runoff water management and quality, 4) Substrate and nutrition management, and 5) Pathogens and crop health management. Outcomes/Impacts: 1) Assist the ornamental nursery industry in efficiently and successfully utilizing available primary and secondary water sources. 2) Mitigate nutrient and pesticide runoff into the environment from nursery production facilities. 3) Better utilization of limited water resources through increased use of secondary water sources instead of primary potable water sources, will 4) increase the available of potable water for other consumer uses.

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ACCESSION NO: 0225797 **SUBFILE:** CRIS
PROJ NO: SC-2098634 **AGENCY:** NIFA SC.
PROJ TYPE: OTHER GRANTS **PROJ STATUS:** EXTENDED
CONTRACT/GRANT/AGREEMENT NO: 2011-51181-30633 **PROPOSAL NO:** 2011-01382
START: 01 SEP 2011 **TERM:** 31 AUG 2013 **GRANT YR:** 2011
GRANT AMT: $50,000

INVESTIGATOR: White, S.; Fernandez, R. T.; Fisher, P.; Hall, C. R.; Irani, T.; Kong, P.; Lea-Cox, J. D.; Newman, J. P.; Oki, L. R.

PERFORMING INSTITUTION:
School of Agricultural, Forest, & Environmental Sciences
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CONTAINMENT, REMEDIATION, AND RECYCLIG OF IRRIGATION WATER FOR SUSTAINABLE ORNAMENTAL CROP PRODUCTION

NON-TECHNICAL SUMMARY: All levels of society from individuals to municipal, industrial, commercial, and agricultural users require high quality water on a daily basis. Runoff of lower quality water, potentially contaminated with fertilizers and pesticides, negatively impacts the environment for other organisms and uses. Developing nursery-level water treatment and handling technologies that reduce agricultural impacts, increase efficiency, and facilitate and increase the adoption and use of alternative water sources can reduce the ornamental industry's dependence on high quality water, which is necessary for their long-term economic sustainability. By using recycled and alternative water sources and improving the quality of runoff water prior to discharge, the ornamental industry will provide society with reduced competition for high quality water, which conserves and improves natural resources for human consumption, recreation, and other organisms in the environment. Ornamental producers have identified runoff containment, remediation, and recycling as an ongoing critical need area, and many requests for proposals from various agencies have reflected this. However, no single researcher has the breadth of knowledge required to adequately address research in these areas. This project presents a collaborative, whole-systems approach utilizing trans-disciplinary expertise to conceive and direct research to address these complex issues. The goals of this project are to a) conduct listening sessions with stakeholders at regional meetings to help identify research priorities and needs in this area and b) use this information and responses from a comprehensive institutional review board approved survey to identify key barriers to recycled water use; to formulate the approach; and to identify the appropriate team members for developing a comprehensive plan for future research. To accomplish these goals we will hold grower listening sessions at five regional and national meetings around the United States; an institution review board (IRB)-approved set of survey questions will be discussed at each meeting. An additional, more comprehensive, IRB approved survey will also be conducted to further define current water use practices and factors limiting recycled irrigation water use. A

stakeholder advisory group will be identified from this group to be involved in the planning and execution of the **SCRI** CAP proposal. It is especially timely to consider how water quality mandates and water shortages will impact intensive ornamental production since adequate containment and treatment technologies for alternative water resources have not been developed. If effective recycling and remediation technologies for ornamental production are developed, this technology will also be readily scalable for adoption by other specialty crops producers whose production systems do not involve as intensive irrigation, fertilizer, and pesticide use.

PROJECT CONTACT:

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ACCESSION NO: 0225498 **SUBFILE:** CRIS
PROJ NO: VA-135907 **AGENCY:** NIFA VA.
PROJ TYPE: HATCH **PROJ STATUS:** NEW
START: 01 JUL 2011 **TERM:** 30 JUN 2016 **FY:** 2012

INVESTIGATOR: Hong, C. X.

PERFORMING INSTITUTION:
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BLACKSBURG, VIRGINIA 24061

INTEGRATED MANAGEMENT OF WATERBORNE PATHOGENS AND WATER QUALITY FOR A SUSTAINABLE GREEN INDUSTRY

NON-TECHNICAL SUMMARY: This project aims to improve and maintain the health of nursery and floral crops through delivery to the consumer, protect water quality and increase water use efficiency by the green industry. The ultimate goals are to move the horticultural production and distribution towards becoming sustainable industries and enable them to better compete in global markets. Supporting objectives are to (1) characterize zoosporic pathogens found in irrigation systems and assess their potential impact on ornamental crop health; (2) understand water quality dynamics, develop guidelines to assist irrigation managers in improving crop quality and productivity, and assess the environmental benefits of increased water recycling practices; (3) significantly increase the understanding of the aquatic biology of Phytophthora species and develop protocols for risk assessment and mitigation of these pathogens in irrigation systems; (4) identify and enhance naturally-occurring pathogen-suppressing microbes in reservoirs; (5) deliver information and education programs and facilitate the BMPs implementation.

This project will increase the profitability and sustainability of the green industry, enhance the aesthetic value of recreational parks and landscapes, and improve consumer satisfaction. It will reduce the risk of dissemination of quarantine pathogens (e.g., Phytophthora ramorum) through trade of ornamental plant stocks. These benefits will extend to other specialty crop producers facing similar crop health and water issues.

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ACCESSION NO: 0222170 **SUBFILE:** CRIS
PROJ NO: VA-422171 **AGENCY:** NIFA VA.
PROJ TYPE: OTHER GRANTS **PROJ STATUS:** NEW
CONTRACT/GRANT/AGREEMENT NO: 2010-51181-21140 **PROPOSAL NO:** 2010-01099
START: 01 SEP 2010 **TERM:** 31 AUG 2015 **GRANT YR:** 2010
GRANT AMT: $2,729,649

INVESTIGATOR: Hong, C. X.; Moorman, G. W.; Lea-Cox, J. D.; Ross, D. R.; Boyle, K. J.; Bosch, D.; Pease, J.; Copes, W. E.; Kong, P.; Carroll, B.; Stanghellini, M. E.; Vinatzer, B. A.

PERFORMING INSTITUTION:
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INTEGRATED MANAGEMENT OF ZOOSPORIC PATHOGENS AND IRRIGATION WATER QUALITY FOR A SUSTAINABLE GREEN INDUSTRY

NON-TECHNICAL SUMMARY: This SREP project addresses three **SCRI** focus areas and aims to improve and maintain the health of nursery and floral crops through delivery to the consumer, protect water quality and increase water use efficiency by the green industry. The ultimate goals are to move the horticultural production and distribution towards becoming sustainable industries and enable them to better compete in global markets. Supporting objectives are to (1) characterize zoosporic pathogens found in irrigation systems and assess their potential impact on ornamental crop health; (2) understand water quality dynamics, develop guidelines to assist irrigation managers in improving crop quality and productivity, and assess the environmental benefits of increased water recycling practices; (3) significantly increase the understanding of the

aquatic biology of Phytophthora and Pythium species and develop protocols for risk assessment and mitigation of these pathogens in irrigation systems; (4) identify and enhance naturally-occurring pathogen-suppressing microbes in reservoirs; (5) assess the changes in production costs and revenue enhancements when the resultant knowledge and technologies are implemented as best management practices (BMPs); and (6) develop and use an online knowledge center to deliver information and education programs and facilitate the BMPs implementation. This project will increase the profitability and sustainability of the green industry, enhance the aesthetic value of recreational parks and landscapes, and improve consumer satisfaction. It will reduce the risk of dissemination of quarantine pathogens (e.g., Phytophthora ramorum) through trade of ornamental plant stocks. These benefits will extend to other specialty crop producers facing similar crop health and water issues.

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Results for Search #5

Item No. 7 of 44

ACCESSION NO: 0226261 **SUBFILE:** CRIS
PROJ NO: CONW-2011-00415 **AGENCY:** NIFA CONK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** EXTENDED
CONTRACT/GRANT/AGREEMENT NO: 2011-33610-30680 **PROPOSAL NO:** 2011-00415
START: 01 SEP 2011 **TERM:** 30 APR 2013 **GRANT YR:** 2011
GRANT AMT: $95,914

INVESTIGATOR: Domyan, S.

PERFORMING INSTITUTION:
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USE OF HYDROPONIC AND LED TECHNOLOGY TO GROW HIGH NUTRIENT LETTUCE, SPINACH AND ARUGULA IN A SMALL, URBAN, HIGH DENSITY, INDOOR FARM

NON-TECHNICAL SUMMARY: In the industrial northeast there is an under-fulfilled, year round demand for fresh, locally grown produce. The demand is measured by the steady growth (13% per year nationally) of farmers? markets since 1995. This project will use innovative hydroponic and LED technologies to study and verify if high nutrient, high quality greens can be grown cost effectively in small, urban, high density, indoor farms. Test growing will focus on optimizing the light wavelengths (color) of low power LED grow lights and the growing times for multiple varieties of greens. Test marketing will be conducted to verify that there is a market for premium priced, high nutrient greens. The selling price and potential market size will be quantified. And, appropriate sales venues will be identified. Urban centers (cities) in the industrial northeast have a large inventory of under-utilized, structurally sound factory buildings which are of no economic value. These same cities have high levels of unemployment with some urban neighborhoods peaking at rates greater than 25%. If Phase I results demonstrate that small, urban, high density, indoor farms are viable, then available urban buildings and the associated available urban workforce will become assets in the creation of such farms. By repurposing derelict buildings into urban, indoor farms the economic health of cities will be rejuvenated both through tax roll restoration and through the creation of new, green, year-round jobs located in urban neighborhoods. The results of Phase I will set the parameters for a Phase II prototype farm.

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Item No. 10 of 44

ACCESSION NO: 0225239 **SUBFILE:** CRIS
PROJ NO: FLAW-2011-00002 **AGENCY:** NIFA FLAK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** EXTENDED
CONTRACT/GRANT/AGREEMENT NO: 2011-33610-30490 **PROPOSAL NO:** 2011-00002
START: 01 JUL 2011 **TERM:** 28 FEB 2013 **GRANT YR:** 2011
GRANT AMT: $99,457

INVESTIGATOR: Mahawela, P. J.

PERFORMING INSTITUTION:
Engen Nanotechnology Inc.
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DEVELOPMENT OF AN EFFICIENT SOLID STATE GROW-LIGHT FOR GREENHOUSE/URBAN AGRICULTURE BASED ON A NOVEL GROWTH PROCESS AND DEVICE ARCHITECTURE

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Item No. 13 of 44

ACCESSION NO: 0230987 **SUBFILE:** CRIS
PROJ NO: IND011815H **AGENCY:** NIFA IND
PROJ TYPE: HATCH **PROJ STATUS:** NEW
START: 01 OCT 2012 **TERM:** 30 SEP 2017

INVESTIGATOR: Lopez, R.; Mitchell, C.

PERFORMING INSTITUTION:
Horticulture
PURDUE UNIVERSITY
WEST LAFAYETTE, INDIANA 47907

INCREASING THE ENERGY EFFICIENCY OF COMMERCIAL GREENHOUSES

NON-TECHNICAL SUMMARY: The wholesale value of bedding, garden, and perennial plants is $1.9 billion for the top 15 producing states (USDA, 2011). These crops are often produced in two distinct phases: a young plant stage, in which seedlings or cuttings are propagated in plug trays or liners and a finish plant stage, in which the young plants are transplanted into a larger finish container where they are grown until they become marketable. Both propagation and finishing occur from mid- to late-winter and early spring when average daily ambient photosynthetic daily light integral (DLI) and temperature are typically low, especially in northern latitudes (Currey et al., 2012; Lopez and Runkle, 2008). Furthermore, **greenhouse** structures and coverings can reduce light transmission by up to 40 percent or more (Hanan, 1998), creating even lower DLIs inside the **greenhouse**. When outdoor DLI is low, the only way to increase DLI is to provide supplemental **lighting** from high intensity discharge lamps (Oh et al., 2010). Additionally, average daily temperatures (ADT) outdoors range from –3 to 9 C (27 to 48 F) in temperate northern latitudes. Therefore, heating systems such as infrared, forced air, perimeter, and radiation units are used to maintain desirable production air temperatures. The energy for heating accounts for 10 to 30 percent of the total operating costs of commercial **greenhouses** in northern latitudes (Brumfield, 2007; Langton et al., 2006). Therefore, due to volatile energy costs and lower profit margins, producers are seeking alternative heating strategies for bedding plant that further reduce overall fuel consumption.

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ACCESSION NO: 0222948 **SUBFILE:** CRIS
PROJ NO: IND011837G **AGENCY:** NIFA IND
PROJ TYPE: OTHER GRANTS **PROJ STATUS:** NEW
CONTRACT/GRANT/AGREEMENT NO: 2010-51181-21369 **PROPOSAL NO:** 2010-01158
START: 01 SEP 2010 **TERM:** 31 AUG 2014 **GRANT YR:** 2010
GRANT AMT: $2,441,298

INVESTIGATOR: Mitchell, C. A.; Lopez, R.; Burr, J.

PERFORMING INSTITUTION:
Horticulture

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DEVELOPING LED LIGHTING TECHNOLOGIES AND PRACTICES FOR SUSTAINABLE SPECIALTY-CROP PRODUCTION

NON-TECHNICAL SUMMARY: Commercial specialty-crop growers in the United States want affordable, efficient electric **lighting** to supplement limited sunlight for **greenhouse** vegetable production during the off-season, to time the flowering of ornamentals for holidays, to propagate seedlings for transplant, and to grow cut flowers. Unfortunately, energy costs of growing specialty crops in colder climates during the off-season have taken many aspects of horticultural production to warmer, sunnier climates with cheaper labor, often outside the U.S. However, concerns about increasing costs and environmental footprint of long-distance transport, concerns about the safety, security, and sanitation of transported specialty crop products, and impoverished local growers have renewed interest in local production. Developing a cost-effective **greenhouse lighting** system will help solve the energy dilemma that prevents establishment of a sustainable specialty-crop industry in the northern U.S. The light-emitting diode (LED) is key to improving energy utilization for **greenhouse lighting**. LEDs are solid state, robust, very long-lived, and can be designed to emit pure, selectable colors. Furthermore, waste heat can be removed separate from light-emitting surfaces. What?s more, the efficiency of converting electricity to light is improving rapidly as the LED industry evolves, so LEDs are becoming more energy efficient all the time! Unlike traditional light sources used in **greenhouses** today, the relative ?coolness? of LED surfaces allows them to be placed close to or touching leaves without overheating or scorching them. Thus, much less electrical power is needed to achieve the same or better plant response than with traditional **lighting** systems. LEDs can be designed so the colors they emit match exactly the colors absorbed most efficiently by plant pigments, improving overall energy efficiency and giving more plant response for less light input. In the floriculture industry, incandescent (IN) lamps long have been used to light **greenhouse** crops at the end of the day or briefly during the night to time precisely when flowering will occur. While IN lamps work well for timing, they emit colors that may cause unwanted stem elongation, are electrically inefficient, short-lived, and are being phased out by the government. Compact fluorescent lamps (CFL) have been tested as an IN substitute, and while they are more electrically efficient and much longer-lived, CFLs lack the colors of light required for the desired flowering response of certain plant types. LEDs can be selected to deliver specific colors required to ensure timing of flowering without also delivering interfering or unused colors, thereby saving energy and preserving plant response. For **greenhouse** crops such as high-wire tomato, which have self-shading problems while the sun tracks across the **greenhouse** and on low-sunlight days, LED arrays can be located within the dark leaf canopy itself without overheating the plants while **lighting** the leaves and fruit clusters for efficient tomato production. Our team will examine all aspects of LED **lighting**, from sociological to economic, and will establish industry standards.

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ACCESSION NO: 0176677 **SUBFILE:** CRIS
PROJ NO: MICL01862 **AGENCY:** NIFA MICL
PROJ TYPE: HATCH **PROJ STATUS:** REVISED
START: 01 JUN 2009 **TERM:** 31 MAY 2014 **FY:** 2012

INVESTIGATOR: Surbrook, T.; Harsh, S.; Runkle, E.; Liao, W.; Safferman, S.; Reese, L.; Go, A.; Althouse, J.

PERFORMING INSTITUTION:
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EAST LANSING, MICHIGAN 48824

ENERGY EFFICIENCY AND ALTERNATIVE ENERGY MANAGEMENT IN PRODUCTION AGRICULTURE

NON-TECHNICAL SUMMARY: The primary focus of the proposed project is to increase energy efficiency and to promote alternative energy use in production agriculture including operations such as biomass drying and **greenhouse** production. This research is closely coupled to an on-going program to train and certify farm energy auditors, and provide them with back-up technical support. Interviews with producers reveal the probability of implementation of recommendations depends upon inclusion of management practices in the recommendations. Also, energy savings products produced for other sectors such as residential, and industrial applications are sometimes not well adapted for use in agricultural environments. Alternate installation techniques based upon field testing are needed to take advantage of some recent developments in energy efficient equipment when applied to agricultural applications. Some locations in Michigan may require two or more renewable energy sources in order to provide a reasonably continuous energy source. Wind energy coupled with solar photovoltaics, or a biogas powered generator may have potential for some locations. The wind machine and biogas powered generator must be synchronized with electrical grid power, and the dc output of the solar array must be inverted and synchronized with grid power. Although components are available to provide power grid interconnection, local installers must be relied upon to make the installation on farms. There are serious safety issues. The National Electrical Code is difficult to follow with respect to these installations and lacks in details. Some installation specifications need to be developed based upon actual field testing of an operating system. With respect to product cooling, geothermal energy is effective, however, often wastefully utilizing large volumes of water. Effective utilization

of water is essential and with proper design can supply farm water needs thus eliminating the need to supply pumping energy. Combined heat and power (CHP) strategies have much potential on farms in the areas of water heating, space heating, and biomass drying. An alliance has been established with the Energy Resource Center and the Midwest CHP Application Center at the University of Illinois (Chicago).

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ACCESSION NO: 0192266 **SUBFILE:** CRIS
PROJ NO: MICL02021 **AGENCY:** NIFA MICL
PROJ TYPE: HATCH **PROJ STATUS:** REVISED
START: 01 MAY 2012 **TERM:** 30 APR 2017 **FY:** 2012

INVESTIGATOR: Runkle, E.; Mitchell, C.; Lopez, R.; Burr, J.; Both, A. J.; Fisher, P.; Erwin, J.; Frantz, J.

PERFORMING INSTITUTION:
Horticulture
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EAST LANSING, MICHIGAN 48824

ENERGY-EFFICIENT PRODUCTION OF FLORICULTURE CROPS

NON-TECHNICAL SUMMARY: Floriculture is the fourth largest agriculture commodity in Michigan, with reported annual wholesale sales >$400 million. Michigan is particularly prominent in the production of garden plants (bedding plants and herbaceous perennials) and propagative materials, most of which are grown in environmentally-controlled **greenhouses**. To remain competitive and profitable, growers of floriculture crops require information to refine production protocols and improve production efficiency. Most bedding and garden plants are produced in **greenhouses** in Michigan from late winter through spring. During this time, high energy inputs are required to maintain a desirable **greenhouse** temperature, making heating costs one of the largest **greenhouse** production expenses. Growers are required to schedule their crops for pre-determined market dates, and if crops are not in flower, there is no market for them. Successful, profitable production therefore requires producing crops to reach the market on time and with the least amount of energy as possible. Light is another limitation in the production of **greenhouse** crops in the Northern U.S. from late autumn to early spring. Many common ornamental crops, including many garden plants, flower earlier when the day length is long (the night length is short). Therefore, **lighting** is used to promote

flowering of these crops. Traditionally, growers have used incandescent lamps to create artificial long days, but they are being phased out of production because of their energy inefficiency. The primary goal of this project is to improve our understanding of how light and temperature can be managed to produce high-quality **greenhouse** crops in an energy-efficient manner. Research will focus on the commercial production of bedding plants and propagative materials in **greenhouses**. A variety of experiments will be performed to determine how temperature influences flowering time and plant quality. Simulations will be performed to estimate the amount of energy consumed for heating in different production scenarios. In addition, we will develop and test light-emitting diodes (LEDs) to control flowering of plants that are sensitive to day length. Plant responses will be compared with light from traditional **lighting** sources. Results from this research will enable **greenhouse** growers to reduce energy costs for heating and light.

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ACCESSION NO: 0185737 **SUBFILE:** CRIS
PROJ NO: NJ12184 **AGENCY:** NIFA NJ.
PROJ TYPE: HATCH **PROJ STATUS:** TERMINATED
START: 01 OCT 2000 **TERM:** 30 SEP 2004 **FY:** 2004

INVESTIGATOR: Durner, E. E.

PERFORMING INSTITUTION:
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FLORAL MANAGEMENT OF STRAWBERRY PLUG PLANTS FOR OUT OF SEASON GREENHOUSE PRODUCTION

NON-TECHNICAL SUMMARY: Availability of fresh strawberries is seasonal. Out of season production is commom in Europe and Japan. Out of season **greenhouse** production of strawberries in U.S. does not exist. Greater understanding of the flowering physiology of the strawberry would be greatly increase the chances of success for an out of season system. The traditional strawberry growers will benefit from this research. Also improved management practices can also be developed.

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ACCESSION NO: 0217900 **SUBFILE:** CRIS
PROJ NO: OHOK-2009-00219 **AGENCY:** NIFA OHOK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** TERMINATED
CONTRACT/GRANT/AGREEMENT NO: 2009-33610-19725 **PROPOSAL NO:** 2009-00219
START: 01 JUN 2009 **TERM:** 31 MAY 2011 **GRANT YR:** 2009
GRANT AMT: $80,000

INVESTIGATOR: Tuck, R.

PERFORMING INSTITUTION:
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HIGHLY EFFICIENT LUMINAIRES FOR SUPPLEMENTAL GREENHOUSE LIGHTING

NON-TECHNICAL SUMMARY: Greenhouse farming is an absolute necessity to revive and create local agriculture businesses in northern "climatically challenged" regions with short growing seasons. Controlled Environment Agriculture (CEA) has made significant strides in **greenhouse** farming technology. State of the art CEA farming utilizes direct control of **lighting**, temperature and carbon dioxide in a hydroponics environment.Providing adequate amounts of photosynthetically active radiation (PAR) has been shown to increase **greenhouse** production capacity to a level capable of supporting large market demand. The challenge for northern markets is to implement such supplemental **lighting** systems at a cost that makes CEA **greenhouse** farming competitive with large out of state farm and ship sources. For this SBIR effort, Cycloptics proposes to combine energy efficient lamps with Cycloptics' patented optimized reflectors to create a luminaire that will produce significant **lighting** energy and cost savings. With Cycloptics' technology, light from such lamps can be precisely controlled to create a highly uniform distribution over large arbitrary target patterns. It is the combination of target efficiency and lamp energy efficiency that yields the energy and cost savings for the proposed luminaire. Initial estimates indicate the new luminaire technology could achieve energy efficiency gains of 25 to 40% relative to existing growth chamber **lighting**. With the proposed **lighting** technology, year-round

greenhouse agriculture could become economically more viable even for rural northern climate zones. If cost and energy efficiency gains can be demonstrated, the benefits align with Specific USDA goals. These include enhancing the international competitiveness and sustainability of rural farm economies by reducing costs of locally grown **greenhouse** produce to or below the cost of imported produce; support increased economic opportunities and improved quality of life in rural America from jobs created and associated with the **greenhouse** vegetable production industry; and enhancing the protection and safety of the agriculture and food supply by increasing local production of food that is easily traceable and better regulated by government entities.

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ACCESSION NO: 0222891 **SUBFILE:** CRIS
PROJ NO: OHOK-2010-02160 **AGENCY:** NIFA OHOK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** EXTENDED
CONTRACT/GRANT/AGREEMENT NO: 2010-33610-21389 **PROPOSAL NO:** 2010-02160
START: 01 SEP 2010 **TERM:** 28 FEB 2013 **GRANT YR:** 2010
GRANT AMT: $400,000

INVESTIGATOR: Tuck, R.

PERFORMING INSTITUTION:
Cycloptics Technologies, LLC
2358 Adirondack Trail
Dayton, OHIO 45409

NEXT GENERATION ENERGY EFFICIENT SUPPLEMENTAL LIGHTING FOR PLANT PRODUCTION

NON-TECHNICAL SUMMARY: Greenhouse farming is an absolute necessity to revive and create local agriculture industries in northern climatically challenged regions with short growing seasons. Controlled Environment Agriculture (CEA) has made significant strides in **greenhouse** farming technology. State of the art CEA farming utilizes direct control of **lighting**, temperature and CO2 in a hydroponics environment. Key advantages of CEA **greenhouse** farming include reduced use of pesticides, faster and higher quality growth, minimal transport costs to local customers, and "vine ripened" produce with minimal spoilage and contamination risks. For CEA **greenhouse** farming to be adopted in rural northern climates, progress is needed to reduce **greenhouse**-operating

costs. While temperature does play some role, **lighting** continues to be the most significant limiting factor in the growth of several specialty crops. Providing adequate amounts of photo synthetically active radiation (PAR) has been shown to increase **greenhouse** production capacity to a level capable of supporting large market demand. The challenge for northern climates is to implement such supplemental **lighting** systems at a cost that makes CEA **greenhouse** farming competitive with large out of state centralized farm and ship sources. In Phase 2 Cycloptics is combining recently available high intensity discharge (HID) bulb technology with its patent-pending, optimized reflector designs to achieve unprecedented plant growth **lighting** energy and cost savings. The new HID bulbs feature small emitters and high PAR efficiency relative to previous HID bulbs, making them ideal for compact and highly energy efficient growth luminaires. Cycloptics can design both direct and indirect **lighting** reflectors for these HID bulbs that can be precisely engineered to a highly uniform distribution over large arbitrary patterns and depths. HID bulbs have up to now been problematic as PAR luminaires for growth applications. Plants nearer the source tended to be burned, while others were not getting enough light. The design and optical performance of Cycloptics reflectors allow them to be placed closer to the plant canopy, enabling smaller volume highly efficient energy curtains for cooler months. The innovative compact reflector design will translate to less shadowing of natural **lighting** in warmer months. It is the combination of target efficiency, compactness, and HID lamp energy efficiency that ultimately yields the energy and cost savings for the proposed luminaire.

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ACCESSION NO: 0013014 **SUBFILE:** CRIS
PROJ NO: ORE00048 **AGENCY:** NIFA ORE
PROJ TYPE: HATCH **PROJ STATUS:** TERMINATED
START: 01 DEC 1999 **TERM:** 30 NOV 2004 **FY:** 2005

INVESTIGATOR: Green, J. L.

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PLANT-GOVERNED MOVEMENT OF WATER AND FERTILIZER IONS INTO THE ROOT MEDIUM

NON-TECHNICAL SUMMARY: A plant can govern fertilizer solubilization and uptake if the root system is divided between a capillary water uptake root medium and a fertilizer medium. Plant-governed hydraulic lift of water by roots in the water pouch and outflow from roots in the fertilizer pouch determines fertilizer quantity solubilized. If salinity is phytotoxic, root growth and water outflow will decrease and govern solubilization and ion uptake.

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ACCESSION NO: 0186078 **SUBFILE:** CRIS
PROJ NO: SC-1700135 **AGENCY:** NIFA SC.
PROJ TYPE: HATCH **PROJ STATUS:** TERMINATED
START: 01 AUG 2000 **TERM:** 30 JUN 2005 **FY:** 2005

INVESTIGATOR: Faust, J. E.

PERFORMING INSTITUTION:
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LIGHT MANAGEMENT STRATEGIES FOR COMMERCIAL GREENHOUSE PRODUCTION

NON-TECHNICAL SUMMARY: Light is frequently a factor limiting crop production in commercial **greenhouses**. Recently developed technologies allow growers to manipulate light with retractable shade curtains. However, strategies for managing retractable shade curtains inside commercial **greenhouse** do not exist. This project will focus on identifying strategies for optimizing the delivery of light to crops grown in commercial **greenhouses**.

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ACCESSION NO: 0221843 **SUBFILE:** CRIS
PROJ NO: WISK-2010-00480 **AGENCY:** NIFA WISK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** TERMINATED
CONTRACT/GRANT/AGREEMENT NO: 2010-33610-20888 **PROPOSAL NO:** 2010-00480
START: 15 JUN 2010 **TERM:** 14 FEB 2011 **GRANT YR:** 2010
GRANT AMT: $90,000

INVESTIGATOR: Morrow, R. C.

PERFORMING INSTITUTION:
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LEDS FOR MANAGING PEST INSECTS IN GREENHOUSES

NON-TECHNICAL SUMMARY: Plant-eating insect pests cause significant economic loss in commercial **greenhouse** growing operations, sometimes amounting to tens of thousands of dollars per hectare. Insects as a vector of plant pathogens also rank very high on the problem list for **greenhouse**/hothouse growers. Integrated Pest Management is a pest control strategy that "uses an array of complementary methods: mechanical devices, physical devices, genetic, biological, legal, cultural management, and chemical management" to help or prevent these economic losses while significantly reducing the use of pesticides. Although host utilization by insects is broadly dictated by factors such as host species, season, plant nutrition, and water status, many insects that are significant economic pests in **greenhouses**, including thrips, aphids, and whiteflies use vision as a primary cue to orient to their hosts. Vision cues are predominantly related to color, or more specifically hue, color saturation, and brightness. Most insects studied have green, UV, and blue receptors, though red receptors have been found in some. Color can be used in two ways to protect crop plants, either as a mechanism to attract insects to traps or "decoy" plants, or to repel insects by interrupting the sequence that begins with their orientation to the plant from a distance and ends with establishment on the plant. A new revolution in horticultural **lighting** is underway with the development of solid-state **lighting** systems, the first **lighting** system that allows control of a lamp's spectral output. During research with plants in controlled environment rooms outfitted with red/blue light emitting diode (LED) arrays it was apparent that plant appearance was radically different than when observed under broad spectrum light sources. This led to the hypothesis that modifying **lighting** to change the appearance of plants might disrupt the ability of pest insects to locate and attack host plants, or inversely, that the appearance of decoy crops and physical traps could be enhanced to increase their effectiveness. This would allow the use of supplemental **lighting** systems that might already be in **greenhouses** to be used as a new tool in a grower's IPM program. The objectives of the proposed project is to identify solid-state **lighting** protocols that: (1) reduce predation of protected agriculture

crops; (2) increase attraction to decoy crops; (3) enhance the attraction to physical traps (i.e., sticky cards); or (4) any combination of the above, while not disrupting beneficial insects or plant growth. If LED systems can be configured to help reduce insect damage and insect-related vectored diseases in **greenhouses**, these systems will gain additional usefulness by becoming an important component of the grower's IPM program, and could help to reduce the annual per hectare costs of **greenhouse** pest control.

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ACCESSION NO: 0226469 **SUBFILE:** CRIS
PROJ NO: WISW-2011-02290 **AGENCY:** NIFA WISK
PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** NEW
CONTRACT/GRANT/AGREEMENT NO: 2011-33610-31179 **PROPOSAL NO:** 2011-02290
START: 01 SEP 2011 **TERM:** 31 AUG 2013 **GRANT YR:** 2011
GRANT AMT: $460,000

INVESTIGATOR: Morrow, R. C.

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LEDS FOR MANAGING PEST INSECTS IN GREENHOUSES PHASE II

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ACCESSION NO: 0228905 **SUBFILE:** CRIS
PROJ NO: WISW-2012-00104 **AGENCY:** NIFA WISK

PROJ TYPE: SMALL BUSINESS GRANT **PROJ STATUS:** TERMINATED
CONTRACT/GRANT/AGREEMENT NO: 2012-33610-19526 **PROPOSAL NO:** 2012-00104
START: 15 JUN 2012 **TERM:** 14 FEB 2013 **GRANT YR:** 2012
GRANT AMT: $100,000

INVESTIGATOR: Morrow, R. C.

PERFORMING INSTITUTION:
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LED LIGHTING FOR MAXIMIZING QUALITY PARAMETERS IN SPECIALTY CROP PRODUCTION

NON-TECHNICAL SUMMARY: Convincing scientific evidence has associated dietary choices with chronic disease expression. Dietary guidelines now in place are designed to prevent the onset of such chronic diseases as tissue-specific cancers, cardiovascular diseases, and osteoporosis. The cornerstone of recommended dietary guidelines is increased consumption of fruits and vegetables. Current USDA dietary guidelines recommend eating 7-9 servings of fruits and vegetables per day. However, average adult consumption in the United States is only 4.4 servings per day, with an estimated 42% of Americans eating < 2 daily servings for fruits and vegetables. Consumption of vegetables provides the human diet with many essential vitamins and minerals important for health maintenance. Vegetables also contain secondary metabolite phytochemicals, which provide benefits beyond normal health maintenance and nutrition and play active roles in chronic disease reductions. If these beneficial compounds could be significantly increased in fresh fruits and vegetables through environmental manipulation, these ?functional foods? could have a significant benefit to human health and well being. The objectives of the proposed project will be to use the unique characteristics of solid-state **lighting**, particularly the ability to control spectral composition and to provide high light intensities in specific wavebands, to investigate the impact of light spectral quality and intensity on the leaf tissue concentrations of nutritionally important compounds and taste factors in brassica and lettuce specialty crops. The information from these tests would likely apply to many other specialty food crops grown in **greenhouses** and other protected environments. Successful completion of the proposed project will provide added value to specialty crops by increasing the nutritional value and levels of beneficial plant compounds. Even a small percentage increase in market price on a **greenhouse** crop that would not require equipment or cultural inputs beyond what is already generally being used in these production systems could have a significant impact on the economic success of this industry. Using data from the 1998 Census of Horticultural Specialties for **greenhouse** lettuce production, a 25% price premium for a lettuce crop with enhanced anti-oxidants could provide added annual revenues of $17,000 for an average producer. Improving the nutritional value of fresh fruit and vegetables would provide health benefits to Americans, who tend to under-

consume fresh fruits and vegetables, in part compensating for this deficiency. Additionally, the advancement of solid-state **lighting** technology and protocols for horticultural crops in protected environments can reduce waste, time to market, and operating costs through increased power efficiencies.

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