2013 University of Arkansas CARS Strawberry Sustainability

COVER SHEET

Project Title:	Winter Production of Nebraska Strawberries: An Idea Whose Time Has Come
Proposal Number:	P13-004
College or University:	University of Nebraska - Lincoln
Lead Project Investigator	Ellen Paparozzi
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Project Duration (Start date and end date): 07/01/2013 to 06/30/2014

Proposal Collaborators:

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SUMMARY/ABSTRACT
For the past 4 years, the University of Nebraska (UNL) strawberry team has developed low cost, sustainable methods for farmers and growers to grow strawberries in a greenhouse during the winter. Our justification is partly based on previous information that many farmers must work outside of the farm during the winter to provide a supplemental income. If winter-time strawberry production could be shown profitable, the farmer would not have to take a different job outside of his area of expertise. We are proposing an experimental project to develop and compare a real-time, commercial strawberry production system, concurrently with our scientifically monitored and on-going prototype production system at UNL. For each experiment, five previously selected cultivars will be grown on water-saving capillary mats using automatic watering and fertilization techniques. Bottom heat to the CapMats™ will be provided through poly tubes under the benches. Reflective polyethylene mulch will cover the mats to minimize evaporation, increase light and to provide a clean surface for the berries. Dormant crowns will be received in early September and planted in a commercially available soilless mix. Harvested strawberries will be weighed and graded for the fresh market. The commercial grower partner will sell his berries. All materials, supplies and setup costs for the heated high tunnel and the production system to be installed at the commercial site will be recorded with a goal of calculating the number of years to return on investment and profitability.

STAKEHOLDER ENGAGEMENT
The University of Nebraska has conducted several successful winter-time strawberry production studies in a simple double–glazed polyethylene Quonset greenhouse. The funding for the past four strawberry projects has come from the Nebraska Department of Agriculture Horticulture Specialty Block Grant Program. These grants were reviewed and selected by growers as well as by university faculty. For this project our plan is to engage the Nebraska Fruit and Vegetable Growers Association through at least one open house/field day at the commercial grower's farm and have him present a project report at the January Great Plain's Growers Conference in St. Joseph, Missouri. Over the last 4 years, we have maintained a website (http://agronomy.unl.edu/cea) that contains all of our oral and poster presentations including videos and an extension guide in order for our work to be available to the public. Our research results have been presented at the annual American Society for Horticultural Science meetings, the Great Plains Growers Conference and the Nebraska Sustainable Agriculture Conference. We currently have published one journal article (in the American Society of Agricultural and Biological Engineering journal, Applied Engineering in Agriculture) with other manuscripts pending. Other articles aimed at the commercial industry have been published both in print and online in Greenhouse Grower magazine. Our website's unique page views continue to grow. Since October 2011, we have had an average of 27 unique page views with a range of 8-52 per month. Since November 2012 not only have our unique page views increased (November=61; December=35; January=98; February=82), but the amount of time spent viewing the page has increased and ranged from 3:09 to 5:34 minutes. These figures indicate a growing interest in the information from our strawberry projects.

PROJECT PURPOSE AND JUSTIFICATION
Strawberries are one of America's favorite fruits. However, during the winter months not only are strawberries expensive in Nebraska ($5-6.50 per pound), but they also lack flavor. Given the increase in shipping costs, the interest in local, year-round food production, and the desire to increase flavor, the Nebraska Strawberry team has been working on creating a low cost, sustainable production system for growing strawberries during the winter. Through this research, we created and cost-accounted an efficiently heated high tunnel/plastic greenhouse, monitored and employed water and heat saving technology and conducted trials of thirteen strawberry cultivars to determine berry mass, berry numbers, sweetness and nutraceutical properties/brix for potential marketing. From our findings, we are now ready to partner with an interested commercial grower to determine the economic feasibility of growing strawberries during the winter in Nebraska.

OBJECTIVES
1-Establish a heated high tunnel typically utilized by specialty crop growers; track associated costs from raw materials to hourly labor to marketing and compare to our estimates. Costs we will track include: materials to set up and equip a 24'x72' heated high tunnel at the grower location, production direct costs such as plants, mix as well as the labor associated with winter strawberries. Marketing costs to deliver the crop to market will also be

recorded.

2-Test the feasibility of a commercial production timeline for growing strawberries in a heated high tunnel on a specialty crop grower's farm and compare yield data to our UNL production system (concurrently) in a double poly greenhouse. The UNL production system will be smaller in scale when compared to the grower's and will emphasize estimating water and natural gas usage plus recording light, temperature, humidity and soil moisture through greenhouse sensors and computer controllers. We will also test 2 additional production timelines with the aim of synchronizing peak strawberry production with peak price per pound.

3-Determine gross profit and years-to-return on investment for strawberry growing and develop a budget for future winter strawberry production under Nebraska conditions.

CITATIONS

Strawberry-related Publications to-date:

Lambe, D.P., S. A. Adams and E. T. Paparozzi. 2012. Estimating construction costs for a low-cost Quonset-style Greenhouse. UNL Extension Publication EC 104. 8 pp.

Meyer, G.E., E.T. Paparozzi, E A. Walter-Shea, E.E. Blankenship, and S.A. Adams. 2012. An Investigation of reflective mulches for use over capillary mat systems for winter-time greenhouse strawberry production. Applied Engineering in Agriculture 28(2):271-279.

Paparozzi, E. T., G,E. Meyer, S. A. Adams , M. E. Conley, B. Loseke and P. E. Read 2012. Greenhouse production of strawberries in winter. HortScience 47(9): S326-327.

Paparozzi, E. T. and G. E. Meyer. 2012. The return of capillary mats. Greenhouse Grower magazine. 30(9): 78-84.

Paparozzi, E. T., G. M. Meyer, M. E. Conley, S. A. Adams, E. E. Blankenship, P. E. Read and V. L. Schlegel. 2011. Cultivar choice affects quality and production of winter grown strawberries. HortScience 46 supplement. - http://ashs.org/db/horttalks/detail.lasso?id=116120

PLAN OF WORK

Our research will begin with determining business start-up costs for a typical farm in Nebraska. Our grower partner, Pekarek's Produce farm in Dwight, Nebraska, will assemble and prepare for production a heated high tunnel. Two strawberry experiments will be conducted from September through March 2014. One will occur at the University of Nebraska research greenhouses in our modified plastic greenhouse and the second experiment in the heated high tunnel at Pekarek's Produce. During this process, the grower will record all costs and hours of labor (both paid and unpaid).

The purpose of the grower experiment is to test a proposed timeline for producing quality, marketable strawberries by growing four previously tested cultivars and one new cultivar. The goal is to determine the best berry producers each week. Farm profitability will also be evaluated.

The university experiment will be a smaller version (mirror) (200-250 plants/house) of the grower experiment (1100 plants). The reasons for this include: more detailed monitoring system for measuring and recording plant light availability, white mulch reflectance, pot moisture and electrical conductivity (EC), relative humidity, air and pot temperatures including ventilation cycles as well as total water and natural gas usage. So one purpose of the university research is to determine if our figures can be extrapolated to a grower production scale.

Additionally, this past year, we discovered that deflowering the strawberries through October successfully delays production until the end of November but decreases yield. We, therefore, plan to test 2 different production timelines to manipulate strawberry production in order to push plants to peak production when the price is highest (November-December). The 'control' production timeline would be employed by our grower partner. This timeline is: plant around mid-September and deflower until October 1. At the university, the first adjusted production timeline would be no flower removal and the second production timeline will be to continue to deflower

1 more week into October than the grower. To conduct both experiments, plants will be received during week 37 (September 9) and during the next week potted up in 6" plastic pots containing a soilless mix. The strawberry plants will be grown using minimal heat by channeling poly tubes that convey heat directly under each bench and minimal water by using capillary mats. The top surface of the capillary mat will be covered with white reflective plastic to increase light reflectance around the plants; black plastic is placed under the mat. The capillary mat system with an automatic time clock controller provides water at selected intervals to the mat. Benches are constructed of bench fabric (similar to lath) on a wood frame and set on cinder blocks for cost effective construction, easy maintenance and removability.

The experimental design for the grower production experiment would be a simple randomized complete block design with 3 benches (replications) and the 5 cultivars (treatments). Data to be taken include: pounds of berries per cultivar per week, person-hours of labor for harvest (weighing and packaging), delivery costs and sale price. The experimental design for the university study will be a split-plot with cultivar as the whole-plot unit and the 2 production timelines as the split-plot unit. There will be five replications across two benches. Data to be taken include: number and pounds of berries per cultivar per week, total water and natural gas usage, growing conditions to include light level, soil moisture capacity, light reflectance on leaves and relative humidity of the greenhouse.

Risks:

Production of a highly profitable crop during a non-typical production period is the ultimate goal of this project. Management of the interior growing environment presents a challenge for this crop given the cooler temperatures and the potential for high air moisture content. Typical environment strategies through increased ventilation and heating of the air will prove difficult and moisture must be controlled through plant water use monitoring even though we will have sensors at both locations. High levels of free moisture result in increased potential for diseases. For sustainable food production, chemical disease control will be a limited option so water and humidity management is critical for this project.

PROJECT IMPACT

Season extension techniques (high tunnels, plasticulture techniques, greenhouse food production) are of great interest and are being developed by growers to increase farm income and spread income over a greater portion of the year. With only field production, harvests seasons for Nebraska produce range from mid-May to early November. With the addition of season extension techniques, production can be distributed over a greater portion of the year. Stable, dependable income is necessary for individual farm success and the success of the Nebraska specialty crop industry.

Farmer profitability for Nebraska and Great Plains growers is the ultimate goal. If growing strawberries can be proven to be profitable in the winter season, locally grown strawberries, having full flavor and providing good nutrition will be available to the public through local grocers, indoor farmer's markets and food service providers. This project has the ability to increase healthy lifestyles through consumption of healthy foods while diversifying and improving rural families' income.

EXPECTED MEASURABLE OUTCOMES

This project's outcomes will be to:

1 - Provide best cost estimates for assembling and operating the high tunnel to produce strawberries
2 - Project the mass (pounds) of strawberries produced for fresh market
3 - Project income received per week per pound of berries
4 - Identify delays or problems encountered during winter strawberry production
5 – Record accurate grower cost accounting records for production particularly fuel consumption as this is second only to labor in terms of major costs.
6 - Estimate crop profitability in terms of years-to-return on investment.
7 - Develop working, operational, management, production and suggested marketing plans for winter-time strawberries.

LOGIC MODEL AND EVALUATION

The key components of this study consist of anticipating and executing the two experiments. In the past, our UNL

team was carefully assembled and as a result has worked well together. Ellen Paparozzi will hold monthly team meetings that will include our grower, Ryan Pekarek, either in person, via Skype or teleconference. Stacy Adams will take the lead on assisting Ryan in obtaining materials and assembling the high tunnel including setting up the sustainable production system. Dave Lambe will work with the grower to set up and record costs associated with the project. Erin Blankenship will work with Ellen and Ryan, our grower, to design both experiments and will facilitate data analysis for information such as comparing strawberry cultivar productivity. Ellen and George Meyer will determine locations for sensors both at the UNL greenhouse and at the grower's high tunnel. George and his undergraduate engineering student will monitor the data in order to make environmental comparisons and trouble shoot temperature and humidity problems. Liz Conley and an undergraduate horticulture student will grow, scout and harvest the strawberries at UNL. Their responsibility will be a 7-day per week for 7 months commitment. As issues arise Ellen and Paul Read will discuss and resolve them.
Evaluation plan – based on the objectives outlined in the proposal, the activities and outputs listed above we will, for both locations, statistically analyze the production data by week by cultivar with price received as a variable. We will then recommend which cultivars are best. We will collect data on all capital costs by breaking down and identifying those initial costs that a grower must pay in order to grow strawberries. As we have already produced some information on growing strawberries in the winter, we will consider our technology transfer successful if the grower finds it easy to establish the heated high tunnel, equip it with our sustainable systems and is able to successfully grow, harvest and market strawberries during this coming winter. The entire project will be deemed successful if we are able to capture all our grower's costs and find them comparable to our projections for metrics such as years-to-return on investment. We will further gauge success based on the field day interaction (an optional participant evaluation may be included), reactions to the data presented by Ryan at the January grower's conference, the unique hits to our website (including the response to the video) and the willingness of Ryan and others to invest in growing strawberries the next winter.

CAPACITY (INSTITUTIONAL AND TEAM)
Budget Management. The oversight and administration practices at the University of Nebraska Agronomy and Horticulture Department provide checks and balances for the use of funds awarded. The department's Business Center works with the PI to monitor the expenses that post and have the following requirements in policy.
First, the Business Center provides detailed Financial Reports to the PI every two weeks for each project the PI is involved with. The PI reviews the expense report to ensure postings are proper for the project. Second, the PI must give approval for all Invoices that will be paid on the project. The PI reviews the Invoice, indicates that it is "Ok to Pay," and identifies the project to be paid from. Third, the Business Center reconciles all activity that posts on the Ledgers to ensure proper documentation for each posting and that the posting does not violate Sponsor guidelines. Fourth, for each person hired on a project, the department requires the PI to fill out an employment form listing the new employee's work on a project. Also, a Personnel Activity Report is generated for each person paid on a project and the PI is required to verify the effort of that person toward the funding source. The Personnel Activity Reports are generated throughout the life of the project.
In conclusion, the PI has the ultimate say on whether a charge should post to a project and the Business Center is there to assist the PI with reviewing the project postings. The policies in place help ensure proper posting and financial administration of the project.

Greenhouse and laboratory facilities. For the last four years, the strawberry projects have paid for a double polyethylene Quonset style greenhouse. It is fully equipped, functional and available for the term of this grant. Dr. Paparozzi has laboratory space in the Plant Sciences Building room 384 to provide supply and bench space for all personnel. Her technologist, Liz Conley is permanently housed there. Dr. George Meyer, has the expertise and computer equipment to set up the greenhouse sensors and monitoring system that will be used in the study.

PERSONNEL AND ROLES
Principal investigator:

Ellen T. Paparozzi, PhD, Professor of Horticulture

Co–Principle Investigators and Project Partners:

Mr. Ryan Pekarek, M.S., Owner Pekarek's Produce, President, Nebraska Fruit and Vegetable Growers Association, Industry Partner
David P. Lambe, M.B.A., Associate Professor of Practice in Horticulture
Stacy A. Adams, M.S., Associate Professor of Practice in Horticulture
George E. Meyer, PhD, Professor of Biological Systems Engineering
Erin E. Blankenship, PhD, Professor of Statistics
Paul Read, PhD, Professor of Horticulture

Ellen Paparozzi, Professor of Horticulture, has been at the University of Nebraska-Lincoln for over 31 years. In this role she teaches physiology, production and plant nutrition courses. The focus of her lab group is to manipulate and link physiological and anatomical plant growth processes to useful horticultural growing situations. She serves as the team leader for the Nebraska Strawberry Team. If this grant is funded, she will be responsible for coordination of all the activities of the team members. She will also serve as principle writer for all grant reports and articles.

Ryan Pekarek, owner of Pekarek's Produce, is the grower partner of the study. The farm has been producing vegetables for 9 years. Currently, the farm is developing production systems to allow for fresh produce to be harvested and marketed during as much of the year as possible. This project will allow the farm to expand its winter season offerings beyond high tunnel production of root crops and crops from storage (potatoes, cabbage, winter squash). Additionally, this project will help to develop the production of strawberries in Nebraska beyond the June field season and the limited high tunnel production that is currently occurring. During the months of the year when the heated high tunnel is not being utilized in strawberry production, it will be used to produce transplants for field and vegetable production. Ryan has worked with other growers as a member and President of the Nebraska Fruit and Vegetable Growers Association and through numerous speaking engagements. All of these activities help to develop the specialty crop industry in Nebraska.

Stacy Adams, Associate Professor of Practice in Horticulture, is controlled environment plant production specialist with extensive background in design and construction of greenhouses and high tunnels, greenhouse management, integrated pest management and vegetable and flowering crop production. Stacy's efforts are to provide professional expertise to the commercial grower through the planning and construction phase, help in the development of the production system and provide crop consultation as needed. Stacy will continue to provide environmental management and production equipment installation and maintenance, as well as provide growing expertise to the research group at the University research greenhouse.

Dave Lambe has recently been involved in researching costs for growers of construction of sustainable greenhouse structures (Lambe, D., S. A. Adams and E. T. Paparozzi. 2012. Estimating construction costs for a low-cost Quonset-style Greenhouse. UNL Extension Publication EC 104. 8 pp). As a member of the advisory board of the Nebraska Buy Fresh Buy Local organization, Dave has and will keep them apprised of progress and plans. Dave's primary role at the University of Nebraska – Lincoln is to teach undergraduate and graduate education in the field of entrepreneurship. Dave's educational background is in accounting, horticulture, and a Masters of Business Administration with an emphasis on strategic management. His role will be to collect and analyze cost data to determine the feasibility of growing and marketing strawberries in Nebraska in the winter.
George Meyer – As a professor of biological systems engineering and member of the strawberry team, he and an electrical engineering associate have been responsible for the electronic instrumentation and data gathering in our greenhouse. For this project, he will provide the growing team with real-time information about greenhouse and crop performance. Data recorded will include: air and canopy temperatures, soil temperatures, soil moisture, and electrical conductivities, air humidity, and solar radiation (both photosynthetically active and total radiation) Real-time data and a webcam will be observable daily over the internet and logged using a LabVIEW 2012® (National Instruments, Austin, TX) program, already written and available for this project. A professional software license is already available with dedicated computers and internet service.
Elizabeth Conley – Liz has been Ellen's research technologist for over 25 years. During that time she finished a Master of Science degree in horticulture and has grown plants under every imaginable condition from small tree liners in the field to hydroponic lettuce and Swedish ivy in the lab and the greenhouse to strawberries on capillary mats in polyethylene greenhouses. When Liz is responsible for growing a crop, she scouts it daily and anticipates

problems. Liz has had the primary growing responsibility for our strawberry grants.
Erin Blankenship – Erin is a faculty member in the Department of Statistics. She has worked with Ellen Paparozzi and the Nebraska Strawberry Team since the first trials in 2009. Erin will set up the experimental design, visit the project as it progresses, advise on data collection, analyze the data and guide the interpretation. As a statistician, Erin brings a different set of eyes to this project as she is totally objective about the results and their interpretation.
Paul Read - Paul will provide advice on cultivar selection and evaluation, and nutrition, disease and cultural management issues. In addition to frequent monitoring of the campus-based portion of the project, I anticipate that I will visit the grower site two or more times to observe and advise, as well as evaluate the plant and fruit characteristics. I will also confer with student workers and project personnel as may be needed. Environmental issues may require additional input and advice (day-length/photoperiod and supplemental lighting for example).

Lead Institution Budget

Current Budget

Personnel: salaries, wages

- Senior Personnel

$20,978

- Undergraduate Students

$7,000

Fringe

- Senior Personnel

$5,664

Equipment

- No items Equipment

$0

Travel

- To site bi-weekly

$4,600

- National Horticulture Conference (ASHS)

$1,500

Participant/trainee support costs

- No items Participant/trainee support costs

$0

Other Direct Costs

- Video

$6,500

- Field Day

$2,000

- Materials & Supplies

$6,900

Indirect costs

- IDC @15%

$14,368

TOTAL REQUEST
$69,510

Lead Institution Budget Justification

At UNL, the prototype greenhouse system is established. The main cost is the Personnel associated with growing the plants, taking data, installing the sensors, downloading and processing the data including recording the data for harvesting and grading of the berries. We will be using the sensors to monitor light, air and soil temperature, relative humidity and soil moisture. The computer and program is already purchased and installed and we already have a data logger for the commercial grower so only a few sensors will need to be purchased. To accomplish this, we plan to hire two students to participate in this study – a horticulture student and an engineering student. We will actively involve them in this project (have them attend meetings, visit the grower) in order to ensure that it will be a meaningful research experience. Materials and supplies will include but not be limited to: expendable items such as plant, mix, pots, labels, white and black plastic, capillary mat items, fertilizer and bees as well as beneficial insects or pesticides, if needed, will also be purchased in order to grow the strawberries for 7 months. This part of the budget also includes monies for the Field Day at Pekarek's Produce and the video production (10 minutes total (possibly split into 2 segments). The video will involve 3-4 trips to the grower's site, editing, and voice overs. Travel in the budget allows trips (including rental of vehicles and gas) to and from the farm in Dwight Nebraska for all cooperators and registration and plane fare for the PI to present the results of this study at the American Society for Horticultural Science meetings in July 2014.

Subcontract budget to: Ryan Pekarek - Pekarek's Produce

Current Budget

Personnel: salaries, wages

- Hourly Labor

$5,000

Fringe

- No items Fringe

$0

Equipment

- No items Equipment

$0

Travel

- Travel to St. Joe meeting

$1,000

Participant/trainee support costs

- No items Participant/trainee support costs

$0

Other Direct Costs

- Materials & Supplies

$34,650

Indirect costs

- No items Indirect costs

$0

TOTAL REQUEST
$40,650

Budget Justification for Subcontract to: Ryan Pekarek - Pekarek's Produce

Funds are requested for a project that will compare a real-time, commercial strawberry production system concurrently with our scientifically monitored and on-going prototype production system at UNL. Sub-contract funds to the grower will be used as follows: Wages (hourly) to hire individual(s)to assist our grower, Ryan Pekarek with tasks including but not be limited to: planting, data collection, harvest, weighing and packaging of the strawberries; Travel for Ryan to travel and present information on the project at the Great Plain's Grower's Conference in St. Joseph, Missouri and to come to Lincoln for meetings; Other Direct Costs identified as Materials and Supplies – these items will include but not be limited to framework, poly, inflation kit and fan, wiggle wire, wood, pedestrian doors, blower, furnace, hardware and other items needed to establish a heated high tunnel. Inside the tunnel, the production system will include bench fabric, wood, cinder blocks, a CapMatII system with a time clock, fertilizer injector, piping, filters and tubing, as well as polyethylene on top of the mat to increase reflected light, keep the area clean for the berries and to keep water from evaporating. Plants, pots, fertilizer and bees as well as beneficial insects or pesticides,if needed, will also be purchased in order to grow the strawberries for 7 months. We anticipate 1000 pounds of berries will be produced by our grower between mid-November and the end of March.

WHAT IS YOUR PRIMARY PRIORITY AREA?
Increase the production season and regional diversity of US strawberry production

PLEASE SELECT ALL OF THE PRIORITY AREAS THAT ARE APPLICABLE TO YOUR PROPOSED PROJECT:
(USE CTRL KEY + CLICK ON OPTIONS TO SELECT ALL THAT APPLY.)
Reduce the energy inputs in production, handling, storage, and transportation
Conserve and preserve water resources used in the production system
Increase product value and economic return to growers and participants throughout the supply chain
Implement meaningful and constructive metrics for strawberry production sustainability