Department of Agriculture, Trade and Consumer Protection
Division of Agricultural Development
Agricultural Development & Diversification Program (ADD)
Grant Project Final Report

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Grant Project Title: **Storage evaluation of new chipping cultivars**

Amount of Funding Awarded: $25,000

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Proposal Background and Description of Market Opportunity

Wisconsin traditionally produces 65,000 acres of potato with an annual farm gate value of $200 million. Wisconsin also has a strong potato processing industry that includes value added products such as chips, fries, frozen processed, fresh pack and seed potatoes. Numerous jobs exist within the potato processing and value added industries in Wisconsin. Approximately 15% of the WI potato crop is processed into potato chips by multinational (Frito Lay) as well as regional companies (Jay's, Herr Foods, Kettle Foods). The raw value of chipping potatoes is influenced by chip color, tuber size, specific gravity, and internal and external defects. Wisconsin potato growers must grower a better quality crop in order to remain competitive in shrinking chipping potato markets.

Fry color has been directly correlated to the reducing sugar content of tuber tissue. Reducing sugars react with free amino acids during frying via the Maillard reaction resulting in brown to black discoloration of the tuber tissue, which is considered undesirable by consumers. Management practices during potato production and storage can have direct impacts on the reducing sugar content of potato tubers. Unlike in processing potatoes, chip potato growers closely monitor chemical maturity of potatoes to optimize time of harvest. In addition, sucrose and glucose concentrations and chip fry color of tubers are monitored bi-weekly in storage to insure potatoes are acceptable quality upon delivery.

Research has documented the importance of crop maturity, specifically chemical maturity, for managing reducing sugar content in stored potatoes. A potato crop is chemically mature when the sucrose content in developing tubers reaches a minimum concentration (Santerre et al. 1986). Chemically mature potato tubers reach minimum reducing sugar content in storage quicker then immature tubers and maintain acceptable reducing sugar concentrations for longer durations in storage (Pritchard and Adam 1992). Potatoes grown for chips are carefully monitored during the growing season and in storage to assure good fry color following cooking (Sowokinos et al. 1988). Following harvest, chipping potatoes are preconditioned until tuber glucose and sucrose concentrations are below acceptable levels. Preconditioning conditions are typically 55 F whereas long term storage conditions are 45 to 50 F. Warmer temperatures increase respiration losses of water and carbohydrates and increase potential for disease development. Minimizing preconditioning period minimizes shrink, but failing to precondition for an adequate period of time can lead to unacceptable fry color later in storage.

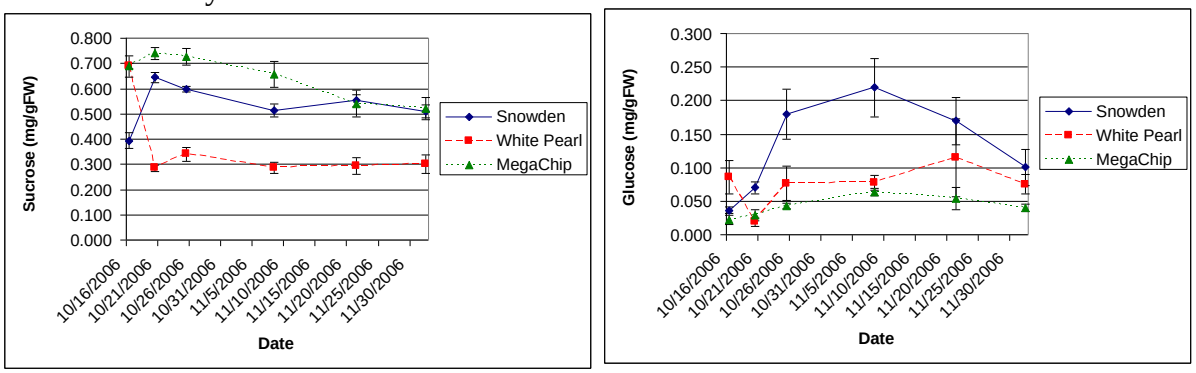
Snowden has been the primary chip potato grown by Wisconsin growers for regional companies since the mid 90's. Snowden has good sugar profile as it matures and preconditions on a consistent basis in storage. Snowden was one of the first cold chipping varieties characterized by a unique set of storage characteristics that has made it ideal for Wisconsin chip growers. A negative aspect of Snowden is that it will senescent sweeten earlier than other chip potatoes. In other words, sugar concentrations of Snowden will begin to increase in March or April causing dark fry color making it unsuitable for

chipping. As a result, Wisconsin chip potato growers have few potatoes available for sale for chipping after March 31. Identification and confirmation of a chipping potato variety with long season storage ability could allow Wisconsin growers to market an additional 50,000 to 100,000 cwt of potatoes per month worth $500,000 to $1,000,000. Those potatoes are currently being sourced from the Southern U.S.

Chipping potato price is also influenced by internal and external defects. Tubers affected by defect do not meet US No. 1 grade and growers are not paid for potatoes that are rejected. Excessive defects can lead to rejection of entire lots of chipping potatoes. Common scab cause surface blemishes that lead to difficulties in peeling chipping potatoes and effect shape of chips. Common scab reduces market yield of chipping potatoes by 5 to 15% within a given year. Common scab reduces the price of chipping potato by $0.35 to $1.05 per hundred weight (cwt) with total losses of $1.8 to 5.4 million annually. Several cultural management practices such as adjusting pH, irrigation, and crop rotation can prevent scab, but no effective chemical control measure is available.

MegaChip is a newly released variety by the University of Wisconsin Potato Breeding Program. MegaChip has excellent yield and tuber size distribution, good specific gravity, and resistance to heat stress compared to current chipping potatoes. More importantly, MegaChip has good to excellent resistance to common scab under Wisconsin production systems reducing the potential losses due to defects caused by surface blemishes. MegaChip has had good chip color and quality when processed directly from the field, but previous research on storage sugars has suggested poor quality out of storage. If storage management profiles can be generated for MegaChip, then growers would be able to produce more acres of MegaChip and reduce losses in chipping potatoes due to scab.

Figure 1. MegaChip sucrose and glucose concentrations during pre-conditioning at the Potato Storage Research Facility.



Research initiated in fall of 2006 on MegaChip indicated that initial tuber sucrose concentrations were higher than Snowden (Figure 1). Higher sucrose concentrations may have resulted from cultivar differences or because MegaChip has later bulking than Snowden and delayed chemical maturity in the field. The higher sucrose concentrations in MegaChip require longer pre-conditioning to minimize and insure future glucose concentrations remain low. The potential need for longer preconditioning of MegaChip may have led to failures in previous storage research trials. MegaChip had lower glucose concentrations compared to Snowden. However, potatoes must be preconditioned properly for successful long term storage

White Pearl and W2310 (data not shown) have been shown to have longer storage potential than Snowden. Snowden has lower sucrose concentrations upon harvest than Snowden requiring shorter preconditioning period (Figure 1). White Pearl also had lower glucose suggesting better fry color throughout storage period. White Pearl was shown to maintain good fry color until July in non-replicated grower trials. W2310 has also shown increased potential for long term storage.

Storage evaluation of new chipping cultivars has always been a “learn as you go process”, mostly at the growers expense. New cultivars are released by breeding programs with good data on production

attributes, specific gravity, potential fry color and yield capabilities from small plot data, but little or no information on storability especially at the bin scale. Small bag samples in storages simply do not provide confidence to predict all of the potential storage issues that may arise during 7 to 8 months of storage such as pressure bruise, chip texture, chip taste etc. Storage losses from new cultivars have reached unacceptable levels (30%) in recent years costing growers $70,000 to 150,000 in the evaluation process. As a result, growers are less willing to store large bins of unproven cultivars.

The new Potato Storage Research Center at the UW-Madison Hancock Agricultural Research Station offers the opportunity to add predictability to a high-risk area of potato production. This facility fills a void between the small bag samples often used in storage evaluations and large commercial sized bins. Identification of "Best Management Practices" in a 2000 cwt sized bin would increase grower confidence and willingness to store a new chip variety and provide insights into optimal storage management conditions. This proposal suggests research activities for several areas of economic interest to chip growers.

Project Objectives and Plan of Work

The goal of this proposal is to determine and demonstrate the "Best Storage Management Practices" for MegaChip, White Pearl, or other varieties with high potential to reduce scab and extend storage season. MegaChip or other new varieties will be compared to Snowden as the standard storage chipping variety. MegaChip has been identified by chip growers in Wisconsin because of its scab tolerance, high yield, and stable chip quality in preliminary storage research trials. White Pearl has long term storage potential. Currently trials are evaluating other chipping potatoes for agronomic and storage qualities that could be included in this project as well. Chipping potato growers and chip companies across the US have high level of interest in finding a variety other than Snowden with improved scab resistance and long term storage potential. Adoption of MegaChip, White Pearl, W2310, or other varieties would not only benefit chipping potato growers, but Wisconsin seed potato growers who currently produce seed. Specific objectives include:

1) Monitor chemical maturity of MegaChip or alternative variety to demonstrate optimal harvest timing.

2) Identify and demonstrate optimal temperature management for preconditioning and long-term storage of MegaChip or alternative variety.

3) Quantify factors influencing the storability of MegaChip and other varieties to demonstrate the value over an extended storage season.

Accomplishments to date

Objective 1) Monitor chemical maturity of MegaChip or alternative variety to demonstrate optimal harvest timing.

We grew MegaChip, W2133, W2310, White Pearl, FL1867, FL1879, and Snowden at the Hancock Ag Research Station. We initiated sampling of 20 tubers from each plot in early August and continued every other week through vine kill. At each sampling tubers were evaluated for sucrose and glucose content to determine chemical maturity. In addition, we monitored chemical maturity of 18 advanced chipping potato breeding lines during the same time period in the US Potato Board chipping trial. Chipping lines were derived from 6 different breeding programs from across the United States and included lines the chip processors and growers are interested in adapting for current use in the industry. Finally, we evaluated chemical maturity and 5 chipping lines from the Spudpro trial which includes the potato breeding lines with the best potential as varieties from the University of Wisconsin Potato Breeding Program.

Objective 2) Identify and demonstrate optimal temperature management for preconditioning and long-term storage of MegaChip or alternative variety.

Small scale related storages

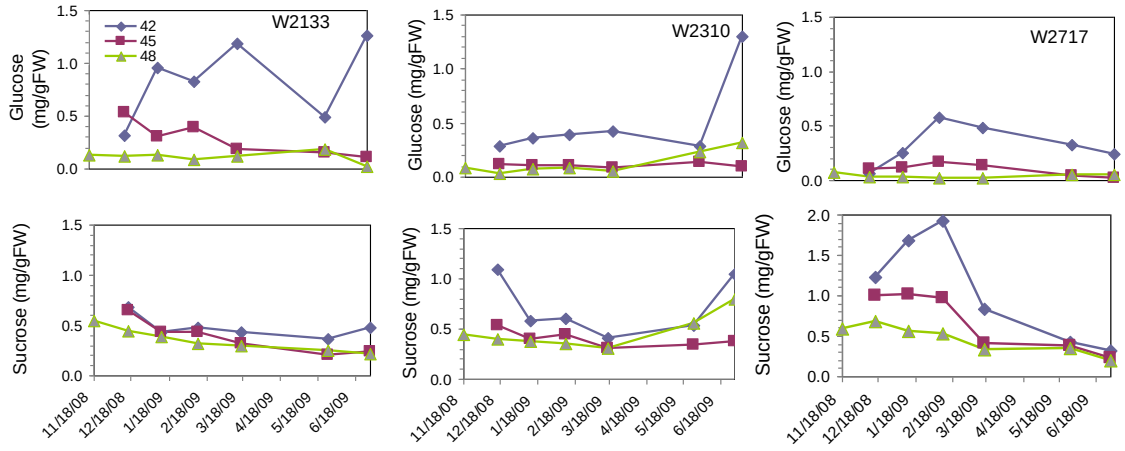
Although this funding focuses on commercial scale storage of potato, several developments in screening varieties for long term storage are important for future research. In small scale research under separate funding, W2133 showed acceptable sucrose levels throughout the storage period across all three temperature regimes (<0.7 mg/g, Figure 1). Unfortunately, glucose was too high, >0.035, especially at 42 F, resulting in chips with dark fry color. We did not allow enough time for preconditioning of W2133 resulting in excessive glucose at the beginning of storage and never recovered. Previous research has shown W2133 to be a good storing chipping potato. The WI chip industry is increasing seed to allow for future commercial scale trials with W2133 which has good yield, long term storage, and other agronomic traits.

W2310 showed acceptable sucrose and glucose levels throughout most of the storage season at 45 and 48 F. W2310 did show signs of senescent sweetening especially at 48 Fwhere sucrose began to increase in May and June, 2009. However, sucrose remained low for W2310 through June when stored at 45 F. Correspondingly, glucose began to increase in W2310 in May and June at 48 F leading to poor fry color, but glucose remained low at 45 F resulting in acceptable quality chips. Cold storage of W2310 at 45 F looks essential for lengthening the storage season and preventing senescent sweetening prior to June. These are small plot trials, so commercial management will require close monitoring to prevent cold induced sweetening and determination of senescent sweetening. W2310 was stored in commercial scale trials fall 2008 through spring 2009 (see below). Plan is to conduct commercial

W2717 had fairly high sucrose at 42 and 45 F through March in the storage, again likely due to inadequate preconditioning. Regardless, sucrose began declining in February reaching acceptable levels in April. W2717 showed no signs of senescent sweetenting and had the lowest glucose levels of all lines evaluated in storage at 45 and 48 F. W2717 has issue agronomically leading to lower yields, but has excellent quality with regard to solids, sugars, and size.

Trials conducted in cooperation with the US Potato Board Chip Committee showed good long term quality for two breeding lines from Cornell, one from Michigan, and one from Colorado. These lines along with W2717 and W2310 continue to perform excellent out of storage across multiple trials in several states.

Figure 1. Glucose and sucrose content of W2133, W2310, and W2717 at three storage temperatures through 8 months in storage.



Commercial Scale Storage

Heartland Farms produced 10 acres of MegaChip and 5 acres of Snowden for commercial scale evaluation in preliminary trials during the summer of 2007. MegaChip did not perform up to expectations and so it was grown for the current research. MegaChip had good yield, tuber size profile, and initial chip quality at harvest. Unfortunately, MegaChip end use quality quickly eroded after harvest and took until the middle of December to precondition. In contrast, Snowden was preconditioned and had been cooled to set point by about the same time. MegaChip glucose levels increased in January and had to be sold quickly to salvage the crop. These preliminary results have decreased producer interest in growing MegaChip for storage, but evaluations continue on small acreages.

Bula Gerringer farms produced 5 acres of W2310, White Pearl, and Snowden and delivered them to the Potato Storage Research Facility in September 2008 for long term commercial storage trials. Potatoes were preconditioned for 4 weeks at 57 F to promote wound healing and allow potatoes to lower Sucrose and glucose levels. Bins were then cooled to 50 F by lowering the temperature 0.1 F every 12 hours. Potato chip quality remained excellent so potatoes were cooled to 48 F in January at the same rate. W2310 chip potatoes still have good chip quality and so temperature is being slowly lowered to 47 F. Sugar concentrations have remained low since preconditioning for Snowden and have had good to excellent chip quality W2310 (Figures 1 and 2). Sugar concentrations for White Pearl recently increased possibly due to cold conditions and inadequate oxygen levels in potato storage (Figure 3). Chips are being fried from potatoes in the bin every other week showing the off color of the White Pearl chips (Figure 1).

White Pearl were stored until the end of April and then sold. White Pearl appears sensitive to elevated carbon dioxide and went off color so did not process well from storage. White Pearl also expressed severe pressure bruise in part due to aggressive storage management for managing potatoes over 70 F at harvest. White Pearl has a number of agronomic and storage issues so has limitations for long term storage, but has still expressed the best cold induced sweetening tolerance among many lines. Snowden also lost quality in April as expected. This trial clearly demonstrates concerns related to long term storage of Snowden.

Figure 1. Color of Snowden White Pearl, and W2310 ptoato chips during January and February 2008.

Figure 2. Snowden sucrose and glucose concentrations in commercial scale reseach bins at the Storage Research Facility in Hancock, WI. Acceptable levels for sucrose and glucose are 0.70 and 0.035 mg/g fresh weight.

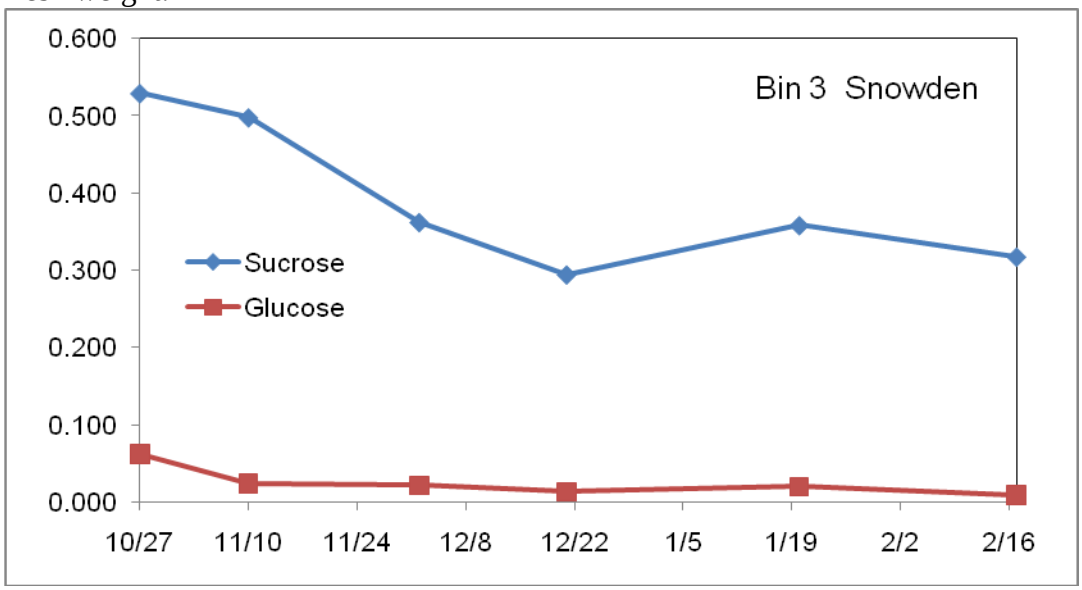


Figure 3. White Pearl sucrose and glucose concentrations in commercial scale reseach bins at the Storage Research Facility in Hancock, WI. Acceptable levels for sucrose and glucose are 0.70 and 0.035 mg/g fresh weight.

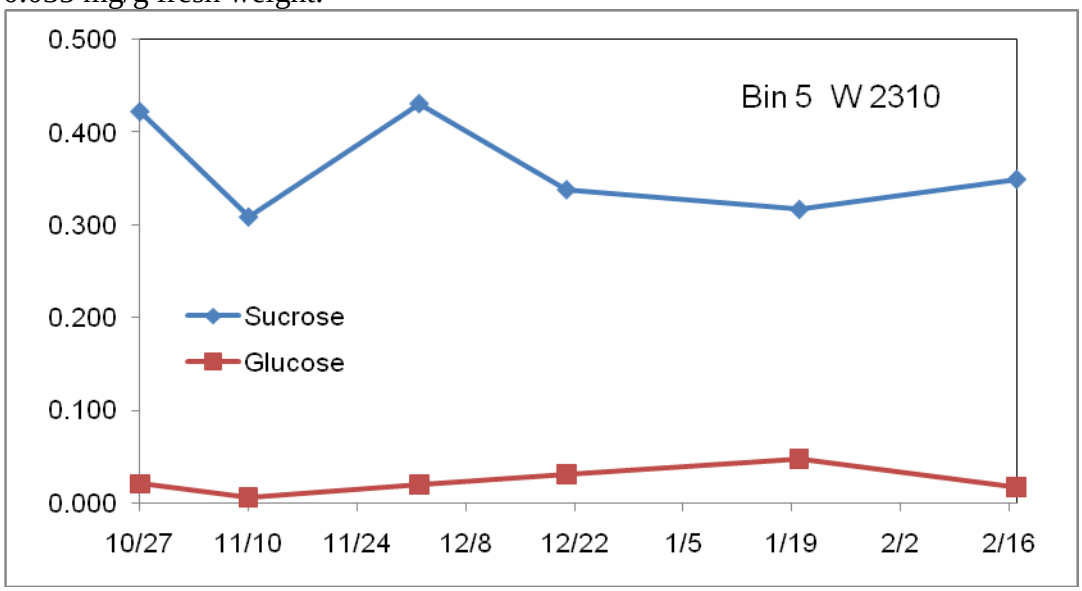
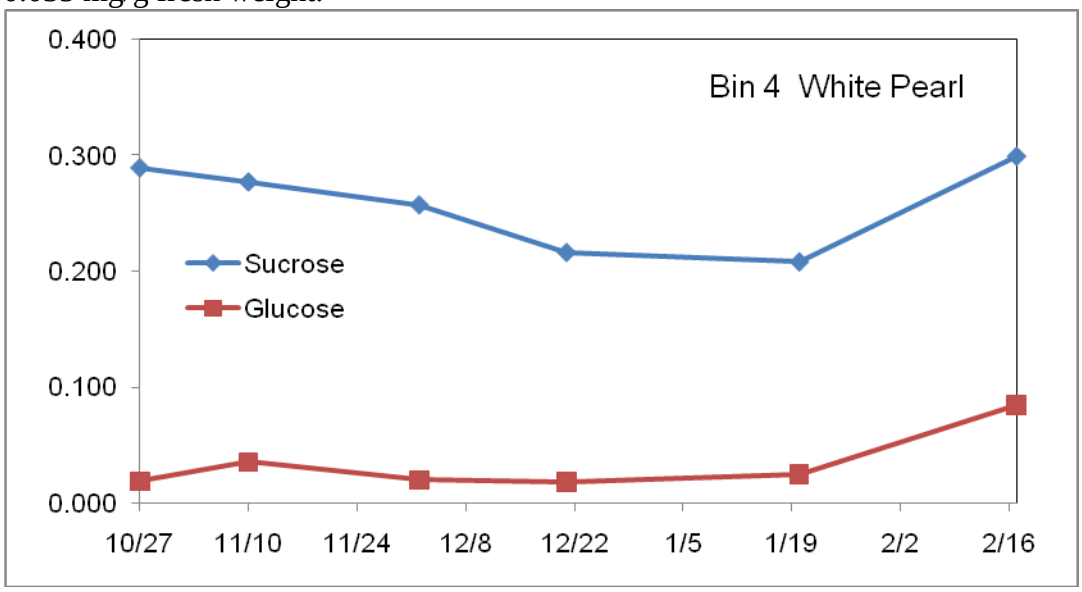


Figure 4. White Pearl sucrose and glucose concentrations in commercial scale reseach bins at the Storage Research Facility in Hancock, WI. Acceptable levels for sucrose and glucose are 0.70 and 0.035 mg/g fresh weight.



W2310 were stored at the Hancock Potato Storage Research Facility until June 6. W2310 had low sugars and good chip color throughout the storage season. The W2310 were processed by Kettle Foods in Beloit and met minimum quality standards for the crop. Kettle is aggressively searching for long term storage chipping potatoes in WI to meet peak demand in May, June, and early July. W2310 results were promising enough to increase interest and lead to further examination in spring/summer 2010. Locally grown chips stored through winter could increase competitiveness of Kettle in Beloit and allow for continued expansion of chip capacity.

Objective 3) Quantify factors influencing the storability of MegaChip and other varieties to demonstrate the value over an extended storage season.

In addition to evaluation fry color and sugars, potatoes are being monitored for numerous other storage characteristics such as sprouting, shrink, pressure bruise and susceptibility to storage disease. We learned in preliminary trials of 2007 that MegaChip is prone to breaking dormany early and if stored need to be treated for sprouting with the first few weeks of filling the storage bin. In this year's research, White Pearl also broke dormancy early and may need to be treated for sprouts within the first few weeks of storage as well. All varieties and breeding lines mentioned under accomplishments in objective 1 are also being evaluated for sprouting, pressure bruise, and shrink.

Taste evaluations were conducted when potatoes were removed from storage. Results are still being compiled, but differences have appeared between different chip lines. Identification of factors that contribute to improved flavor could allow for improved breeding and chips with lower salt or other flavor requirements. More expansive flavor tests will be completed with additional funding.

Outreach

In the past 12 months, I have presented several times at different potato industry meetings. I was invited to present at the National Potato Council Expo in San Antonio, Texas. I also presented on storage management and chipping potato potential at the Wisconsin Potato Grower Education Conference in Stevens Point, WI. An article was prepared for publication in the September 2009 issue of the Badger

Common Tater. Finally, results were presented at the potato storage research summit in mid August at the Hancock Ag Research Station.

Complimentary Research

Funds from the Agriculture Diversification and Development program were proposed as state match for USDA Specialty Crop Research Initiative Grant entitle 'Optimizing starch and sugars for end use quality in potato. The competitive USDA SCRI proposal was rated high and will be resubmitted with current budget of over $4 million. Other matching funds have been derived through the WPVGA worth over $20,000. Kettle Foods has expressed interest in funding research after the 2nd and final year of this project.