

**MANAGEMENT OF COLORADO POTATO FOR SUSTAINABLE  
TUBER YIELD, TUBER QUALITY, AND ECONOMIC  
IMPLICATIONS**

**SUMMARY OF RESEARCH PROGRESS REPORT FOR 2013**

**AND RESEARCH PROPOSAL FOR 2014**

**SUMMITTED TO:**

**COLORADO POTATO ADMINISTRATIVE COMMITTEE (CPAC) -  
AREA II**

***SUBMITTED BY***

**SAMUEL Y.C. ESSAH**

## SUMMARY OF 2013 RESEARCH STUDIES

Each potato cultivar has its own unique set of cultural management requirements to attain maximum tuber yield and quality. To attain sustainable yield and quality potential of any potato cultivar, optimum management guidelines for the cultivar need to be followed. The objective of the 2013 research studies was to establish cultivar specific management guidelines for the successful, sustainable, and economic production of new and existing potato cultivars, which optimize their genetic potential, while minimizing economic inputs and environmental degradation. In 2013, horticultural evaluations were conducted on 30 potato cultivars and advanced selections in 15 trials at 6 locations in the San Luis Valley of Colorado. Tests included 16 Russets, 7 yellow flesh specialty potatoes, 2 purple specialty potatoes, and 5 Reds. The trials assessed the influence of different cultural management practices on plant growth, development, tuber yield, tuber size distribution, and tuber quality of the cultivars studied, in an effort to establish optimum management guidelines for each cultivar. Studies conducted in 2013 included the response of potato cultivars to different nitrogen (N) application rates. Nitrogen rate treatments ranged from 0 (control) to 240 lb N/A. The effect of N rate treatments on mid-season petiole nitrate nitrogen concentration was evaluated. The response of early and medium maturity Russet potato to nitrogen application timing was investigated. The effect of extra late N application on the performance of Russet potato cultivars was also evaluated. Late N application treatments included 20 and 40 lb inorganic and organic N fertilizer per acre, and a control where no extra late N was applied. The response of Russet potato to in-row seed spacing was evaluated. The effect of soil amendments on potato root development, nutrient uptake, tuber yield and quality was evaluated. The response of russet potato to the form and rate of potassium (K) fertilizer application was studied in 2013. The influence of ten preceding green manure cover crops on red potato performance was evaluated. Twenty two advanced selections from the CSU potato breeding program were evaluated under grower management conditions in order to determine the yield stability as well as the optimum management practices suitable for each cultivar to attain its yield and quality potential. Observations from the 2013 field studies and some of the data collected were presented at the Southern Rocky Mountain Agricultural Conference in Monte Vista, CO; to potato growers in northern Colorado; and at various professional meetings in the United States. A field day was organized for potato growers at the San Luis Valley Research Center, Colorado, and for some potato consultants, to allow stakeholders to see how different potato cultivars perform under different management treatments. Some of the results were published in the Spud Item (a monthly publication by CPAC to potato growers), potato magazines such as the Spudman magazine, and the Potato Grower magazine. Some of the results were also published in peer reviewed journal.

Cultivar specific management guidelines were developed for some new cultivars.

## **Some Cultivar Specific Management Guidelines Updated at the end of the 2013 Research Studies**

### **Field Management of Crestone Russet (CO99053-3RU)**

Crestone Russet is a medium maturity Russet cultivar. Pre-cut seed to a size of 2.5 to 3.0 oz. and allow seed to suberize before planting. For maximum marketable tuber yield, plant seed at in-row spacing of 13 inches, and between row spacing of 34 inches. Available nitrogen (N) (residual soil N + irrigation water N + applied N) rate required for optimum tuber yield and quality should be between 160-170 lb. N/A. This recommendation does not include nitrate nitrogen mineralization from previous crop stubble and from soil organic matter. Increasing the available N rate above 170 lb. N/A can significantly reduce tuber specific gravity and increase the production of more tuber misshapes. Apply 30-35% of the required seasonal N rate pre-plant or at planting. Apply the remaining N rate requirement in split applications during the growing season. Begin in-season N application after tuber formation. Finishing N application early in the season is recommended. In the San Luis Valley, N application should be completed by the end of July or at least 30 days before vine kill. This will allow for tuber skin maturation (skin set). Late N application delays skin set. Petiole nitrate N concentration should range from 17,000 ppm at 50 days after planting (DAP) down to 5,000 ppm at 88 DAP.

Harvest tubers about 18-21 days after vine kill.

### **Field Management of Mercury Russet (CO99100-1RU)**

Mercury Russet is an early Russet variety. Pre-cut seed to a size of 2.5 to 3.0 oz. and allow seed to suberize before planting. To obtain maximum marketable size tubers, seed tubers should be planted at in-row spacing of 12 to 13 inches, with between row spacing of 34 inches. Available nitrogen (N) (residual soil N + irrigation water N + applied N) rate required for optimum tuber yield and quality should be between 140 to 150 lb N/A. This recommendation does not include nitrate nitrogen mineralization from previous crop stubble and from soil organic matter. To gain early plant vigor, and to obtain maximum tuber yield, apply about 60-65% of the required seasonal N pre-plant or at planting. Apply the remaining N rate requirement in split applications during the growing season. Begin in-season N application after tuber formation. Finishing N application early in the season is recommended. Optimum petiole nitrate N concentration should range from 22,000 ppm at 50 days after planting (DAP) down to 6,000 ppm at 70 DAP for maximum total tuber yield. To maximize marketable tuber yield, petiole nitrate N concentration should range from 16,000 ppm at 50 DAP down to 8,000 ppm at 70 DAP. Do not plan on vine kill. The vines of Mercury Russet will die naturally when tubers are mature.

A total of 15 inches of irrigation water throughout the growing season is sufficient, while maintaining soil moisture content above 65 to 70%.

Tubers can be harvested between 90 to 100 days after planting.

## **2014 RESEARCH PROPOSAL**

### **Project Title**

Development of cultivar specific management guidelines for new Colorado potato cultivars

### **Funding Source**

Colorado Potato Administrative Committee (CPAC), Area II

### **Investigator**

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Assistant Professor and Extension Specialist  
Colorado State University, Department of Horticulture and Landscape Architecture  
San Luis Valley Research Center

### **Nature and Scope of Proposed Research**

The development of cultivar specific management guidelines for new potato cultivars aims at tailoring cultural management guidelines to individual potato cultivars. Management guidelines consist of cultivar specific management information pertinent to production such as nutrient management, irrigation/water management, plant population management (in-row seed spacing), reducing the risk of pesticide use without compromising tuber yield and quality, and vine kill and harvest date management for improved tuber skin set.

The proposed research for 2014 will evaluate the response of new Colorado potato cultivars to several cultural management practices, including nutrient management, with emphasis on nitrogen (N) use efficiency, and plant population (in-row seed spacing) management.

The performance of several advanced potato selections grown under different management practices and in different soil types will be evaluated in grower fields.

### **Objectives of Proposed Research**

The general objectives of this proposal are to develop cultural management guidelines for the successful, sustainable, and economic production of new potato cultivars grown in the San Luis Valley, which optimize their genetic potential while minimizing environmental degradation. The management strategies should be agronomically sound, economically advantageous, and environmentally responsible.

The specific objectives of this research proposal are;

1. Define optimum nitrogen fertilizer application rates for the efficient use of nitrogen by Colorado potato cultivars, which will lead to maximum tuber yield, tuber size, and production of quality tubers.
2. Define optimum in-season petiole nitrate-nitrogen concentration levels for Colorado potato cultivars that will aid in efficient in-season nitrogen fertilizer management.
3. Evaluate the proper timing of nitrogen fertilizer application for efficient nitrogen use that will optimize tuber yield and quality of Colorado potatoes.
4. Define optimum in-row seed spacing for the production of maximum tuber yield, tuber size, and quality of potato cultivars grown in the San Luis Valley.
5. Evaluate the yield and quality response of several advanced potato selections from the Colorado Potato Breeding Program to different management practices under grower conditions.
6. Evaluate the economic implications of different management guidelines that maximize net returns of potato growers.

## **Materials and Methods**

### ***Objective 1 Define optimum nitrogen application rates for the efficient use of nitrogen by Colorado potato cultivars, which will maximize tuber yield, tuber size, and production of quality tubers.***

Nitrogen (N) fertilizer requirement for production of maximum tuber yield, tuber size, and quality tubers, differ among potato cultivars. In irrigated potato cropping systems, the crop preceding potatoes, soil residual nitrogen, and irrigation water nitrogen, all influence the amount of nitrogen needed to be applied to obtain maximum yield and quality tubers. There is the need to establish available N (applied, plus soil, plus irrigation water N) fertilizer required for the efficient use of N by new Colorado potato cultivars. The response of individual cultivars to N rate will be graphed, and regression lines will be developed for each cultivar to determine the optimum N rate that will yield maximum tubers of premium size and quality. Treatments will be replicated four times in a randomized complete block design.

***Objective 2 Define optimum in-season petiole nitrate-nitrogen concentration levels for Colorado potato cultivars that will aid in efficient in-season nitrogen fertilizer management.***

While the total nitrogen applied can significantly influence tuber yield, tuber size, and quality of potato tubers, in-season nitrogen fertilizer management can also influence the efficient use of applied N, and can influence tuber yield, tuber size distribution, and quality. Developing optimum petiole nitrate-nitrogen concentration levels for new Colorado potato cultivars can aid growers in the proper management of in-season nitrogen application.

In-season nitrogen application will begin one week after tuber formation, and will continue at 3 to 4 days intervals until the application of the required N rate is completed (normally between the second and third week of July). Petiole samples will be taken from all experimental plots at weekly intervals until one week after the final nitrogen fertilizer application is done. Petiole samples collected will be oven dried, ground, and analyzed for petiole nitrate-nitrogen concentration.

***Objective 3 Evaluate the proper timing of nitrogen fertilizer application for efficient nitrogen use that will optimize tuber yield and quality of new Colorado potatoes.***

While the total nitrogen applied can influence tuber yield, size, and quality of potato tubers, the appropriate timing of the nitrogen applied can significantly influence how efficient the applied nitrogen is used to maximize tuber yield, tuber size, and quality. A study will be conducted to evaluate the effect of early, mid, and late application of N on the performance of new potato cultivars grown in the San Luis Valley. Treatments will include (i) the application of 2/3 of the required nitrogen pre-plant, and the remaining 1/3 applied during the growing season (ii) application of half (1/2) of the required nitrogen pre-plant and the remaining half applied during the growing season (iii) application of 1/3 of the required nitrogen pre-plant, and the remaining 2/3 of the required nitrogen applied during the growing season. A control treatment will be included where no nitrogen will be applied pre-plant, but all the required nitrogen will be applied during the growing season. The effect of the nitrogen application timing treatments on nitrogen use efficiency, tuber yield, tuber size distribution, and quality of new potato cultivars will be evaluated.

***Objective 4 Define optimum in-row seed spacing that will maximize tuber yield, tuber size, and quality of potato cultivars grown in the San Luis Valley***

In-row seed spacing is one of the production factors under grower control, which can be used to manipulate tuber size and yield. Different markets require different tuber size. It is therefore important that we evaluate the optimum in-row seed spacing needed for maximum tuber yield and production of premium size tubers for different markets. Studies will be conducted to evaluate the response of tuber yield, tuber size, and quality of new potato cultivars to in-row seed spacing.

**Objective 5 Evaluate the yield and quality performance of several advanced potato selections from the Colorado Potato Breeding Program when grown under different management practices in grower fields.**

The objective of this study is to evaluate tuber yield, tuber yield stability, and quality performance of advanced selections from the Colorado Potato Breeding Program when grown under different management practices and in different soil types. Several advanced selections of Russets, Reds, yellow flesh potatoes, specialty type potatoes, and fingerlings, will be planted in strips on grower farms. The farms that will be selected will differ in crop management practices and in soil type. Clones entered in this study will be evaluated for maturity date. At harvest, each clone will be evaluated for yield, tuber size and tuber quality. This study will help in the identification of early maturing cultivars and how they respond to different management practices.

**Objective 6 Evaluate the economic implications of different management guidelines that maximize the net returns of potato growers.**

Economic analysis will be performed for the different management guidelines evaluated for Colorado potato cultivars, using the principle of net returns. The optimum economically advantageous management guideline will be recommended to potato growers.

**Data Collection**

*Soil and Water Samples*

Soil samples from experimental plots and water samples from the irrigation well will be taken in the spring and analyzed for their nutrient content. This will indicate the amount of residual nitrogen and other nutrients in the soil before planting, and how much nitrate nitrogen is supplied to the crop from the irrigation water at each time of irrigation. Soil samples will also be taken at the end of the crop harvest and analyzed for the nutrients that were not used by the crop. This will help evaluate for nutrient use efficiency.

*In-Season Plant Sampling and Measurements*

The effect of treatments on sprout emergence, crop stand, green leaf production, and canopy development will be evaluated. During tuber bulking, plants will be sampled to evaluate treatment effects on stem number, tuber set, mean tuber weight, and tuber bulking rate.

Petiole samples will be taken at four different dates during the growing season for petiole nutrient analysis. This will help establish in-season petiole nitrate, phosphorous, and potassium curves for individual cultivars.

## *Tuber Yield and Quality Evaluation*

Potato tubers will be harvested and evaluated at the end of the growing season for yield and tuber size distribution. Tubers from each plot will be weighed and graded for external (misshapes, knobs, growth cracks) and internal (hollow heart and brown center) defects. The harvested tubers will be separated into various size distribution groups based on weight (<4 oz, 4-6 oz, 6-8 oz, 8-10 oz, 10-12 oz, 12-16 oz, and >16 oz), and diameter [<2 inches (in.), 2-4 in., >4 in., >2 in. but <10 oz, >2 in. and >10 oz], to evaluate treatment effects on tuber size profile for each cultivar. Ten large (10-16 Oz) tubers from each plot will be taken for hollow heart and brown center evaluation. Specific gravity will be measured using the weight-in-air/weight-in-water method.

### **Statistical Analysis**

All data will be subjected to analysis of variance to test for main effects and interactions among cultivars and treatments where appropriate. When significant interaction effects are detected, the proc mixed procedure in SAS will be used to analyze the data to estimate differences between treatment means. Some treatment means will be separated using the *a priori* single degree of freedom contrast.

### **How this Project Will Enhance the Competitiveness of Colorado Potato Growers**

Each potato cultivar has its own unique set of cultural management requirements for the production of maximum tuber yield, tuber size, and high quality tubers. More often than not, growers of a new cultivar are not able to obtain the yield and quality potential of the cultivar because they do not have information on the specific management requirements for the cultivar. Growers of a new cultivar are more successful when release is accompanied by appropriate management guidelines. The best cultural management guidelines are obtained from field experiments conducted in replicated trials in specific production regions. Also, in the cultivar evaluation and development process, shortcomings of advanced selections and new cultivars may be identified and appropriate cultural management strategies are explored to solve such cultivar specific problems. Cultivar specific management guidelines developed from this research project will result in the successful and sustainable production of new Colorado potato cultivars grown in the San Luis Valley.

### **Extension-Outreach Plan for Reporting Project Information to Growers**

Data from this project will be presented at the Southern Rocky Mountain Agricultural conference in Monte Vista.

Extension fact sheets will be developed for each potato cultivar entered in this project to highlight management guidelines for each cultivar.

Results from this project will be posted on the CSU website, the CSU potato program website, as well as on the San Luis Valley Research Center website.

Management guidelines for specific cultivars will be documented in the spud items for quick release to potato growers.



Summary of data from the project will be printed and hard copies distributed to potato growers in the San Luis Valley.

### **Potential for Results to Leverage Additional Outside Funding**

This project will provide preliminary data for the submission of proposals to agencies such as USDA - NIFA as part of the potato development and improvement project, and to USDA-NRCS, and Western SARE for nutrient use efficiency research proposals. Funding from the Environmental Protection Agency (EPA) could help in research involving reduction in fertilizer use, and sustainable potato production. Other sources of funding could be from fertilizer companies, and compost dealers for nutrient management studies.

### **Timeline of Proposed Research and Expected Short Term (1 yr.) and long Term (3-5 yrs.) Outcomes**

Potato seed will be cut and cured in April. All potato seed will be planted between May 1 and May 20, 2013. In-season nitrogen application will be completed in July. Petiole samples will be collected in July. Sampling for tuber bulking will be done in August. Potato vines will be killed in August, and tubers harvested in late September. Tuber sizing and grading will be done in October and November. Statistical analysis and report writing will be done in December and January. Results will be posted on the website in February, and printed data distributed to growers at the same time. Some results of the research data will be presented at the Southern Rocky Mountain Agricultural Conference in February. At the end of the 2014 growing season, cultural management guidelines will be updated for some of the currently cultivated russet and specialty potato cultivars. Preliminary information on management guidelines for some new and advanced russet potatoes will be documented at the end of the 2014 growing season. Cultural management guidelines will be completed for some cultivars at the end of the 2014 growing season. Potato cultivars that will be released between 2014 and 2019 will be accompanied by management guidelines for the successful production of those cultivars.

## ANNUAL BUDGET

### Personnel

Three non-student help will be needed to get the field and laboratory studies completed successfully.

Three persons working for 32 weeks (3840 hours) @ \$8.5/hr = \$32,640.00

Fringe Benefits for personnel = \$ 2,360.00

**Total Wages and Fringe Benefits for Personnel** \$35,000.00

### Materials and Supplies

Potato sacks, gloves, masks, sample paper bags,  
field stakes, flags, and scissors \$2,000.00

Fertilizer purchase \$2,000.00

**Total Materials and Supplies** \$4,000.00

### Services

Soil and water analysis \$ 400.00

Petiole sample analysis: 100 Samples per sample date x 4  
sample dates x \$19.00/sample \$7,600.00

**Total Services** \$8,000.00

**Travel** \$2,000.00

**Total amount of this request** \$49,000.00

## **Budget justification**

### **Salaries and Wages for Personnel:**

Because of the extensive field and lab work involved in the studies proposed, including soil sampling, seed cutting, potato planting, in-season data collection (whole plant sampling, petiole sampling), extensive fertilizer application before and during the growing season, potato harvest, sizing and grading, data compilation and analysis, considerable financial resources are committed to personnel. Thirty five thousand dollars (\$35,000.00) is requested for wages and fringe benefits in this budget.

### **Materials and Supplies:**

Field supplies include items such as field stakes, flags, sample paper bags, gloves, masks, scissors, and potato sacks for harvesting. Fertilizer will be purchased. Four thousand dollars (\$4,000.00) is requested for materials and supplies in this budget.

### **Services:**

Soil samples will be taken from each experimental plot before planting and from each nutrient management plot after harvest. Petiole samples will be taken at four different dates during the crop growing season. Water samples will also be taken from the irrigation well. All samples collected will be sent to a soil, water, and plant nutrient analytical lab for analysis. Eight thousand dollars (\$8,000.00) is being requested for shipment and payment of sample analysis.

### **Travel**

Two thousand dollars (\$2,000.00) is being requested for part payment of travel expenses to potato evaluation and development meetings, as well as potato cultivar management meetings.