

An Application of Systems Engineering

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Systems engineering was used to develop a protocol for producing gourmet small red potatoes. Several characteristics led to rapid development and delivery of this technology:

- The end user was a vital member of the research team from start to finish.
- A specification for the end product was developed.
- A narrow niche market was targeted.
- The production system was configured in the laboratory prior to field testing.

The goal was to reduce tuber size distribution by increasing potato seed population. Other costly inputs were reduced or eliminated. N fertilizer use was reduced from the conventional 160 lbs./acre at planting to 40 lbs. N at planting and 4 lbs. maintenance foliar N/week. Because the potatoes were vine-killed after 64 days, exposure to late blight and associated costs and risks were virtually eliminated. The enterprise budget for producing small red potatoes was about \$750/acre, yielded 180 cwt./acre, and was valued at \$40/cwt. The enterprise budget for conventional round white potatoes was \$1,800/acre, yielded about 250 cwt./acre, and was valued at \$8.75/cwt. Growers were contracted to produce small red potatoes in the third year of the project.

The Maine potato industry targets three markets for its crop: processing, round whites, and seed potatoes. Processing potatoes are often contracted for potato chips or french fries, round white potatoes are sold in bags for supermarkets, and seed potatoes are sold to growers throughout the East Coast. In the past 30 years potato acreage dropped from about 158,000 to 66,000 acres, reducing Maine's impact on the commodity market.

Many factors drove this decline, but demand for Russet Burbank as fresh stock and for processing shifted major production to the West, where growing seasons are longer and water is controlled. Maine has a growing season of roughly 120 days and continues to produce high-quality potatoes for each of its three markets. Although some Maine growers successfully grow Russet Burbank, the growing season is too short, and the comparative advantage of the West is too great to compete successfully.

For many of the potato producers, the decline in Maine market share is troubling. Production practices attempt to approach the yield potential by utilizing the maximum growing season. However, efforts to increase tuber yield of long season indeterminate potatoes can be associated with reduced tuber quality.

To maximize the growing season, tillage operations occur in the spring as soon as the soil is dry enough to plow and harrow, and potato seed (usually cut seed) is planted at the earliest possible time. Stand losses are sometimes incurred due to activities of soil-borne pathogens and weak vines due to cold wet soils. Strategies to increase yield frequently rely on increased fertility and produce large canopies that persist to time of vine killing.

In addition to regional competition, production costs are driven up by pests and disease incidence. Disease is an ever-present problem and is controlled primarily by agrochemicals and/or crop rotation. The number of crops that are rotated with potatoes in Maine is limited by the availability of "good" potato land, lack of economically significant rotation crops, and poor understanding of rotation crop benefits.

During an informal meeting, a frozen-food processor expressed interest in and identified a market for a frozen product utilizing small red potatoes. One of the problems with small red potatoes is supply. Small potatoes are generally graded as "creamers," the smallest size class from a harvest. The processor approached ARS to develop a management system to produce a red potato to their specification: 1 1/2 - 2 1/4 in. diameter, deep red color, delivered by the second week of August.

To stay within the research criteria of our location, the system needed to: 1) reduce N and pesticide use; and 2) increase opportunities for increasing crop rotation. A system was developed in the laboratory (prior to field experimentation) based upon knowledge (not information) about potato morphology, population dynamics, varietal characteristics, and fertilizer-use efficiency. This system was configured using systems engineering techniques. Some aspects of the project that were important are:

- A specific product and potential markets were specified with industry personnel.
- Small potatoes are a niche product. Their mar

ket, however narrow, could be "global."

- Various alternatives for production could be identified.
- Alternatives provided a means for reaching research goals.

Preliminary data showed that growing small determinate potatoes took about 64 days from planting to vine kill. Whole seed was sown at a 10 cm. spacing during the 3rd week in May (about 2 weeks after conventional practice) to take advantage of warmer soils. The seed was planted with 40 lbs. N/acre. Canopies were maintained with 4 lbs. foliar N/ week beginning with vine emergence and coinciding with prophylactic fungicide application. Tuber size was monitored on a weekly basis, and daily as they approached target size. When tuber size reached the target, plants were vine-killed, and tubers were dug two weeks later, washed, and graded.

Mean tuber yield was 180 cwt./acre; 42% of the tubers were between 1 1/2 and 1 7/8 in.; 25% were between 1 7/8 and 2 in.; and 25% were between 2 and 2 1/4 in. in diameter. Since the tubers were dug in early August, sufficient growing season remained to produce a cover crop. In comparison to conventional round white tuber production, fertilizer and pesticide use were reduced by more than 60%. The enterprise budget was about \$750 for small red potatoes and \$1,800/acre for round whites. Wholesale values for small red potatoes were \$40 and \$8.75/cwt for round whites, and net returns for small red potatoes acre were \$6,450/acre and \$388 for round whites.

In the third year of the project the food processor contracted local potato producers to grow small red potatoes using our management protocol. The growers accepted the contract with the willingness to follow production guidelines. Despite variation in field scale tuber yield, results were consistent with our experience. Potatoes were delivered to the processor in early August and the potatoes found their way into frozen gourmet diet meals soon after.

Niche products offer small farmers opportunity. The commodity market often overlooks marginal products. Profit margins can be very attractive, and radical changes in production practices are easier to implement because attention is focused on producing a specific product. Narrow market-based products often require development of management practices to meet product specifications.

This project used systems engineering as a tool for developing a management system to meet product goals. One of the factors essential for success was that the

processor (end user) was part of the development team. System development did not require expending resources on a lot of new empirical studies, but instead required synthesizing knowledge already available in the literature. This case study demonstrates an alternative model for agricultural research that can positively impact small farm livelihood and development of new small farm enterprises.