# THE WALLENDAL PROJECT
# PART 1
# ROTATION RESEARCH

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**Background:**

Production of potatoes, *Solanum tuberosum* L., in Wisconsin and throughout the North Central region typically includes the intensive use of pesticides, fertilizer and irrigation water. The extensive reliance on pesticides and other external inputs as well as environmental concerns associated with potato production were the driving forces behind the development of a comprehensive integrated crop and pest management program for Wisconsin growers. Computer software, Potato Crop Management (PCM), was developed with support from the North Central Region IPM program and released to growers in 1989. The program was based on extensive and long term component and integrated research related to many aspects of pest management and crop production. PCM integrates several important aspects of crop and pest management into a systems approach that encompasses both preventative strategies designed to avoid or reduce problems and therapeutic strategies designed to manage problems once they develop in the crop. Since the release of PCM, growers and IPM consultants in Wisconsin and neighboring states have reported extensive use of the program on approximately 60,000 acres with estimated savings exceeding $1,000,000 per year with significant reductions in pesticide application.

PCM is a comprehensive program, but by design, is targeted at only a portion of the total farming enterprise, the potato crop. A need exists to incorporate IPM information for the crops commonly used in rotation with potatoes so that growers have a guide for the entire farming system. Potato production in Wisconsin usually includes a two to three year rotational sequence involving marketable commodities (snap beans, sweet corn, field corn, peas) and non-harvested cover crops (alfalfa, red clover, sorghum sudan, rye) which can enhance the long term productivity of the land. Both types of rotational crops have advantages to the overall farming enterprise. Cover crops may serve to hold the soil and nutrients in place, act as trap crops for insect pests or reservoirs for natural enemies, and have allelopathic effects on weeds and diseases. Many cover crops do not provide short term economic returns to growers, but may promote long term benefits to the overall enterprise which may be of equal or greater value. In contrast, marketable rotational crops provide short term income to the grower and may also provide some additional long term benefits. Some rotational crops, however, may contribute to the survival and increase of important pest problems.

The current research was initiated to investigate the short and long term benefits and risks of six specific rotational sequences involving marketed and non-marketed crops grown in rotation with potatoes. Factors are being identified that contribute to or interfere with the preventative management of pests in the potato crop. Information developed from this research will be integrated with existing preventative and therapeutic strategies currently utilized in the PCM software.

**Research Progress:**

The project was designed as a long term (six year) experiment to investigate six specific two and three year rotations involving potatoes. Plots were established near Grand Marsh, WI in 1991 on a 25 A grower field with irrigation. The land was donated by the Wallendal Supply, Inc. who also supply equipment, seed and guidance in conducting the experiment. Each crop included in each of the six rotations is planted each year to insure that weather variation from year to year does not bias one rotation over another. (Table 1 and Figure 1). This arrangement means that instead of six plots per replication, a total of fifteen plots per replication are planted. The location of each plot is permanently marked to ensure the integrity of each rotation plot over time. Crops planted each year include potato, snap bean, sorghum-sudan, sweet corn and red clover.

The cultural methods employed in this field experiment are identical to the production practices used by Wallendal Supply in their farming operation and those methods used on the potato crop are identical to those recommended by the PCM program. Comprehensive records were maintained for each crop and crop rotation. This trial used the potato cultivar 'Russet Burbank', a cultivar grown on approximately 60% of the acreage in Wisconsin. Tubers from this experiment are stored and processed by Ore-Ida Foods, Inc. The snap bean and sweet corn cultivars used in the experiment were supplied by DelMonte, Inc. and the produce from this trial was harvested and processed by their local processing plants.

Research was conducted in 1991 and 1992 to establish baseline data on the effect of each rotation on factors related to crop productivity and pest populations. In 1993, the first cycle of the two rotations (1,2,3) (see Table 1) was completed and the first cycle of the three year rotations (4,5,6) will be completed in 1994. The progress of this project as related to the specific objectives is as follows:

**1. Identify factors associated with six rotational sequences which contribute to the long term preventative management of pests, crop health and productivity of potato.**

**a) Evaluation of biology and ecology of insect pest complexes in each rotation.**

Populations of insects were monitored each week on each crop rotation. The PCM program (growing degree day module) was used to predict the developmental stages and optimal timing for control of the Colorado potato beetle on potato and key insect pests on rotational crops. Beneficial insects were identified and quantified in each rotation through the use of sweep nets in the foliage and Berlese funnel apparatus for soil borne insects.

**b) Evaluation of weed populations in each rotation and the change in weed seed bank in the soil.**

Weed populations were evaluated in each rotation in each year. Data on identity and weed numbers were recorded. Herbicides were applied to each cropping rotation at the minimum effective rate in agreement with best management weed control practices established through past and ongoing component research. In addition, various types of cultivation, correlated with crop growth and weed emergence, were utilized for weed control to further reduce the reliance on herbicides. Soil samples collected each year and are being analyzed for changes in weed seed populations for each rotation.

**c) Evaluation of pathogens as affected by each rotation.**

Daily data on air temperatures, relative humidity, irrigation and rainfall were collected and used to predict the appearance of potato early and late blights (PCM program - disease module). The initiation and subsequent timing of fungicide sprays were scheduled using the PCM program. Data on incidence and severity of potato early blight was recorded at weekly intervals during each growing season. In addition, data on bacterial stem decay, white mold and early dying symptoms were also recorded on the potato crop at timely intervals. The snap bean cultivar used in the trial has field tolerance to bacterial brown spot and root rot, but is susceptible to white mold. Incidence and severity of white mold were recorded at harvest. At the conclusion of each growing season, soil samples were collected for assay of plant parasitic nematodes, *Verticillium dahliae*, and root rot potential (snap beans). In this way, we are able to assess the impact of each rotation over time on a range of economically important plant pathogens. In addition we are comparing sap squeezing and soil assay techniques to monitor the effect of rotation on *Verticillium dahliae* on potato.

**d) Monitor the inorganic soil nitrogen and crop removal of N for each rotational sequence.**

Fertilizer applications were made according to the University of Wisconsin Soil Test Recommendations to insure adequate nutrition for each crop in the rotation. Appropriate nitrogen credits were given for leguminous crops used in the rotation. During the growing season, potato petioles were sampled to determine the nitrogen status of the crop and the need for supplemental N. Component research included in this field trial focused on refining the petiole nitrate test for use on Russet Burbank potatoes. At the conclusion of each season, soil samples were taken to determine the soil nitrogen. Samples of the harvested crops were collected to determine the crop removal of N.

**e) Measure the relative "soil health" for each rotational sequence.**

Soil samples were collected twice during the growing season for analysis of soil health. Samples are being analyzed for microbial activity (based on release of $CO_2$ to determine a relative soil health rating for each crop in each rotation. While the 1993 cropping season is the first year for this evaluation, the multiple starting dates of each rotation will facilitate the comprehensive evaluation of soil health over time and a comparison of these data with yearly performance data.

**f) Compare the long and short term benefits of each rotational sequence.**

All of the above mentioned data are being compiled each year and analyzed to determine the benefits of each rotation. These data will be used to compile information for growers on possible impacts of each type of rotational crop on the farming enterprise. The information will include cultural and rotational options that growers may use instead of chemical control for various pest problems.

**g) Analyze the long term economic benefits of each rotational program.**

Complete records are being maintained on all fixed and variable costs, total gross returns and total net returns for each rotation. Since potatoes, snap beans and sweet corn are being marketed directly to Ore-Ida Foods, Inc. and DelMonte, Inc., crop values reflect prices being paid to local growers. Cost of pesticides and fertilizer reflect true market values. As the two and three year rotations are completed, a complete economic analysis is being conducted that will reflect economic benefits and risks associated with each rotation.

**2. Develop a computerized management program for rotational sequences involving potatoes.**

Expansion of the PCM software is underway and will include modules for the management of both snap beans and sweet corn. Management modules for snap beans include irrigation scheduling, a degree day calculator for predicting insect development and crop maturity and assessment of the potential for development of white mold. Modules for sweet corn include irrigation scheduling and insect management. All of these modules will be included in an enterprise management program that addresses the improved management of potato and the crops likely to be grown in rotation with potato in Wisconsin.

One of the valuable assets of the current project is the daily interaction with producers in growing the various crops included in this rotational trial. Their comments based on many years of practical experience blended with information we have gleaned from several years of component and integrative research are helping to build a comprehensive program for improved crop management. Growers are actively using the PCM program for managing the potato crop with reduced chemical and irrigation inputs and are eager to use improved and expanded versions of this crop management software.

Currently, the PCM program is being converted from a DOS platform to a Paradox for Windows® platform. This new graphical format will allow easier data entry and exchange, presentation of all data summaries as graphs, comparison of environmental and crop/pest data between fields in a graphical format, the ability to compare multiple years of crops in the same field, development of a pictorial database comprised of scanned slides of common pest problems and entry of a textual database of crop and pest management information. The Windows® format also permits easier expansion of the program as additional cropping and management modules are developed. As of December, 1993, the new version of PCM is about 80% complete and work has started on preparing the modules for snap beans and sweet corn. Demonstrations of the new program format have already been presented to the Wisconsin Potato and Vegetable Growers Association. Additional presentations are planned for winter educational meetings for crop producers in Wisconsin plus a featured plenary session at the National IPM Workshop in April, 1994. The comprehensive program running under Windows® will be ready for *beta* - testing by selected growers and researchers during the 1994 growing season.

**3. Potential Benefits Related To This Research.**

Previous surveys of grower users of the Potato Crop Management software indicated that they were adopting this new technology for use on their farms. Benefits included substantial reductions in pesticide use, but perhaps more importantly, software users appeared to have a better understanding of overall pest management activities that could be implemented in a timely manner on their farms. Thus the current PCM software has become an effective delivery tool of pest management information to growers and implementors of IPM technology. The approach we are using in this project draws upon years of disciplinary research and combines this vast database with integrative research that develops solutions to long-standing farm problems. As we revise, convert and expand our software technology, we anticipate this new software to have a positive effect on the adoption of new IPM methodology. A concurrent USDA-Extension Service project is attempting to determine why growers adopt IPM on their farms and what barriers exist to greater adoption. A survey will be conducted this winter concerning who uses IPM, how the use of the PCM program has affected pesticide use in potato production and the benefits achieved from IPM and PCM adoption. From this survey, we hope to gain a better understanding of benefits derived from use of the PCM software as well as grower needs that could be addressed through further software development.

**Table 1. Summary of current and projected two and three year rotations implemented at the Wallendal Farm.**

| Rotation | First two years of project | | Rotations for 1993-1996 | | | |
|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
| 1 A | Potatoes | Snap Beans | Potatoes | Snap Beans | Potatoes | Snap Beans |
| 1 B | Snap Beans | Potatoes | Snap Beans | Potatoes | Snap Beans | Potatoes |
| 2 A | Potatoes | Sorghum Sudan | Potatoes | Sorghum Sudan | Potatoes | Sorghum Sudan |
| 2 B | Sorghum Sudan | Potatoes | Sorghum Sudan | Potatoes | Sorghum Sudan | Potatoes |
| 3 A | Potatoes | Sweet Corn | Potatoes | Sweet Corn | Potatoes | Sweet Corn |
| 3 B | Sweet Corn | Potatoes | Sweet Corn | Potatoes | Sweet Corn | Potatoes |
| 4 A | Potatoes | Snap Beans | Sorghum Sudan | Potatoes | Snap Beans | Sorghum Sudan |
| 4 B | Snap Beans | Sorghum Sudan | Potatoes | Snap Beans | Sorghum Sudan | Potatoes |
| 4 C | Sorghum Sudan | Potatoes | Snap Beans | Sorghum Sudan | Potatoes | Snap Beans |
| 5 A | Potatoes | Snap Beans | Sweet Corn | Potatoes | Snap Beans | Sweet Corn |
| 5 B | Snap Beans | Sweet Corn | Potatoes | Snap Beans | Sweet Corn | Potatoes |
| 5 C | Sweet Corn | Potatoes | Snap Beans | Sweet Corn | Potatoes | Snap Beans |
| 6 A | Potatoes | Snap Beans | Red Clover | Potatoes | Snap Beans | Red Clover |
| 6 B | Snap Beans | Red Clover | Potatoes | Snap Beans | Red Clover | Potatoes |
| 6 C | Red Clover | Potatoes | Snap Beans | Red Clover | Potatoes | Snap Beans |

| Rotation 1 | Rotation 2 | Rotation 3 | Rotation 4 | Rotation 5 | Rotation 6 |
|---|---|---|---|---|---|
| Potatoes | Potatoes | Potatoes | Potatoes | Potatoes | Potatoes |
| Snap Beans | Sorghum-Sudan | Sweet Corn | Snap Beans | Snap Beans | Snap Beans |
| Potatoes | Potatoes | Potatoes | Sorghum-Sudan | Sweet Corn | Red Clover |
| | | | Potatoes | Potatoes | Potatoes |

**Fig. 1. Schematic diagram of Wallendal field and rotational sequence used during 1991-1993**