CROP ROTATION: THE FUTURE OF POTATO INDUSTRY IN ATLANTIC CANADA

The ability of Atlantic Canada's potato industry to remain competitive on international markets is intimately linked to its resource management strategy. Product quality and lower costs of production are key elements in allowing the Canadian industry to maintain its market share and gain new market opportunities. Resource management, and especially soil and crop management, is a most important factor in product quality and lower costs of production.

Potato production systems must achieve both economical and environmental sustainability. From an environmental perspective, soil quality, as well as surface and ground water protection, are the main challenges of the potato industry. Crop rotation is an effective management strategy to meet these challenges.

The ***Crop Rotation Systems for Potato Production in Atlantic Canada*** study, prepared by the Eastern Canada Soil and Water Conservation Centre, evaluates the economical and environmental performance of different crop rotation systems in this region's potato industry. It is based on the most recent data available world wide.

Potato production systems in Atlantic Canada:

Limited areas, where soil and climatic conditions are suitable, are available for potato production in Atlantic Canada. The potato production systems vary considerably throughout this region.

Noticeable differences exist between the two main potato production provinces as well as within farm size groups in each province. The dominant rotation system in Prince Edward Island is the "one year in two" potato rotation. In New Brunswick, the production system is characterized by forms of continuous potatoes (two or more consecutive years of potatoes). The larger operations in New Brunswick allocate approximately one third of their land to rotation crops, compared to one half in Prince Edward Island.

The size of potato farms also varies between provinces. Prince Edward Island has the largest potato farms, with 613 producers cultivating an average of 140 hectares of which 52 hectares are allocated to potato production. New Brunswick's 442 potato farms have an average 85 hectares of cultivated land of which 48 hectares are in potatoes. Nova Scotia's potato industry is characterized by the presence of a large number of small, diversified mixed vegetable and livestock producers. Only nine of the 137 potato producers cultivate more than 53 hectares of potatoes. Newfoundland follows the same pattern; 172 of its 177 potato producers allocate less than 7 hectares to this production.

Rotations Improve Soil and Crop Productivity

Production systems where potatoes are grown no more than 1 year in 2 (50%) and cereals and/or forages are included in rotation, can improve soil and crop productivity. More frequent potato cropping, 2 years in 3 (66%) and especially continuous potatoes (100%), degrades the soil and lowers both total and marketable potato yields.

Crop rotation systems which include cereals and forages will maintain higher levels of soil organic matter than continuous potatoes. In soils with low organic matter levels, inclusion of these rotation crops may increase the organic matter content resulting in greater soil structural stability. Stable soil structure reduces soil erosion by wind and water and increases the ability of the soil to resist compaction. Soil erosion removes organic matter which in turn reduces the stability or strength of the soil's structure.

The organic matter content of soil under frequent (more than 1 year in 2) potato production decreases with time to levels which may not sustain profitable yields. Figure A illustrates that the amount of organic matter lost through decomposition is greater

than the amount of organic matter returned to the soil by the crop. This does not include further depletion of the soil organic matter which would result from rotations that increase soil erosion.

Potatoes produce little plant residue and subsequently contribute very small quantities of organic matter to the soil. In addition, this residue provides relatively little humus (the stable portion of the organic matter). Consequently, potatoes grown frequently deplete the soil of organic matter at a greater rate than most other crops resulting in a lower level of stable organic matter over the long-term (20 years or more). In order to maintain or increase the organic matter content in the soil, it is necessary to rotate potatoes with crops which produce greater amounts of plant residues that result in stable organic matter.

Frequent potato production will result in low long-term levels of stable organic matter, probably less than 2% where erosion is occurring. Potato rotation systems including cereals and forages (potato-barley-clover) will maintain acceptable levels of stable organic matter on soils where erosion is controlled and tillage intensity is reduced.

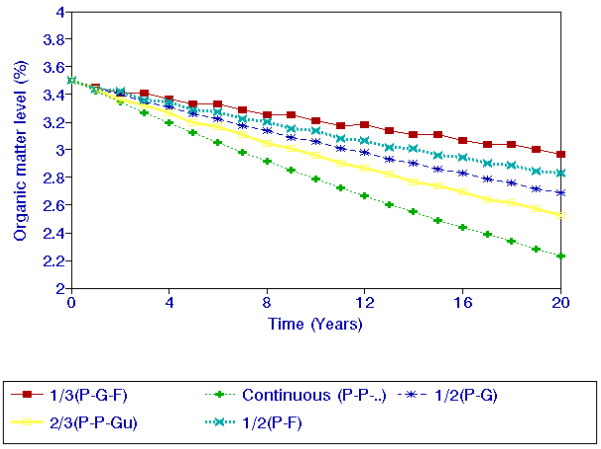

Figure A. Depletion of stable organic matter under five different crop rotation systems.

Compaction caused by the wheel traffic of heavy field equipment reduces the productivity of a soil. It inhibits root penetration and negatively affects soil aeration, soil moisture and temperature regimes, all of which reduce potato yield. Rotation systems which improve soil structure through increased organic matter content, improve the resistance of the soil to compaction. In addition to maintaining higher levels of organic matter, cereal and forage crops require fewer field operations, resulting in less compaction. Field operations cause greater compaction when conducted under high moisture conditions.

A well structured soil will permit more water to enter the soil and drain through it, thereby reducing surface runoff. This reduces soil erosion within the field and the transport of sediments, which can carry pollutants, from the field to streams, rivers and lakes.

Yields of potato crops may be more stable when grown in rotation with cereals and forages. Increased organic matter content and improved soil structure through rotation will enhance the soil's ability to withstand climatic variations (drought and water-logging) and reduce yield fluctuations.

Crop rotations which maintain acceptable levels of soil organic matter generally have improved water and nutrient holding capacity and availability. In addition, rotations with legumes such as clover and alfalfa can reduce the nitrogen-fertilizer requirements and increase yield potentials of potato crops.

Crop rotation can also be an effective method of controlling insects, disease, and fungi in potato production systems. Although it may not be possible to eliminate these pests through rotations with cereals, grasses, clover or alfalfa, rotating these crops with potatoes can reduce the pest damage caused to potatoes thereby decreasing the need for costly alternative control measures.

Ultimately, good crop rotation can improve both total and marketable potato yields. Studies from around the world have consistently demonstrated yield benefits from reduced potato cropping frequency (Figure B).

Rotation trials in Prince Edward Island have shown that reducing potato cropping frequency from continuous potatoes to 1 year in 3 increases total potato yield by 29% and marketable yield by 41%.

Potato yields are very sensitive to the selection and sequence of rotation crops. Potatoes following a crop of red clover have a potential marketable yield 1.33 times greater than following potatoes. The potato yield benefits from red clover have been found to be greater than other rotation crops such as barley.

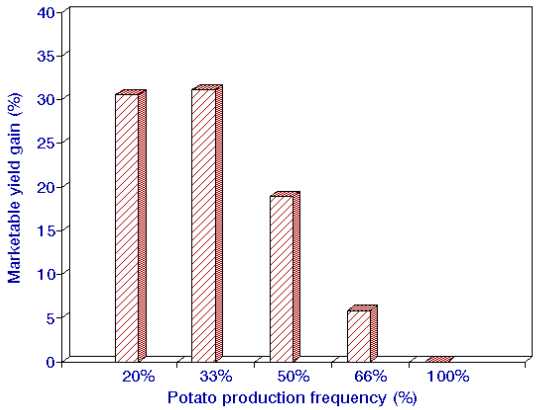

Figure B. Effect of potato cropping frequency on marketable potato yield.

The noticeable difference in marketable yields shown in Figure B illustrates the importance of crop rotations on the quality of potatoes. This improved quality is the result of better pest control and better potato size distribution.

Rotations Improve Economic Sustainability

Ultimately, the choice of rotation crops in potato production is based on the financial viability of the complete sequence of crops in rotation. This assessment includes the impact of rotation systems on the marketable yield of potatoes, on the cost of production, and the relative viability of cereal and forages.

Soil represents about 30% of potato farm assets. Its protection, through the adoption of better rotations and other conservation practices, will influence the sustainability of the potato farm. By conserving the productive capacity of the land, producers will maintain and may even improve their ability to produce, and thus to meet their financial obligations.

Although a crop of potatoes can be an important source of gross income, it requires a high level of inputs. A study estimated that the production of a single hectare of potatoes costs around $3200.

Cash costs (out-of-pocket costs such as fertilizers, pesticides, hired labour) represent almost 90% of the cost of producing potatoes, while the non-cash costs (depreciation and the unpaid family labour) make up the remaining 10%. It is very important to consider cash costs and thus the cash flow situation of any business when evaluating its short-term viability. The long-term viability will, to a great extent, depend on the ability of the producer to set monies aside for the maintenance and replacement of equipment and buildings. The inability of a producer to cover depreciation charges will jeopardize his/her productive capacity. A number of these costs may be influenced by a change in rotation systems.

A New Brunswick cost of production study has shown that the use of a 1 year in 2 rotation system, or better, resulted in a reduction of $150 (5% of cash costs) in the cost of producing one hectare of potatoes. This reduction was, for the most part, due to a decrease in the use of fertilizers and pesticides.

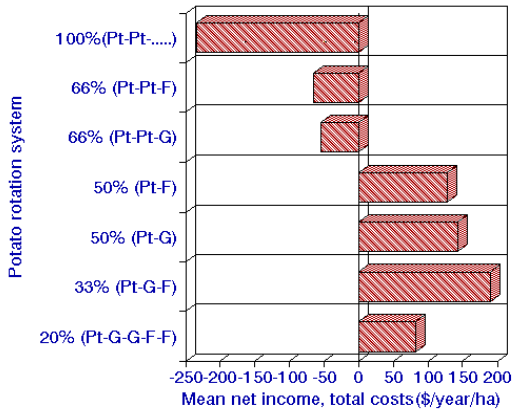

Figure C. Profitability of rotation systems: total cost.

By changing from continuous potatoes to a three year rotation system, it is possible to increase potential marketable yield by 31%. This marketable yield increase could in turn lead to an increase in gross income of up to $945 per hectare.

By integrating these results with the net income generated by grains and forages, it was possible to evaluate the profitability of various rotation systems (Figures C and D). Although all rotation systems appear to be profitable when evaluated on the basis of cash costs, all rotation systems involving growing potatoes for two consecutive years or more, generate a net loss when one considers all costs (including depreciation and unpaid labour). This indicates that, although it may be financially feasible in the short-term or mid-term to use potato production systems involving some form of continuous potatoes, it will only lead to mid-term and long-term financial difficulties. The 1 year in 3 rotation is the most profitable on a total cost basis.

Grain is more profitable than forages as a rotation crop due to the poor financial performance of forages. However, the use of cereals alone in a 1 year in 2 rotation with potatoes would have short falls from an agronomic stand point. Underseeding cereals with high residue crops such as clover or ryegrass could compensate to some degree for these agronomic short comings.

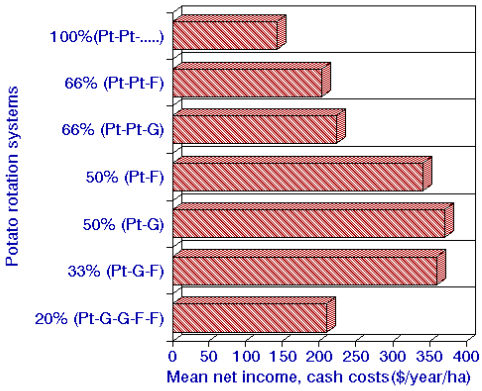

Figure D. Profitability of rotation systems: cash cost.

The decision to adopt forages or cereals as rotation crops will, to great extent, depend upon their effect on the yield and cost of production of the potato crop. Although these crops could be responsible for financial loss, the agronomic benefits which they generate are quite substantial though difficult to quantify.
It is possible to make profits from grain production. Some cereal producers have managed to out-yield the industry reaching 5.5 t/ha of barley, nearly twice the average of similar operations. For the most part, this yield increase was not achieved through

increasing inputs but rather through the optimum use of available inputs. Through this `best management' approach to cereal production, these producers have succeeded in generating a profit of almost $300 per hectare rather than suffering a loss. Such financial performance makes cereals an attractive rotation crop.

If it is assumed that these yields could be achieved by any producer, the financial benefit from a potato-grain rotation would increase the mean net income by approximately $180 per hectare, making this the best rotation from a financial standpoint. The potato-grain-forage rotation is, however, quite close to the two year rotation involving grains.

The generally poor economic performance of cereal production has deterred a number of producers from adopting it. To produce small grains on a small area is often not profitable. In order to make this alternative more appealing smaller producers could form equipment pools in order to share the capital cost of the machinery with other producers. They could also gain a better rotation, while helping a producer who wants to expand his grain operation achieve economies of scale, by renting some of their land to grain producers. Land swapping may also be an interesting alternative in some cases.

There are other factors that may prevent the producers from adopting better rotation systems. Amongst these are land availability, land tenure, economies of scale and the level of farm debt.

Land availability: The lack of arable land is often raised as a factor that prevents the adoption of better rotations. Land availability appears to be a serious issue in the main potato production region of New Brunswick. A reduction in the area used for potato production on a farm could result in a loss of economies of scale. In the long-term, such a situation could result in the inability of producers to acquire technologies which are essential to the continued competitiveness of the industry. In the short-term, it would increase the average cost of production of these farms to the point where they may no longer be able to compete. Land availability also is a concern in the main horticultural regions of P.E.I., Nova Scotia, and Newfoundland.

Land tenure: Benefits from a better rotation system can take many years to materialize. Land renting, unless in a long term agreement, may discourage investments required for the adoption of conservation systems.

Farm debt: The level of farm debt appears to be a factor which prevents producers from selecting less intensive cropping systems. When facing high debt the producer may try to meet his/her financial obligations by increasing cash-flow through continuous potato production. By selecting intensive potato production systems, a producer will become highly vulnerable to crop failure which would then result in his/her inability to meet financial obligations.

In general, Atlantic potato producers devote the same relative resources to interest payments. However, smaller New Brunswick farmers carry a larger debt load in relation to their paying capacity. This may hinder their ability to borrow or to make medium and long-term investments.

Transition period: The transition period is one of the dominant concerns of producers when implementing a new rotation system, especially if major changes are required. There are many unknowns associated with the duration of this period and how best to deal with them. It is generally accepted that most of the yield benefits derived from a new rotation system will take place within two rotation cycles. For example, a change from 2 years of potatoes in 3 to 1 year in 3 would take about six years before most of the yield benefits were achieved.

Little is known about the agronomic processes involved in the transition period. An integrated management strategy, including the monitoring of soil properties and crop response, must be prepared and reviewed on a regular basis.

A change in rotation system will usually create a redistribution of the fixed or indirect costs. There are considerable costs to be covered in the first years of the transition period. After the initial years, a producer would start to realize some of the yield benefits, progressively improving viability. In order to deal with the transition the producer could change his/her rotation in one field, wait for the yield benefits to occur, and then move on to another field. This would spread the financial impacts of the transition over a longer period of time.

The purchase or rental of additional land could reduce the negative financial effect of this transition period. The cost of the transition period could be further reduced by pooling resources with other producers. This initiative could result in a significant reduction of depreciation and other fixed costs borne by one farm.

Conclusions

Crop rotation is a very good example of the positive connection which can be established between economical and environmental sustainability. The study shows that the most environmentally sound rotation systems are also the most profitable.

This report confirms the recommendation of the Atlantic Provinces Agriculture Services Coordinating Committee for a three year rotation with potato production. This rotation satisfies most of the water conservation, soil productivity and farm profitability concerns.

Only the potato production frequencies less that 50% proved to be economically viable. Crop rotations can bring significant benefits at all levels. The adoption of an adequate soil management (comprehensive soil testing) and integrated pest management strategy would enhance the ability of a producer to take advantage of rotation benefits such as reduced need for fertilizers and pesticides.

Crop rotation studies must be extended to other rotation systems, such as the recent inclusion of soybeans in the potato rotation in P.E.I., and the diversified horticulture production systems in Nova Scotia and Newfoundland.

Studies in the Atlantic region, Canada, the United States and European countries consistently confirm the importance of crop rotation systems in optimizing potato yields and quality. The future of Atlantic Canada's potato industry relies, to a great extent, on the ability of producers to adopt appropriate crop rotation systems.