The Economics of Potato Crop Rotations in Southern Manitoba

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Key Words: Crop rotation, Sustainability, Potato, Canola, Wheat, Oat, Alfalfa

Abstract

Rapid expansion of the potato industry in Manitoba has led to increased potato production in Manitoba. While the introduction of potatoes into current cropping systems may provide an opportunity for producers to increase the profitability of their farming operation, development of economically and environmentally sustainable production systems is key to the long-term success of the industry. Currently, little information is available about the economic and environmental impacts of such crop rotations with respect to potato production in Canada. Recognizing the importance of sustainable production systems, in 1998, a potato crop rotation study was established at Manitoba Crop Diversification Center (MCDC) at Carberry to develop recommendations for irrigated potato management in southern Manitoba. Six crop rotations ranging from two to four years in duration, and containing potatoes in combination with oilseed, cereal and/or legume crops, were included in this study. Each phase of each rotation was present in each year making a total of 18 treatments. This paper discusses the economic return of these six different crop rotations. The data with respect to all the production practices, including storage, transport and marketing for the period of 1998 to 2001 were collected and analyzed using a computer model developed for this purpose. Econometrics View software was used to develop this model, and the model takes into account the whole system for each rotation when analyzing the data. The preliminary results suggest that, for the period of 1999 through 2000, both potato-canola and potato-oat-wheat rotations appeared to be promising rotations. However, the poor potato yield of the potato-oat-wheat rotation in 2001 resulted in low average net income for that rotation. The higher net benefit of the potato-canola rotation during the time period analyzed was primarily the result of a higher proportion of the tuber yield being of marketable size, not for higher gross tuber or canola yields. It is, however, difficult to make firm conclusions at this point of time as to which rotation will be most profitable in the long term. This is mainly because of the rotation treatments have only been in place since 1998 and, as such, observed differences among rotations may be a function not only of the rotation but also of environmental conditions and management within a given year.

Introduction

Recent expansion of the potato processing industry in southern Manitoba coupled with increased demand for potato around the world has resulted in significant increase in potato production. Commercial potato production was first recorded in Manitoba in 1908, when 20,800 acres produced 2.3 million cwt. of potatoes (Manitoba Agriculture and Food, 2002). The area planted to potatoes rose to 45,000 acres in 1918, and remained between 30,000 and 40,000 acres until the late 1940s, when the seeded area dropped to below 20,000 acres for more than a decade. With the expansion of the potato processing industry and increased use of irrigation, the area seeded to potatoes continued to grow. In 2000, the total area planted to potatoes reached a record 78,000 acres.

The adoption and use of diversified crop rotation practices are becoming widely accepted by producers in North America, and crops that may provide rotational benefits are being included in production systems. For example, growing nitrogen-fixing legume or pulse crops may contribute to soil nitrogen thereby reducing the fertilizer requirements for the next crop. Crop rotation may also reduce the possible pest and diseases thereby reducing the cost incurred on inputs such as pesticides.

Empirical evidence suggests that crop rotation may increase not only the total or gross yield of the primary crop but also the marketable yield (Guertal E.A., E.M. Bauske and J.H. Edwards, 1997). While the economic and environmental benefits of crop rotations have been known for many years (Heady, 1957; Honeycutt, Clapham and Leach, 1995; Lazarus and White1984; Patterson and Satrk, 1995), in practice, considerably less attention has been paid to quantifying such underlying benefits up to the recent past. Among these benefits, increased yield, less disease, and less pests and weeds are the important determinants of profitability of the industry. In addition, for many years, researchers used a neoclassical production function approach to explain production and economic efficiency without any regard for the sustainability of the production process. The problem in the production function approach is the presumption that a uniform set of production factors can substitute freely for one another to increase efficiency without any regard for the environmental and structural variability that occurs in agricultural and social systems (Gillespie, Lyson and Power, 1995). Although most crop rotation experiments in Canada have examined the impact of rotations on agronomic aspects of field crops, little research has been conducted to include economic and environmental impacts of crop rotation systems. The objective of this study was to evaluate the economic impacts of six potato crop rotations using a system approach.

Materials and Methods:

In 1997, the researchers at the Brandon Research Center, Agriculture and Agri-Food Canada (AAFC) and the Manitoba Crop Diversification Centre (MCDC) at Carberry initiated a potato crop rotation study at MCDC. The objective of this ongoing experiment was to develop recommendations for irrigated potato management in southern Manitoba by identifying agronomically and economically viable potato rotations that minimize yield and quality losses due to disease and weeds and maintain soil quality.

Six crop rotations ranging in duration from two to four years, and containing potatoes in combination with oilseed, cereal and/or legume crops were included in this study. Each phase of each rotation was present in each year for a total of 18 treatments. The experiment consists of a randomized complete block design with four replicates. The six crop rotations were:

Potato-Canola (P-W)
Potato-Wheat (P-C)
Potato-Canola-Wheat (P-C-W)
Potato-Oat-Wheat (P-O-W)
Potato-Wheat-Canola-Wheat (P-W-C-W)
Potato-Canola (underseeded to alfalfa)-alfalfa-alfalfa (P-C(A)-A-A).

All crops were managed using best management practices with respect to tillage, seeding, nutrient management, weed, insect, and disease control. Nitrogen, phosphorus, potassium and sulfur nutrients in the form of urea, monoamonium phosphate, potassium chloride and ammonium sulfate were applied as required for each crop species.

Economic Model

Net accounting and budgeting method was used to analyze the net economic benefits of six different potato rotations. The cost model was divided into eight sub-models based on types of field operations: fuel and lubrication, labour, fixed costs, repair costs, chemical costs, fertilizer costs, seed costs, and 'other' costs involved in farming operations.

The total cost can be divided into total fixed cost (TFC) and total variable cost (TVC). TFC, which includes machinery, irrigation equipment and storage equipment, was calculated using following formula.

$$\text{TFC} = \sum_{i=1}^{I} FC_i \text{ where } \text{FC}_\text{i} \text{ is the fixed cost of } \text{i}^{\text{th}} \text{machinery (or implement)}$$

The TVC include remaining all other cost items such as repair and maintenance, oil and fuel, labour, seed, chemical, fertilizer, irrigation, transport, insurance premium, interest cost on variable inputs, land tax and miscellaneous cost. If M is the total number of variable cost items for growing a particular crop and vc_m is the cost of m^{th} variable input, the TVC is:

$$\text{TVC} = \sum_{m=1}^{M} vc_m, \text{ where m} = 1,..., \text{M}$$

Total gross income for each crop in rotation was calculated as follows.

$$\text{Total gross income} = \sum_{n=1}^{N} Q_n * \mathrm{P_n} + \sum_{n=1}^{N} \mathrm{IPQ}_{\mathrm{n}}$$

where, Q_n and P_n represents the quantity and price of n^{th} commodity and IPQ_n represents the insurance payout for n^{th} commodity, if the quantity produced is less than the ten-year average yield in Manitoba.

For the purpose of computing income for each crop, the constant (2001) prices were used for all three years. The use of constant prices facilitates to compare net income of crops between years without inflationary effect. For potatoes, contract prices provided by the Midwest Food Products Inc., Carberry, Manitoba for 2001 were used. Based on these contract prices and assuming potato delivery would be taken place on mid March, the price of $7.00 per cwt was used for marketable potatoes. The prices for bonus and small potatoes were also taken from the same source. For other crops, the average farm gate prices for 2001 provided by the Manitoba Agriculture and Food were used. Accordingly, prices for canola, wheat, oats and alfalfa were $ 0.265, $ 0.165, $ 0.114, and $ 0.073 per kg, respectively.

Data were analyzed using a computer model developed in Econometric software (version 4). The model was written in such a way that it uses the system approach in analyzing data. Statistical analyses were also performed to examine the differences in potato yield among rotations.

Results and Discussion:

This section discusses the yield, net income and cost incurred on different rotations in the experiment. As can be seen from the following tables, the yield and net income varied among crops and rotations. However, it is important to note that, given that the rotation treatments have only been in place since 1998, it unclear at this point in the study if observed differences in yield and net returns are the result of rotation, or of environmental and/or management during a given year.

Potato yield:

The marketable[1] potatoes (main) in the six different potato rotations were shown in Table 1. On average, marketable potato (main) yield varied between 252 cwt/ac to 303 cwt/ac

[1] According to the Midwest Food Product Inc., total marketable potatoes include all the potatoes with a diameter greater than 1.75 inches. The main category of potatoes is those potatoes with a diameter 2 inches and greater. The potatoes with diameter 1.75 inches and above but less than 2 inches are categorized as small potatoes, which are further divided into two sub-categories based on length: less than 3” long and greater than 3 inches long. The other category of potato is bonus potato that has a diameter greater than 2 inches but weigh more than 10 ounces.

among rotations. The differences in marketable tuber yield among rotations in 1999 and 2000 were not statistically significant but it was significant (P-value =0.008) in 2001.

Table 1. Marketable potato yield of six different rotations: 1999 – 2001 (cwt/ac)

Rotation	1999	2000	2001	Average
P-W	249	292	276	272
P-C	283	312	314	303
P-C-W	279	284	233	266
P-O-W	288	319	195	267
P-W-C-W	275	285	197	252
P-C(A)-A-A	280	314	254	283

Wheat yield:

Table 2 shows the wheat yield from five different crop rotations in the study. In 2000, wheat yield ranged from 3042 to 3269 kg/ha. Wheat from P-W, P-C-W, and P-W-C-W rotations in 1999 and P-W-C-W rotation in 2001 produced comparatively lower yield than wheat yield in other rotations. However, on average, almost all rotations produced similar wheat yields.

Table 2. Wheat Yield: 1999 – 2001 (kg/ha)

Rotation	1999	2000	2001	Average
P-W	2266	3269	2923	2819
P-C-W	2330	3042	2681	2684
P-O-W	3032	3062	2607	2901
P-W-C-W	2382	3183	3034	2866
P-W-C-W	2874	3151	2461	2829

Canola yield:

Canola was included in four different rotations in this study and Table 3 represents the canola yield for all three years together with the three-year average yield. The canola yield in year 2000 was very low in all four rotations, which also affected the overall average yield. The canola yield in the P-C(A)-A-A rotation is not directly comparable with the canola yield in other canola-containing rotations because management practices (e.g. seeding rate, fertilizer application) for the P-C(A)-A-A rotation in which canola is underseeded with alfalfa were somewhat different than other rotations in the study.

Table 3. Canola Yield: 1999 – 2001 (kg/ha)

Rotation	1999	2000	2001	Average
P-C	1606	1008	1853	1489
P-C-W	1678	1273	1947	1632
P-W-C-W	2103	1156	1841	1700
P-C(A)-A-A	1198	818	1942	1319

Oat yield:

Oat is present in only one rotation (P-O-W) in this experiment. The average oat yield in 1999 was 4759 kg/ha and 3217 and 4151 kg/ha for 2000 and 2001, respectively, producing a three-year average of 4043 kg/ha.

Alfalfa yield:

Alfalfa is also present in only one rotation but in two consecutive phases. The alfalfa yield in 1999, 2000 and 2001 was shown in Table 4. The average yield of alfalfa varied over time producing an average yield of 3762 and 4515 kg/ha for the two phases in this rotation, P-C(A)-A-A and P-C(A)-A-A, respectively.

Table 4. Alfalfa Yield: 1999 – 2001 (kg/ha)

Rotation	1999	2000	2001	Average
P-C(A)-A-A	2414	4374	4497	3762
P-C(A)-A-A	4416	4557	4574	4515

Net Income from six different crop rotations: 1999 – 2001

The average net income for six different potato crop rotations from 1999 – 2001 was shown in Figure 1. It should, however, be noted that as the rotation treatments had been in place for a short time, these results may not reflect the expected economic returns from these rotations in the long run. Based on 1999, 2000 and 2001 data, the computed net income of these rotations varied from $47 to $189 per acre. The lowest net income of $47/ac was generated from the potato-wheat-canola-wheat (P-W-C-W) rotation. This rotation, however, produced the highest potato gross yield of 400 cwt/ac. It is worthwhile to note that the highest net income of potato-canola (P-C) rotation ($189/ac) was due to the higher proportion of the marketable tubers of this rotation, not for higher gross tuber or canola yield. As shown in Table 1, potato yield (main) from potato-canola rotation was 303 cwt./ac, which is about 13% higher than the average marketable potato yield (main) of the other five rotations (268 cwt/ac). Canola consistently produced the lowest net income from all six rotations reflecting its higher cost of production. Results also suggest that potato was the key determinant of net income (or profitability) of all these rotations for the period 1999-2001.

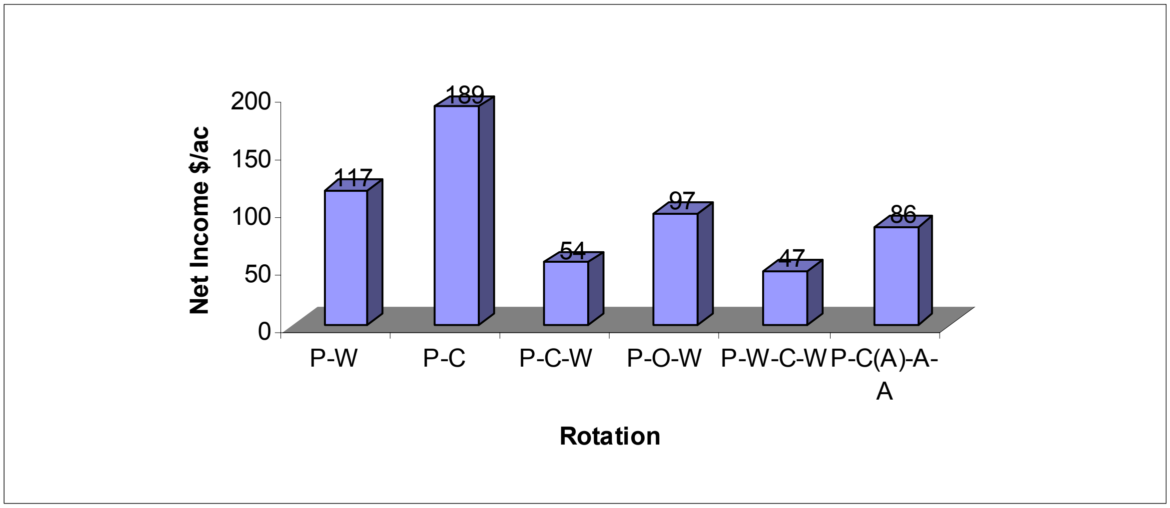

Figure 1. Average Net Income of Six Different Crop Rotations, 1999 – 2001

Distribution of total cost

The costs incurred for different inputs (machinery, seed, fertilizer, chemical, labour and other cost) in the six different crop rotations were shown in Figure 2. The machinery costs, which include land preparation, fertilizing, spraying, harvesting, storage and transport varied from $167 to $305 per acre among rotations. The machinery cost is comparatively higher in P-C ($305/ac) and P-W ($300/ac) rotations than in other rotations reflecting the use of more of equipment for tillage and harvesting. In contrast, in P-C(A)-A-A rotation, tillage and chemical use is minimal especially during the alfalfa phase of this rotation.

The cost of seed varied from $48 to $86 per acre among rotations reflecting different seed prices, and some other additional seed-related costs such as seed treatments on potato and canola. The cost of fertilizer also varied from $24 to $51 per acre reflecting the different fertilizer applications in each rotation. Fertilizer cost on P-C(A)-A-A rotation was the lowest ($24) because no fertilizer was applied to established alfalfa. Similarly chemical cost varied from $130 per acre in P-C(A)-A-A rotation to $257 per acre in P-C rotation.

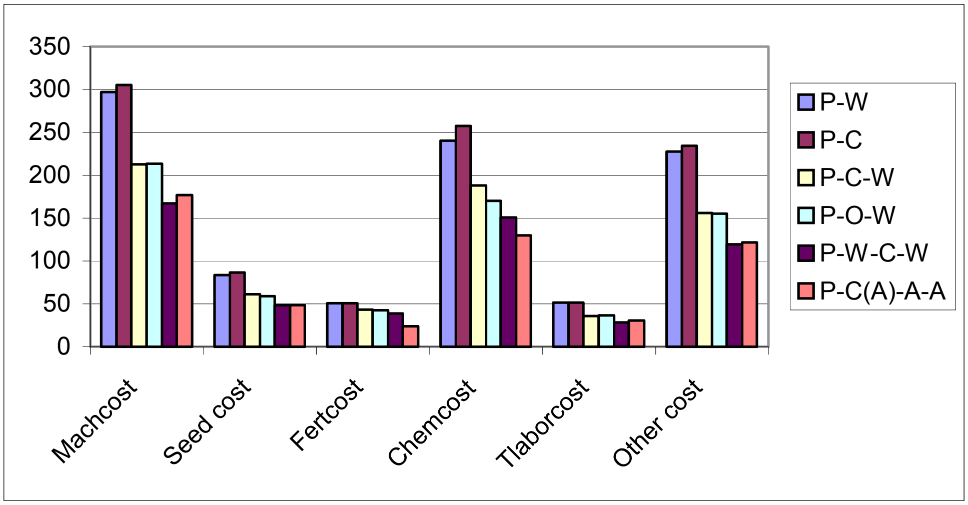

Figure 2. Distribution of input costs: Average 1999 - 2001

Summary and Conclusions

A potato rotation experiment was initiated at MCDC, Carberry in 1997 to develop guidelines for sustainable irrigated potato production by identifying agronomically and economically viable crop rotations for Manitoba. Six different crop rotations ranging from two to four years in duration, and containing potatoes in combination with oilseed, cereal and/or legume crops, were included in this study. Costs of production and income of these six different crop rotations in 1999 through 2001 were analyzed to examine the economic impact of each rotation.

The potato yield data for 1999 through 2001 shows that there is no significant variation of marketable potato yield among rotations in 1999 and 2000 but that there is a significant difference in marketable potato yield among rotations in 2001. In 2001, the potato-canola rotation produced the highest percentage of marketable potato tubers while the lowest percentage of marketable potato tubers was produced in potato-wheat-canola-wheat rotation. Crop yield needs to be observed for at least one more rotation cycle in order to reach any conclusions about the rotational effects because the performance of crops within each rotation may change over time as the rotations mature.

Average net income of these six rotations varied from $47 to $189 per acre. Both potato-canola and potato-oat-wheat rotations generated the higher net income in 1999 and 2000. However, the poor potato yield of potato-oat-wheat rotation in 2001 resulted in low average net income for that rotation. The higher net benefit of the potato-canola rotation during the time period analyzed was primarily the result of a higher proportion of the tuber yield being of marketable size, not for higher gross tuber or canola yields. As can be seen from these results, potato was the key determinant of net income or profitability of all these rotations.

Given the short period of time that this rotation has been in place, observed differences among rotations may be a function not only of rotation, but also of management and environmental factors within a given year. As such, the experiment may not yet be mature enough to clearly identify rotational effects.

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