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Pesticide Free Production: Characteristics of farms and farmers participating in a pesticide use reduction pilot project in Manitoba, Canada

Orla M. Nazarko, Rene C. Van Acker*, Martin H. Entz, Allison Schoofs, and Gary Martens

Department of Plant Science, University of Manitoba, Winnipeg, Manitoba, Canada R3T 2N2.
*Corresponding author: rene_van_acker@umanitoba.ca

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Abstract

Strategies for pesticide use reduction have suffered from limited adoption. The impact of such strategies will be greater if they appeal to farmers with typical demographics and attitudes. A participatory, on-farm study was conducted to assess the potential of Pesticide Free Production™ (PFP) to be widely implemented on mainstream farms in Manitoba, Canada. PFP is a flexible, simple framework intended to appeal broadly to farmers who may not have adopted other pesticide use reduction initiatives. It may also provide a marketable food product label. This novel crop production system prohibits the use of in-crop pesticides and seed treatments during one crop year, as well as prior use of residual pesticides. Applications of nonresidual pesticides (such as glyphosate) are permitted prior to crop emergence. Synthetic fertilizer use is permitted at any time. The objectives of this study were: (1) to determine if the demographic and attitudinal characteristics of farms and farmers participating in a PFP pilot project varied depending on the level of PFP implementation; and (2) to compare the characteristics of farms and farmers participating in the pilot project with standards representing average farms and farmers in Manitoba. A total of 71 farmers, representing 120 fields and 11 crops, participated in the study. Fields and farmers were categorized into three groups, based on whether or not fields: (1) achieved PFP certification status and (2) were in transition to organic production. There were few demographic differences among groups. Demographic characteristics of participating farmers were typical for Manitoba, with the exception that participating farmers who were not in transition to organic production had higher levels of education than a random sample of Manitoba farmers. Attitudinal orientation (adherence to a conventional versus an alternative agricultural paradigm) of participants who were not in transition to organic production was similar to that of a random sample of Manitoba farmers. Fields and farms on which PFP was implemented were relatively large in the context of Manitoba averages. Participants indicated high satisfaction with certifiable PFP crops and high levels of interest in implementing future PFP. Pesticide free production demonstrates significant potential for broad adoption in this region.

Key words: Pesticide Free Production, PFP, integrated pest management, IPM, participatory research, pesticide use reduction, low-input agriculture, Manitoba, Alternative–Conventional Agriculture Paradigm scale, ACAP scale, flax, spring wheat, barley, oats

Introduction

Pesticide use reduction has received considerable attention as a means to mitigate negative environmental impacts, reduce production costs, and meet demand for specialized markets. While various strategies for pesticide use reduction exist, their adoption in the North American Northern Great Plains (NGP) has been limited. In the province of Manitoba, Canada, organic crop production comprises less than 0.5% of the province's total field crop area [unpublished data, Organic Producers' Association of Manitoba (OPAM)]. Frameworks for pesticide use reduction with more flexibility than organic production have been developed (e.g. integrated pest management, IPM), but have not been widely implemented[1,2]. Despite this, a large proportion of farmers may be amenable to imple-

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menting approaches to achieve some degree of pesticide use reduction[3,4].

In order to capture mainstream farmers' interest in pesticide use reduction, a team of farmers, researchers and extension workers in Manitoba developed Pesticide Free Production™ (PFP) in 1999. Representatives from the University of Manitoba, Agriculture and Agri-Food Canada in Brandon, Manitoba, and Manitoba Agriculture and Food were involved. PFP is a flexible, simple framework intended to appeal broadly to farmers who may not have adopted other pesticide use reduction initiatives. PFP crops are defined as nongenetically modified crops that are not treated with pesticides after the crop emerges, and are not grown where residual pesticides are considered to be agronomically active[5]. These guidelines prohibit the use of in-crop pesticides and pesticidal seed treatments for one crop year. Prior use of pesticides is permitted only if the product is considered not to have active residual at the time of PFP crop seeding, as indicated by the manufacturer's recropping restrictions. Synthetic fertilizer use is permitted at any time, and applications of nonresidual pesticides, such as glyphosate, are permitted prior to the emergence of the PFP crop. PFP may draw mainstream farmers to explore integrated approaches to pest and crop management. It may also provide a marketable food product label[6].

According to classical technology adoption theory, technology adoption in agriculture is related to demographic characteristics of farmers, and occurs initially among young, well-educated farmers who operate relatively large farms, and own rather than rent land[7]. However, innovations that are primarily focused on environmental benefits ('environmental innovations', e.g., IPM) are fundamentally different from traditional technologies, in that they may be complex groupings of practices which are not necessarily applicable to all farms, and they may offer more benefit to society as a whole than they do to adopters[8]. The demographic and attitudinal characteristics important in the adoption of environmental innovations may be different than those for traditional technologies. Some studies have found demographic and attitudinal differences between farmers practicing conventional versus reduced-input agriculture[9,10]. Others have found that farmers interested in reducing pesticide use are demographically and attitudinally similar to mainstream farmers[3,4,11]. Farmer support for reduced-input practices has also been reported to be related more to attitudinal than demographic factors[11].

The potential impact of a given pesticide use reduction strategy will be greater if the strategy appeals to farmers with average or typical demographics and attitudes. The adoption of pesticide use reduction strategies can be facilitated through targeted extension if the target group of farmers and farms can be characterized.

The objective of this study was to assess the potential of Pesticide Free Production to be widely implemented on mainstream farms in Manitoba, Canada. We aimed to meet this objective by: (1) determining if the demographic and attitudinal characteristics of farms and farmers participating in a PFP pilot project varied, depending on level of PFP implementation; and (2) comparing the characteristics of farms and farmers participating in the pilot project with standards representing average farms and farmers in Manitoba.

Materials and Methods

Participant and field selection

Farmer participation was an integral part of the project. Participatory research utilizes farmers' expertise and can promote rapid adoption of novel production systems[12]. The specific requirements for PFP meant that participation was constrained by interest among Manitoba farmers, resulting in nonrandom, purposive sampling. Participants were recruited in the late winter of 2000 and 2001, via newspaper and radio advertisements, promotion by provincial agricultural representatives, and word of mouth among farmers. No compensation was offered, and participants were informed that there were no clear premium marketing opportunities for PFP-certified grain at the time the study was conducted. Farmers were selected to participate if their fields could meet PFP certification criteria. Several farmers volunteered more than one field.

During the first year of the project (2000), all volunteered grain crop fields were included. Fields in transition to organic certification were included. In 2001, there was sufficient interest in PFP that the study was narrowed to include only those crops showing high levels of farmer interest [spring wheat (*Triticum aestivum* L.), oats (*Avena sativa* L.), barley (*Hordeum vulgare* L.) and flax (*Linum usitatissimum* L.)].

Questionnaire design

Participants were asked to complete a detailed written questionnaire distributed by mail. Questionnaire design was in accordance with University of Manitoba ethical research requirements and based on guidelines provided by Sudman and Bradburn[13], Jackson[14] and Babbie[15]. The questionnaire was pretested on ten subjects with farming backgrounds, and modified where required. Unclear responses were clarified via telephone interviews. The questionnaire consisted of questions regarding farmers' agronomic practices, demographic information and feedback about PFP. In addition, a series of questions designed to determine farmers' adherence to an alternative or a conventional agricultural worldview was included [Alternative–Conventional Agriculture Paradigm scale (ACAP scale)][9]. The reliability of this scale has been established by its repeated use in sociological research, in both the United States and Canada[3,4,9,10,16,17]. The scale has been shown to be related to farmers' production practices[16,17]. In our study, the only modification made to this series of questions was to change the term 'US agriculture' to 'North American agriculture'.

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Another questionnaire was used to follow up with farmers who had produced certifiable PFP fields, conducted via telephone 1 year after harvest of the PFP crop. Open-ended questions were used to elicit responses about weed densities the year after PFP.

In order to gain information about the demographic and attitudinal characteristics of typical Manitoba farmers, a questionnaire was conducted by a professional polling company with significant agricultural experience (Ipsos-Reid Corporation, Winnipeg, MB) in February 2002. A stratified random sample of 154 farmers (each with over 130 ha of seeded cropland) was used, with proportions representing the population distribution in each Manitoba census district. A telephone survey was used to minimize self-selection of respondents. The margin of error was ±8% at the 95% level of confidence. The refusal rate was 30%, which is within the normal range for agricultural surveys conducted by Ipsos-Reid.

Data analysis

Fields and farmers were categorized into three groups, representing different levels of pesticide use reduction in the year PFP was attempted. Initially, fields were divided into two groups, based on whether or not the field met PFP certification requirements. Fields that met the requirements were further subdivided into two groups, based on whether or not the field was in transition to organic certification. The classification was based on the farmer's ability to meet PFP certification requirements rather than a determination of the 'successfulness' of a field in terms of pest pressure. The three groups of fields were as follows: (1) those not certifiable as PFP (*noncertifiable fields*); (2) those certifiable as PFP but not in transition to organic certification (*certifiable, nontransitional fields*); and (3) those certifiable as PFP and in transition to organic certification (*certifiable, transitional fields*). Farmers were categorized into three groups comparable to the field-based groupings: (1) those with no certifiable PFP fields (*farmers without certifiable fields*); (2) those with certifiable PFP fields whose farms were not in transition to organic (*farmers with certifiable fields, nontransitional farms*); and (3) those with certifiable PFP fields whose farms were in transition to organic (*farmers with certifiable fields, transitional farms*). When considered together, the noncertifiable and certifiable, nontransitional groups are referred to as the 'conventional' groups. It should be emphasized that the 'noncertifiable' designation does not necessarily imply typical Manitoba fields or farmers. For example, two fields in the noncertifiable group were in transition to organic but were not certifiable as PFP because a residual herbicide had been used previously.

The relatively small number of participants meant that separation of observations by year, soil type, or tillage system would have resulted in groups so small as to prohibit meaningful comparison. Observations were combined into one data set across both years, providing a broad description of farmers and fields involved in PFP. Duplicate values were removed if farmers participated in both years.

Analysis of variance (ANOVA) was performed for comparisons of continuous numerical variables. Participant group was the only source of variation included in the model. Fisher's protected LSD was used to separate means. When data could not be transformed to meet normality, Mann–Whitney and Kruskal–Wallis tests were used. These are the non-parametric equivalents of two-sample *t*-tests and one-way ANOVA, respectively[18]. Pairwise comparisons using the Mann–Whitney test were carried out if the overall Kruskal–Wallis test was significant ($P < 0.05$). When the outcome of a nonparametric test agreed with the outcome of ANOVA ($P < 0.05$), the ANOVA result was presented. If data could be transformed to meet normality, but results agreed with the outcome of ANOVA on the untransformed data, the results for the untransformed data were presented. Contingency tables and chi-square statistics were generated for comparisons of frequencies of categorical data. If tables contained response variables that were not ordinal, Pearson's chi-square was used to test the null hypothesis of no general association. For tables with ordinal response categories, the Mantel–Haenszel chi-square was used to test for linear response[18]. When zero counts were generated in a table, or if more than 20% of table cells had an expected value of less than 5, Fisher's exact test was used[18]. Contingency tables were used to generate pairwise comparisons if the overall chi-square test was significant ($P < 0.05$).

Information describing typical Manitoba farms and farmers was obtained from government agencies, farmer surveys conducted by various organizations, and peer-reviewed publications. Comparative information for which there was no published source was obtained from appropriate industry representatives.

Results and Discussion

Participation

Less than 1% of annual cereal and oilseed fields in Manitoba are produced without a herbicide application[19]. Given this context, participation in the project was very good. A total of 71 farmers and 120 fields were included, of which the majority were located in western Manitoba (agroecoregion 2 of the Northern Great Plains)[20]. This region produces fewer high-value crops and more forage crops than Manitoba's other major agroecoregion (agroecoregion 1), and also has a relatively high frequency of reduced-tillage[19]. Farmers volunteered 11 crops for the study, primarily cereals [spring and winter wheat, fall rye (*Secale cereale* L.), barley, and oats], as well as flax. In total, 2368 ha of the 2850 ha volunteered was PFP-certifiable, representing 83% of the land area and 68% of fields volunteered. The proportion of certifiable fields varied depending on the crop type. Detailed information

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Table 1. Reasons for farmer interest in Pesticide Free Production (PFP).

Farmer group	Input cost reduction	Marketing opportunities	Health concerns	Prevention of pesticide resistance	Environmental concerns
	Average score[1]				
Without certifiable PFP fields	4.7 (0.13)[2]	4.5 (0.22)a	3.9 (0.32)a	4.1 (0.30)	3.5 (0.29)
With certifiable fields, nontransitional farms	4.6 (0.14)	3.1 (0.23)b	4.0 (0.19)a	3.5 (0.21)	4.0 (0.18)
With certifiable fields, transitional farms	4.6 (0.21)	4.1 (0.19)ab	4.6 (0.18)b	4.0 (0.24)	4.3 (0.19)
P value	0.89	>0.001	0.03	0.23	0.11
n	66	64	66	65	65

a, b Means followed by the same letter within columns are not significantly different ($P > 0.05$) according to Fisher's protected LSD.
[1] Scores range from 1 to 5, with 5 indicating high interest.
[2] Numbers in parentheses represent standard errors.

regarding farmer participation and agronomic characteristics of participating farms is reported elsewhere[21].

Participant interest in reduced-input agriculture

Reasons for participant interest in PFP. Economic considerations are often very important in the adoption of conservation or reduced-input practices[22], and our results demonstrate that the same is true of PFP implementation. The highest-ranking reason for interest in PFP among all groups was input cost reduction, and there were no significant differences in scores for this factor (Table 1). This can be attributed to the current financial difficulties for grain farmers in western Canada. Input cost is one factor over which farmers can maintain some control[23]. There was significantly higher interest in marketing opportunities among farmers without certifiable fields than among farmers with certifiable fields, nontransitional farms. This suggests that farmers who did not retain fields for certifiable PFP did so partly because of the lack of premium marketing opportunities for PFP grain at that point in time, and that this group may be more likely to implement PFP if such opportunities were available.

Noneconomic factors can also be important in farmers' decisions to reduce agrichemical use[24]. This was true of all groups of PFP participants, who rated their interest in PFP for three different noneconomic reasons as above 3.5 on a 5-point scale (Table 1). Interest in PFP because of concern for their own or their families' health was significantly higher for farmers with certifiable fields, transitional farms than for farmers in either of the other two groups. Several participants stated that their health had been negatively impacted by exposure to pesticides. There were no significant differences among groups in the level of interest in PFP because of concern about the environment, or because it could reduce the risk of pesticide resistance. Others have reported that concern about environmental pollution is consistently positively correlated with farmer willingness to adopt pesticide use reduction practices[11]; however, economic factors often take precedence over such concerns[25].

Participant interest in organic production. Several participants were farming organically but were not certified, citing certification costs and marketing difficulties as disincentives to certification. Some farmers were interested in alternating between organic and conventional production on a given field, but could not obtain organic certification for such fields. Others were using synthetic fertilizer but no pesticides on a long-term basis. PFP became a label for reduced-pesticide practices that these farmers were already implementing. Farmers in transition to organic production were interested in PFP as a market for transitional crops. In this dryland region, soil erosion and water conservation are important considerations, leading some farmers to state that the combination of zero-tillage and regular PFP may be more sustainable than organic production that relies more heavily on tillage for weed control.

Only 44% of the 25 participants who were in transition to organic planned to convert their entire farm to organic, even though this is required by many certification agencies[24] (data not shown). PFP may provide an alternative for farmers who are interested in organic production but prefer not to convert their entire farm.

Field selection for PFP attempts

From a list of options, farmers were asked to choose their reasons for attempting PFP on the given field. All certifiable, transitional fields were selected for PFP because of their transitional status. Among the other two groups, there were differences with respect to the distribution of reasons for field selection. Nineteen percent of certifiable, nontransitional fields were selected for PFP 'by default'; meaning that the window for herbicide application was missed or that the field was underseeded to a forage species that did not permit herbicide application. Selection of fields for PFP on the basis of advance preparation for reduced-input crop production was the most common reason given for both noncertifiable fields (63%) and certifiable, nontransitional fields (71%). A lower proportion of fields in both groups was selected without the farmer indicating

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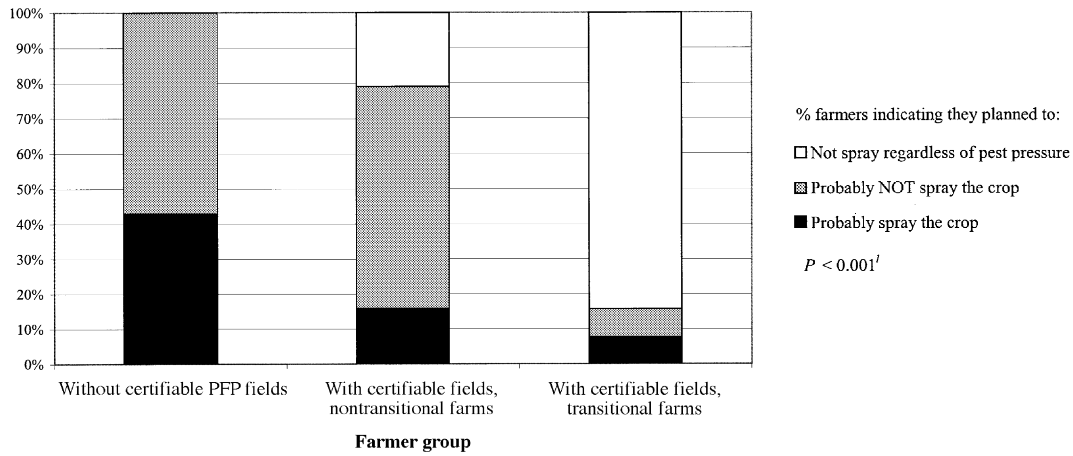

Figure 1. Farmers' approach to Pesticide Free Production (PFP) during early-season crop development ($n = 32$; question asked in 2001 only). [1]Analysis was based on differences in distribution of approaches, rather than proportion of responses for each approach.

any advance preparation for reduced inputs, with 25% of noncertifiable fields and 11% of certifiable, transitional fields selected for this reason.

Farmer commitment to PFP during early-season crop development

During the initial stages of the project, the level of commitment towards implementing PFP was significantly different among groups ($P < 0.001$) (Fig. 1). Compared to farmers with certifiable fields, a relatively large proportion of farmers without certifiable fields indicated that their PFP attempt would likely not be successful because they probably would apply pesticide to the field. Similarly, a larger proportion of farmers with certifiable fields indicated that they planned not to spray the field regardless of the level of pest or weed infestation, as compared to farmers without certifiable fields. Results suggest that farmers with certifiable fields had a somewhat higher level of commitment to achieving PFP certification than farmers without certifiable fields.

Demographic characteristics of participants

Age and number of years of farming experience. Age group was not significantly different among project participants, nor between participants and the random sample of Manitoba farmers (Table 2). As a comparison, 67% of Manitoba farmers were under 55 in 2001[26]. The average number of years of farming experience was also not significantly different among groups (Table 2). While younger, less experienced farmers are expected to be more environmentally aware and more likely to adopt sustainable practices[23], there is no consensus regarding the relationship between farmers' age and environmental concern[11].

Farm income and off-farm employment. There were no significant differences in net farm income categories among groups (Table 2). While higher income is often associated with early adoption of traditional technologies[27], farmers' income and environmental concern are generally not significantly related[11]. Net farm income of project participants was not significantly different from that found in the random sample of Manitoba farmers. The average net farm income in Manitoba in 2001 was $21,815 (Canadian dollars)[28].

There were no significant differences in the level of off-farm employment among groups (Table 2). However, off-farm employment in all groups was less than the Manitoba average (46% in 2001)[26]. There is no consensus regarding the relationship between off-farm income and pesticide use reduction[11]. Farmers with off-farm employment may find it less risky to experiment with pesticide use reduction because they have an alternative income. On the other hand, farmers without off-farm employment might have time to manage their systems intensively in order to achieve pesticide use reduction.

Educational level. Farmers with certifiable fields, transitional farms and farmers without certifiable fields had significantly higher proportions of post-secondary education than the random sample of Manitoba farmers ($P = 0.03$) (Table 2). Classical technology adoption theory predicts that farmers with more education will be more likely to adopt new innovations[27]. It would therefore be expected that farmers with higher levels of education would be more likely to implement pesticide use reduction. However, there was a decreasing proportion of participants with post-secondary education among groups with greater reductions in pesticide use ($P = 0.10$) (Table 2). This lends some support to criticism of the classical technology adoption theory on the grounds that it does not adequately describe the adoption of nontraditional, environmental innovations. Despite this, results do indicate that the majority of project participants had higher than average levels of education. Most comparisons between conventional and organic farmers do not show significant differences in level of formal education[11,25].

Field and farm size. Field sizes for all participant

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groups ranged from 3 to 130 ha. Average field sizes were not significantly different among participant groups ($P = 0.065$) (Table 3). However, certifiable, nontransitional fields tended to be smaller than certifiable, transitional fields. It appears that farmers who were not in transition to organic production were more likely to implement pesticide use reduction on smaller fields, which is consistent with classical technology adoption theory regarding the initial stages of adoption[27]. However, average field sizes for all participant groups were larger than the 21 ha average field size for annual crops in Manitoba[19], and larger than the average field size on organic farms in the NGP (17.6 ha)[29]. This indicates that fields on which PFP was implemented were relatively large in the context of typical Manitoba farms, and suggests that participating farmers were willing to experiment with pesticide use reduction on a relatively large scale.

Farmers operating smaller farms may be more likely to adopt sustainable practices[16,23]. However, the role of farm size in the adoption of sustainable farming practices has been inconsistent in most comparative studies[25]. Average farm size was not significantly different among participant groups, nor between the three participants groups and the random sample of Manitoba farmers (Table 3). Average farm size for all participant groups was larger than the Manitoba average of 361 ha in 2001[28]. Our results suggest that PFP is of interest to farmers operating relatively large farms.

Number of people involved in farm operation. The number of people involved in the farm operation was not significantly different among groups, nor was the land area farmed per farm operator (Table 3).

Land tenure. The proportion of rented fields was not significantly different among groups (Table 3). There were no significant differences among groups in terms of the proportion of farm land that was rented (Table 3). There is conflicting evidence over the role of land ownership in the adoption of sustainable farming practices[8]. Tenancy (rather than ownership) has been found to be negatively related to the adoption of sustainable practices[16]. However, economic pressures may override incentives for conservation associated with land ownership[30].

Production of livestock. The integration of livestock into the farm operation can increase the use of forages and allow for herbicide use reduction[31]. In the present study, the proportion of farms producing livestock (primarily beef cattle) was not significantly different among participant groups and the random sample of Manitoba farmers (Table 3). Values were similar to those reported by Statistics Canada[28].

Production of pedigreed seed. There were no significant differences in the proportion of pedigreed seed growers in each group (Table 3). In 2002, 680 farms in Manitoba produced certified seed (Iris Yuill, Manitoba Seed Growers Association, personal communication), representing 3.6% of Manitoba farms. Pedigreed seed

Table 2. Demographic and attitudinal characteristics of farmers attempting to produce Pesticide Free Production (PFP) crops.

Group	Mean years farming experience	Age 55 or less	Net farm income >US$25,000	Off-farm work	Post-secondary education	Previous PFP crop	Mean ACAP score[1]
		- - - - - - - -	- - - - - - - %	- - - - - - - -	- - - - - - - -		
On-farm study participant groups							
Without certifiable PFP fields	27.3 (2.83)[2]	61.5	83.3	20.0	76.9a	25.0a	88.0 (3.85)a
With certifiable fields, nontransitional farms	22.6 (1.15)	88.9	52.0	39.3	65.4a	53.6a	92.2 (1.79)ab
With certifiable fields, transitional farms	26.9 (1.86)	72.7	66.7	39.1	50.0ab	66.7b	97.9 (2.55)b
Random sample of Manitoba farmers[3]		74.7	72.6	–	43.4b	–	88.9 (1.05)a
P value for PFP participant group effect	0.11	0.12	0.61	0.29	0.10	0.02	0.046
P value for random sample versus PFP groups	–	0.25	0.15	–	0.033	–	0.011
n[4]	65	62	58	66	61	65	61

a, b Means followed by the same letter within columns are not significantly different ($P > 0.05$) according to Fisher's protected LSD.
[1] Primary operator's score for Alternative–Conventional Agricultural Paradigm scale (ACAP); scores range from 24 to 120, with lower scores indicating adherence to a conventional paradigm[9].
[2] Numbers in parentheses represent standard errors. Standard errors are not reported for percentage values that represent yes/no responses.
[3] Random sample of 154 Manitoba farmers conducted by Ipsos Reid Corp. (Winnipeg, MB).
[4] Number of observations within PFP groups only.

Table 3. Demographic characteristics of farms on which Pesticide Free Production (PFP) was attempted.

Farmer group	Mean farm size	Mean field size	Mean no. farm operators	Mean ha per operator	Mean rented land per farm	Project field rented	Pedigreed seed farms	Livestock farms
	- - - - - - - - - - - - - - - - -	- - - - - - - - - - - - - - ha	- - - - - - - - - - - - - - - -	- - - - - - - - - - - - - - - - -		- - - - - - - - - -	%	- - - - - - - - - -
On-farm study participant groups								
Without certifiable PFP fields	669 (98.5)[1]	31.3 (4.29)	2.6 (0.40)	283 (40.8)	17.6 (4.51)	5.6	20.0	46.7
With certifiable fields, nontransitional farms	655 (87.8)	25.5 (2.30)	2.6 (0.20)	271 (32.4)	25.3 (4.18)	14.8	21.4	42.9
With certifiable fields, transitional farms	528 (79.0)	38.6 (6.09)	2.1 (0.19)	235 (33.6)	24.4 (5.67)	18.8	34.8	43.5
Random sample of Manitoba farmers[2]	495 (34.1)	–	–	–	–	–	–	37.7
P value for PFP participant group effect	0.51	0.065	0.19	0.65	0.55	0.40	0.26	0.87
P value for random sample versus PFP groups	0.16	–			–	–	–	0.84
n^3	66	120	66	66	66	114	66	66

[1] Numbers in parentheses represent standard errors. Standard errors are not reported for percentage values that represent yes/no responses.
[2] Random sample of 154 Manitoba farmers conducted by Ipsos Reid Corp. (Winnipeg, MB).
[3] Number of observations within PFP groups only.

growers are highly represented in all PFP participant groups. Seed growers may be more likely to have the intensive crop management skills required to implement pesticide use reduction. They also tend to have increased access to grain-cleaning facilities to reduce the impact of weed seeds that are separable from grain. However, contamination tolerances for weeds in seed crops are very low, and seed growers may be concerned about weed densities in fields intended for seed production subsequent to PFP. Some participants did select fields for PFP that were intended for seed production, and stated that they terminated PFP attempts only because of the potential impact of weeds on the certification of the seed crop.

Affiliations with agricultural organizations. Membership in different types of farm organizations may be representative of, or may influence, farmers' perceptions of acceptable farming practices and knowledge of sustainable practices[10,22]. There were, however, no significant differences in organizational affiliation among groups in this study (Table 4).

Agricultural paradigm scores

There were significant differences in average Alternative–Conventional Agricultural Paradigm (ACAP) scale scores among participant groups (Table 2). Farmers without certifiable fields had a significantly lower average ACAP score than farmers with certifiable fields, transitional farms. This indicates adherence to a more conventional paradigm among farmers without certifiable fields. Farmers with certifiable fields, nontransitional farms had an average ACAP score intermediate to, but not significantly different from, both other groups. The average ACAP score of the random sample of Manitoba farmers was not significantly different from either of the 'conventional' groups of participants, but was significantly lower than the average score of farmers with certifiable fields, transitional farms (Table 2). This indicates that participating farmers who were not in transition to organic had attitude scores typical of Manitoba farmers. Beus and Dunlap[9] found that members of known alternative agriculture groups had average scores of 90 or over on this scale, while a random sample of farmers in Washington State had an average score of 80.9. Allen and Bernhardt[16] found that farmers using alternative production practices scored over 89, while those using conventional production practices scored below 80. In our study, average scores for all PFP participant groups and the random sample of Manitoba farmers were over 88, suggesting that paradigmatic orientations of North American farmers may be shifting toward the alternative paradigm, or that attitudes vary by region. Our findings support previous work indicating that farmer paradigmatic orientation is related to production practices[17], in terms of farmer adoption of organic production.

Farmers' perceptions related to PFP

Perception of PFP as an acceptable practice. The proportion of farmers stating that they thought PFP was a practice acceptable to most farmers was not significantly

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Table 4. Affiliation of farmers attempting Pesticide Free Production (PFP) with agricultural organizations (n = 66).[1]

	Agricultural organization				
Farmer group	**Sustainable**[2]	**General**	**Commodity**[3]	**Other**[4]	**None**
	% farmers				
Without certifiable PFP fields	12.5	56.3	37.5	6.3	31.3
With certifiable fields, nontransitional farms	29.6	33.3	14.8	7.4	21.9
With certifiable fields, transitional farms	30.4	34.8	43.5	0.0	30.4
P value	0.38	0.28	0.07	0.46	0.91

[1] Farmers could belong to more than one group.
[2] Organic producer groups, zero-tillage groups, National Farmers' Union, or sustainable agriculture societies.
[3] For example, canola, cattle or seed producers' associations.
[4] Other, nonagricultural, rural community groups, e.g., municipal drainage committee.

Table 5. Farmers' perceptions of Pesticide Free Production (PFP) and weed densities.

Farmer group	**PFP was financially beneficial**	**Expect to increase future pesticide use**[1]	**PFP is acceptable to the majority of farmers**	**More tolerant to weeds than most farmers**
	%			
Without certifiable PFP fields	–	–	30.8	28.6
With certifiable fields, nontransitional farms	90.3	6.0	35.7	30.0
With certifiable fields, transitional farms	90.9	0.0	40.9	54.6
P value	1.00[2]	1.00[2]	0.54	0.36[2]
n	53	30[3]	63	38[3]

[1] On the certifiable PFP field, as a result of having grown a PFP crop.
[2] Fisher's exact test was used due to small sample size.
[3] Small sample size because question asked of producers only in 2001.

different among groups (Table 5). The perception that a practice is accepted by the farming community is important in its adoption[8], and may influence adoption more than farm demographic characteristics[11]. About one-third of farmers in all groups stated that they consider PFP to be a generally acceptable practice.

Perception of the financial outcome of PFP. Over 90% of farmers with certifiable fields stated that PFP was at least as profitable as producing a conventional crop (Table 5). Because premium markets for PFP grain were not yet established when this study was conducted, all farmers indicated that financial benefits were due to reductions in input costs. Many farmers indicated that the profitability of PFP was due to their management and selectivity in choosing fields for PFP. Other studies have demonstrated that production of crops without in-crop herbicide can result in similar average gross returns when compared to crops receiving herbicide[32]. Farmers' perceptions of the economic outcome of reduced pesticide use are critical to its adoption[11]. Positive perceptions of the financial viability of PFP support its potential for adoption.

Tolerance to weed densities. The proportion of farmers stating that they were more tolerant to weed pressure (than they would expect other farmers to be) was not significantly different among groups (Table 5).

Satisfaction with certifiable PFP. Farmers with certifiable fields were asked to rate their satisfaction with producing a PFP crop as good, fair or poor. Differences between the two certifiable groups were significant ($P = 0.04$). Satisfaction was relatively low for certifiable, transitional fields (50% good, 36% fair, 14% poor), but higher for certifiable, nontransitional fields (74% good, 19% fair, 8% poor). Ninety-eight percent of farmers with certifiable fields surveyed 1 year after harvest indicated that they had no regrets about producing a PFP crop. This may reflect farmers' choice of suitable fields and their level of commitment to PFP. The need for good decision-making regarding field selection was frequently mentioned by participants as a requirement for successful pesticide use reduction.

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Previous experience with reduced pesticide crop production

There were significant differences in the proportion of farmers in each group who stated they had grown a crop without in-crop pesticide prior to attempting a PFP crop as part of this project (Table 2) ($P = 0.02$). Farmers with certifiable fields, transitional farms had significantly more experience with pesticide-free crops compared to the other groups. Other differences were not significant.

Future pesticide use intentions

Very few farmers stated that they thought they would have to increase their future pesticide use as a consequence of producing a certifiable PFP crop, and there were no significant differences among groups (Table 5). The majority of farmers also indicated that weed densities were manageable with their regular herbicide regime the year after PFP (data not shown). This supports the idea that PFP can allow for an overall reduction in pesticide use in a long-term cropping system.

Future intentions to produce PFP crops

Interest in future implementation of PFP was focused on spring and winter cereals; however, farmers suggested virtually every major crop in this region for future PFP attempts. There were no significant differences among groups in the proportion of farmers indicating that they would be interested in implementing PFP regularly depending on the availability of a marketing premium (Fig. 2). However, the level of interest in future PFP was lowest among farmers without certifiable fields.

When asked how long they would wait until attempting PFP on a field on which they had previously attempted PFP, farmers without certifiable fields were most likely to be unsure (75%) (data not shown).The majority of farmers with certifiable fields, transitional farms were planning to implement PFP the following year as part of their transition to organic production. More than half of farmers with certifiable fields, nontransitional farms indicated that they would try PFP on the same field within 3 years, but only 13% indicated that they would attempt it on the same field 2 years in a row. Eighty percent of participants with certifiable fields intended to attempt PFP on some part of their farm the year following project participation (data not shown).

Several farmers suggested that their implementation of PFP in the future would depend on their crop rotation as well as premium marketing opportunities. A number of farmers indicated that they did not plan to alter their current management to achieve PFP, but would only implement PFP opportunistically on fields that happened to have low weed densities. Other participants suggested that they were trying to reduce their agrichemical input use regardless of whether or not they met PFP guidelines, but were still interested in being part of a group of farmers interested in pesticide use reduction.

Participants cited a number of barriers to PFP adoption. The availability of a marketing premium as an incentive was most commonly cited, followed by high weed densities requiring herbicide application. Other, less commonly cited, barriers included restrictions regarding use of residual herbicides; overcoming farmers' expectations of weed-free fields resulting from herbicide application; achieving identity-preserved separation of PFP grain; weed seed production in the absence of herbicides; management skills required for PFP; and lower crop yields.

Marketing premiums required by participants

Participants were asked what marketing premium they would require for regular implementation of PFP. Data for 2001 only were used, because of the lack of response to an

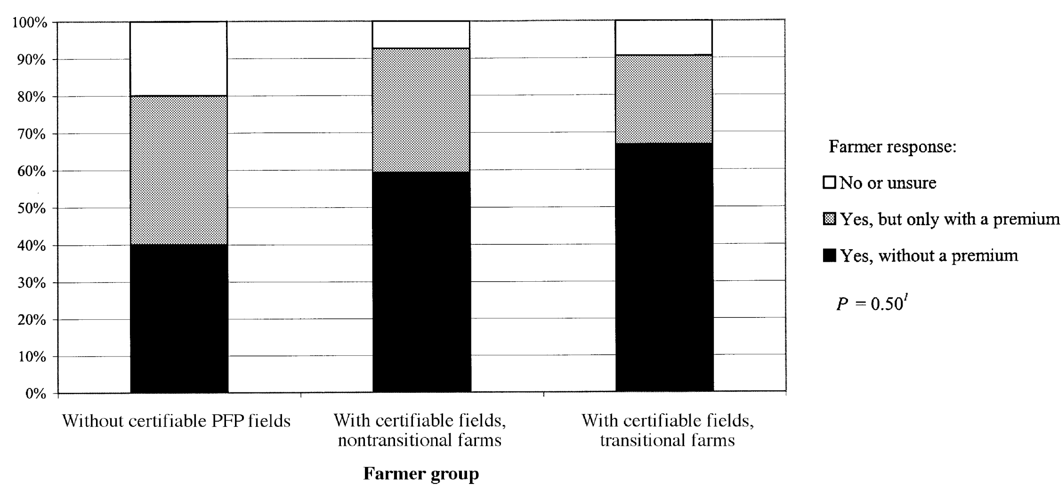

Figure 2. Response of farmers to the question 'Would you try Pesticide Free Production (PFP) in a regular crop rotation?' ($n = 63$). [1]Analysis was based on differences in distribution of responses, rather than differences in proportion of responses for individual categories.

open-ended question in 2000. Farmers suggested that price premiums in the range of 20% above conventional grain prices for wheat, oats, barley and flax would be required, and farmers with certifiable fields, nontransitional farms tended to suggest the lowest premiums (data not shown). The suggestion of relatively high premiums by farmers without certifiable fields may be an indication of their high level of interest in marketing as a reason for PFP, while those with certifiable fields, nontransitional farms may require less compensation because of high interest in PFP for other reasons (Table 1). For farmers with certifiable fields, transitional farms, the requirement for premiums may reflect the expectations of high premiums for organic production. A recent survey regarding consumer interest in PFP food products indicated that there is a high probability that Canadian consumers are willing to pay low to moderate premiums for PFP food products at the retail level[6].

Summary and Conclusions

Demographic characteristics of participants were generally similar regardless of their level of success with PFP. This suggests that demographic characteristics did not strongly influence participants' success in implementing PFP. Participants with certifiable fields, transitional farms had a significantly higher average ACAP scale score compared to those without certifiable fields, indicating stronger adherence to an alternative agricultural paradigm. However, the average ACAP score of participants with certifiable fields, nontransitional farms was not significantly different from other groups. This suggests that farmer attitudes may be more important for the adoption of organic production than for the implementation of PFP.

There were also few differences between participants and their farms and average farmers and farms in Manitoba. One exception was that PFP project participants who were not in transition to organic production had higher levels of education than is typical of Manitoba farmers. The paradigmatic orientation of farmers interested in PFP, who were not in transition to organic production, was similar to that of a random sample of Manitoba farmers. Fields and farms on which PFP was implemented were relatively large in the context of Manitoba averages. Our findings indicate that farmers who were interested in, and successfully implementing, PFP independently of a transition to organic production can be considered to be typical farmers for this region. Pesticide Free Production therefore shows good potential to be broadly adopted in this region. If farmers implemented PFP once every 4 years on one-third to one-half of their farms, land treated with pesticide would be reduced by approximately 8–12%. Our results also suggest that the development of this pesticide use reduction approach (PFP) could be facilitated via mainstream rather than marginal extension channels.

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