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Canadian Manure Management Practices on Cropland from the Farm Environmental Management Survey (FEMS) 2011

Canada

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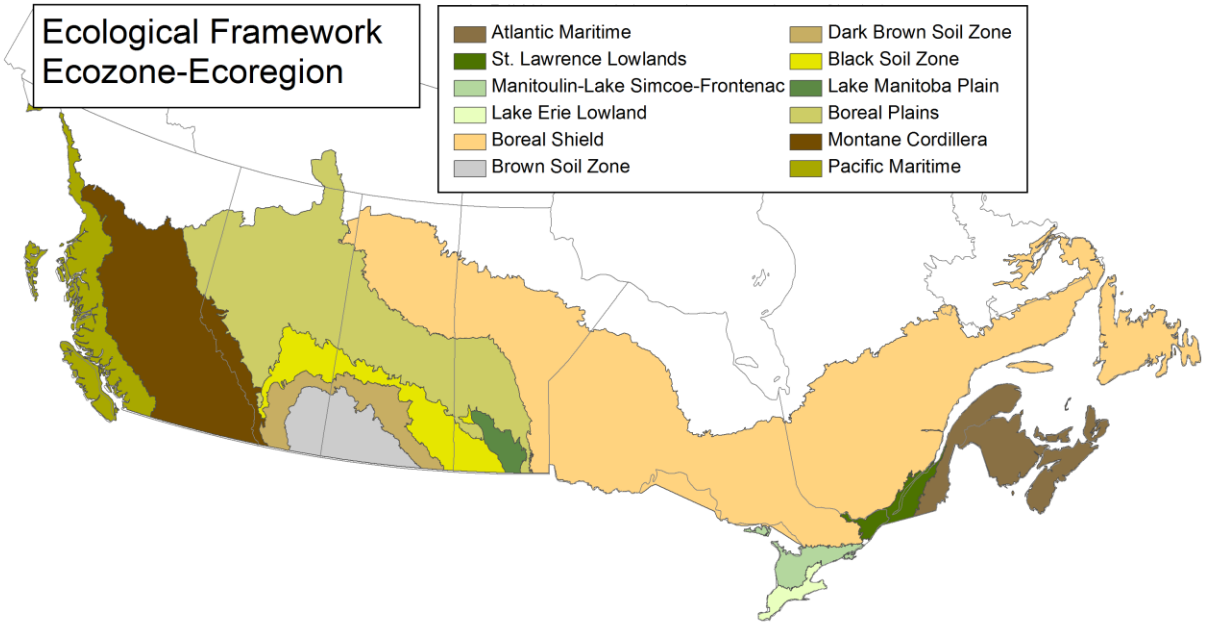
Executive Summary

This report provides key findings regarding Canadian manure management practices on cropland as reported in the Farm Environmental Management Survey (FEMS) 2011 survey. The FEMS 2011 survey was conducted by Statistics Canada in partnership with Agriculture and Agri-Food Canada (AAFC). Similar questions were designed for liquid and solid manure. By analyzing these separately it is possible to compare practices for these two different manure sources. Results are provided for Canada as a whole, and also smaller units such as province, ecoregion, crop type, or livestock type. Where possible comparisons are made with results from the FEMS 2006 survey. Finally, this report does not address the amount of manure produced on Canadian farms, nor the rates of manure application on land, since FEMS did not collect this type of information.



Source: Statistics Canada

1. Fate of Manure Produced on Livestock Farms

A large majority of farms spread all of their stored manure in 2011 on their own operation, 76% for solid manure and 87% for liquid manure. This is a reflection of available cropland to receive manure, the benefits of manure land application, and possibly the prohibitive cost of transporting manure great distances.

For both manure types, only about 4% of farms removed all of their manure from their operation. This practice was most common on poultry farms, 30% for solid manure and 35% for liquid manure, but also more prevalent on pork farms with liquid manure (12%). These trends are likely because more farms of these types do not have land available to apply manure. This practice also occurred more often in the Pacific Maritime ecoregion for solid manure (12%) and in Manitoba for liquid manure (13%). This is possibly a reflection of greater concentration of landless poultry farms in the Pacific Maritime ecoregion and landless pork farms in Manitoba.

About 8% of farms with stored solid manure kept all of it in storage in 2011, whereas only 2% of farms with stored liquid manure kept all of it in storage. Keeping solid manure in storage was most prevalent in the prairie provinces / ecoregions and the Montane Cordillera ecoregion of B.C. (ie. 20 to 25%). This practice was also most prevalent with beef farms (17%). On beef farms solid manure accumulates in outdoor confined feeding bedding packs. These manure/bedding packs are typically removed after a feeding cycle is finished, but the manure may be stockpiled for a period of time before land application.

Comparison with FEMS 2006 also shows that a large majority of farms spread all of their manure on their operation. However, in 2006, the percent of farms that removed all of their manure from their operation was slightly higher, while the percent that kept all of their manure in storage was lower.

2. Crop Types Grown on Land Receiving Manure

Across Canada, land receiving solid manure was used for growing perennial forages (45%), cereals (27%), corn (14%), and oilseeds (9%) in 2011. Land receiving liquid manure was used for growing perennial forages (39%), corn (32%), oilseeds (14%), and cereals (14%).

In the prairie provinces / ecoregions the percent of land area in perennial forage and corn was somewhat less, but greater for cereals and oilseeds for both types of manure, compared to other provinces / ecoregions.

Dominant use of manured land for growing perennial forages, corn, and cereals is a reflection of the feed needs of livestock farms that produce manure, even though corn and cereals could also be grown for other purposes.

In 2006, a somewhat higher percent of farms used manured land for growing corn and cereals for both manure types, and a lower percent of farms grew perennial forages on land receiving solid manure.

3. Extent of Manure Application

This section reports extent of manure application in two ways. The first is based on total cropland area. The second is based on only farms that applied manure and specific crop types on those farms that received manure.

a) Area of Manured Land versus Total Cropland

Across Canada, a very small percentage of cropland area received manure application in 2011, 6.3% for solid manure and 4.2% for liquid manure.

However, these values were higher for specific crop types. For example, 21% and 19% of perennial forage and corn land received solid manure application, and 12% and 29% of perennial forage and corn land received liquid manure application, respectively. These higher values can be attributed to livestock farms that utilize their manure to grow these crop types for feed on their own operations. Greater utilization of liquid manure on corn land may be associated with dairy and pork farms which most commonly produce this type of manure. The percent of cropland receiving solid or liquid manure is considerably less in the prairie provinces / ecoregions (0 to 6%) compared to other provinces / ecoregions (9 to > 50%). This is

likely due to larger cropland areas per farm and also a lower percentage of livestock or mixed farms in the prairies.

Comparison of these results with FEMS 2006 was not possible due to different analysis methodology.

b) Extent of Manure Application for Farms Applying and Crop Types Receiving Manure

When considering only farms across Canada that apply manure and crop types on these farms that received manure, a much higher percentage of acres received manure based on these crop types versus total cropland (ie. 29% for solid manure and 58% for liquid manure). These higher values also hold true for most ecoregions, provinces, and specific crop types. This is a reflection of the relatively low percent of farms that apply manure, particularly in liquid form. The higher percentage of acres receiving liquid manure may be an indication of greater ability to transport liquid manure long distances and/or apply manure at lower rates.

Differences between ecoregions, provinces, and crop types are somewhat similar to the previous section, except not nearly as great. Smaller differences are expected since farms with no manure application are removed from the analysis. Similar trends means that most regions or crop types receiving less manure on a total cropland area basis, are also receiving less manure on farms where it is applied. For regions like the prairies, the first reason in the previous section, namely larger cropland areas per farm still applies. However, there may be other reasons for regional differences, such as varying regulations in different provinces that may influence the percent of land that receives manure application.

Comparison of these results with FEMS 2006 was not possible due to different analysis methodology.

4. Frequency of Manure Application

Frequency of manure application in this survey means how often land typically receives manure, not how often a manure storage is emptied or pumped. Applying manure “once per year” was the most common frequency across Canada, but the percent of acres was higher for solid (53%) than liquid (40%). Also, a much higher percent of acres received liquid manure “twice a year” (31%) or “> twice a year” (14%), than solid manure (10% and 4%). This is likely due to many farms not having enough liquid manure storage capacity to land apply only once per year.

For both manure types, applying “> once per year“ was less prevalent in prairie provinces / ecoregions. For solid manure, applying “> once per year” was somewhat more prevalent for perennial forages and corn compared to other crop types. For liquid manure, applying “> twice per year” was much more prevalent for perennial forages.

The lowest frequency of manure application “< once every two years” occurred most often in the prairies and Ontario (20 - 25%) and on cereal and oilseed crop types (15 - 30%). This may be a reflection of larger cropland areas per farm with more land available to receive manure.

The highest incidence of “> twice per year” for liquid manure in the Pacific Maritime ecoregion (48%) is likely associated with dairy farms growing multiple harvests of grass forage each year.

This question was not included in the FEMS 2006 survey.

5. Season of Manure Application

Across Canada, most land received solid manure application in fall (43%) or spring (25%). For liquid manure season of application was fairly evenly split between spring (25%), fall (22%), and "spring & fall" (23%). For both manure types a smaller percentage of land (< 12%) received manure in summer, "spring & summer", or other periods.

While fall application increases risk of environmental impacts (eg. loss of nutrients and pathogens) this risk may be reduced in regions with lower precipitation and/or frozen soils in winter. Indeed, the highest rates of fall application occurred in the semi-arid prairie region (51% for solid and 39% for liquid manure) where soils are frozen for the longest period. Conversely, the lowest rate of fall application (20% for solid and 13% for liquid) occurred in the high rainfall Pacific Maritime ecoregion, where soils often remain unfrozen over winter.

Corn land received more manure of both types in spring and less in fall, compared to other crop types. This may be reflective of areas where corn is more commonly grown, such as Quebec, Ontario, and B.C, as opposed to the prairies.

In 2006 more manure of both types was applied in spring and/or summer, and less in fall.

6. Method of Manure Application

a) Solid Manure

The survey asked if solid manure was incorporated, but not how it was applied, because all solid manure is inherently broadcast applied. After application about 50% of acres, across Canada, had this manure incorporated with tillage equipment. For different geographic areas incorporation ranged from 25% to 75% of area, with lower percentages in the Atlantic provinces/ecoregion and Quebec, and higher values in the prairie and Ontario ecoregions/provinces.

Incorporation of manure on perennial forages was much lower (20%) than all other crop types (80%). It is actually not possible to incorporate manure on established forages without adversely impacting the forage stand, so it is assumed that any incorporation on perennial forages was done prior to establishment. Lower incorporation in Atlantic and Quebec regions can likely be attributed to greater incidence of perennial forages on solid manured land.

In 2006, somewhat more farms (60%) incorporated solid manure, likely due to a lower percentage of perennial forages receiving manure, as already indicated in section 2.

b) Liquid Manure

Across Canada, the most common method for applying liquid manure was a "low boom applicator, below crop canopy" (37%), with most of this occurring in Quebec (62%). "Spread and worked into the soil" and "spread and not worked into the soil" were used on 34% and 29% of acres, respectively. The first practice was most common in Ontario and the second most common in Atlantic regions and B.C. "Direct injection into the soil" was used on 13% of acres, with most of this occurring in the prairies, on cereal and oilseed crops.

Most applications on perennial forage land involved either “low boom applicator, below crop canopy” (44%) or “spread and not worked into the soil” (48%). This result is expected as all other methods could potential damage forage stands. Most applications on corn land involved either “spread and worked into the soil” (58%) or “low boom applicator, below crop canopy” (38%).

“Spread and not worked into the soil” is the least efficient method of application. However, not including perennial forage land, this practice was only used on about 10 to 20 % of other crop types.

In 2006, results were similar except for somewhat less “low boom applicator, below crop canopy” and more “spread and not worked into the soil”.

7. Timing of Manure Incorporation

This analysis is based on a subset of data from the previous question, involving land and crops where manure was “spread and worked into the soil”.

Across Canada, incorporation times were shorter for liquid manure than solid. For instance, 34% of land had liquid manure incorporated within one day of application, compared to 25% for solid manured land. At the other extreme, only 19% of liquid manured land was incorporated more than 2 days after application, compared to 42% for solid manured land.

There were few differences between ecoregions except for longer incorporation times in the prairies, most notably Saskatchewan for solid manure; and longer incorporations times in Ontario most notably the Lake Erie Lowland, for liquid manure.

There were also few differences between crop types, except for shorter incorporation times for liquid manure on oilseed cropland and solid manure on corn land.

Results from 2006 were very similar to 2011.

8. Testing of Manure for Nutrient Content

Almost half (49%) of farms tested liquid manure for nutrient content, but only 11% of farms tested solid manure. Greater testing of liquid manure could be due to its more homogeneous composition resulting from agitation prior to land application, and/or greater nutrient management planning/regulation associated with large intensive livestock operations. While solid manure may also include these types of operations, a significant percentage of farms with solid manure involve smaller beef cow/calf producers.

With both types of manure there was considerable variability between provinces, with Quebec reporting the greatest percent of farms testing solid manure (41%) and liquid manure (71%). There was less variability between crop types, except for a somewhat higher percentage of farms with corn land testing solid manure (20%).

In 2006 similar results were found, except for a somewhat lower percentage of farms testing for liquid manure (42%).

9. Decision Factors for the Rate and Amount Of Manure To Apply

Respondents were asked to rate the importance of 9 different factors for deciding on the rate and amount of manure to apply. For solid manure “past experience”, “crop nutrient requirement”, “land available”, and “growing conditions” were the most important. For liquid manure the most important factors were “crop nutrient requirement”, “soil testing”, and “past experience”. In general, most liquid manure factors were ranked higher than solid manure factors, suggesting that rate and amount of liquid manure is more carefully managed than solid manure.

For both manure types, farms from Quebec ranked most factors higher than in other provinces. Also, for both manure types, farms that grew corn indicated greater overall importance for decision factors and farms that grew perennial forages indicated less importance.

In 2006 the structure of this question and wording of specific factors was slightly different. Nevertheless, results appear to be somewhat similar, with a few exceptions. In 2006, for solid manure, “soil testing” and “manure transport” were more important, and “growing conditions” were less important. For liquid manure, “land available to apply manure” was more important in 2006.

A. Introduction

This report provides key findings regarding Canadian manure management practices on cropland as reported in the Farm Environmental Management Survey (FEMS) 2011 survey. The FEMS 2011 survey was conducted by Statistics Canada in partnership with Agriculture and Agri-Food Canada (AAFC). Analysis and results provided in this report were generated by AAFC's Science and Technology Branch (STB). Specific aspects of manure management included in this report are extent of land area and crop types receiving manure, application method, season and frequency of application, manure nutrient testing, and decision factors for applying manure. This report does not address the amount of manure produced on Canadian farms, nor the rates of manure application on land, since FEMS did not collect this type of information. Finally, this report compliments another FEMS 2011 report entitled “Canadian Manure Storage and Treatment Practices”.

B. Geographic and Sector Framework

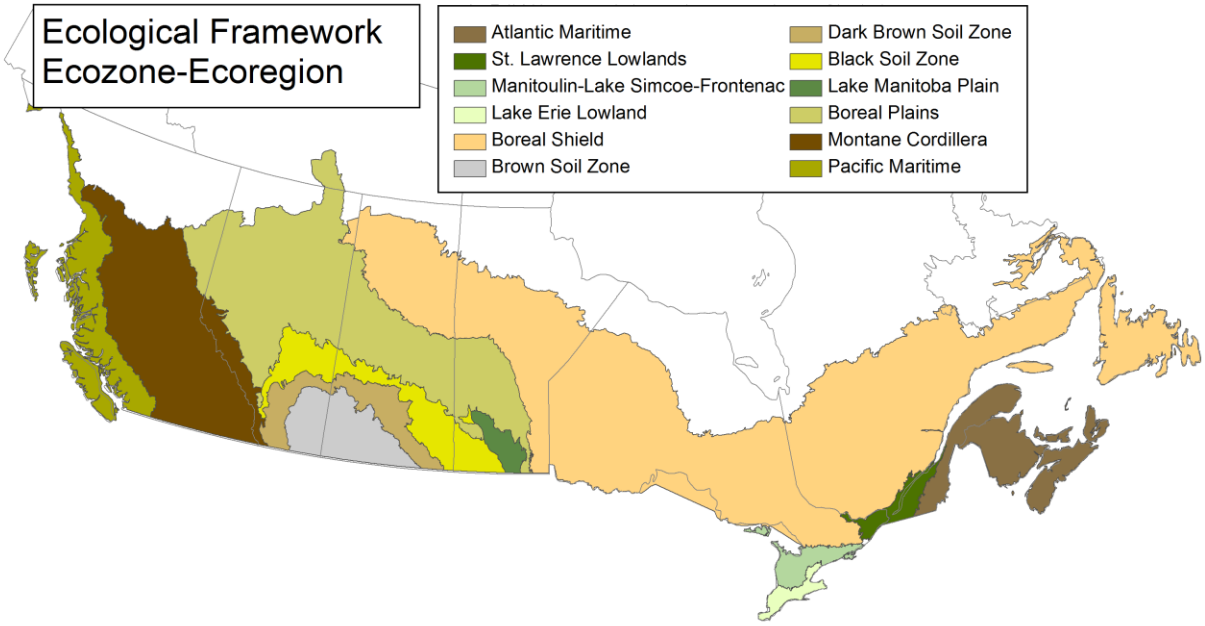
Results are provided by province and by ecozones-ecoregions. Ecozones-ecoregions are based on Canada’s national ecological framework (see the following website: http://sis.agr.gc.ca/cansis/nsdb/ecostrat/index.html). In this framework, large ecozones are made up of smaller ecoregions. For this survey, only ecozones with significant agricultural land were chosen, and some ecoregions were used for areas with higher areas of agricultural land and/or number of farms. The relationship between the national ecological framework and the FEMS ecozones-ecoregions is shown in Table 1. The FEMS ecozones-ecoregions are shown in Figure 1.

Table 1: Relationship Between Canada's Ecological Framework and FEMS Ecozone-Ecoregions

Canada's National Ecological Framework		FEMS Ecozone-Ecoregion
Ecozones	Ecoregions	
Atlantic Maritime		Atlantic Maritime
Mixedwood Plains	St. Lawrence Lowlands	St. Lawrence Lowlands
	Manitoulin-Lake Simcoe	Manitoulin-Lake Simcoe-Frontenac
	Frontenac	
	Lake Erie Lowland	Lake Erie Lowland
Boreal Shield		Boreal Shield
Prairies	Mixed Grassland	Brown Soil Zone
	Cypress Upland	
	Fescue Grassland	Dark Brown Soil Zone
	Moist Mixed Grassland	
	Aspen Parkland	Black Soil Zone
	Boreal Transition	
	Lake Manitoba Plain	Lake Manitoba Plain
Boreal Plains		Boreal Plains
Montane Cordillera		Montane Cordillera
Pacific Maritime		Pacific Maritime

Source: Environment Canada and Agriculture and Agri-Food Canada

Figure 1: FEMS Ecozones-Ecoregions

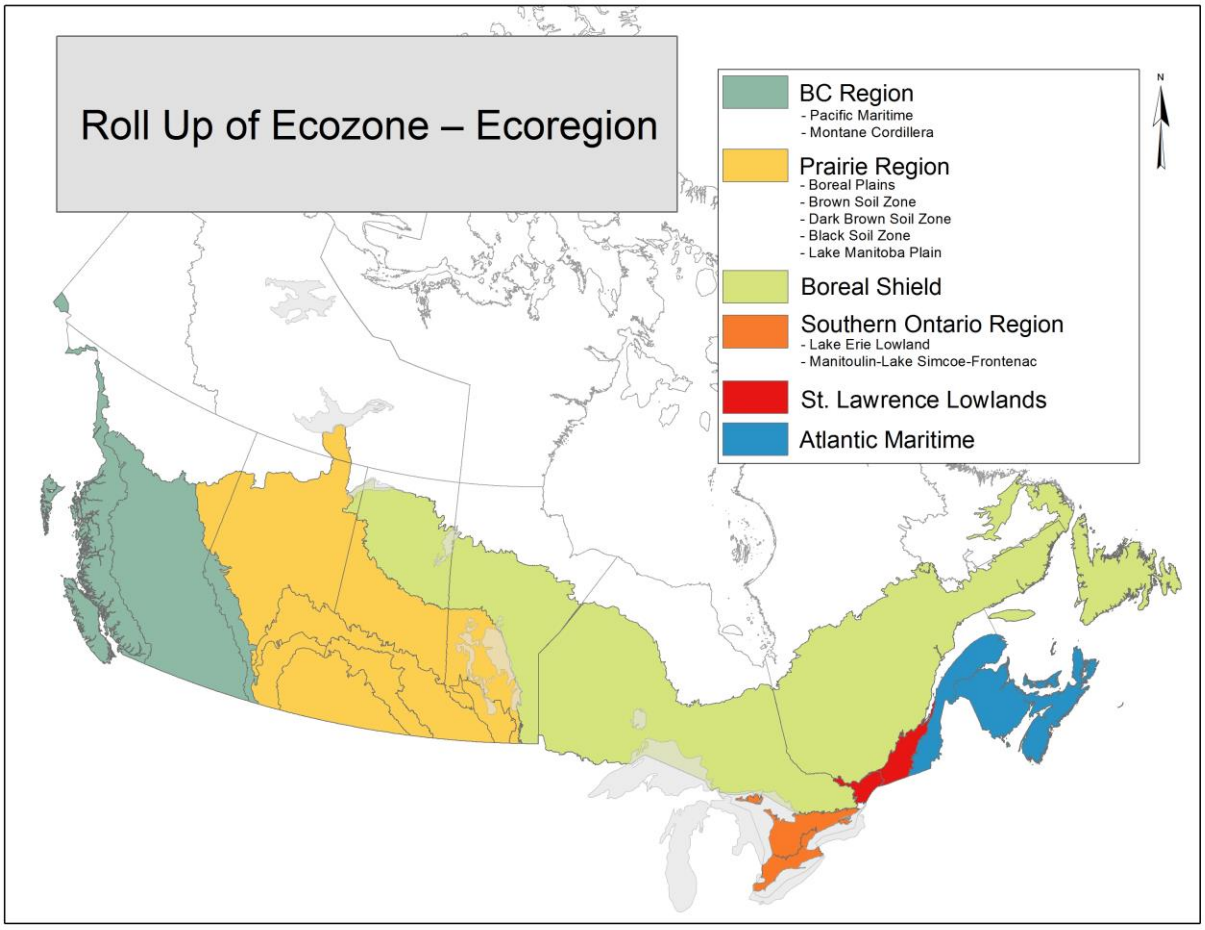


Source: Statistics Canada

For provincial reporting, results are also provided based on groups of provinces that have similar climate. Similarly, for ecozone-ecoregion reporting, results are also provided based on a roll up of groups that have similar climate, as shown in Figure 2.

In some cases results are provided based on livestock sector storing manure, such as dairy, beef, pork, poultry and other livestock. More commonly results are based on the type of crop receiving manure applications, such as cereals, oilseeds, corn, perennial forage, fruits & vegetables, and other. Hereinafter, for this report, "ecozones-ecoregions" are referred to as ecoregions for simplicity sake.

Figure 2: Roll Up of FEMS Ecozones-Ecoregions



Source: Statistics Canada and Agriculture and Agri-Food Canada

C. Survey Design and Analysis Methods

The FEMS survey was designed as two separate modules, livestock and crop, with farms completing only one of the two modules to reduce survey burden. About 7,000 farms completed each module, amounting to about 6.3% of all farms in Canada. Farms were selected from Statistics Canada's Farm Register (based on 2011 Census of Agriculture data) to adequately represent different regions and production sectors across the country. To be selected for the livestock module farms had to be classified as a livestock or mixed farm, while for the crop

module they were classified as crop or mixed farms, as defined by the farm registry. More information on the survey design and questionnaires can be found at: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5044&Item_Id=122432

Questions pertaining to manure application to cropland were asked in both the crop and livestock module. Similar questions were asked separately for solid manure, and liquid or semi-solid manure (Note: The latter is simply referred to as "liquid" from now on). However, as shown in Table 2a, for many farms, questions on only one type of manure were asked based on a screening question that first asked farmers which type of manure they spread more of on their operation. As a general rule farms that spread more liquid manure were not asked questions about solid manure, and farms that spread more solid manure were not asked questions about liquid manure. About 3 times more farmers answered questions pertaining to solid manure than liquid manure. Also, somewhat more farmers from the livestock module answered questions pertaining to manure land application than the crop module.

Table 2a: Percentage of Farms Answering Questions on Manure Application to Cropland based on the Screening Question "Which Type of Manure Did You Spread More Of On Your Operation?"

Farms Answering Manure Land Application Questions for	Module	**Farms that Spread More Of**				
		Solid (%)	Liquid or semi-solid (%)	Spread same amount of both (%)	Did not spread manure (%)	Total (%)
Liquid Manure	Crop		8.4			8.4
	Livestock		4.3	5.0		9.3
Solid Manure	Crop	31.4				31.4
	Livestock	38.6		3.8	0.8	43.2
Both Types of Manure	Crop			0.7		0.7
	Livestock			6.9		6.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Note for Table 2a: Percent values add up to 100.

Respondents were asked to report the two primary crop types receiving manure application, and the number of acres on which liquid or solid manure was applied on land growing these crops. Subsequent questions on specific management of manure on cropland were targeted to each crop type separately.

Results are always reported on a percentage of land area (ie. acres) or farms basis, not the actual number of acres or farms. Therefore, while this analysis involves a subset of total acres and farms, the sample size in most cases is considered large enough to represent reasonably well geographic regions or crop groupings on a percentage basis. As much as possible, results are reported on a percent of acres rather than farm basis, since the former provides a more accurate assessment of the degree to which various practices are undertaken.

Tables 2b and 2c provide an indication of how the dataset is apportioned on an acre basis among different types of manure and provinces, ecoregions, or sectors. When considering the results to specific questions throughout this report, it is useful to refer back to these tables to gain a perspective of the relative proportion of acres that are represented by these features. For example, while there may be interesting results for practices involving liquid manure

application in the brown soil zone, the significance of these results is diminished by the fact that this subset represents only 0.6% of the total land in Canada receiving manure application.

Table 2b: Percentage of Land Area Receiving Manure Application by Manure Type and Province [1]

Province	Manure Type	
	Liquid (%)	Solid (%)
Newfoundland	[2] x	0.04
PEI	0.3	0.5
Nova Scotia	0.7	0.6
New Brunswick	0.5	0.6
Atlantic	1.6	1.7
Quebec	17.5	10.3
Ontario	10.7	13.0
Manitoba	3.2	5.6
Saskatchewan	1.2	11.1
Alberta	4.5	16.4
Prairie	8.9	33.1
B.C.	1.2	2.0
Canada	39.9	60.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 2c: Percentage of Land Area Receiving Manure Application by Manure Type and Ecoregion [1]

Ecoregion	Manure Type	
	Liquid (%)	Solid (%)
[3] Atlantic Maritime	6.7	5.1
St. Lawrence Lowlands	12.5	6.3
Manitoulin-Lake Simcoe-Frontenac	5.7	8.3
Lake Erie Lowland	2.5	2.7
Southern Ontario	8.3	11.0
Boreal Shield	2.4	2.7
Brown Soil Zone	0.6	5.0
Dark Brown Soil Zone	1.3	7.0
Black Soil Zone	4.0	11.4
Lake Manitoba Plain	1.3	1.8
Boreal Plains	1.6	8.2
Prairie Region	8.8	33.4
Montane Cordillera	0.3	1.1
Pacific Maritime	0.9	0.5
[3] B.C. Region	1.2	1.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 2b and 2c:

[1] Percent values add up to 100 for all values within each table, and is based on total number of acres involving questions on manure land application. This approach allows one to compare different provinces or ecoregions for a specific type of manure (within column) and also compare different types of manure for specific provinces or ecoregions (within row).

[2] Values with an " x " indicate that data has been suppressed because there are not enough farm records to meet the confidentiality requirements of the Statistics Act. This symbol has the same meaning for all subsequent tables in this report.

[3] The B.C. Region in the ecoregion table does not include the Peace Region. The Atlantic Maritime region includes PEI, New Brunswick, Nova Scotia, and eastern Quebec. These definitions also apply to all subsequent ecoregion tables in this report.

In each reporting section below, each set of tables is followed by "key results" which highlight the primary differences between provinces, ecoregions, or livestock / crop sectors (where applicable). This is followed by "comments" which provide some interpretation and likely reasons for these results.

Finally, a brief comparison with FEMS 2006 is provided. In 2006 geographic analysis was only done on a percent of farm basis at the provincial level, not ecoregion, so comparisons are only made on this basis with 2011. However, farm based results from 2011 are not shown because they are usually very similar to the acreage based values. Also, in 2006 these questions were only asked in the crop module, which may result in a greater proportion of mixed farms in 2011. However, this did not appear to impact results in most cases. There may be other specific differences for specific questions as noted in each section.

Results are provided first for solid manure and then liquid manure. In the liquid manure sections additional comments are provided to compare results with solid manure for similar type questions.

D. Solid Manure Application to Cropland

1. Fate of Solid Manure Produced on Livestock Farms

Table 3a: Percentage of Farms Managing Stored Solid Manure in Various Ways Prior to the 2011 Growing Season, by Livestock Sector [1]

Sector [2]	[1] Spread on operation	[2] Removed from operation	[3] Remained in storage	[1] Spread on operation and [2] Removed from operation	All other combinations
Dairy	89.9	2.7	2.2	2.4	2.8
Beef	72.4	1.9	17.4	1.2	7.1
Pork	84.7	x	x	x	x
Poultry	55.9	30.0	x	9.1	3.7
Other [3]	70.0	8.5	8.2	x	12.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 3b: Percentage of Farms Managing Stored Solid Manure in Various Ways Prior to the 2011 Growing Season, by Province [1]

Province	[1] Spread on operation (%)	[2] Removed from operation (%)	[3] Remained in storage (%)	[1] Spread on operation and [2] Removed from operation (%)	All other combinations (%)
Newfoundland	x	x	x	x	x
PEI	77.7	x	x	x	x
Nova Scotia	79.1	x	x	x	x
New Brunswick	83.2	x	x	x	x
Atlantic	79.8	6.2	4.1	3.4	6.5
Quebec	87.5	4.0	2.4	1.9	4.2
Ontario	86.3	3.5	4.1	2.7	3.3
Manitoba	70.8	3.8	18.6	1.3	5.6
Saskatchewan	66.5	2.3	22.4	0.9	7.9
Alberta	67.1	2.2	20.9	1.0	8.8
Prairie	67.6	2.5	21.0	1.0	7.9
B.C.	59.7	11.5	17.7	4.3	6.8
Canada	75.6	3.5	13.1	1.8	6.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 3c: Percentage of Farms Managing Stored Solid Manure in Various Ways Prior to the 2011 Growing Season, by Ecoregion [1]

Ecoregion	[1] Spread on operation (%)	[2] Removed from operation (%)	[3] Remained in storage (%)	[1] Spread on operation and [2] Removed from operation (%)	All other combinations (%)
Atlantic Maritime	84.2	3.7	3.8	2.6	5.7
St. Lawrence Lowlands	87.3	4.5	2.3	2.8	3.1
Manitoulin-Lake Simcoe-Frontenac	87.9	2.7	4.0	2.2	3.1
Lake Erie Lowland	81.3	7.7	x	4.7	3.5
Southern Ontario	86.7	3.7	3.8	2.7	3.2
Boreal Shield	83.1	4.5	5.7	1.0	5.7
Brown Soil Zone	64.2	1.9	25.7	x	7.3
Dark Brown Soil Zone	67.8	1.9	19.9	x	9.1
Black Soil Zone	72.0	2.9	17.9	x	6.4
Lake Manitoba Plain	67.6	5.0	18.7	x	6.3
Boreal Plains	62.9	2.2	24.1	x	9.9
Prairie Region	67.4	2.5	21.2	1.0	7.9
Montane Cordillera	56.1	9.4	24.0	3.3	7.3
Pacific Maritime	69.3	16.8	3.7	6.9	x
B.C. Region	62.1	12.8	14.8%	5.0	5.4%

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 3a, 3b, and 3c:

[1] The specific question asked: "What became of the solid manure that was stored on your operation prior to the 2011 growing season? The dataset for this question is somewhat different from the methodology explained in the previous section, which applies to most of this report. It includes all farms from the livestock module, except those that had previously indicated "liquid or semi-solid manure" as the dominant source of manure spread on their operation. Note that practices [1] and [2] do not distinguish who does this work, and encompasses all scenarios including work done by the farmer, a hired custom operator, or another party purchasing manure from the farmer. Farms could indicate more than one management practice, but data is classified into specific groups. The first three columns indicate only one practice, while the fourth involves two practices. By deduction the fifth column includes up to 3 combinations: [1] & [3], [2] & [3], and [1], [2], & [3]. For multiple practices, the question did not provide a way to indicate the extent to which each was done.

[2] Sector is the type of livestock that contributed most to gross farm receipts.

[3] Other livestock include bison, sheep, goats, horses, mink, duck, emus, ostrich, etc.

Key Results

1. Across Canada, about three-quarters of farms spread all of their stored solid manure prior to the 2011 growing season. This practice was dominant in all provinces and ecoregions, but tended to be slightly higher in Atlantic and central Canada, and a bit lower in western Canada.

2. With the exception of the Pacific Maritime ecoregion, all provinces and ecoregions in western Canada had a higher percentage of farms, about 20%, not spreading any solid manure but keeping it in storage, compared to central and Atlantic Canada.

3. The province of B.C. and in particular the Pacific Maritime ecoregion, had a higher percentage of farms, about 12% and 17%, respectively, that removed all stored solid manure from their operation prior to the 2011 growing season.

4. For all sectors, "spread on operation" was the most common practice, but not as dominant for poultry farms. A much higher percentage of poultry farms had all of their manure removed from their operation, compared to other sectors. A higher percentage of beef farms had all of their manure remain in storage.

5. Combinations of multiple practices were minor, ranging from 5 to 12% of farms for most provinces, ecoregions, and sectors.

Comments

1. A large majority of farms spreading all of their stored solid manure on their own operation is a reflection of available cropland to receive manure and the benefits of manure land application. However, manure is a bulky material often involving prohibitive cost associated with transporting a great distance. Therefore the potential exists for a farm operation with stored manure to not spread manure on all of its land, and for lands closer to the manure storage to receive too much manure. This is addressed further in section D3b, however, this survey was not able to determine the rate or amount of manure applied to land.

2. A higher percentage of farms in Western Canada (excluding Pacific Maritime ecoregion) keeping all of their manure in storage, may be partly associated with the cow/calf beef sector

where outdoor corrals do not need to be cleaned out until fall when animals return from summer pasture. This manure would typically be spread on land in the fall after the growing season (see section D.5)

3. More farms in the poultry sector and Pacific Maritime ecoregion having all manure removed from the operation may be a reflection of minimal cropland available to receive manure.

Comparison with FEMS 2006

While data was analyzed somewhat differently, it appears that in 2006 “spread on operation” was even more dominant, “removed from operation” was slightly more, and “remained in storage” was considerably less. Nevertheless, differences between provinces in 2006 were similar to 2011.

2. Crop Types Grown on Land Receiving Solid Manure

Table 4a: Percentage of Acres Growing Various Crop Types on Land Receiving Solid Manure in Canada [1]

Crop Subgroup	Crop Type(s)	%
Perennial Forage	alfalfa, clover, various grass species, grass/legume mixes, pasture	44.9
Spring Cereals	oats, barley, spring wheat, durum wheat, spring, rye, mixed grains	27.0
Corn	corn for grain or seed, fodder corn	14.1
Oilseeds	canola, flax, mustard, soybeans, sunflower	9.1
Other Annuals	buckwheat, sugar beets, canary seed, triticale, green manure, other annual crop, other annual forage	1.9
Fallow	fallow	1.2
Pulses	Dry field peas, lentils, dry beans	0.42
Vegetables	many different kinds	0.41
Potatoes	potatoes	0.30
No Crop	no crop	0.27
Winter Cereals	winter wheat, fall rye	0.25
Other Unknown	other unknown	0.19
Small Fruit		0.12
Tree Fruit		0.04

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 4b: Percentage of Acres Growing Various Crop Groups [2] on Land Receiving Solid Manure, by Province [1]

Province	Perennial Forages (%)	Cereals (%)	Corn (%)	Oilseeds (%)	Fruit and Vegetables (%)	Other (%)
Newfoundland	92.3	x	x	x	5.9	x
PEI	33.0	19.8	8.9	13.9	23.8	x
Nova Scotia	75.7	x	11.7	x	6.7	x
New Brunswick	84.6	6.3	x	x	1.9	x
Atlantic	66.2	9.1	8.0	5.5	10.2	x
Quebec	60.2	10.6	22.5	4.8	0.4	1.5
Ontario	42.0	8.9	38.7	5.8	0.8	3.8
Manitoba	50.7	23.8	7.4	11.8	x	5.8
Saskatchewan	34.3	43.8	0.7	12.4	0.5	8.3
Alberta	35.8	46.4	2.2	12.7	0.2	2.6
Prairie	37.9	41.7	2.6	12.5	0.4	5.0
B.C.	82.2	7.0	6.0	x	4.1	x
Canada	44.9	27.2	14.1	9.1	0.9	3.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 4c: Percentage of Acres Growing Various Crop Groups [2] on Land Receiving Solid Manure, by Ecoregion [1]

Ecoregion	Perennial Forages (%)	Cereals (%)	Corn (%)	Oilseeds (%)	Fruit and Vegetables (%)	Other (%)
Atlantic Maritime	76.9	10.9	5.3	2.3	3.7	0.8
St. Lawrence Lowlands	39.6	7.4	42.8	8.3	0.2	1.7
Manitoulin-Lake Simcoe-Frontenac	47.0	9.0	38.2	4.0	0.5	1.4
Lake Erie Lowland	17.8	10.8	44.5	11.7	2.3	12.9
Southern Ontario	39.7	9.4	39.7	5.9	0.9	4.3
Boreal Shield	74.8	14.3	5.0	3.6	0.8	1.6
Brown Soil Zone	34.4	45.3	2.8	8.4	x	8.1
Dark Brown Soil Zone	31.4	44.8	2.9	18.1	x	2.9
Black Soil Zone	31.8	44.4	1.5	15.3	x	6.8
Lake Manitoba Plain	55.4	16.9	10.9	8.3	x	7.8
Boreal Plains	52.6	37.4	1.8	6.1	x	1.7
Prairie Region	38.5	41.4	2.6	12.2	0.4	5.0
Montane Cordillera	87.2	8.0	x	x	2.7	x
Pacific Maritime	67.6	x	20.8	x	10.4	x
B.C. Region	81.0	5.7	7.5	x	5.2	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 4a, 4b and 4c:

[1] Percent of acres is based on farms reporting acres for the two largest crop types, by area, grown on land that had solid manure spread on it.

[2] Crop groups in Tables 4b and 4c are defined as per the crop types listed in Table 4a. For perennial forages, oilseeds, and corn the crop subgroup listed in Table 4a is identical to the crop group in Tables 4b and 4c. However, the "cereals", "fruit and vegetables", and "other" crop groups each involve several crop subgroups from Table 4a, as follows:

a) Cereals includes spring cereals and winter cereals
b) Fruit and vegetables includes small fruit, tree fruit, vegetables, and potatoes
c) Other includes other annuals, fallow, pulses, other unknown, and no crop

Key Results

1. Across Canada, almost half of land receiving solid manure was used for growing perennial forages, over one quarter for cereals, and just under one quarter for corn or oilseed crops. Solid manure application on all other crop types was very small on an acreage basis.

2. Perennial forages were the dominant crop type on solid manured land in Atlantic provinces and B.C., with the exception of PEI where considerable land was also used for fruits & vegetables (eg. potatoes), cereals, and oilseeds. In central Canada and prairie provinces perennial forages were still the most common or 2nd most common crop type grown on solid manured land. However, in these provinces many other crop types were also grown, most notably significant acres of cereals in the prairies and corn in central Canada.

3. Ecoregion results appear to follow provincial patterns for the most part. However, some notable features at the ecoregion level include:

a) Corn was the most common crop type grown on solid manured land in the St. Lawrence and Lake Erie Lowlands.
b) Cereals was the most common crop type grown on solid manured land in the Brown, Dark Brown, and Black Soil Zones.
c) Only in the Lake Erie Lowland was perennial forage a minor crop type grown on solid manured land.
d) Despite the dominance of perennial forage in B.C., the Pacific Maritime had considerable corn and fruits & vegetables grown on solid manured land.

Comments

1. The dominance of perennial forage grown on solid manured land is not surprising for livestock farms that rely on forage for feed. While the 2nd and 3rd most common crop types, cereals and corn, can be grown for non-feed purposes, it is likely they are also being utilized by livestock farms for feed on lands receiving solid manure applications.

Comparison with FEMS 2006

In 2006, corn and cereals were more commonly grown by farms on solid manured land than perennial forage. The reason for the increase in perennial forage and decrease in cereals / corn in 2011 is unclear, but may be associated with a trend for dairy and beef producers to increase forage and reduce grain in feed rations.

3. Extent of Solid Manure Application

This section reports extent of solid manure application in two ways. The first is based on total cropland area. The second is based on only farms that applied solid manure and the specific crop types on those farms that received solid manure. The latter approach provides an indication of a farm's capacity to utilize manure as a nutrient source for specific crop types.

a) Area of Solid Manured Land versus Total Cropland

Table 5a: Percentage of Total Harvested Cropland Receiving Solid Manure, by Crop Type and Province [1]

Province	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Cereals (%)	Oilseeds (%)	Other (%)	All Crops (%)
Newfoundland	35.4	x	12.0	x	x	x	31.6
PEI	30.6	x	9.7	26.6	23.7	x	19.4
Nova Scotia	44.6	31.0	5.1	x	x	x	27.8
New Brunswick	50.3	x	1.6	32.5	x	x	29.9
Atlantic	43.4	30.2	6.4	27.3	22.7	x	25.1
Quebec	46.9	16.9	2.6	28.8	5.7	19.9	24.8
Ontario	29.0	19.0	5.6	7.1	2.3	47.7	13.3
Manitoba	24.4	14.2	x	4.1	1.7	2.7	5.7
Saskatchewan	11.4	46.6	38.4	2.6	1.1	1.0	2.6
Alberta	13.3	58.9	x	5.8	2.7	2.5	6.0
Prairie	14.1	23.1	5.1	3.9	1.7	1.4	4.1
B.C.	22.6	50.5	11.6	4.3	x	x	15.1
Canada	20.6	19.0	5.7	4.4	1.9	2.0	6.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 5a and 5b:

[1] Accuracy of data is somewhat constrained by the following:

a) Land area receiving solid manure is limited to two primary crops grown on solid manured land, while harvested land includes up to 5 annual crop types, 3 perennial forage types, and 3 fruit types. While this means that the amount of solid manured land could be greater than reported, more in-depth analysis of this issue suggests that this underestimate is relatively small because many farms that reported solid manure application did not report more than 2 harvested crop types.

b) Land area receiving solid manure includes farms from both crop and livestock modules, while harvested cropland is only from the crop module. Nevertheless, appropriate weighting differences are used to relate data from different survey modules.

c) Only farms that spread more solid manure than liquid, are included in the solid manure data, therefore, also contributing to some underestimate of solid manured land area.

Table 5b: Percentage of Total Harvested Cropland Receiving Solid Manure, by Crop Type and Ecoregion [1]

Ecoregion	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Cereals (%)	Oilseeds (%)	Other (%)	All Crops (%)
Atlantic Maritime	58.9	32.8	6.5	36.5	14.3	16.6	39.3
St. Lawrence Lowlands	28.6	15.6	1.5	19.0	4.4	14.4	15.0
Manitoulin-Lake Simcoe-Frontenac	32.8	33.0	5.2	11.1	4.1	31.0	22.2
Lake Erie Lowland	18.3	9.6	5.9	3.8	1.6	x	6.1
Southern Ontario	30.1	19.7	5.6	7.2	2.3	74.9	13.5
Boreal Shield	41.2	34.7	3.7	14.8	4.4	17.0	24.8
Brown Soil Zone	12.9	29.5	x	3.1	2.1	0.9	3.3
Dark Brown Soil Zone	12.0	x	x	3.6	2.4	0.7	3.8
Black Soil Zone	13.7	20.5	x	4.1	1.8	2.4	4.1
Lake Manitoba Plain	34.6	10.4	x	2.8	0.9	4.8	5.1
Boreal Plains	13.7	38.8	x	4.9	0.8	1.8	5.1
Prairie Region	13.9	23.4	5.1	3.9	1.7	1.4	4.1
Montane Cordillera	32.5	x	9.1	46.3	x	x	30.6
Pacific Maritime	49.6	70.6	13.7	x	x	x	32.8
B.C. Region	35.8	50.5	11.6	22.2	x	x	31.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

1. Across Canada, only a small percentage of cropland (6.3%) received solid manure applications. Perennial forages and corn crops received the most solid manure, each about 20% of the land area used to grow these crop types, while remaining crop types received solid manure on 5% or less of land area.

2. The percent of cropland receiving solid manure was considerably less in prairie ecoregions and provinces, compared to the rest of Canada. An exception to this trend was the Lake Erie Lowland in southern Ontario which also had a very low percent of cropland receiving solid manure.

Comments

1. The higher percent of cropland receiving solid manure for perennial forages and corn, is likely a reflection of these crops predominantly being grown for livestock feed, and therefore more commonly grown on livestock or mixed farms as opposed to crop farms which normally do not have access to a supply of manure.

2. The low percent of cropland receiving solid manure in the prairies, is likely due to larger cropland areas per farm in this region and/or fewer livestock farms compared to crop farms. Both reasons may be valid, since the latter reason seems to only partially account for this trend, as more fully discussed in the next section.

Comparison with FEMS 2006

In FEMS 2006 the analysis methodology was somewhat different so results are not comparable.

b) Extent of Manure Application for Farms Applying Solid Manure

Table 6a: Percentage of Cropland Receiving Solid Manure for Farms Applying Solid Manure, by Crop Type and Province [1]

Province	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Cereals (%)	Oilseeds (%)	Other (%)	All Crops (%)
Newfoundland	x	x	x	x	x	x	81.3
PEI	44.2	x	26.8	44.1	x	x	34.8
Nova Scotia	43.0	x	83.9	x	x	x	47.7
New Brunswick	41.2	x	x	x	x	x	46.3
Atlantic	43.4	65.1	33.9	47.3	35.7	x	41.9
Quebec	54.8	50.2	43.9	62.6	45.4	32.2	52.7
Ontario	38.8	49.7	71.4	42.6	17.4	x	40.6
Manitoba	20.9	40.9	x	26.8	20.0	23.4	23.4
Saskatchewan	19.7	x	x	23.8	10.2	22.7	20.9
Alberta	34.7	51.6	x	20.7	12.1	22.2	21.3
Prairie	25.6	54.6	96.5	22.3	12.8	22.8	21.4
B.C.	33.2	x	53.8	13.5	x	x	34.2
Canada	34.8	50.5	47.2	23.8	15.1	23.9	28.7

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 6b: Percentage of Cropland Receiving Solid Manure for Farms Applying Solid Manure, by Crop Type and Ecoregion [1]

Ecoregion	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Cereals (%)	Oilseeds (%)	Other (%)	All Crops (%)
Atlantic Maritime	51.6	73.2	34.1	59.8	35.7	57.9	50.4
St. Lawrence Lowlands	58.8	49.4	31.6	86.7	41.3	x	52.0
Manitoulin-Lake Simcoe-Frontenac	39.2	58.8	x	39.4	29.3	x	45.3
Lake Erie Lowland	55.1	31.6	89.6	55.6	10.1	x	29.6
Southern Ontario	39.8	49.8	70.9	46.0	17.1	x	41.1
Boreal Shield	38.2	x	65.2	32.3	36.4	x	38.1
Brown Soil Zone	30.0	x	x	18.0	22.8	13.0	20.5
Dark Brown Soil Zone	26.1	x	x	14.7	14.8	x	16.7
Black Soil Zone	18.3	x	x	26.5	10.9	28.4	20.7
Lake Manitoba Plain	11.7	32.0	x	40.0	40.7	29.4	26.5
Boreal Plains	33.8	x	x	31.4	11.0	x	28.8
Prairie Region	25.5	54.6	96.5	22.2	12.7	22.8	21.4
Montane Cordillera	35.3	x	36.6	x	x	x	36.1
Pacific Maritime	56.9	x	68.3	x	x	x	62.9
B.C. Region	40.9	x	53.8	x	x	x	44.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 6a and 6b:

[1] This analysis only considers, at the individual farm record level, harvested crop types that received solid manure application. All harvested acres for farms that did not apply solid manure plus harvested acres of crop types not receiving solid manure on farms that applied solid manure are both not included in this analysis. This analysis, therefore, provides an indication of the extent to which producers applied solid manure on all acres of a crop type that received solid manure. This approach was used because farms were asked to report up to 8 different harvested crop types, but were limited to only 2 crop types receiving solid manure application. Note that a very small percentage (<2.5%) of land in this data set received both solid and liquid manure application. Therefore, application of liquid manure on the same land would not be a significant reason to limit application of solid manure.

Key Results

1. As expected, the percent values in this section for specific crop types, provinces, and ecoregions are always greater than the previous section, because the calculation is always based on a smaller subset of harvested crop types receiving solid manure, rather than total harvested crop types.

2. Also as expected, the differences between provinces, ecoregions, and crop types in this section appear to be smaller than the previous section. This is because variations in the percent of farms that apply solid manure in different provinces, ecoregions, and crop types have been removed from the analysis.

3. A higher percentage of corn and fruit & vegetable acres received solid manure, and a lower percentage of oilseeds received solid manure, compared to other crop types.

4. The percent of cropland receiving solid manure was somewhat less in prairie ecoregions and provinces, compared to the rest of Canada. An exception to this trend is the Lake Erie Lowland in southern Ontario which was similar to the prairies. These regional trends are similar to the previous section based on total harvested cropland.

Comments

1. The large increase in percent of acres for fruit & vegetables in this section (47.2%), compared to the previous section (5.7%), is an indication that a relatively small percentage of fruit & vegetable farms apply solid manure. Conversely, the smaller increase in the percent of acres for perennial forage in this section (34.8%), compared to the previous section (20.6%), is an indication that a higher percentage of farms growing perennial forage apply solid manure.

2. Similar conclusions can be drawn when comparing the increase in percent of acres for regions and provinces in this section compared to the previous section, but in this case the differences seem to be less evident.

3. Lower percent values in the prairie provinces / ecoregions, but smaller differences compared to other regions, provides evidence that both reasons described in the 2nd comment of the previous section are valid.

4. The key message from this analysis is that, for most regions and crop types, a majority of cropland did not receive solid manure application for farms and crop types receiving solid manure. This may suggest that generally farms have more than enough land to receive solid manure. However, there may be other factors that influence a farmer's decision on how much land receives manure application, such as transportation distance or the presence / absence of regulations. If these latter factors are relevant, this raises the question of whether too much manure is being applied on land located close to the manure storage. This survey cannot answer this question since it did not collect information on manure application rates. While provincially based manure management regulations may influence the percent of land receiving manure, the primary differences in this section are prairie versus non prairie provinces which is more likely influenced by larger cropland areas per farm in the prairies.

Comparison with FEMS 2006

In FEMS 2006 the analysis methodology was somewhat different so results are not comparable.

4. Frequency of Solid Manure Application

Table 7a: Percentage of Acres Receiving Solid Manure Applications at Various Frequencies[1], by Province

Province	More than twice a year (%)	Twice a year (%)	Once per year (%)	Once every two years (%)	Less than once every two years (%)
Newfoundland	x	x	x	x	x
PEI	x	x	44.3	18.3	30.0
Nova Scotia	x	14.1	61.8	14.6	6.3
New Brunswick	x	21.3	54.1	12.9	10.4
Atlantic	x	15.1	53.3	14.9	14.8
Quebec	9.5	23.3	55.2	7.1	4.9
Ontario	2.3	16.1	57.6	12.6	11.4
Manitoba	x	3.2	57.4	17.7	21.2
Saskatchewan	1.1	1.9	50.5	24.4	22.2
Alberta	6.7	4.6	47.9	16.7	24.1
Prairie	3.8	3.5	50.4	19.4	23.0
B.C.	7.3	9.4	63.3	11.5	8.5
Canada	4.4	10.0	53.2	15.5	16.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 7b: Percentage of Acres Receiving Solid Manure Applications at Various Frequencies[1], by Crop Type

Crop Type	More than twice a year (%)	Twice a year (%)	Once per year (%)	Once every two years (%)	Less than once every two years (%)
Cereals	1.1	4.7	54.4	17.9	21.9
Corn	1.7	19.7	57.9	11.4	9.3
Oilseeds	0.6	5.3	46.5	16.2	31.5
Perennial Forage	8.1	11.6	53.2	15.5	11.6
Other	2.7	5.1	45.0	12.6	34.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 7c: Percentage of Acres Receiving Solid Manure Applications at Various Frequencies[1], by Ecoregion

Ecoregion	More than twice a year (%)	Twice a year (%)	Once per year (%)	Once every two years (%)	Less than once every two years (%)
Atlantic Maritime	10.6	20.9	53.4	8.7	6.4
St. Lawrence Lowlands	4.2	20.3	59.9	10.4	5.2
Manitoulin-Lake Simcoe-Frontenac	1.7	17.2	58.0	15.7	7.4
Lake Erie Lowland	5.8	15.1	48.7	4.0	26.3
Southern Ontario	2.7	16.7	55.7	12.8	12.1
Boreal Shield	7.0	20.0	58.1	5.1	9.7
Brown Soil Zone	x	3.6	40.1	22.1	23.6
Dark Brown Soil Zone	1.4	7.2	48.8	18.7	24.0
Black Soil Zone	2.9	2.1	54.2	18.7	22.0
Lake Manitoba Plain	x	x	60.5	17.3	20.1
Boreal Plains	3.8	2.8	50.3	19.7	23.4
Prairie Region	3.8	3.5	50.4	19.4	22.9
Montane Cordillera	x	5.8	62.5	17.0	9.6
Pacific Maritime	12.2	16.4	66.8	x	x
B.C. Region	7.6	9.5	64.0	11.8	7.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 7a, 7b, and 7c:

[1] Frequency of manure application in this survey means how often land typically receives manure, not how often a manure storage is emptied or pumped. Data is based on individual responses indicating the most common frequency for each crop type reported.

Key Results

1. "Once per year" was the most common frequency of solid manure application in every province, ecoregion, and crop type. The percent value for this frequency did not vary greatly, however lower values (ie. 40 – 45%) were found in PEI, the brown soil zone, and for oilseed and "other" crop types. Higher percent values (ie. > 60%) were found in Nova Scotia, B.C., Lake Manitoba Plain, and the two ecoregions in B.C.

2. Applying solid manure more often than once per year (14.4%) was less prevalent than applying less than once per year (32.3%).

3. There were greater differences between provinces, ecoregions, and crop types for both lower and higher manure spreading frequencies. For example,

a) A higher percent of acres in Quebec received solid manure greater than once per year, and a higher percent in prairie provinces received solid manure less than once per year, compared to other provinces.

b) A higher percent of acres in Atlantic Maritime, Pacific Maritime, St. Lawrence Lowland, and Boreal Shield received solid manure greater than once per year, and a higher percent in prairie ecoregions received solid manure less than once per year, compared to other ecoregions.

c) A higher percent of acres of corn and perennial forage received solid manure greater than once per year, and a higher percent of cereals, oilseeds, and other crop types received solid manure less than once per year.

Comments

1. Differences in frequency of solid manure application by region may be related to the amount of available land to receive manure. For example, less frequent application in the prairie province / ecoregions may be due to greater cropland area per farm, as already indicated in the previous section. It could also be related to differences in storage capacity, however, this would likely be influenced largely by the degree of solid manure storage infrastructure. For instance, storing solid manure as a manure pack in an outdoor corral or pile on the ground does not involve any significant infrastructure cost. Indeed, other analysis on manure storage practices reveals that farms in the prairie provinces / ecoregions have lower adoption of solid manure storage infrastructure such as impermeable pads, roofs, or runoff containment.

2. Differences in application frequency by crop types, may simply reflect the geographic region where these crop types are most prevalent. For example, cereals and oilseeds are more prevalent in the prairie provinces / ecoregion. However, perennial forages are more suited for multiple manure applications per year particularly if forages are harvested multiple times per year. Also, fall application of manure on perennial forages facilitates nutrient uptake and storage in roots and crowns which may enhance winter survival.

Comparison with FEMS 2006

This question was not asked in the FEMS 2006 survey.

5. Season of Solid Manure Application

Table 8a: Percentage of Acres[2] Receiving Solid Manure Application in Various Seasons[1], by Crop Type

Crop Type	Spring (%)	Summer (%)	Fall (%)	Spring & Fall (%)	Spring & Summer (%)	Other Periods (%)
Cereals	26.5	9.5	50.0	7.0	0.7	6.4
Corn	40.0	1.9	26.0	20.4	1.3	10.5
Oilseeds	23.6	4.8	50.4	7.5	9.6	4.1
Perennial Forage	21.2	14.5	42.8	5.9	3.5	12.1
Other	22.0	23.7	36.6	4.3	2.4	11.1
Total	25.4	10.9	42.9	8.3	2.9	9.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 8b: Percentage of Acres[2] Receiving Solid Manure Application in Various Seasons[1], by Province

Province	Spring (%)	Summer (%)	Fall (%)	Spring & Fall (%)	Spring & Summer (%)	Other Periods (%)
Newfoundland	x	x	x	x	x	x
PEI	37.7	x	39.7	16.2	x	x
Nova Scotia	32.7	x	32.8	18.6	x	8.4
New Brunswick	18.6	x	44.4	14.4	x	x
Atlantic	29.8	4.0	38.3	16.4	3.3	8.1
Quebec	24.5	14.1	32.8	11.1	7.7	9.8
Ontario	27.4	10.0	33.4	15.3	1.8	12.2
Manitoba	14.2	11.5	64.0	4.3	x	3.9
Saskatchewan	18.7	12.7	57.3	3.5	x	7.6
Alberta	30.3	9.7	42.4	5.2	x	9.4
Prairie	23.7	11.0	51.0	4.5	1.9	7.9
B.C.	41.8	6.7	23.4	3.9	4.3	20.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 8c: Percentage of Acres[2] Receiving Solid Manure Application in Various Seasons[1], by Ecoregion

Ecoregion	Spring (%)	Summer (%)	Fall (%)	Spring & Fall (%)	Spring & Summer (%)	Other Periods (%)
Atlantic Maritime	22.7	15.3	33.6	10.4	8.1	9.8
St. Lawrence Lowlands	30.0	7.8	33.9	16.4	5.1	6.9
Manitoulin-Lake Simcoe-Frontenac	29.2	8.5	32.9	17.3	2.1	10.1
Lake Erie Lowland	24.6	17.6	26.9	7.7	0.5	22.6
Southern Ontario	28.0	10.7	31.4	14.9	1.7	13.2
Boreal Shield	18.0	12.7	42.9	8.3	5.4	12.7
Brown Soil Zone	14.4	16.4	51.6	3.7	x	13.7
Dark Brown Soil Zone	19.4	8.6	50.2	5.0	x	9.8
Black Soil Zone	28.6	9.5	51.2	2.9	x	7.2
Lake Manitoba Plain	10.4	14.2	68.2	3.4	x	3.8
Boreal Plains	30.6	10.9	45.5	6.8	x	4.9
Prairie Region	24.0	11.0	50.6	4.5	2.0	7.9
Montane Cordillera	36.9	7.1	23.1	3.2	x	28.3
Pacific Maritime	52.2	5.4	19.7	7.5	x	7.6
B.C. Region	41.7	6.5	22.0	4.5	3.4	21.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 8a, 8b, and 8c:

[1] Farms were asked to report the percent of solid manure that was applied during four different seasons for each of their two reported crop types. Total percent for each crop type added up to 100. The four seasons were defined as follows:

1. right after harvest 2010
2. during winter
3. before crop growth began in 2011
4. after crop growth began in 2011

In order to facilitate analysis and reporting, 6 classes were developed as per the above tables and calculated for each crop type receiving manure for each respondent. The classes are defined as follows:

a) Spring: at least 70% of manure applied during season 3
b) Summer: at least 70% of manure applied during season 4
c) Fall: at least 70% of manure applied during season 1
d) Spring & Fall: manure applied during season 3 and 1 together is at least 80%, and the percent of manure applied in season 3 & 1, individually, are both greater than seasons 2 & 4.
e) Spring & Summer: manure applied during season 3 and 4 together is at least 80%, and the percent of manure applied in season 3 & 4, individually, are both greater than seasons 1 & 2.
f) Other Periods: All other relevant data that doesn't fit into above classes.

[2] The survey does not ask percent of acres receiving manure in different seasons, but rather percent of manure applied in different seasons. Therefore, to facilitate reporting based on acres it is necessary to assume that the average rate of manure application for a specific region or crop type, does not vary between seasons. This assumption may not be entirely true, but possibly acceptable due to the narrow range of application rates that are feasible with manure spreading equipment. Despite this uncertainty, this approach provides more useful information than reporting on a percent of farms basis because the amount of manure applied per farm is highly variable and unknown.

Key Results

1. Across Canada, the most common season for solid manure application was fall, followed by spring. Together these two periods accounted for two-thirds of solid manure application, with the remaining periods each contributing about 10% or less.

2. Notable differences between provinces and ecoregions were as follows:
   a) greater fall application and less spring & fall application in the prairie provinces / ecoregions, compared to other areas.
   b) greater spring application than fall only occurred in the B.C. ecoregions / province.

3. Seasonal distribution of solid manure application did not vary much for most crop types, except for corn. For this crop more solid manure was spread in spring and in spring & fall, and less was applied in fall.

Comments

1. Fall application is viewed as less desirable than spring due to lower crop nutrient uptake and greater potential losses of nutrients and pathogens to the environment. However, in most regions of Canada frozen soils during winter may help to reduce losses. If fall applied manure is incorporated before winter, then losses specifically associated with spring snowmelt and water runoff can be reduced. This is addressed in the next section. The prairie ecoregions / provinces may be least impacted by losses due to longer frozen periods and low precipitation amounts during the winter. Despite these potential losses, fall application remains a popular

practice for a number of reasons. First, this is a season when a farmer has more time available to do field work. Second, solid manure containing bedding material has a high carbon / nitrogen ratio and requires a period of decomposition before nutrients become available for crop uptake. Even though the rate of decomposition during winter is slow, this relatively long period enables nutrients to become available for plant uptake much earlier than if the manure had been applied in spring.

2. The only ecoregion in Canada with unfrozen soils in winter is the Pacific Maritime. This region also has the greatest amount of rainfall during this period. Not surprisingly, this region has the lowest incidence of primarily fall application (19.7%) and also has provincial regulations discouraging producers from spreading during this time.

3. Seasonal trends for manure application in corn may be associated with similar trends in provinces / ecoregions where corn is primarily grown, such as Quebec, Ontario, and possibly B.C. Another specific reason for lower fall application with corn may be associated with grain corn in Quebec and Ontario that is typically harvested too late in fall to allow for solid manure application before winter.

Comparison with FEMS 2006

When comparing 2011 with 2006 there is one notable, significant difference. In 2006 the values for spring and fall classes are essentially reversed, making spring the most common and fall the second ranked season, across Canada. The reason for this change is uncertain. Comparison of weather data from these two periods shows little difference, discounting any speculation of a later harvest in 2006 resulting in less time to spread manure. A more plausible theory is that with the trend toward increasing cropland areas per farm, farmers must apply more manure in fall since less time is available in spring due to increased crop establishment activity (ie. seedbed preparation, fertilizing, planting, etc.).

6. Incorporation of Solid Manure Application

Table 9a: Percentage of Acres With Solid Manure Incorporated After Spreading[1], by Province

Province	Spread & not worked into the soil (%)	Spread & worked in to the soil (%)
Newfoundland	x	x
PEI	37.5	64.3
Nova Scotia	78.3	30.7
New Brunswick	75.7	28.3
Atlantic	65.0	40.5
Quebec	74.9	31.0
Ontario	47.1	59.5
Manitoba	48.3	56.5
Saskatchewan	52.7	50.5
Alberta	36.5	64.6
Prairie	43.9	58.5
B.C.	57.0	47.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 9b: Percentage of Acres With Solid Manure Incorporated After Spreading[1], by Ecoregion

Ecoregion	Spread and not worked into the soil (%)	Spread and worked in to the soil (%)
Atlantic Maritime	79.7	24.4
St. Lawrence Lowlands	57.4	48.5
Manitoulin-Lake Simcoe-Frontenac	50.2	56.0
Lake Erie Lowland	36.2	75.8
Southern Ontario	46.7	60.9
Boreal Shield	76.7	28.5
Brown Soil Zone	49.1	53.7
Dark Brown Soil Zone	38.9	63.9
Black Soil Zone	40.7	61.5
Lake Manitoba Plain	54.8	48.2
Boreal Plains	48.3	54.0
Prairie Region	44.2	58.3
Montane Cordillera	55.3	50.8
Pacific Maritime	57.1	46.5
B.C. Region	55.8	49.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 9c: Percentage of Acres With Solid Manure Incorporated After Spreading[1], by Crop Type

Crop Type	Spread and not worked into the soil (%)	Spread and worked into the soil (%)
Cereals	22.2	80.1
Corn	18.4	87.2
Oilseeds	27.2	78.0
Perennial Forage	82.2	21.4
Other	40.1	73.7
Canada	50.7	53.4

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 9a, 9b, and 9c:

[1] Percent values add up to > 100 because farms were able to indicate both methods for specific crop types. The question did not allow for reporting the number of acres each method was used, so it was assumed a particular method was used on all acres for the designated crop type. While this could create an overestimate of acres for farms using both methods, the percent of farms indicating both methods was very small (3%). Also, percent values in these tables should not change significantly if these overestimates were consistent across different provinces, ecoregions, and crop types.

Key Results

1. Across Canada, about half of applied solid manure was incorporated and half was not. However, there were significant differences between crop types, with most perennial forage land not experiencing manure incorporation, and all other crop types having most manure incorporated.

2. There was considerably less incorporation of manure in the following provinces and ecoregions:
   a) Provinces: Nova Scotia, New Brunswick, and Quebec.
   b) Ecoregions: Atlantic Maritime, Boreal Shield

Comments

1. Much less manure incorporation on forage is expected, since this perennial crop would be destroyed if manure was incorporated. Where there was some incorporation on forage it was likely prior to planting a new forage stand or while breaking up an old forage stand for re-planting. Solid manure application with incorporation on all other crop types, most of which are annual, is typically done after crop harvest in fall or prior to crop planting in spring.

2. Provinces and ecoregions with less incorporation are likely associated with areas that have a higher percentage of manured land in perennial forage production, as shown in Tables 4a and 4b.

Comparison with FEMS 2006

In 2006, about 60 percent of farms incorporated solid manure compared to about half in 2011. The likely reason for less incorporation in 2011 is due to the larger percent of land receiving manure that is in perennial forage, as discussed previously in section D.2.

7. Timing of Solid Manure Incorporation After Application

Table 10a: Percentage of Acres Having Solid Manure Incorporated At Various Times After Spreading[1], by Crop Type

Crop Type	< 2 hours after spreading (%)	Same day, > 2 hours after spreading (%)	1-2 days after spreading (%)	3-5 days after spreading (%)	> 5 days after spreading (%)
Cereals	4.3	20.3	30.4	17.3	27.8
Corn	3.6	34.7	34.6	14.3	12.8
Oilseeds	4.3	16.0	33.7	14.0	32.0
Perennial Forage	4.5	11.3	32.9	17.8	33.5
Other	x	14.0	52.7	9.5	21.8
Canada	4.0	20.9	33.5	15.8	25.8

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 10b: Percentage of Acres Having Solid Manure Incorporated At Various Times After Spreading[1], by Province

Province	< 2 hours after spreading (%)	Same day, > 2 hours after spreading (%)	1-2 days after spreading (%)	3-5 days after spreading (%)	> 5 days after spreading (%)
Newfoundland	x	x	x	x	x
PEI	x	23.8	41.7	13.1	16.0
Nova Scotia	x	39.3	34.8	13.1	x
New Brunswick	x	15.5	41.9	x	21.6
Atlantic	3.7	25.6	40.7	13.9	16.2
Quebec	8.6	38.7	32.9	10.9	9.0
Ontario	1.9	26.9	35.9	18.1	17.2
Manitoba	6.9	20.3	35.6	14.7	22.4
Saskatchewan	3.2	7.3	27.3	18.0	44.2
Alberta	3.6	18.9	34.5	15.3	27.7
Prairie	4.0	15.8	32.6	16.0	31.6
B.C.	8.0	16.1	27.5	11.1	37.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 10c: Percentage of Acres Having Solid Manure Incorporated At Various Times After Spreading[1], by Ecoregion

Ecoregion	< 2 hours after spreading (%)	Same day, > 2 hours after spreading (%)	1-2 days after spreading (%)	3-5 days after spreading (%)	> 5 days after spreading (%)
Atlantic Maritime	6.0	21.5	38.3	17.4	16.9
St. Lawrence Lowlands	7.0	40.8	37.9	9.8	4.4
Manitoulin-Lake Simcoe-Frontenac	0.7	32.7	33.1	15.7	17.8
Lake Erie Lowland	4.4	15.4	37.8	23.6	18.9
Southern Ontario	1.8	27.4	34.5	18.1	18.1
Boreal Shield	5.2	30.4	25.9	15.8	22.7
Brown Soil Zone	x	13.3	23.5	21.5	41.5
Dark Brown Soil Zone	x	12.0	27.6	11.3	47.9
Black Soil Zone	4.2	13.2	40.4	15.7	26.5
Lake Manitoba Plain	x	14.9	45.6	12.7	23.2
Boreal Plains	9.1	24.6	28.2	18.6	19.5
Prairie Region	4.1	15.6	32.6	16.0	31.8
Montane Cordillera	6.2	8.7	25.5	10.7	48.9
Pacific Maritime	10.6	27.2	42.2	14.8	5.2
B.C. Region	7.5	14.1	30.3	11.9	36.3

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 10a, 10b, and 10c:

[1] Data in this section is based on respondents who indicated “Spread and worked into the the soil” from the previous section. Percent values add up to 100 because farms were asked to choose only one option, the one most commonly practiced. The question did not allow for reporting specific acres that the incorporation time was used, so it is assumed a particular incorporation time was used on all acres of the specified crop type. While this assumption may not be correct, percent values would not change significantly if the extent to which the most common incorporation time was used was consistent across provinces, ecoregions, and crop types.

Key Results

1. Across Canada, there was considerable variability in incorporation times as indicated by the significant percentage of acres in each time period. However, only a small percent of acres had solid manure incorporated less than 2 hours after spreading.

2. In general, western provinces and ecoregions had somewhat longer incorporation times, with the exception of the Pacific Maritime and Boreal Plains ecoregions.

3. A higher percentage of corn acres had solid manure incorporated the same day as spreading, compared to other crop types.

Comments

1. In general, quicker incorporation time helps to reduce odour and nutrient losses. Nutrient losses can occur through ammonia volatilization to the atmosphere, or with water runoff if an intense rainfall event occurs before incorporation can take place. Most ammonia volatilization occurs within 24 hours of application, so incorporation on the same day is required to reduce this type of loss.

2. Incorporating solid manure less than two hours after application may not be feasible, if the moisture content of the manure is too high to allow for proper mixing with the soil. In other words it is often necessary to allow the manure to dry out for a short period of time before incorporation.

3. Longer incorporation times in most prairie provinces / ecoregions and the Montane Cordillera may be related to logistics of managing larger cropland areas per farm receiving manure and / or less importance of managing manure when it provides a smaller proportion of nutrient source for large cropland areas per farm. Shorter incorporation times for corn is likely related to more of this crop being grown in Ontario, Quebec, and the Pacific Maritime ecoregion.

Comparison with FEMS 2006

In 2006, a slightly lower percent of farms incorporated manure on the same day, and a slightly higher percent incorporated 1 - 2 days after spreading. There was little difference in the percent of farms incorporating manure greater than 2 days after spreading.

8. Testing of Solid Manure for Nutrient Content

Table 11a: Percentage of Farms Testing Solid Manure for Nutrient Content in 2011, by Province

Province	%
Newfoundland	9.5
PEI	5.3
Nova Scotia	14.8
New Brunswick	5.2
Atlantic	9.1
Quebec	41.2
Ontario	6.5
Manitoba	4.8
Saskatchewan	0.7
Alberta	3.7
Prairie	2.9
B.C.	5.1
Canada	10.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 11b: Percentage of Farms Testing Solid Manure for Nutrient Content in 2011, by Ecoregion

Ecoregion	%
Atlantic Maritime	27.6
St. Lawrence Lowlands	31.5
Manitoulin-Lake Simcoe-Frontenac	4.7
Lake Erie Lowland	14.2
Southern Ontario	7.1
Boreal Shield	23.4
Brown Soil Zone	1.9
Dark Brown Soil Zone	3.0
Black Soil Zone	3.3
Lake Manitoba Plain	5.7
Boreal Plains	2.1
Prairie Region	2.9
Montane Cordillera	5.1
Pacific Maritime	6.1
B.C. Region	5.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 11c: Percentage of Farms Testing Solid Manure for Nutrient Content in 2011, by Crop Type [1]

Crop Type	%
Cereals	9.8
Corn	20.1
Oilseeds	12.8
Perennial Forage	9.5
Other	12.4

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Table 11c:

[1] This question is not asked for specific crop types. Farms are permitted to report up to two crop types. If a farmer reports two crop types grown on land receiving solid manure it is assumed that tested manure was applied to both crop types.

Key Results

1. Across Canada, only about 10% of farms tested solid manure for nutrient requirement.

2. However, there was considerable variability between provinces. For example, the percent of farms testing solid manure was considerable higher in Quebec (41.2%), and almost negligible in Saskatchewan (0.7%). Similarly, ecoregion differences followed provincial trends but not as dramatically.

3. Somewhat higher manure testing occurred for corn, than other crop types.

Comments

1. Higher percent values in Quebec may reflect provincially based manure management programs and regulations which promote or require manure testing.

2. Higher percent values for corn may be a reflection of this crop accounting for a higher proportion of manured land in Quebec than most other provinces (see Table 4b). There may also be a tendency for more manure testing for application on corn land, because it arguably has a higher nutrient requirement and lower nitrogen use efficiency than most other crop types.

Comparison with FEMS 2006

In 2006, a similar percent of farms tested solid manure for nutrient content, with very similar differences between provinces.

9. Decision Factors for the Rate and Amount Of Solid Manure To Apply

Table 12a: Percentage of Farms Indicating Various Priority Ratings for the Importance of Different Factors for Deciding on the Rate and Amount of Solid Manure to Apply [1]

Decision Factor [2]	Priority Rating [3]				Overall Rating [4] (0 to 3)
	[3] High (%)	[2] Medium (%)	[1] Low (%)	[0] None (%)	
past experience	42.9	38.6	8.5	10.1	2.14
crop nutrient requirement	32.4	36.0	13.7	17.9	1.83
land available	31.4	29.5	17.9	21.2	1.71
growing conditions	31.3	27.0	19.0	22.8	1.67
manure nutrients	24.5	28.8	18.8	27.8	1.50
fertilizer cost	27.6	25.0	15.7	31.7	1.48
manure transport	23.2	27.0	23.8	25.9	1.48
information sources	20.1	27.7	21.3	30.9	1.37
soil testing	24.9	22.1	14.9	38.0	1.34

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Table 12a:

[1] The question was only for farms in the crop module, mainly to limit the length of the already larger livestock module questionnaire.

[2] Decision factors in above table are abbreviated, with full wording provided below.

a) past experience: The quantity of fertilizer used in the past, or based on experience
b) crop nutrient requirement: Nutrient requirement of crop grown or carryover nutrients from last crop
c) land available: Amount of land available to receive manure
d) growing conditions: Soil moisture, temperature or other growing conditions
e) manure nutrients: Nutrient content of manure
f) fertilizer cost: Cost of fertilizer or amount of fertilizer applied
g) manure transport: Cost of transporting manure or distance from manure storage
h) information sources: External sources of information (crop advisor, fertilizer dealer, provincial recommendations, neighbours etc)
i) soil testing: Soil testing or plant analysis

[3] Farms can only indicate one priority rating per factor

[4] Overall rating provides a single weighted value for each decision factor based on the percent of responses for each priority rating. To do this the priority ratings are given numeric values as follows: high=3, medium=2, low=1, and none=0. This rating is used in the following 3 tables.

Table 12b: Overall Ratings Calculated to Reflect the Importance of Different Factors for Deciding on the Rate and Amount Solid Manure to Apply, by Province

Province	past experience	crop nutrient requirement	land available	growing conditions	manure nutrients	fertilizer cost	manure transport	information sources	soil testing	Average Rating [1]
NL	2.37	1.81	1.83	1.78	1.90	1.23	1.25	1.39	1.60	1.69
PEI	2.48	2.11	1.74	1.58	1.65	1.89	1.75	1.54	1.63	1.82
NS	2.17	1.89	1.72	1.81	1.71	1.61	1.23	1.40	1.66	1.69
NB	2.40	1.91	1.86	1.48	1.34	1.45	1.35	1.13	1.28	1.58
Atlantic	2.33	1.96	1.77	1.66	1.61	1.63	1.41	1.37	1.55	1.70
QC	2.15	2.29	2.03	2.26	2.09	1.73	1.48	1.98	2.17	2.02
ON	2.14	1.93	1.63	1.76	1.51	1.53	1.19	1.45	1.46	1.62
MB	2.23	1.82	1.83	1.46	1.39	1.55	1.99	1.13	1.24	1.63
SK	2.12	1.45	1.65	1.25	1.13	1.28	1.83	0.96	0.68	1.37
AB	2.07	1.51	1.63	1.33	1.23	1.32	1.65	1.11	0.96	1.42
Prairie	2.11	1.54	1.67	1.33	1.22	1.34	1.77	1.06	0.91	1.44
BC	2.28	1.81	1.55	1.83	1.68	1.36	1.18	1.34	1.08	1.57

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 12c: Overall Ratings Calculated to Reflect the Importance of Different Factors for Deciding on the Rate and Amount Solid Manure to Apply, by Ecoregion

Ecoregion	PE	CNR	LA	GC	MN	FC	MT	IS	ST	AR [1]
Atlantic Maritime	2.23	2.06	1.91	1.94	1.81	1.65	1.47	1.70	1.85	1.85
St. Lawrence Lowlands	2.21	2.30	1.91	2.21	1.95	1.77	1.39	1.85	2.03	1.96
Manitoulin-Lake Simcoe-Frontenac	2.11	1.91	1.63	1.80	1.45	1.48	1.20	1.52	1.33	1.60
Lake Erie Lowland	2.19	2.00	1.69	1.72	1.79	1.73	1.23	1.38	1.86	1.73
Southern Ontario	2.13	1.94	1.64	1.78	1.55	1.55	1.21	1.48	1.49	1.64
Boreal Shield	2.04	1.91	1.84	1.78	1.66	1.35	1.20	1.52	1.65	1.66
Brown Soil Zone	2.05	1.43	1.70	1.10	1.16	1.14	1.89	0.97	0.94	1.37
Dark Brown Soil Zone	2.00	1.42	1.55	1.12	0.94	1.16	1.45	1.00	0.54	1.24
Black Soil Zone	2.18	1.64	1.71	1.41	1.33	1.45	1.91	1.13	1.04	1.53
Lake Manitoba Plain	2.41	1.80	1.75	1.48	1.27	1.82	2.11	1.33	1.26	1.69
Boreal Plains	2.06	1.50	1.66	1.46	1.32	1.33	1.67	0.99	0.68	1.41
Prairie Region	2.11	1.55	1.67	1.33	1.22	1.34	1.76	1.06	0.90	1.44
Montane Cordillera	2.41	1.77	1.57	1.79	1.57	1.42	1.18	1.20	1.02	1.55
Pacific Maritime	2.23	1.89	1.50	1.90	1.93	1.29	1.20	1.63	1.32	1.65
BC Region	2.33	1.82	1.54	1.84	1.73	1.36	1.19	1.38	1.15	1.59

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 12d: Overall Ratings Calculated to Reflect the Importance of Different Factors for Deciding on the Rate and Amount Solid Manure to Apply, by Crop Type [2]

Crop Type	past experience	crop nutrient requirement	land available	growing conditions	manure nutrients	fertilizer cost	manure transport	information sources	soil testing	Average Rating [1]
Cereals	2.07	1.68	1.74	1.46	1.34	1.58	1.81	1.25	1.21	1.57
Corn	2.43	2.44	1.88	2.16	1.93	1.97	1.51	1.94	2.16	2.05
Oilseeds	2.26	1.83	1.80	1.69	1.60	1.67	1.78	1.39	1.42	1.72
Perennial Forage	2.04	1.65	1.70	1.70	1.39	1.27	1.21	1.23	1.15	1.48
Other	2.35	2.13	1.60	1.68	1.84	1.61	1.57	1.59	1.62	1.78

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 12b, 12c, and 12d:

[1] Average rating is the average of all overall ratings for a specific province, ecoregion, or crop type. It provides an indication of the importance of all decision factors. Higher average ratings could be interpreted that the rate and amount of solid manure application is more carefully managed.

[2] This question is not asked for specific crop types. Farms are permitted to report up to two crop types. If a farmer reports two crop types grown on land receiving solid manure it is assumed that the indicated priority ratings for each decision factor apply to both crop types.

Key Results

1. As shown in Table 12a, “past experience” was the most important factor, overall, impacting decisions on the amount and rate of solid manure to apply. Crop nutrient requirement, land available, and growing conditions were the next most important factors, with remaining factors having a medium - low overall rating.

2. For the most part, the above order of priority held true for specific provinces, ecoregions, and crop types (as per overall ratings in Tables 12b, 12c, and 12d), with the following notable exceptions.
   a) Soil testing and information sources were more important factors for applying solid manure in Quebec, the St. Lawrence Lowlands, and on land growing corn.
   b) Manure transport was a more important factor in the prairie provinces /ecoregions, particularly Manitoba and the Lake Manitoba Plain.
   c) Fertilizer cost was somewhat more important in PEI, the Lake Manitoba plain, and on land growing corn.

3. Average ratings varied considerably between provinces, ecoregions, and crop types. This is also borne out in individual overall ratings, as noted below.
   a) Six out of nine factors were ranked higher for Quebec, than all other provinces.
   b) Five out nine factors were ranked lower for Saskatchewan, than all other provinces.
   c) Seven out of nine factors were ranked higher for St. Lawrence Lowlands, than all other ecoregions.
   d) Seven out of nine factors were ranked lower for the Brown or Dark Brown Soil Zones, than all other ecoregions.
   e) Eight out of nine factors were ranked higher for corn, than all other crop types.
   f) Six out of nine factors were ranked lower for perennial forage, than all other crop types.

4. The variability between provinces, ecoregions, and crop types was greater for some factors than others. Interestingly, the factor with the least variability "past experience" was the highest ranked one overall, while the factor with the most variability "soil testing" was the lowest ranked one overall.

Comments

1. The dominance of "past experience" as the most important factor suggests that most farmers have been applying solid manure for a considerable number of years. Past experience is a credible source of information particularly if it considers unique, local field conditions and is flexible to change based on less than ideal results and new information/technology. Unfortunately, the wording of this factor doesn't distinguish a less credible interpretation such as "tradition" or "reluctance to change".

2. Overall, low to medium ratings for most factors may reflect a perception of limited value for solid manure on many farms. There may be a number of reasons for this perception, such as:

a) The amount nutrients provided by solid manure may be small, compared to the total crop nutrient requirements for a farm. This may be a bigger factor for crop and mixed farms, compared to livestock farms, and could have been investigated further if farms from the livestock module had also been asked this question.
b) Compared to commercial fertilizer, solid manure is more bulky and expensive to transport, more variable in nutrient content, and more difficult to land apply uniformly. Nutrients in solid manure are found in various forms. Organic forms must mineralize before they become available for plant uptake. The rate of mineralization is variable and often uncertain, occurring over a number of years. As a result the motivation and rationale for precise management is less likely with solid manure than with fertilizer.

3. The reason for greater overall ratings for Quebec, St. Lawrence Lowlands, and corn production is likely the same as the rationale provided under comments in the previous section on "manure nutrient testing", for example, more vigorous manure management programs and regulations. Variability of these programs and regulations in other provinces, could possibly also account for some differences in overall ratings in other provinces as well.

Comparison with FEMS 2006

In 2006, a similar question was asked, however, with the following differences:

a) Instead of providing a priority rating for each factor, farmers were asked simply to indicate if each specific factor was considered (ie. a yes / no response). The analysis then focused on calculating the percent of farmers that indicated "yes" to various factors. Differences in percent values can be considered as indicators of the relative importance of a factor compared to another, and can thus be compared with the differences in overall ratings calculated for 2011.
b) The specific wording of factors in 2011 has changed slightly from 2006.

Given the above limitations, it appears that the results from 2006 are similar to 2011, with the following exceptions:

a) Greater importance of soil testing and manure transport.
b) Less importance of growing conditions.

Provincial trends were also similar to 2011. For instance, in 2011 provinces can be lumped into two groups with higher average ratings for Manitoba and east, and lower ratings for

Saskatchewan and west, shown in Table 12b. The same trend occurred in 2006 with a higher percent of farms indicating importance of various decision factors for the first group than the second group. Despite a somewhat different metric between the two years, in 2006 the differences between these two groups appeared to be even greater. This would suggest some improvement in management in western Canadian provinces since 2006, despite still not being at the same level as farms in eastern provinces, particularly Quebec.

E. Liquid Manure Application to Cropland

1. Fate of Liquid Manure Produced on Livestock Farms

Table 13a: Percentage of Farms Managing Stored Liquid Manure in Various Ways Prior to the 2011 Growing Season, by Province [1]

Province	[1] Spread on operation (%)	[2] Removed from operation (%)	[3] Remained in storage (%)	[1] Spread on operation and [2] Removed from operation (%)	All other combinations (%)
Newfoundland	x	x	x	x	x
PEI	87.0	x	x	x	x
Nova Scotia	85.7	x	x	x	x
New Brunswick	90.0	x	x	x	x
Atlantic	87.1	x	x	x	x
Quebec	88.9	3.7	0.8	4.6	2.0
Ontario	88.5	3.0	2.4	4.3	1.8
Manitoba	75.2	12.9	x	x	x
Saskatchewan	61.5	x	23.2	x	x
Alberta	85.6	x	x	x	8.7
Prairie	77.6	8.0	6.1	x	5.8
B.C.	84.8	x	x	x	x
Canada	87.1	4.0	2.1	4.1	2.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 13b: Percentage of Farms Managing Stored Liquid Manure in Various Ways Prior to the 2011 Growing Season, by Livestock Sector [1]

Sector [2]	[1] Spread on operation (%)	[2] Removed from operation (%)	[3] Remained in storage (%)	[1] Spread on operation and [2] Removed from operation (%)	All other combinations (%)
Dairy	94.5	0.8	1.3	1.4	2.0
Beef	77.1	x	12.3	x	x
Pork	70.2	11.5	x	12.8	4.1
Poultry	55.0	34.9	x	x	x
Other [3]	x	x	x	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 13c: Percentage of Farms Managing Stored Liquid Manure in Various Ways Prior to the 2011 Growing Season, by Ecoregion [1]

Ecoregion	[1] Spread on operation (%)	[2] Removed from operation (%)	[3] Remained in storage (%)	[1] Spread on operation and [2] Removed from operation (%)	All other combinations (%)
Atlantic Maritime	91.2	2.6	x	3.3	x
St. Lawrence Lowlands	87.3	4.1	1.0	4.8	2.8
Manitoulin-Lake Simcoe-Frontenac	89.3	x	x	x	x
Lake Erie Lowland	85.0	x	x	9.0	x
Southern Ontario	82.3	8.0	2.9	5.0	1.8
Boreal Shield	91.6	x	x	x	x
Brown Soil Zone	81.3	x	x	x	x
Dark Brown Soil Zone	88.8	x	x	x	x
Black Soil Zone	76.2	x	x	x	x
Lake Manitoba Plain	84.4	x	x	x	x
Boreal Plains	65.7	x	11.6	x	x
Prairie Region	77.7	8.1	6.1	x	5.8
Montane Cordillera	84.7	x	x	x	x
Pacific Maritime	85.3	x	x	x	x
B.C. Region	85.1	x	x	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 13a, 13b, and 13c:

[1] The specific question asked: "What became of the liquid manure that was stored on your operation prior to the 2011 growing season? The dataset for this question is somewhat different from the methodology explained in section C of this report. It includes all farms from the livestock module, except those that had previously indicated "solid manure" as the dominant source of manure spread on their operation. It should be noted that practices [1] and [2] does not distinguish who does this work, and encompasses all scenarios including work done by the farmer, a hired custom operator, or another party purchasing manure from the farmer. Farms could indicate more than one management practice, but data is classified into specific groups. The first three columns indicate only one practice, while the fourth involves two practices. By deduction the fifth column includes up to 3 combinations: [1] & [3], [2] &[3], and [1], [2], & [3]. For multiple practices, the question did not provide a way to indicate the extent to which each was done.

[2] Sector is the type of livestock that contributed most to gross farm receipts.

[3] Other livestock include bison, sheep, goats, horses, mink, duck, emus, ostrich, etc.

Key Results

1. Across Canada, the vast majority (87.1%) of farms spread all of their stored liquid manure prior to the 2011 growing season. This very high percentage was consistent in most ecoregions and provinces, except for somewhat lower values in the Boreal Plains and Saskatchewan. This

practice was dominant for all livestock sectors, but showed greater variability ranging from just over half for poultry to almost all dairy farms.

2. All other ways of managing stored liquid manure each involved less than 5% of farms. However, the following are notable exceptions of provinces, ecoregions, or sectors involving a higher percent of farms:

a) "Removed from operation" most notably in the poultry sector, but also somewhat higher in Manitoba, and the pork sectors.
b) "Remained in storage" most notably in Saskatchewan, but also somewhat higher in Boreal Plains, and beef sector.
c) "Spread on operation and removed from operation" in Lake Erie Lowland and pork sector.

Comments

1. As with solid manure, a very large majority of farms spreading all of their stored liquid manure on their own operation is a reflection of available cropland to receive manure and the benefits of manure land application. Liquid manure, like solid, is also bulky and costly to transport any great distance. Nevertheless, liquid can often be transported more efficiently through pipeline systems. Liquid manure typically contains fewer nutrients than solid, particularly slurries with high water content. However, more of the nutrients in liquid manure are available for crop uptake in the first year. Liquid manure can also be applied more precisely to achieve more uniform distribution and desired target rates. Therefore, liquid manure tends to be viewed as a more reliable nutrient source than solid, and this may explain a somewhat higher percentage of farms spreading all of their liquid manure on their own operation, compared to solid manure. Nevertheless, as with solid manure, the potential exists for not all land on a farm to receive liquid manure applications. This is addressed further in section E3b.

2. As with solid manure, significantly more farms in the poultry sector having all manure removed from the operation may be a reflection of minimal cropland available to receive manure.

3. Other FEMS analysis and reporting on liquid manure storage suggests that most ecoregions, provinces, and livestock sectors have at least 30% of farms with storage capacity exceeding one year. However, this section's analysis shows that very few farms, with the exception of Saskatchewan, utilized the option to keep manure in storage. In fact, across Canada, the percent of farms that kept all of their manure in storage was considerably lower for liquid (2.1%) than solid (13.1%). This may also reflect a higher short term nutrient benefit with liquid manure.

Comparison with FEMS 2006

While data was analyzed somewhat differently, it appears that across Canada in 2006 "spread on operation" was virtually the same, "removed from operation" was slightly more, and "remained in storage" was slightly less.

In 2006, the percent of farms that "spread on operation" was slightly lower in prairie provinces compared to other provinces, which is a similar trend to 2011. However, in 2006 Saskatchewan had a significantly higher percentage that "spread on operation" compared to 2011. For other

fate of manure practices the percentage values are too low with too much data suppression to compare provinces from the two time periods.

2. Crop Types Grown on Land Receiving Liquid Manure

Table 14a: Percentage of Acres Growing Various Crop Types on Land Receiving Liquid Manure in Canada [1]

Crop Subgroup	Crop Type(s)	%
Perennial Forage	alfalfa, clover, various grass species, grass/legume mixes, pasture	38.8
Corn	corn for grain or seed, fodder corn	32.0
Oilseeds	canola, flax, mustard, soybeans, sunflower	13.9
Spring Cereals	oats, barley, spring wheat, durum wheat, spring, rye, mixed grains	13.0
Other Annuals	buckwheat, sugar beets, canary seed, triticale, green manure, other annual crop, other annual forage	1.0
Winter Cereals	winter wheat, fall rye	0.56
Vegetables	many different kinds	0.27
Other Unknown	other unknown	0.22
Small Fruit		0.03
Potatoes	potatoes	x
Tree Fruit		x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 14b: Percentage of Acres Growing Various Crop Groups [2] on Land Receiving Liquid Manure, by Province [1]

Province	Perennial Forages (%)	Cereals (%)	Corn (%)	Oilseeds (%)	Fruit and Vegetables (%)	Other (%)
Newfoundland	x	x	x	x	x	x
PEI	48.3	x	x	x	x	x
Nova Scotia	74.8	x	23.0	x	x	x
New Brunswick	75.7	x	x	x	x	x
Atlantic	71.5	5.0	20.0	x	x	x
Quebec	55.5	7.3	26.7	8.8	0.2	1.5
Ontario	22.1	6.2	61.7	8.0	x	1.3
Manitoba	24.1	16.1	21.2	33.6	x	x
Saskatchewan	19.5	42.3	x	34.7	x	x
Alberta	10.2	50.8	3.0	35.7	x	x
Prairie	16.4	37.3	9.5	34.8	x	x
B.C.	66.4	x	26.5	x	1.2	x
Canada	38.8	13.5	32.0	13.9	0.6	1.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 14c: Percentage of Acres Growing Various Crop Groups [2] on Land Receiving Liquid Manure, by Ecoregion [1]

Ecoregion	Perennial Forages (%)	Cereals (%)	Corn (%)	Oilseeds (%)	Fruit and Vegetables (%)	Other (%)
Atlantic Maritime	75.4	8.3	10.7	2.3	x	x
St. Lawrence Lowlands	39.1	4.4	43.1	8.3	x	2.2
Manitoulin-Lake Simcoe-Frontenac	20.1	6.6	66.1	4.0	x	x
Lake Erie Lowland	19.3	8.1	59.4	11.7	x	x
Southern Ontario	19.9	7.0	64.0	5.9	x	x
Boreal Shield	68.3	14.2	9.8	3.6	x	x
Brown Soil Zone	x	25.9	x	8.4	x	x
Dark Brown Soil Zone	10.8	53.5	x	18.1	x	x
Black Soil Zone	11.5	50.6	x	15.3	x	x
Lake Manitoba Plain	13.8	16.5	23.8	8.3	x	x
Boreal Plains	28.8	15.3	17.9	6.1	x	x
Prairie Region	16.2	37.9	9.0	12.2	x	x
Montane Cordillera	76.3	x	17.7	x	x	x
Pacific Maritime	63.9	x	30.3	x	1.5	x
B.C. Region	81.0	x	7.5	x	1.2	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 14a, 14b and 14c:

[1] Percent of acres is based on farms reporting acres for the two largest crop types, by area, grown on land that had liquid manure spread on it.

[2] Crop groups in Tables 14b and 14c are defined as per the crop types listed in Table 14a. For perennial forages, oilseeds, and corn the crop subgroup listed in Table 4a is identical to the crop group in Tables 14b and 14c. However, the "cereals", "fruit and vegetables", and "other" crop groups each involve several crop subgroups from Table 4a, as follows:

a) Cereals includes spring cereals and winter cereals
b) Fruit and vegetables includes small fruit, tree fruit, vegetables, and potatoes
c) Other includes other annuals, fallow, pulses, other unknown, and no crop

Key Results

1. Across Canada about 70% of land receiving liquid manure was used for growing perennial forages or corn, with slightly more perennial forage acres than corn. Most of the remaining 30% was evenly split between cereals and oilseeds, with fruits, vegetables, and other crops together accounting for only about 2% of liquid manure acres.

2. There were considerable differences between provinces and ecoregions, with different trends than the overall results noted above. For example,

a) Perennial forages were dominantly grown on liquid manured land in Atlantic and B.C. provinces / ecoregions, the Boreal Shield, and Quebec.
b) Cereals on liquid manured land was more common in the prairie provinces / ecoregions, particularly Saskatchewan, Alberta, and the Brown / Dark Brown Soil Zones.
c) Liquid manured corn was dominant in Ontario, Manitoulin-Lake Simcoe-Frontenac, and the Lake Erie Lowland, and very common in the St. Lawrence Lowlands.
d) Liquid manured oilseeds was more common in the prairie provinces, and the Brown / Dark Brown Soil Zones.

3. Compared to solid manure, land receiving liquid manure was used more for growing corn and less for cereals. Percentage values for other crop types were somewhat similar, although there was some decrease in the percent value for perennial forage on liquid manured land compared to solid.

Comments

1. Higher use of liquid manured land for growing corn may be associated with dairy and pork farms growing this crop for feed, since dairy and pork sectors tend to store most manure in liquid form. Another possible reason is the high nutrient requirements of corn, relative to other crop types, and the greater reliability of liquid manure as a nutrient source to help meet this requirement.

Comparison with FEMS 2006

The above noted trend in 2011 for liquid manured land to be used more for growing corn and less for cereals compared to solid manure, also occurred in 2006. Nevertheless, both corn and cereals appeared to be more common on liquid manured land in 2006 compared to 2011. The percent value for perennial forages in 2006 was similar to 2011**.**

3. Extent of Liquid Manure Application

This section reports extent of liquid manure application in two ways. The first is based on total cropland area. The second is based on only farms that applied liquid manure and specific crop types on those farms that received manure. The latter approach provides an indication of a farm's capacity to utilize manure as a nutrient source for specific crop types.

a) Area of Liquid Manured Land versus Total Cropland

Table 15a: Percentage of Total Cropland Receiving Liquid Manure, by Crop Type and Province[1]

Province	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Oilseeds (%)	Cereals (%)	Other (%)	All Crops (%)
Newfoundland	93.4	x	x	x	x	x	83.6
PEI	24.6	x	x	x	x	x	10.7
Nova Scotia	49.3	68.3	x	x	x	x	31.0
New Brunswick	40.7	x	x	x	x	x	27.0
Atlantic	42.5	68.4	x	x	x	x	22.8
Quebec	73.3	33.9	2.1	17.7	33.5	34.1	41.9
Ontario	12.6	24.9	x	2.6	4.1	14.0	10.9
Manitoba	6.5	22.9	x	2.7	1.6	x	3.2
Saskatchewan	0.7	x	x	0.3	0.3	x	0.3
Alberta	1.1	22.1	x	2.1	1.7	x	1.7
Prairie	1.6	22.8	x	1.3	0.9	x	1.1
B.C.	10.9	[2]100.0	x	x	x	x	9.1
Canada	11.8	28.6	2.7%	1.9	1.4	0.4	4.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 15b: Percentage of Total Cropland Receiving Liquid Manure, by Crop Type and Ecoregion[1]

Ecoregion	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Oilseeds (%)	Cereals (%)	Other (%)	All Crops (%)
Atlantic Maritime	76.2	86.7	x	36.0	36.9	x	51.8
St. Lawrence Lowlands	55.9	31.1	x	11.6	22.1	36.5	29.7
Manitoulin-Lake Simcoe-Frontenac	9.7	39.6	x	4.2	5.6	x	15.4
Lake Erie Lowland	18.5	11.9	x	1.3	2.6	x	5.7
Southern Ontario	11.3	23.9	3.9	2.2	4.0	x	10.1
Boreal Shield	32.6	58.8	x	7.5	12.8	x	21.5
Brown Soil Zone	1.4	x	x	1.0	x	x	0.4
Dark Brown Soil Zone	0.8	x	x	0.8	0.8	x	0.7
Black Soil Zone	1.7	x	x	1.4	1.6	x	1.5
Lake Manitoba Plain	5.9	15.6	x	3.2	1.9	x	3.5
Boreal Plains	1.5	76.2	x	1.0	0.4	x	1.0
Prairie Region	1.5	21.6	x	1.3	0.9	x	1.1
Montane Cordillera	8.4	x	x	x	x	x	9.1
Pacific Maritime	79.6	[2]100.0	x	x	x	x	56.0
B.C. Region	22.0	86.9	x	x	x	x	23.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 15a and 15b:

[1] Accuracy of data is somewhat constrained by the following:

a) Land area receiving liquid manure is limited to two primary crops grown on liquid manured land, while harvested land includes up to 5 annual crop types, 3 perennial forage types, and 3 fruit types. While this means that the amount of liquid manured land could be greater than reported, more in-depth analysis of this issue suggests that this underestimate is relatively small because many farms that reported liquid manure application did not report more than 2 harvested crop types.
b) Land area receiving liquid manure includes farms from both crop and livestock modules, while harvested cropland is only from the crop module. Nevertheless, appropriate weighting differences are used to relate data from different survey modules.
c) Only farms that spread more liquid manure than solid, are included in the liquid manure data, therefore, also contributing to some underestimate of liquid manure land area.

[2] Actual calculated value exceeded 100, possibly due to much higher proportion of liquid manure data originating from livestock module. Value reduced to 100, but is likely somewhat < 100.

Key Results

1. Generally, across Canada only a small percentage of cropland (4.2%) received liquid manure. Corn crops received the most liquid manure (28.6%) followed by perennial forages (11.8%). Remaining crop types received liquid manure on 3% or less of land area.

2. The percent of cropland receiving liquid manure was considerably less in prairie provinces / ecoregions, compared to the rest of Canada. Parts of Ontario and B.C. (eg. Lake Erie Lowland and Montane Cordillera ecoregions) and PEI also had a low percent of cropland receiving liquid manure. On the other hand, provinces of Newfoundland and Quebec and the Atlantic Maritime, Pacific Maritime, and St. Lawrence Lowlands ecoregions had a larger percent of cropland receiving liquid manure.

3. Compared to solid manure (see section D3a) liquid manure was applied to an even lower percentage of total cropland area (4.2% versus 6.3%). Similarly, for each crop type, liquid manure was applied to a lower percentage of land compared to solid, except corn. In the latter case liquid was applied to 28.6%, while solid was applied to 19% of corn area.

Comments

1. More corn and perennial forages receiving liquid manure, is likely a reflection of these crops predominantly being grown for livestock feed, as explained in section D3a. More specifically, the higher percentage of corn land receiving liquid manure may be a reflection of dairy farms which produce dominantly liquid manure and have a large reliance on corn silage for feed. However, part of this trend may also be due to crop farmers growing corn in close proximity to hog farms supplying liquid manure.

2. The low percent of cropland receiving liquid manure in the prairies, could be due to larger cropland areas per farm in this region or fewer livestock farms compared to crop farms. Both reasons may be valid, since the latter reason seems to only partially account for this trend, as more fully discussed in the next section.

Comparison with FEMS 2006

In FEMS 2006 the analysis methodology was somewhat different so results are not comparable.

b) Extent of Manure Application for Farms Applying Liquid Manure

Table 16a: Percentage of Cropland Receiving Liquid Manure for Farms Applying Liquid Manure, by Crop Type and Province [1]

Province	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Oilseeds (%)	Cereals (%)	Other (%)	All Crops (%)
Newfoundland	x	x	x	x	x	x	x
PEI	x	x	x	x	x	x	62.9
Nova Scotia	83.8	98.7	x	x	x	x	88.5
New Brunswick	63.3	x	x	x	x	x	66.4
Atlantic	71.2	82.8	x	96.0	x	x	72.5
Quebec	81.2	55.0	x	90.8	60.8	82.0	67.9
Ontario	75.0	65.5	x	76.8	47.5	85.5	65.8
Manitoba	65.5	40.4	x	31.3	23.7	x	33.5
Saskatchewan	x	x	x	x	x	x	17.2
Alberta	70.4	x	x	39.8	x	x	42.2
Prairie	53.1	50.1	x	33.9	25.7	x	32.3
B.C.	84.5	96.6	x	x	x	x	78.5
Canada	76.0	61.2	45.6	49.0	36.3	82.9	57.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 16b: Percentage of Cropland Receiving Liquid Manure for Farms Applying Liquid Manure, by Crop Type and Ecoregion [1]

Ecoregion	Perennial Forage (%)	Corn (%)	Fruits & Vegetables (%)	Oilseeds (%)	Cereals (%)	Other (%)	All Crops (%)
Atlantic Maritime	77.4	85.2	x	97.0	82.4	x	80.5
St. Lawrence Lowlands	79.7	51.0	x	82.6	50.4	82.4	59.9
Manitoulin-Lake Simcoe-Frontenac	67.6	75.3	x	79.2	51.6	x	71.0
Lake Erie Lowland	96.2	70.9	x	x	x	x	77.6
Southern Ontario	80.0	74.4	x	83.6	50.1	x	72.7
Boreal Shield	73.8	x	x	71.6	37.3	x	66.6
Brown Soil Zone	x	x	x	x	x	x	x
Dark Brown Soil Zone	x	x	x	x	x	x	16.0
Black Soil Zone	x	x	x	56.4	32.4	x	44.2
Lake Manitoba Plain	x	x	x	19.0	21.8	x	21.8
Boreal Plains	40.8	x	x	74.6	25.0	x	33.6
Prairie Region	52.9	49.9	x	34.4	25.6	x	32.3
Montane Cordillera	86.5	x	x	x	x	x	90.1
Pacific Maritime	83.5	95.1	x	x	x	x	88.4
B.C. Region	84.5	96.6	x	x	x	x	88.9

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 16a and 16b:

[1] This analysis only considers, at the individual farm record level, harvested crop types that received liquid manure application. All harvested acres for farms that did not apply liquid manure plus harvested acres of crop types not receiving liquid manure on farms that applied liquid manure are both not included in this analysis. This analysis, therefore, provides an indication of the extent to which producers applied liquid manure on all acres of a crop type that received liquid manure. This approach was used because farms were asked to report up to 8 different harvested crop types, but were limited to only 2 crop types receiving liquid manure application. Note that a very small percentage (<2.5%) of land in this data set received both solid and liquid manure application. Therefore, application of solid manure on the same land would not be a significant reason to limit application of liquid manure.

Key Results

1. As expected, the percent values in this section for specific crop types, provinces, and ecoregions are always greater than the previous section, because the calculation is always based on a smaller subset of harvested crop types receiving liquid manure, rather than total harvested crop types.

2. Also as expected, the differences between provinces, ecoregions, and crop types in this section appear to be smaller than the previous section. This is because variations in the percent of farms that apply liquid manure in different provinces, ecoregions, and crop types have been removed from the analysis.

3. A higher percentage of perennial forage, corn and "other" crop types received liquid manure, compared to fruits/vegetables, and oilseeds and cereals.

4. The percent of cropland receiving liquid manure was somewhat less in prairie ecoregions and provinces, compared to the rest of Canada. These regional trends are similar to the previous section based on total harvested cropland.

5. Compared to solid manure (see section D3a) liquid manure was applied to a considerably higher percentage of cropland area (57.6% versus 28.7%) for farms that grow crop types receiving manure. This trend also occurred for each crop type, with the exception of fruits & vegetables where a similar percentage of land received manure regardless if it is liquid or solid.

Comments

1. The large increase in percent of acres for all crop types in this section, compared to the previous section, is an indication that a relatively small percentage of farms apply liquid manure. Similar conclusions could be drawn when comparing the increase in percent of acres for most ecoregions and provinces in this section compared to the previous section.

2. A higher percentage of cropland receiving liquid manure compared to solid manure, for farms and crop types receiving manure, may be an indication of the greater ability to transport liquid manure long distances (eg. pumping through pipelines/hoses). It could also be due to liquid manure being perceived as a higher value or more reliable source of nutrients based on a more available, consistent nutrient supply and ability to apply liquid manure more precisely at targeted rates.

Comparison with FEMS 2006

In FEMS 2006 the analysis methodology was somewhat different so results are not comparable.

4. Frequency of Liquid Manure Application

Table 17a: Percentage of Acres Receiving Liquid Manure Applications at Various Frequencies[1], by Province

Province	More than twice a year (%)	Twice a year (%)	Once per year (%)	Once every two years (%)	Less than once every two years (%)
Newfoundland	x	x	x	x	x
PEI	x	x	73.2	x	x
Nova Scotia	x	39.0	32.7	x	x
New Brunswick	x	49.9	39.6	x	x
Atlantic	15.5	39.0	41.7	2.2	1.5
Quebec	19.5	39.4	36.8	2.6	1.6
Ontario	8.6	25.4	45.9	3.9	16.3
Manitoba	x	12.1	49.4	17.3	18.2
Saskatchewan	x	14.5	19.6	x	45.7
Alberta	9.4	34.7	39.3	4.3	12.3
Prairie	7.0	24.1	40.2	9.9	18.8
B.C.	38.1	21.4	38.5	x	x
Canada	14.0	31.4	40.4	4.6	9.6

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 17b: Percentage of Acres Receiving Liquid Manure Applications at Various Frequencies[1], by Crop Type

Crop Type	More than twice a year (%)	Twice a year (%)	Once per year (%)	Once every two years (%)	Less than once every two years (%)
Cereals	3.4	18.7	57.1	5.9	15.0
Corn	3.5	29.6	48.0	5.2	13.7
Oilseeds	3.7	25.7	44.7	8.4	17.5
Forage	29.8	39.8	26.5	2.4	1.5
Other	4.0	13.5	58.7	x	17.4

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 17c: Percentage of Acres Receiving Liquid Manure Applications at Various Frequencies[1], by Ecoregion

Ecoregion	More than twice a year (%)	Twice a year (%)	Once per year (%)	Once every two years (%)	Less than once every two years (%)
Atlantic Maritime	25.9	38.0	34.2	1.3	0.6
St. Lawrence Lowlands	11.9	38.4	42.9	4.0	2.8
Manitoulin-Lake Simcoe-Frontenac	9.6	24.1	40.8	2.4	23.1
Lake Erie Lowland	11.8	27.6	44.8	3.2	12.6
Southern Ontario	10.3	25.2	42.0	2.6	19.9
Boreal Shield	18.0	33.2	40.6	x	x
Brown Soil Zone	x	x	x	x	x
Dark Brown Soil Zone	x	24.1	21.9	x	45.2
Black Soil Zone	x	32.2	43.1	9.4	7.7
Lake Manitoba Plain	x	x	47.0	x	26.
Boreal Plains	x	15.6	53.9	10.1	16.3
Prairie Region	7.1	24.1	40.3	9.5	19.0
Montane Cordillera	x	17.6	64.6	x	x
Pacific Maritime	47.9	23.2	28.5	x	x
B.C. Region	38.6	21.7	38.4	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 17a, 17b, and 17c:

[1] Frequency of manure application in this survey means how often land typically receives manure, not how often a manure storage is emptied or pumped. Data is based on individual responses indicating the most common frequency for each crop type reported.

Key Results

1. "Once per year" was the most common frequency of liquid manure application overall (40.4%), closely followed by "twice a year" (31.4%), with "more than twice per year" in third place (14%).

2. "Once per year" was also the most common frequency for most provinces, ecoregions, and crop types, with the following notable exceptions:
   a) "Twice a year" was most common in Nova Scotia, Quebec, Atlantic Maritime, and for forages.
   b) "More than twice a year" was most common in the Pacific Maritime.
   c) "Less than once every two years" was most common in Saskatchewan and the Brown Soil Zone.

3. In general, liquid manure was spread more frequently on forages compared to other crop types, and less frequently in prairie provinces/ecoregions than other areas.

4. Compared to solid manure (see section D4), liquid manure was spread more frequently.

Comments

1. Regional differences in frequency of liquid manure application may be related to the amount of available land to receive manure or the amount of liquid manure storage capacity. For example, less frequent application in the prairie province / ecoregions may be due to greater cropland area per farm. Other FEMS analysis shows that storage capacity of liquid manure storages in the prairie region is somewhat longer than in other regions.

2. More frequent application on forages and in the Pacific Maritime ecoregion, may be associated with multiple grass forage harvests per year on dairy farms. For other crop types involving only one harvest, it is often not feasible to apply manure part way through the growing season.

3. More frequent application of liquid compared to solid manure, may reflect the need to empty liquid manure storages at various times throughout the year due to limited storage capacity. For instance, other FEMS analysis reveals that over 60% of farms have less than 12 months of liquid manure storage capacity. This is inherently not an issue with solid manure which can usually be stockpiled in an open area.

Comparison with FEMS 2006

This question was not asked in the FEMS 2006 survey.

5. Season of Liquid Manure Application

Table 18a: Percentage of Acres[2] Receiving Liquid Manure Application in Various Seasons[1], by Province

Province	Spring (%)	Summer (%)	Fall (%)	Spring & Fall (%)	Spring & Summer (%)	Other Periods (%)
Newfoundland	x	x	x	x	x	x
PEI	x	x	x	x	x	x
Nova Scotia	26.6	x	x	23.6	x	8.4
New Brunswick	x	x	x	x	x	x
Atlantic	29.8	x	18.6	23.8	7.8	13.9
Quebec	27.7	17.7	13.4	14.6	12.1	14.4
Ontario	31.8	9.5	20.7	28.6	2.2	7.1
Manitoba	11.2	x	60.9	15.2	x	7.2
Saskatchewan	13.3	x	46.7	23.1	x	x
Alberta	10.4	4.5	22.4	45.8	x	12.0
Prairie	11.1	3.7	39.4	31.9	3.6	10.4
B.C.	35.7	x	15.5	9.9	8.5	24.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 18b: Percentage of Acres[2] Receiving Liquid Manure Application in Various Seasons[1], by Ecoregion

Ecoregion	Spring (%)	Summer (%)	Fall (%)	Spring & Fall (%)	Spring & Summer (%)	Other Periods (%)
Atlantic Maritime	23.4	17.0	13.0	13.6	16.5	16.5
St. Lawrence Lowlands	29.1	14.7	16.6	21.0	7.6	11.1
Manitoulin-Lake Simcoe-Frontenac	38.9	9.7	16.9	26.4	2.5	5.5
Lake Erie Lowland	32.1	x	20.4	27.2	x	12.2
Southern Ontario	36.9	9.1	18.0	26.7	1.9	7.5
Boreal Shield	19.6	18.6	22.7	13.8	9.7	15.5
Brown Soil Zone	x	x	x	x	x	x
Dark Brown Soil Zone	16.8	x	37.8	27.5	x	x
Black Soil Zone	12.3	x	21.8	49.7	0.6	14.0
Lake Manitoba Plain	x	x	77.7	x	x	x
Boreal Plains	8.8	x	55.1	15.1	x	11.2
Prairie Region	11.2	x	39.1	32.1	3.5	10.4
Montane Cordillera	43.7	3.8	19.6	x	x	x
Pacific Maritime	33.4	x	13.3	11.2	x	24.5
B.C. Region	36.2	x	15.0	10.0	x	24.4

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 18c: Percentage of Acres[2] Receiving Liquid Manure Application in Various Seasons[1], by Crop Type

Crop Type	Spring (%)	Summer (%)	Fall (%)	Spring & Fall (%)	Spring & Summer (%)	Other Periods (%)
Cereals	26.7	3.0	30.6	30.5	2.2	7.0
Corn	43.6	5.2	13.8	30.3	2.1	4.9
Oilseeds	18.9	4.8	36.8	30.1	2.5	6.9
Forage	12.1	21.0	19.7	12.0	14.5	20.8
Other	43.0	26.6	19.6	x	x	x
Canada	25.3	11.4	21.7	22.7	7.1	11.7

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 18a, 18b, and 18c:

[1] Farms were asked to report the percent of liquid manure that was applied during four different seasons for each of the two reported crop types. Total percent for each crop type added up to 100. The four seasons were defined as follows:

1. right after harvest 2010
2. during winter
3. before crop growth began in 2011
4. after crop growth began in 2011

In order to facilitate analysis and reporting, 6 classes were developed as per the above tables and calculated for each crop type receiving manure for each respondent. The classes are defined as follows:

a) Spring: at least 70% of manure applied during season 3
b) Summer: at least 70% of manure applied during season 4
c) Fall: at least 70% of manure applied during season 1
d) Spring & Fall: manure applied during season 3 and 1 together is at least 80%, and the percent of manure applied in season 3 & 1, individually are both greater than seasons 2 & 4.
e) Spring & Summer: manure applied during season 3 and 4 together is at least 80%, and the percent of manure applied in season 3 & 4, individually are both greater than seasons 1 & 2.
f) Other Periods: All other relevant data that doesn't fit into above classes.

[2] The survey does not ask percent of acres receiving manure in different seasons, but rather percent of manure applied in different seasons. Therefore, to facilitate reporting based on acres it is necessary to assume that the average rate of manure application for a specific region or crop type, does not vary between seasons. This assumption may not be entirely true, but possibly acceptable due to the narrow range of application rates that are feasible with manure spreading equipment. Despite this uncertainty, this approach provides more useful information than reporting on a percent of farms basis because the amount of manure applied per farm is highly variable and unknown. .

Key Results

1. Across Canada the most common season for liquid manure application was "spring", followed closely by "spring & fall" and "fall". Together these three periods accounted for more than two-thirds of liquid manure application, with the remaining periods each contributing about 11% or less.

2. Notable differences between provinces and ecoregions were as follows:
   a) generally greater fall application and less spring application in the prairie provinces and ecoregions, compared to other areas. However, there were some large differences for specific provinces (eg. Manitoba versus Alberta).
   b) other trends were hard to determine partly due to high data suppression.

3. Seasonal distribution of liquid manure application varied considerably between crop types, as follows:
   a) "Spring" was the most common season for applying liquid manure on corn and "other" crop types.
   b) "Fall" and "Spring & Fall" together were the most common seasons for oilseeds and cereals.
   c) Liquid manure on forages tended to be fairly evenly split between most classified seasons.

4. Compared to solid manure (see section D5) less liquid manure was spread in "fall" and more was spread in "spring & fall" and "spring & summer".

Comments

1. Greater fall application for oilseeds and cereals may be associated with prairie provinces/ecoregions where these crop types are more common, while greater spring application for corn and "other" crop types may be associated with non-prairie regions.

2. Greater fall application in the prairies is not surprising given the long period of time this region has frozen soils and also lower precipitation amounts during the winter. On the other

hand, the lowest percent of primarily fall application occurs in the Pacific Maritime ecoregion, which has the greatest risk of overwinter nutrient losses due to unfrozen soils and high precipitation.

3. Greater values for liquid compared to solid for multiple seasons “spring & fall” and “spring & summer”, is consistent with the trend in the previous section showing greater frequency of liquid manure application compared to solid.

Comparison with FEMS 2006

In 2006 the values for “spring” are higher and the values for “spring & fall” are lower. This is similar to the result for solid manure (see section D5), except that for solid manure “fall” had lower values in 2006. As discussed in section D5 the reason for differences between 2006 and 2011 is uncertain, although a trend toward less spring and more fall application may be related to increasing cropland areas per farm causing time constraints for spring field work.

6. Liquid Manure Application Method

Table 19a: Percentage of Acres Utilizing Various Liquid Manure Application Methods, by Province[1]

Province	Direct injection into soil (%)	Low boom applicator, below crop canopy [2] (%)	Spread and not worked into the soil (%)	Spread and worked into the soil (%)
Newfoundland	x	x	x	x
PEI	x	x	43.1	55.2
Nova Scotia	x	x	73.0	35.0
New Brunswick	x	x	74.4	19.1
Atlantic	x	x	68.9	32.7
Quebec	2.7	61.9	26.8	14.0
Ontario	6.0	23.9	27.0	61.2
Manitoba	61.7	x	15.4	25.6
Saskatchewan	60.9	x	x	38.8
Alberta	24.8	x	32.8	42.5
Prairie	42.8	16.0	23.3	36.0
B.C.	x	14.9	51.1	35.9
Canada	12.9	37.3	28.5	33.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 19b: Percentage of Acres Utilizing Various Liquid Manure Application Methods, by Ecoregion[1]

Ecoregion	Direct injection into soil (%)	Low boom applicator, below crop canopy [2] (%)	Spread and not worked into the soil (%)	Spread and worked into the soil (%)
Atlantic Maritime	1.8	47.8	42.5	14.6
St. Lawrence Lowlands	3.6	58.8	20.9	23.7
Manitoulin-Lake Simcoe-Frontenac	3.4	28.6	21.4	67.3
Lake Erie Lowland	12.8	14.9	34.1	56.7
Southern Ontario	6.3	24.4	25.3	64.1
Boreal Shield	6.6	35.5	47.1	16.1
Brown Soil Zone	61.8	x	x	x
Dark Brown Soil Zone	50.8	x	x	35.4
Black Soil Zone	23.7	x	38.6	41.4
Lake Manitoba Plain	78.0	x	x	13.6
Boreal Plains	46.7	x	15.0	42.1
Prairie Region	42.4	16.3	23.3	36.3
Montane Cordillera	x	x	51.0	44.6
Pacific Maritime	x	15.5	52.0	31.7
B.C. Region	x	15.1	51.7	35.2

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 19c: Percentage of Acres Utilizing Various Liquid Manure Application Methods, by Crop Type [1]

Crop Type	Direct injection into soil (%)	Low boom applicator, below crop canopy [2] (%)	Spread and not worked into the soil (%)	Spread and worked into the soil (%)
Cereals	24.4	26.0	20.6	44.4
Corn	10.2	37.5	10.0	58.3
Oilseeds	32.5	30.1	20.9	33.9
Forage	3.8	44.0	48.1	10.3
Other	x	18.8	34.4	32.7

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 19a, 19b, and 19c:

[1] This question was asked twice, once for each of two primary crop types grown on land that received liquid manure application. Acres is based on the area of land of each of the two primary crop types grown on land that received liquid manure. Respondents are asked to indicate all that apply. If a farm indicated > 1 method for a particular crop type, it is assumed that each method is used on the entire number of acres reported since there is no other way to interpret. This assumption may be correct for instances where frequencies of application (see section E4) are greater than once per year, but not for other

frequencies. While there is some potential of over reporting acres, some further analysis suggests that the total number of acres is within 95% accuracy. Therefore, while percent values added together exceed 100, the relative proportion of these values should not be significantly impacted.

[2] The full wording of this method in the survey questionnaire was “low boom applicator, below crop canopy (e.g. sleighfoot or sidedress)”.

Key Results

1. Across Canada the percent of acres was fairly evenly split among three methods: “low boom applicator, below crop canopy” (37.3%), “spread and worked into the soil” (33.5%), and “spread and not worked into the soil” (28.5%). The fourth method “direct injection into soil” was used on fewer acres (12.9%).

2. There were considerable differences in the method of application between provinces, ecoregions, and crop types, most notably:
   a) Considerably more direct injection in prairie provinces/ecoregions compared to other areas, and more direct injection with oilseeds and cereals than other crop types.
   b) Considerably more low boom applicator in Quebec, the St. Lawrence Lowlands, and Atlantic Maritime ecoregions.
   c) More “spread and worked into the soil” in Ontario, PEI, and southern Ontario ecoregions, and also more for corn than other crop types.
   d) More “spread and not worked into the soil” in B.C. and Atlantic provinces/ecoregions.
   e) Forages primarily utilized application methods that involved no soil disturbance , such as “spread and not worked into the soil” and “low boom applicator”.

Comments

1. Direct injection is often the preferred method of application to maximize nutrient efficiencies, and minimize environmental impacts such as odour and nutrient/pathogen movement/losses offsite via surface runoff. However, there is risk of damaging roots of perennial forage stands with direct injection. Direct injection is most commonly used in the prairies for injecting liquid manure on land used for growing oilseeds and cereals.

2. Low boom applicators are designed to reduce odor and risk of nutrient/pathogen losses on fields in perennial crops where direct injection is not possible. Higher adoption in Quebec is likely due to greater regulation. Despite being the most common practice across Canada, data for many provinces and ecoregions is suppressed. This is because a large percentage of Canadian farms that apply liquid manure are from the province of Quebec.

3. The higher incidence of non-incorporated broadcasted liquid manure in B.C. and Atlantic is likely associated with higher percentages of perennial forage cover, as shown in section E2.

4. There are more methods available to apply liquid manure than solid. While all solid manure is surface broadcast applied, slightly more than half of the liquid is applied this way. Of the liquid manure that is surface broadcast (ie. 28.5% + 33.5%) just over half is incorporated (33.5%). For solid manure also just over half is incorporated (53.4%).

Comparison with FEMS 2006

Results from both periods are similar, except in 2011 there is some increase in “low boom applicators” and corresponding decrease in “spread and not worked into the soil”. This shift has likely occurred primarily on perennial forage land in Quebec, and could reflect a transition period as farms comply to recent regulation. Other provincial trends are similar between the two reporting periods.

7. Timing of Liquid Manure Incorporation After Application

Table 20a: Percentage of Acres Having Liquid Manure Incorporated At Various Times After Spreading[1], by Crop Type

Crop Type	On the same day as it was spread (%)	1-2 days after it was spread (%)	3-5 days after it was spread (%)	More than 5 days after it was spread (%)
Cereals	39.3	37.5	16.5	6.8
Corn	28.9	53.9	14.3	2.9
Oilseeds	52.6	35.1	9.4	x
Forage	27.3	42.4	11.1	19.3
Other	29.1	61.5	7.5	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 20b: Percentage of Acres Having Liquid Manure Incorporated At Various Times After Spreading[1], by Province

Province	On the same day as it was spread (%)	1-2 days after it was spread (%)	3-5 days after it was spread (%)	More than 5 days after it was spread (%)
Newfoundland	x	x	x	x
PEI	x	x	x	x
Nova Scotia	x	51.5	x	x
New Brunswick	x	x	x	x
Atlantic	45.7	42.0	x	x
Quebec	46.1	44.1	6.2	3.6
Ontario	26.6	53.8	15.2	4.3
Manitoba	24.0	57.0	16.7	x
Saskatchewan	x	x	x	x
Alberta	46.5	27.3	x	x
Prairie	37.2	36.8	17.3	8.7
B.C.	40.7	40.6	x	x
Canada	33.9	47.0	13.5	5.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 20c: Percentage of Acres Having Liquid Manure Incorporated At Various Times After Spreading[1], by Ecoregion

Ecoregion	On the same day as it was spread (%)	1-2 days after it was spread (%)	3-5 days after it was spread (%)	More than 5 days after it was spread (%)
Atlantic Maritime	49.8	36.7	5.1	x
St. Lawrence Lowlands	37.0	48.7	13.1	1.2
Manitoulin-Lake Simcoe-Frontenac	28.8	59.1	10.4	x
Lake Erie Lowland	20.6	42.7	22.4	x
Southern Ontario	26.7	54.9	13.5	4.9
Boreal Shield	36.5	45.0	x	x
Brown Soil Zone	x	x	x	x
Dark Brown Soil Zone	x	71.3	x	x
Black Soil Zone	44.2	25.4	x	x
Lake Manitoba Plain	x	x	x	x
Boreal Plains	47.2	31.4	17.3	x
Prairie Region	37.4	36.6	17.2	8.7
Montane Cordillera	x	x	x	x
Pacific Maritime	36.6	53.9	x	x
B.C. Region	39.6	41.1	x	x

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 20a, 20b, and 20c:

[1] Data in this section is based on respondents who indicated “Spread and worked into the the soil” from the previous section. Percent values add up to 100 because farms were asked to choose only one option, the one most commonly practiced. The question did not allow for reporting specific acres that the incorporation time was used, so it was assumed a particular incorporation time was used on all acres of the specified crop type. While this assumption may not be correct, percent values would not change significantly if the extent to which the most common incorporation time was used does not greatly change among different provinces, ecoregions, and crop types.

Key Results

1. Across Canada, about one-third of liquid manure was incorporated on the same day it was applied, and most liquid manure was incorporated within 2 days of application.

2. In general, there were few differences between provinces and eocregions, except for somewhat longer incorporation times in Ontario, Manitoba, and the Lake Erie Lowland.

3. Liquid manure spread on land used for oilseed production appeared to have shorter incorporation times than other crop types.

4. Liquid manure was incorporated sooner than solid manure (see section D7).

Comments

1. Quicker incorporation of liquid manure compared to solid, is likely a reflection of a greater desire to minimize ammonia volatilization losses since the % of total nitrogen in ammonia form is higher in liquid than solid manure. Quicker incorporation of liquid may also be related to mitigating increased odour, particularly when considering most liquid is from hog and dairy, and most solid is from beef.

Comparison with FEMS 2006

Results from 2006 on a farm basis are virtually the same as 2011.

8. Testing of Liquid Manure for Nutrient Content

Table 21a: Percentage of Farms Testing Liquid Manure for Nutrient Content in 2011, by Province

Province	%
Newfoundland	x
PEI	x
Nova Scotia	36.4
New Brunswick	x
Atlantic	31.3
Quebec	70.6
Ontario	24.4
Manitoba	50.6
Saskatchewan	32.7
Alberta	27.3
Prairie	37.2
B.C.	21.4
Canada	49.1

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table21b: Percentage of Farms Testing Solid Manure for Nutrient Content in 2011, by Crop Type [1]

Crop Type	%
Cereals	48.7
Corn	46.6
Oilseeds	48.1
Forage	51.5
Other	64.0

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 21b:
[1] This question is not asked for specific crop types. Farms are permitted to report up to two crop types. If a farmer reports two crop types grown on land receiving liquid manure it is assumed that tested manure was applied to both crop types.

Table 21c: Percentage of Farms Testing Liquid Manure for Nutrient Content in 2011, by Ecoregion

Ecoregion	%
Atlantic Maritime	67.0
St. Lawrence Lowlands	61.6
Manitoulin-Lake Simcoe-Frontenac	24.9
Lake Erie Lowland	28.7
Southern Ontario	26.0
Boreal Shield	58.3
Brown Soil Zone	50.0
Dark Brown Soil Zone	34.7
Black Soil Zone	27.6
Lake Manitoba Plain	54.5
Boreal Plains	40.7
Prairie Region	37.6
Montane Cordillera	x
Pacific Maritime	21.0
B.C. Region	21.5

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Key Results

1. Across Canada, about 50% of farms tested liquid manure for nutrient requirement.

2. However, there was considerable variability between provinces and ecoregions. For example, the percent of farms testing liquid manure was considerable higher in Quebec and Manitoba. Ecoregion differences also followed provincial trends.

3. There was little difference in the frequency of soil testing based on the crop type grown on liquid manured land.

4. Compared to solid manure, liquid was tested much more often. Nevertheless, regional trends were similar, for example, considerably higher testing of both solid and liquid manure in Quebec.

Comments

1. Greater testing of liquid manure compared to solid likely reflects a perception of liquid being a more consistent and valuable nutrient source. This is due partly to a more homogeneous material attained via agitation, but also liquid manure containing more available nutrients for crop uptake in the short term. This provides increased confidence in nutrient test results, for determining upcoming crop nutrient needs. This trend could also be due to greater nutrient management planning and regulation associated with intensive livestock operations that store liquid manure. Most liquid manure comes from reasonably large intensive livestock operations (eg. dairy, hog, poultry) which have increasingly been required to adhere to regulations on

manure management. On the other hand a greater percentage of solid manure comes from smaller beef cow/calf operations which may not be subject to as much regulatory control.

2. As noted in section D8, higher percent values in Quebec may reflect provincially based manure management programs which promote or require testing of both liquid and solid manure. This may also be occurring in Manitoba and some other provinces for liquid.

Comparison with FEMS 2006

Since 2006 there has been a slight increase in percent of farms testing liquid manure, from 41.6% to 49.1%. This increase has occurred in all provinces except Ontario, which has seen a slight decrease from 31.4% to 24.4%.

9. Decision Factors for the Rate and Amount Of Liquid Manure To Apply

Table 22a: Percentage of Farms Indicating Various Priority Ratings for the Importance of Different Factors in Deciding on the Rate and Amount of Liquid Manure to Apply [1]

Decision Factor [2]	Priority Rating [3]				Overall Rating [4] (0 to 3)
	[3] High (%)	[2] Medium (%)	[1] Low (%)	[0] None (%)	
crop nutrient requirement	65.4	22.4	7.3	4.8	2.48
soil testing	60.1	25.6	5.7	8.5	2.37
past experience	57.1	28.8	7.5	6.6	2.36
information sources	50.6	30.8	9.9	8.7	2.23
growing conditions	53.7	25.3	9.9	11.1	2.22
manure nutrients	49.1	31.9	9.3	9.7	2.20
land available	52.1	24.4	9.5	13.9	2.15
fertilizer cost	41.1	28.3	12.4	18.3	1.92
manure transport	26.0	27.5	24.2	22.3	1.57

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Table 22a:

[1] The question was only for farms in the crop module, mainly to limit the length of the already larger livestock module questionnaire.

[2] Decision factors in above table are abbreviated, with full wording provided below.

a) crop nutrient requirement: Nutrient requirement of crop grown or carryover nutrients from last crop
b) soil testing: Soil testing or plant analysis
c) past experience: The quantity of fertilizer used in the past, or based on experience
d) information sources: External sources of information (crop advisor, fertilizer dealer, provincial recommendations, neighbours etc)
e) growing conditions: Soil moisture, temperature or other growing conditions
f) manure nutrients: Nutrient content of manure
g) land available: Amount of land available to receive manure
h) fertilizer cost: Cost of fertilizer or amount of fertilizer applied
i) manure transport: Cost of transporting manure or distance from manure storage

[3] Farms can only indicate one priority rating per factor

[4] Overall rating provides a single weighted value for each decision factor based on the percent of responses for each priority rating. To do this the priority ratings are given numeric values as follows: high=3, medium=2, low=1, and none=0. This rating is used in the following 3 tables.

Table 22b: Overall Ratings for the Importance of Different Factors for Deciding on the Rate and Amount Liquid Manure to Apply, by Province

Province	crop nutrient requirement	soil testing	past experience	information sources	growing conditions	manure nutrients	land available	fertilizer cost	manure transport	Average Rating [1]
NL	2.26	1.91	2.74	1.65	2.12	1.60	1.85	2.31	1.12	1.95
PEI	2.43	2.01	2.48	1.73	1.81	1.95	1.62	1.76	1.72	1.95
NS	2.45	2.48	2.06	2.39	1.97	2.04	1.91	2.04	1.47	2.09
NB	2.10	1.66	2.37	1.80	1.90	1.87	2.43	2.07	1.86	2.01
Atlantic	2.33	2.12	2.27	2.04	1.92	1.95	2.00	2.00	1.64	2.03
QC	2.61	2.62	2.35	2.47	2.45	2.42	2.20	2.03	1.66	2.31
ON	2.50	2.31	2.40	2.16	2.20	2.10	2.21	1.92	1.51	2.14
MB	2.39	2.10	2.30	1.81	1.75	2.26	1.70	1.58	1.43	1.92
SK	2.12	1.40	2.32	1.79	0.99	1.56	1.57	1.35	0.94	1.56
AB	1.59	1.89	2.23	1.57	1.51	1.72	2.11	1.62	1.73	1.77
Prairie	2.04	1.90	2.28	1.71	1.53	1.94	1.83	1.56	1.46	1.81
BC	2.34	1.89	2.52	1.98	2.06	1.79	2.02	1.78	1.47	1.98

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 22c: Overall Ratings for the Importance of Different Factors for Deciding on the Rate and Amount Liquid Manure to Apply, by Ecoregion

Ecoregion	CNR	ST	PE	IS	GC	MN	LA	FC	MT	AR [1]
Atlantic Maritime	2.48	2.50	2.20	2.32	2.33	2.32	2.07	1.94	1.75	2.21
St. Lawrence Lowlands	2.62	2.54	2.41	2.41	2.39	2.31	2.25	2.08	1.62	2.29
Manitoulin-Lake Simcoe-Frontenac	2.56	2.33	2.42	2.24	2.14	2.24	2.17	1.84	1.61	2.17
Lake Erie Lowland	2.29	2.30	2.30	2.14	2.32	2.00	2.26	2.00	1.24	2.09
Southern Ontario	2.48	2.32	2.38	2.21	2.19	2.17	2.20	1.89	1.49	2.15
Boreal Shield	2.63	2.50	2.27	2.09	2.37	2.20	2.02	1.78	1.57	2.16
Brown Soil Zone	2.19	1.74	2.56	2.63	1.30	2.63	2.63	1.93	2.37	2.22
Dark Brown Soil Zone	1.75	2.20	1.65	2.00	1.20	1.85	1.65	1.09	0.65	1.56
Black Soil Zone	1.53	1.77	2.19	1.37	1.42	1.67	1.81	1.42	1.44	1.62
Lake Manitoba Plain	2.41	1.75	2.45	1.86	1.58	2.41	1.52	1.23	1.43	1.85
Boreal Plains	2.57	2.10	2.58	1.72	1.89	1.92	2.02	2.13	1.79	2.08
Prairie Region	2.05	1.93	2.28	1.73	1.54	1.95	1.84	1.56	1.46	1.81
Montane Cordillera	2.15	1.85	2.63	1.69	1.43	1.77	1.95	1.65	1.29	1.82
Pacific Maritime	2.40	1.87	2.47	2.09	2.31	1.80	2.02	1.82	1.54	2.04
BC Region	2.33	1.87	2.52	1.97	2.05	1.79	2.00	1.77	1.46	1.97

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Table 22d: Overall Ratings for the Importance of Different Factors for Deciding on the Rate and Amount Liquid Manure to Apply, by Crop Type [2]

Crop Type	crop nutrient requirement	soil testing	past experience	information sources	growing conditions	manure nutrients	land available	fertilizer cost	manure transport	Average Rating [1]
Cereals	2.48	2.49	2.32	2.18	2.11	2.36	2.09	1.92	1.75	2.19
Corn	2.68	2.53	2.43	2.38	2.33	2.29	2.16	2.08	1.62	2.28
Oilseeds	2.49	2.52	2.43	2.24	2.25	2.30	2.18	2.03	1.62	2.23
Forage	2.39	2.27	2.34	2.14	2.25	2.08	2.18	1.78	1.52	2.11
Other	2.35	2.01	2.16	2.17	1.99	2.12	1.95	1.83	1.23	1.98

Source: Statistics Canada (raw data), and Agriculture and Agri-Food Canada (table calculation)

Notes for Tables 22b, 22c, and 22d:

[1] Average rating is the average of all overall ratings for a specific province, ecoregion, or crop type. It provides an indication of the importance of all decision factors. Higher average ratings could be interpreted that the rate and amount of solid manure application is more carefully managed.

[2] This question is not asked for specific crop types. Farms are permitted to report up to two crop types. If a farmer reports two crop types grown on land receiving liquid manure it is assumed that the indicated priority ratings for each decision factor apply to both crop types.

Key Results

1. As shown in Table 22a, the top three decision factors, all with a medium - high rating, were "crop nutrient requirement", "soil testing", and "past experience". All remaining factors were in the medium range, except for "manure transport" which was given a "low to medium" overall rating.

2. The above order of priority often held true for specific provinces, ecoregions, and crop types, with the following notable exceptions, as per Tables 22b and 22c.

a) Lower priority for "crop nutrient requirement" in Alberta, and Dark Brown and Black Soil Zones.
b) Lower priority for "soil testing" in New Brunswick, Saskatchewan, and the Black Soil Zone.
c) Lower priority for "past experience" in the Dark Brown Soil Zone.
d) Higher priority for "information sources" in Quebec, Nova Scotia, the Brown Soil Zone and St. Lawrence Lowlands.
e) Higher priority for "growing conditions" in Quebec and St. Lawrence Lowlands, and lower priority in Saskatchewan, the Brown, Dark Brown, and Black Soil Zones, and the Montane Cordillera ecoregion.
f) Higher priority for "manure nutrients" in Quebec, Manitoba, Manitoba Lake Plain, and the Brown Soil Zone.
g) Higher priority for "land available" in New Brunswick and the Brown Soil Zone.
h) Lower priority for "fertilizer cost" in the Dark Brown Soil Zone.
i) Higher priority for "manure transport" in the Brown Soil Zone, but lower in the Dark Brown Soil Zone, Saskatchewan, and Newfoundland.

3. Average ratings varied somewhat between provinces, ecoregions, and crop types. In general prairie provinces/ecoregions, with the exception of the Brown Soil Zone and Pacific Maritime ecoregions, had lower average ratings than other provinces/regions. More specific comparisons from Tables 22b, 22c, and 22d are as follows:

a) Five out of nine factors were ranked higher for Quebec, than all other provinces.
b) Six out nine factors were ranked lower for Saskatchewan, than all other provinces.
c) Five out of nine factors were ranked higher for the Brown Soil Zone, than all other ecoregions. However, the other four factors for this ecoregion were rated considerably lower resulting in an overall rating that was not the highest, but second to the St. Lawrence Lowlands. The latter ecoregion ranked highest in the other four factors.
d) Seven out of nine factors were ranked lower for the Dark Brown or Black Soil Zones, than all other ecoregions.
e) Seven out of nine factors were ranked highest for corn, compared to other crop types.
f) Six out of nine factors were ranked lower for "Other", than all other crop types.

4. The variability between crop types, provinces, and ecoregions was greater for some factors than others. For provinces and ecoregions, the factor with the least variability was "past experience" and the factor with the highest variability was "growing conditions". For crop types, the lowest variability occurred with "information sources" and "land available", while the highest variability occurred with "soil testing".

5. Compared to solid manure, liquid manure factors were generally given a higher rating than solid. With liquid manure, "soil testing" and "information sources" in particular were ranked much higher, than with solid. There also appeared to be less variability in overall ratings for different crop types with liquid manure compared to solid manure.

Comments

1. Overall, higher decision factor ratings for liquid manure, compared to solid, is an indicator of a more carefully managed crop input. Much higher rating for "soil testing" indicates greater value placed on nutrient value of liquid manure. Much higher ratings for "information sources" may be an indicator of the need for technical expertise in making decisions on liquid manure application. All of this is consistent with increased liquid manure testing, compared to solid manure, as discussed in the previous question.

2. There are some similarities in provincial and ecoregion differences, between liquid and solid manure, such as higher ratings for Quebec and the St. Lawrence Lowlands. However, with liquid manure there appears to greater variability for some prairie based ecoregions (ie. high ratings for Brown Soil Zone compared to low ratings for Dark Brown and Black Soil Zones). The reason for this variability is uncertain, but one could speculate that it might be related to the proportion of farms that exceed a size threshold that have a regulatory requirement for nutrient management planning. In other words this proportion may be greater in the Brown Soil Zone.

Comparison with FEMS 2006

In 2006, a similar question was asked, however, with the following differences:

a) Instead of indicating a priority rating for each factor, farmers were asked simply to indicate if each specific factor was considered. The analysis then focused on calculating the percent of farmers that indicated various factors. Differences in percent values can be considered as indicators of the relative importance of a factor compared to another, and can thus be compared with the differences in overall ratings calculated for 2011.

b) The specific wording of factors in 2011 has changed slightly from 2006.

Given the above limitations, it appears that the results from 2006 are similar to 2011, with the following exception:

a) Land available to apply manure was more important in 2006

Provincial trends were somewhat similar to 2011. However, in 2006 there appeared to be an even greater spread between the higher percent of farms (higher priority of factors) in Quebec, compared to the lower percent (lower priority) for prairie provinces. This suggests greater management improvement in prairie provinces where decision factors were the lowest, and is a similar trend that was noted with solid manure in section D9.