**Development of a Manitoba Soils Test for Cadmium**

**Manitoba Pulse Growers Association**

Interim Report:

The following information should be treated as confidential between AAFC and MPGA until verification and final report.

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**Principal and Collaborating Researchers**

Dr. Malcolm Morrison, AAFC – Ottawa, 960 Carling Ave, Ottawa, Ontario,

K1A 0C6. 1-613-759-1556 [Malcolm.morrison@agr.gc.ca](mailto:Malcolm.morrison@agr.gc.ca)

Eugene Gawalko, Anja Richter, Grains Research Lab, Canadian Grain Commission, 1404-606 Main St., Winnipeg, Manitoba, R3C 3G8. [egawalko@grainscanada.gc.ca](mailto:egawalko@grainscanada.gc.ca) [arichter@grainscanada.gc.ca](mailto:arichter@grainscanada.gc.ca)

Dr. Cindy Grant, AAFC – Brandon Research Centre, Grand Valley Road, Brandon, Manitoba, R7A 5Y3. 1-204-578-3570 [Cynthia.Grant@agr.gc.ca](mailto:Cynthia.Grant@agr.gc.ca)

Dr. Elroy Cober, AAFC - Ottawa, Bldg 110, Ottawa, Ontario, K1A 0C6.

613 759 1610 [Coberer@agr.gc.ca](mailto:Coberer@agr.gc.ca)

Mark Sandercock AAFC Morden Research Station, Morden, Manitoba [Mark.sandercock@agr.gc.ca](mailto:Mark.sandercock@agr.gc.ca)

**MPGA Priority**: Quality oriented varieties with food quality characteristics.

**Brief Project Description and Results**

Cadmium (Cd) is a toxic metal that has been identified in many crops in Canada in several important crop production regions. When consumed, Cd binds to mammalian tissues, particularly the liver and kidney, and in high doses causes organ failure and cancer. A limit of 200 ppb has been proposed by the World Health Organization for export grains. AAFC research in Manitoba from 2005 has established that in certain regions of the province (Morden, Carmen, Portage la Prairie), some soybean varieties accumulated up to 4 to 5 times the WHO allowable limit while in other regions (Winnipeg) the concentration of the same variety was less than 200 ppb. Cadmium uptake is affected by the genetics of the variety and the amount of Cd in the soil. An AAFC soybean breeding program has been initiated to breed low accumulating food-quality soybean varieties for Manitoba.

**Objectives:** The objectives of the two year project was to establish a relationship between soil and seed cadmium concentration and the development of a soils test producers can use to determine the status of their fields. Low cadmium accumulating varieties of soybean are being developed by AAFC to use on fields resulting in high soil cadmium concentration. The goal of the project is to lower the average seed cadmium concentration of soybean grown in Manitoba.

**Results:** MPGA funded research to survey soybean farms in the affected region. Fifty farms were sampled for grain and soil from producer’s fields in 2011 and 2012 (100 farms total). The 2011 seed was ground and analysed for cadmium concentration at the Grains Research Laboratory in Winnipeg. The average seed cadmium concentration was 225 ppb with a range from 27 to 1014. One half of the farms surveyed had seed cadmium concentrations below the 200 ppb CODEX limit. Soil cadmium ranged from 83 to 442 ppb with an average of 178 ppb. A relationship was developed between seed and soil cadmium concentration using 2011 result (Figure 1). The results are very similar to one developed in 2009 using soils from several regions of the country (Figure 2). Generally, from the data a soil cut-off concentration of 160 to 170 ppb can be used to distinguish between fields that will result in soybean seed with a concentration greater than 200 ppb.

**Milestones and Progress:**

2011 Spring and Summer:

* Selection of consulting company:
  + AAFC Morden was chosen to conduct the research and Mark Sandercock was the lead at Morden
* Selection of farms for soil and seed testing:
  + Farms were selected representing an area from the Manitoba escarpment east to the Red River and from an east west line extending through Carman south to the border. Within each field 4 sites were selected and marked with GPS coordinates.
* Data collection.
  + Soybean seed and soil were collected from each site in each field.

2012 Winter:

* Soil Cd extraction and analysis.
  + Soil was sent to Brandon, Manitoba for analysis.
* Seed ground and Cd analysis.
  + Soybean seed was threshed in Morden, shipped to Ottawa for grinding and shipped to GRL for processing.
* Data interpretation and reporting.
  + In late spring the data was received from Brandon and Winnipeg.
* Producers are informed about the Cd in their soils and soybean samples.
  + This has not been done yet

2012 Summer:

* Second summer of data collection following 2011 protocol.
  + Seed and soil samples have been collected

2013 Winter:

* Soil Cd extraction and analysis.
* Seed ground and Cd analysis.
* Data interpretation,model development, report writing, project evaluation to determine the next steps in Manitoba.

**Background Information from Original Proposal**

**Literature review**

Selecting low cadmium (Cd) accumulating varieties of staple crops, such as soybean, will provide Canadians with a healthy food supply and help secure international export markets. High levels of Cd have been recorded in staple food crops such as durum wheat, potato, soybean, and rice (Grant et al. 2008). Health Canada established a non-carcinogenic toxicological reference value of 0.0008 mg/kg/day (mg of soybean/kg of body weight/day) for Cd (2006). To put this in perspective, a 100 kg person could consume 400 g of soybean containing 0.2 ppm Cd while a 25 kg child could consume 100 g of soybean. If the concentration of Cd in the seed doubled to 0.4 ppm the adult and child could then consume only 200 and 50 g of soybean, respectively, well within achievable daily limits. If consumed in excess, Cd binds to mammalian tissues, particularly the liver and kidney, causing organ failure and cancer (Malan and Farrant 1998). Trade regulations established by the World Health Organization (CODEX Alimentarius) set a maximum of 0.2 mg/kg of Cd (200 ppb) in soybean (2008).

While the major factor affecting Cd concentration in soil is the natural abundance of the element, the application of fertilizers, manure and sewage sludge to fields has increased its concentration (Shute and Macfie 2006). In environments where it is more bio-available, Cd uptake by plants increases. Grant et al. (2008) documented the extensive Canadian experience breeding low-Cd accumulating durum wheat. In durum wheat, low-cadmium accumulation is controlled by a single dominant gene, which seems to have no or minor adverse effects on other traits. The first low cadmium durum cultivar was released in 2004 and now occupies more than 25% of the acreage. Any new durum cultivars registered in Canada must now be low cadmium accumulators.

Differences in Cd accumulation and mobility, as well as in Cd toxicity symptom intensity exist among soybean varieties (Grant et al. 2008; Arao et al. 2003. Cadmium has been shown to reduce root elongation and damage root structure, interfering with the translocation of other nutrients (Marchiol et al. 1996). Often visible symptoms of Cd damage occur far after the concentrations of the seed have exceeded WHO limits, increasing the Cd levels in the food system. Of the Canadian soybean cultivars that have been tested, 70% are high Cd accumulators and 30% are low Cd accumulators (Morrison et al. 2009). There is also a good relationship between available soil Cd concentration and seed concentration.

**Research Objectives:**

1. Collect soil and soybean seed samples from farms in the affected regions of Manitoba.
2. Analyse samples for Cd concentration and develop the relationship between available soil Cd and accumulated seed Cd.
3. Identification of commercial laboratories in Manitoba capable and interested in determining Cd concentration in soil.

**Experiment Activities and Methods.**

2011-2012: Obtain a cooperator in Manitoba to sample seed and soil from 55 farms in the region previously identified as having the highest seed Cd concentration. Ideally, the cooperator would be an Ag Advisory company knowledgable of soybean farmers in southern Manitoba. Also, it would be best if the farmers were growing varieties suitable for a food market. Soil samples (200 g) would be collected from the top 15 cm of the soil. The aim would be to have 5 samples collected from a 100 ha field. Each soil sample would have a GPS coordinate. Seed samples from 3 plants at the same location as the soil sample would be collected shortly before harvest. Seed and soil samples would be analyzed for Cd concentration, and other related elements, and a relationship developed between seed and soil concentration.

2012-2013: Second summer of soil and seed data collection from farms in the affected region following the 2011 protocol. Soils and seed Cd data base will be used to develop the relationship between seed and soil concentration in Manitoba. Summarize and review results with farmer stakeholders, MPGA, and the provincial government.

**Benefits and Impacts on Pulse Growers:**

A viable food-grade soybean industry depends upon meeting the WHO limit of 200 ppb in all soybean sold for human consumption. To add value to the soybean crop in Manitoba by capturing the high value food-grade market it is necessary that farms high in soil Cd concentration be identified, and low Cd varieties grown. Animal manure, from a feed source high in Cd, will increase the soil Cd concentration, therefore, even feed soybean should be low Cd accumulators.

**Budget**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  | 2011-2012 | 2012-2013 |
| AAFC A-base dollars | |  |  | 20,000.00 | 20,000.00 |
| CGC A-base dollars | |  |  | 6,000.00 | 6,000.00 |
| Total |  |  |  | 26,000.00 | 26,000.00 |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| MPGA contribution | |  |  |  |  |
| Manitoba Agricultural Consultant | | | | 17,250.00 | 17,250.00 |
| Soil analysis @ 12.50 per sample | | | | 3,953.00 | 3,953.00 |
| Seed analysis @ 12.50 per sample | | | | 3,953.00 | 3,953.00 |
| Shipping |  |  |  | 1,380.00 | 1,380.00 |
| Total MPGA contribution | | |  | 26,536.00 | 26,536.00 |
|  |  |  |  |  |  |
| Total Project costs (MPGA +AAFC+ CGC) | | | | 52,536.00 | 52,536.00 |
|  |  |  |  |  |  |
| MPGA two year contribution | | |  | 53,072.00 |  |

**Communications plan**

It is very important to communicate to Manitoba soybean producers that in some regions of the province the soybean varieties that they are growing may have the potential to accumulate a large amount of Cd in the seed. Many nations, interested in importing soybean from Manitoba, will be very interested in learning that the MPGA is proactively pursuing a plan to ensure that all food quality soybean produced in Manitoba have a low concentration of seed Cd. It is important that the province, the industry and the growers are on the same page when these proactive steps at reducing Cd are announced. Communication will be in the form of reports to MPGA. Data will be published in the scientific literature when appropriate.



Figure 1. Relationship between Soil and Seed Cadmium from Manitoba data.



Figure 2. Relationship between available soil cadmium and soybean seed cadmium.

**References:**

Arao, T., Ae, N., Sugiyama, M., and Takahashi, M. 2003. Genotypic differences in cadmium uptake and distribution in soybeans. Plant and Soil 251: 247-253.

Grant CA, Clarke JM, Duguid S, Chaney RL. 2008 Selection and breeding of plant varieties to minimize cadmium accumulation. Science of the Total Environment 390: 301-310.

Health Canada. 2006. Federal Contaminated Site Risk Assessment In Canada: Part II: Health Canada Toxicological Reverence Values (TRVs). Available: http://www.hc-sc.gc.ca/ewh-semt/pubs/contamsite/part-partie\_ii/trvs-vtr-eng.php.

Malan HL, Farrant JM. 1998 Effects of the metal pollutants cadmium and nickel on soybean seed development. Seed Science Research 8: 445-453.

Marchiol L, Leita L, Martin M, Peressotti A, Zerbi G. 1996 Physiological responses of two soybean varietiess to cadmium. Journal of Environmental Quality 25: 562-566.

Morrison, M.J., Elroy Cober, Vaino Poysa, Eugene Gawalko. 2009. “Soil Cadmium concentration influences soybean seed concentration. Joint meeting of the CSA and CSSA. Guelph, ON. Aug 2009. (seminar).

Morrison, M.J., Vanessa Mongeon, Elroy Cober, Vaino Poysa, Eugene Gawalko. 2010. A method for selecting low cadmium (Cd) accumulating soybean varieties. Joint meeting of the CSA and CSSA. Saskatoon Sask. June 2010. (seminar).

Shute, T., and Macfie, S.M. 2006. Cadmium and zinc accumulation in soybean: A threat to food safety? Science of the Total Environment 371: 63-73.