Canada Organic trade association
Biologique Association pour le commerce des produits biologiques

Glyphosate Residue in Canada

Contamination Risk And Related Market Access Barriers

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EXECUTIVE SUMMARY

Glyphosate is a broad spectrum, systemic herbicide ingredient widely used throughout the world. Authorized in Canada for weed control and sprayed throughout the growing season, substantially increased glyphosate use over the past few decades has led to subsequent exposure risk for non-target areas. Organic farms with conventional neighbors risk glyphosate exposure mainly through spray drift and by wind erosion of soil-bound glyphosate that is carried by the wind drops from the air, sometimes along with precipitation. Due to its timing, glyphosate applied as a pre-harvest "aid" on conventional crops presents a particular risk factor for organic crop harvests.

Beginning in 2011, identification of glyphosate residues on organic lentils led to the implementation of a glyphosate testing protocol for EU imports of conventional and organic commodities. After two years of crimped trade, in 2013 the EU raised its Maximum Residue Limit (MRL) for conventional lentils from 0.1 ppm to 10 ppm. Conventional lentils are expected to have glyphosate concentrations of up to 4 ppm, if label instructions for pre-harvest application are followed. MRLs for organic commodities have not been set for any residues, because the third-party verification and certification process mandated by organic standards provide quality assurance that organic products have been produced without prohibited substances.

Since 2011, an "orientation value" of 0.01 ppm (+/- 50%), first established by the German trade group Bundesverband Naturkost Naturwaren (BNN) in 2001, has been applied by many European buyers to test organic commodities for glyphosate, ostensibly to rout out and rule out fraud. Increased low-level testing for glyphosate has led to rejection or delay of substantial amounts of Canadian exports to Europe. The European market share loss since 2011 for the Canadian organic sector due to increased glyphosate testing is understood to be significant; precise accounting is impossible since Harmonized System codes have not yet been assigned for organic commodities.

Europe contends that organic crop glyphosate contamination on organic crops is likely due to post-harvest handling practices and fraudulent commingling. Meanwhile, the emergent Canadian organic sector view is that the test results represent the presence of on-farm background levels of glyphosate. This perspective is supported by a growing body of research, which has identified the widespread presence and a greater persistence of glyphosate in the environment than previously thought. Data made available for this report suggests that Canadian product test results are coming in at very low levels (maximum ~0.05 ppm). Additional research into glyphosate test results for Canadian organic product since 2011 is merited in order to distinguish basic glyphosate background levels from concentrated drift exposure. The organic sector can apply this information in many ways, including:

- In the development of protocols used by farmers, certifiers and traders when low-level glyphosate contamination is identified,
- To facilitate trade of compliant product; and in
- Crafting effective messaging that puts the level of glyphosate contamination identified on organic products into context with both background and contamination levels typical in conventional products.

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PART 1. BACKGROUND AND LITERATURE REVIEW.

Glyphosate is the world's most widely used herbicidal active ingredient (a.i.) (Duke and Powell, 2008). A weak organic acid, it is highly soluble (easily dissolved) in water. Its chemical name **N-(*phosphonomethyl*) glycine** describes its component chemical compounds, which are, in non-technical terms: (a) chemical groups that contain phosphorus and carbon, and (b) the amino acid glycine, which is a building block of proteins. Technical grade glyphosate is an odorless, white crystalline powder with >90% purity (WHO, 1994).

In Canada, glyphosate has been registered for use as an herbicide since 1976 (CCME, 2012). Since the 1999 expiration of the Monsanto Company's glyphosate herbicide patent, many other companies (including, but not limited to: Dow AgroSciences, Nufarm, AstraZeneca, Cenex/Land O'Lakes and Syngenta) have formulated proprietary herbicides that use glyphosate as the main phytotoxic (plant-killing) agent (Table 1) (Pauly, 2006).

Table 1. Ingredients and their roles in glyphosate-based herbicide products.[1]

Component	Role
a. Glyphosate	Kills plants.
b. Salt cations[2]: isopropylamine (IPA), monoammonium, diammonium, or potassium.	Glyphosate combines with these cations, creating a salt that improves glyphosate mixing with other ingredients.
c. Adjuvants (Surfactants and inerts)	These ingredients improve glyphosate leaf penetration. Individual listing of these ingredients is not required on product labels.
d. Other additives: sulfuric acid, phosphoric acid.	For improved wetting, leaf adherence, chemical stability, wider-spectrum effectiveness and reduced toxic loading for water-based ecosystems. Patent claims suggest that the manufacture, shipping, storage and application of glyphosate cost less when these additives are included.

Since its introduction in the 1970's, glyphosate has been promoted for plant control in many settings, including for agriculture, industry, forestry, and for urban and residential

[1] Information compiled from WHO, 1994; Young, 1995; Hartzler et al., 2006; Blumel, 2013; Penn State University Extension, 2014.

[2] A cation is a positively charged ion (ions can be simple atoms or complex molecules are either positively or negatively charged). Opposites attract: the positively charged cations named above are drawn to form a bond with glyphosate molecules, which are negatively charged. Together, they form a salt. The bonds

[2] A cation is a positively charged ion (ions can be simple atoms or complex molecules are either positively or negatively charged). Opposites attract: the positively charged cations named above are drawn to form a bond with glyphosate molecules, which are negatively charged. Together, they form a salt. The bonds holding glyphosate salts together are fairly weak, which makes glyphosate readily dissolvable in water.

areas. Agricultural applications, however, have always dominated glyphosate sales and use (Humphries et al., 2005; McGee et al., 2010).

Glyphosate is popular with farmers for several reasons. First and foremost, glyphosate provides extremely effective weed control. When growing conditions are good, most weeds sprayed with glyphosate at recommended rates die within a period of 10-14 days after application (Flaten et al., 2010). Glyphosate use provides significant flexibility in farmers' approach to weed and crop management, at relatively low cost. This is especially true when compared to weed control systems reliant on other, less broadly effective herbicides that have come under increasingly strict controls with regard to their use over time (Battaglin et al. 2005; Cerdiera and Duke 2006; Gianessi, 2008; Kremer and Means 2009). Glyphosate is also the preferred herbicide choice for weed control in no- and low-tillage farming systems (also called "conservation agriculture"), which have seen widespread adoption during the past three decades (Cerdiera and Duke, 2006; Triplett and Dick 2008).

Glyphosate costs dropped 40% between 1999 when Monsanto's glyphosate patent expired, and 2005. This time period coincided with the introduction to agriculture of genetically modified (GM) crops engineered to be resistant to glyphosate, and the rapid acceptance of these GM cultivars by farmers (Gianessi, 2008). Global land area planted to glyphosate-resistant GM crops has increased each year since their introduction (James, 2011). In 2012, Canada had 11.6 million hectares planted to glyphosate-resistant crops (canola, corn, soybean and sugar beet), up from 10.4 million hectares in 2011 (ISAAA, 2012). Because of their glyphosate resistance, fields planted to these crop varieties can be sprayed at many points during the growing season (Table 2).

Table 2. Registered (authorized) label uses of glyphosate-based herbicides in Canadian agriculture.[3]

Label uses	Non glyphosate-resistant crops	Glyphosate-resistant crops
1.Weed "burn-down" in "pre-emergent" situations, i.e., fields not yet planted to field crops. Purpose: early season weed control, influential for crop yields later in the season.	✔	✔
2. For spot treatment of weeds on areas adjoining fields.	✔	✔
3. As a "post-emergence" control for additional waves of weed growth among crops during the growing season.	✖	✔
4. As a "pre-harvest aid" or "management tool" applied 7-14 days before harvest to control weeds growing among crops.	✖	✔
5. Post-harvest application to rid fields of weeds and prevent seed set before winter.	✔	✔

[3] Information compiled from Flaten et al., 2010 and Monsanto Canada, 2014.

Because it is being sprayed multiple times by more farmers within a growing season, glyphosate use has increased exponentially worldwide in recent years. This is true for many areas of Canada (Humphries et al., 2005; Beckie, 2011; Messing et al, 2011). In Ontario, agricultural usage of glyphosate increased by approximately 76 percent from 2003 to 2008 (from 1,170,762 kg a.i.[4] to 2,062,648 kg a.i.) (McGee et al., 2010).[5] While the increased planting of glyphosate-tolerant crops can account for much of the increased use of glyphosate herbicides generally in Ontario and elsewhere, it must be noted that data gathered on agricultural glyphosate use is not collected in a manner that permits identification of how much glyphosate is being used on particular crops at any given point of time during the year (Hugh Martin, personal communication, May 20, 2014).

1.1. Characteristics of Glyphosate

Highly water-soluble; combines easily with other substances—Because glyphosate's chemical structure also makes it highly water soluble, it is not rain-fast, and therefore applications of glyphosate in wet conditions or when rain is anticipated are discouraged (Brønstad and Friestad, 1985; Hartzler et al. 2006).

When mixing up batches of glyphosate herbicide, standard practice calls for the addition of ammonium sulfate. The sulfate portion of ammonium sulfate binds preferentially with certain elements (specifically calcium, magnesium and sodium) commonly present in water. Without the addition of ammonium sulfate, these elements would bind with glyphosate, reducing its absorption by leaves and thus greatly decreasing its effectiveness as an herbicide (Buhler and Burnside, 1983; Hall et al., 1999; Bernards et al., 2005; Peterson and Thompson 2009). Dust on leaves also can inhibit glyphosate absorption into leaves and reduce its herbicidal potential (Zhou, 2006).

Systemic—Glyphosate is a "systemic" herbicide, which means that once it has been sprayed on the leaves that is actively growing, it is readily absorbed by the plant and is rapidly and readily transferred throughout plant tissue, down to roots as well as through stems to shoots and buds (Franz et al., 1997; Székacs and Darvas, 2012). Wherever it is distributed throughout the plant, glyphosate negatively affects plant metabolism, preventing the synthesis of certain amino acids-–and, by consequence, proteins—that the plant needs to function, grow and stay alive, resulting fairly rapidly in necrosis (plant death) (Steinrücken and Amhrein, 1980; Becerril et al., 1989; Franz et al., 1997; Reddy and Zablotowicz, 2003).

Broad-spectrum, non-selective—Glyphosate-based herbicides are described as being "broad spectrum" and "non-selective" because they are effective wherever they are sprayed, killing grasses, annuals, biennials, deep-rooted perennials and woody plants (Franz et al., 1997). They function especially well when conditions are optimal for plant growth (i.e., there is warmth and sun with humidity and no drought) and when plants are actively growing. Upon maturity, changes in plant cells halt glyphosate's translocation to

[4] The acronym "a.i." stands for "active ingredient". See beginning of this document.
[5] The next publication of Ontario's Survey of Pesticide Use (with data from 2013) is expected in 2014.

other plant tissues. For example, sprayed after seed set, glyphosate will not be transferred within the plant from leaves to seeds if they are already mature and drying out (Franz et al., 1997; Hartzler et al., 2006). In growing seasons when environmental conditions slow the physiological maturation of crops, residues of glyphosate and its main metabolite (breakdown by-product)—aminomethylphosphonic acid (AMPA)—in mature seed will tend to be higher (Cessna et al., 2000).

Sorbs (binds) strongly to soil particles—Glyphosate binds strongly with mineral and organic components of soil (also called sorption). Soil binding limits the ability of soil microbes to access and metabolize (break down/decompose) glyphosate (Zablotowicz et al., 2009; Capri and Vicari, 2010). Phosphorus loading in soil (due to additions of fertilizer, for example) has shown reduce glyphosate sorption in soil. This is because glyphosate binds preferentially to soil phosphorus relative to other soil components, forming a compound that is potentially more available for degradation by soil microbes (Sprankle et al., 1975b).

Decomposition/removal from environment depends primarily on soil microbes— Once glyphosate has been sprayed, its dissipation (removal from the environment) occurs mainly through degradation by soil microbes (Sprankle et al., 1975a; Piccolo et al., 1996; Degenhardt et al., 2012). Because glyphosate is not used as a carbon energy source by most soil microorganisms, its degradation in soil is thought to occur via a "co-metabolic" process—in other words, aerobic and anaerobic soil microbial species break down glyphosate together in complex pathways that are difficult to fully characterize (Borggaard and Gimsing, 2008). This metabolic process depends on soil conditions that are not particularly well understood, especially with regard to northern ecosystems (Helander et al, 2012).

Other pathways for removal from the environment—Glyphosate bound to soils and sediments may erode and get carried away with infiltrating water, including in surface runoff during spring melt from glyphosate sprayed the previous fall (Forlani et al 1999; Takacs et al. 2005; Humphries et al, 2005; Borggaard and Gimsing 2008; Peruzzo et al 2008; Farenhorst et al. 2008; Degenhardt et al., 2012). When bound to soil, glyphosate can also be carried off as dust through wind erosion (Humphries et al., 2005, Battaglin et al., 2014). Photo-degradation (light-induced chemical breakdown) and uptake/sorption by aquatic plants can occur, but these are minor pathways for glyphosate removal from the environment (Sprankle et al 1975a; WHO 1994, Roustan et al. 2014). Because of its low vapor pressure, loss of glyphosate by evaporation (volatilization) is not expected to occur (Brønstad and Friestad, 1985).

1.2. Environmental Assessment

Until fairly recently, glyphosate and its major metabolite derivative AMPA have not been included in regular environmental assessments because:

a) They are not typically present in the environment at "toxic" levels set by governmental guidelines (Struger et al., 2008; Battaglin et al. 2014);

b) Testing detection limits have lacked the precision required to quantify glyphosate and AMPA concentrations at levels likely to be found in the environment (WHO 1994; Battaglin and Kotok 2014);

c) Glyphosate and AMPA residue testing has typically been complicated and expensive (Byer et al. 2008); and

d) Test results for low concentrations of glyphosate commonly are commonly variable and hard to reproduce. Analysis methods typically do not capture about 10-25% of actual amount of glyphosate present in a sample (WHO 1994).

New methods of glyphosate analysis are continually being developed, however, and improvements in testing capabilities since the mid-2000s have lowered detection limits (WHO 1994; Humphries et al., 2005;). Extensive evaluation is still generally considered to be prohibitively expensive (Byer et al., 2008). With better levels of detection, glyphosate's presence and impact in the environment can now be more precisely evaluated with regular monitoring Humphries et al., 2005; Kremer and Means 2009; Chang et al., 2011, Messing et al. 2011; Battaglin and Kolok 2014).

1.3. Glyphosate Persistence And Impact In The Environment

Not surprisingly, improved levels of detection have confirmed the widespread ubiquity of glyphosate and AMPA at low levels throughout the environment (Battaglin et al., 2005; Szekacs and Darvas, 2012; Battaglin et al., 2014). Meta-analysis of research involving a wide range of soil types has identified that once in the soil, glyphosate's half-life (the time required for half of the amount of a compound to degrade or dissipate from the environment) is about a month, with a range from 1 to ~130 days (Giesy et al., 2000). Glyphosate's main metabolite AMPA has been reported to typically have a half-life of 76-240 days in soil (Giesy et al 2000; Monsanto, 2005). The half-life of both glyphosate and AMPA in water has been reported to be 7-14 days (Giesy et al., 2000). The actual half-life of glyphosate in field settings varies widely, however, because variable conditions that affect soil microbe populations—such as temperature, soil type, soil water content, soil depth and soil pH and soil organic matter quality—all affect glyphosate degradation rates (Sprankle et al., 1975b; Moshier and Penner 1978; deJonge et al., 2001, Borggaard and Gimsing 2008; Farenhorst et al., 2009; Capri and Vicari, 2010; Helander et al., 2012).

Glyphosate sorption on soil also has important implications for soil microbes[6]. Researchers have noted, however, that current research methods are neither sensitive nor thorough enough for the impact on soil microbes of glyphosate presence, persistence and

[6] In one study, after spraying Roundup Ready® (glyphosate-resistant) canola twice during the spring of a dry year (2 weeks after canola seeding, then again one month later) at a rate of 440 g active ingredient (a.i)/ha of glyphosate herbicide product, soil glyphosate levels at 4 and 10 months following the spraying event tested at 1.67 µg/g and 0.75 µg/g, respectively.[6] Soil glyphosate 17 months after the initial spring spraying events (i.e., well into the subsequent growing season,) was 0.73 µg/g; this data highlights how drought conditions and winter temperatures can potentially slow the degradation process (removal) of glyphosate from soil/the environment (Humphries et al., 2005). This observation is consistent with other research results (Laitenen et al 2006; Capri and Vicari 2010; Helander et al., 2012).

accumulation to be fully understood (Zabaloy et al., 2012; Helander et al., 2012).

For decades, glyphosate was perceived as being "safe" for the environment and potentially less detrimental eco-toxicologically than other herbicide active ingredients (Giesy et al., 2000). This widely held perception was largely based on results of laboratory bioassays or short-term field studies conducted primarily within the U.S (Helander et al., 2012). The fact that glyphosate binds strongly to soil organic matter and mineral particles, thus deactivating its phytotoxic (plant killing) capacity, was regularly cited as evidence to suggest that glyphosate additions have a neutral ecological effect (Sprankle et al, 1975b; Piccolo et al., 1996). More recently, researchers have questioned the wisdom of the wide use of these research assessments to make generalizations regarding glyphosate's eco-toxicity that are not likely to be representative of typical agro-environments and climatic conditions worldwide (Helander et al., 2012; CCME, 2012).

Up until about the mid-2000s, peer-reviewed research suggested that glyphosate and AMPA both carried a low risk of toxicity for wildlife, in part because these chemicals pass through the guts of animals without alteration (i.e., they are not metabolized and do not bio-accumulate (WHO 1994; Carlisle and Trevors, 1988; Giesy et al., 2000; Henderson et al., 2010; CCME, 2012). A growing body of research has since cast doubt on the glyphosate's safety. Numerous studies have identified changes at the cellular level and other negative effects on non-target organisms (both animals and plants) following exposure to glyphosate (Relyea 2005a, b, c; Watrud et al., 2011; CCME, 2012; Battaglin et al. 2014, and many others). In addition, the surfactants commonly used in glyphosate-based herbicide formulations, which had previously had escaped toxicological evaluation because they are not the active ingredient of a glyphosate-based herbicide, have since come under scrutiny. Researchers have identified that these surfactants are toxic within the environment, individually as well as through synergistic effects with glyphosate (Székács et al., 2014; Annett et al., 2014).

Concern about glyphosate's eco-toxicity is underscored by the fact that applications of greater concentrations than recommended labeled rates and repeated applications (see Table 2) in conventional and conservation ("no-till") tillage agriculture systems have increasingly become standard practice, leading to recent characterization of glyphosate as a "contaminant of concern" (Cerdeira and Duke, 2006; Lupwayi et al., 2009; Székács et al., 2014; Battaglin and Kolok, 2014).

Heavily reliance and repetitive use of glyphosate has also led to the emergence in the late 1990's of glyphosate-resistant weeds, a situation which has come to include a wide variety of weed types and an ever-larger land area since the mid-2000s (Dill et al. 2008; Beckie, 2011, Benbrook, 2012). To limit further proliferation of glyphosate-resistant weeds, the use of techniques such as alternate cropping and tillage and applying herbicides in addition to glyphosate has been recommended (Beckie 2011; Benbrook 2012, Majewski et al., 2014). Though the adoption of such strategies has been evaluated as being the most effective (and cost-effective) approach for long-term weed control, most farmers have opted to stick with using glyphosate-based herbicides fairly exclusively and repeatedly within a growing season (Beckie, 2011).

In order to manage the growing problem and presence of glyphosate-resistant weeds, Canada's pesticide regulations were recently modified so that growers can mix and apply un-labeled tank mixtures of glyphosate-based herbicides with other herbicides. Tank mixtures may include 2,4-D and other chemicals known to persist in the environment and which may have negative eco-toxicological effects on non-target organisms, as long as these "mixing partners" are registered for use in the crop (PMRA 2010; Monsanto Canada, 2014). This change is an example of a government policy that, while being put in place to extend glyphosate's efficacy into the future and to facilitate the glyphosate resistance management, will potentially add to negative environmental impacts associated with glyphosate use into the future (Beckie, 2011; Benbrook, 2012).

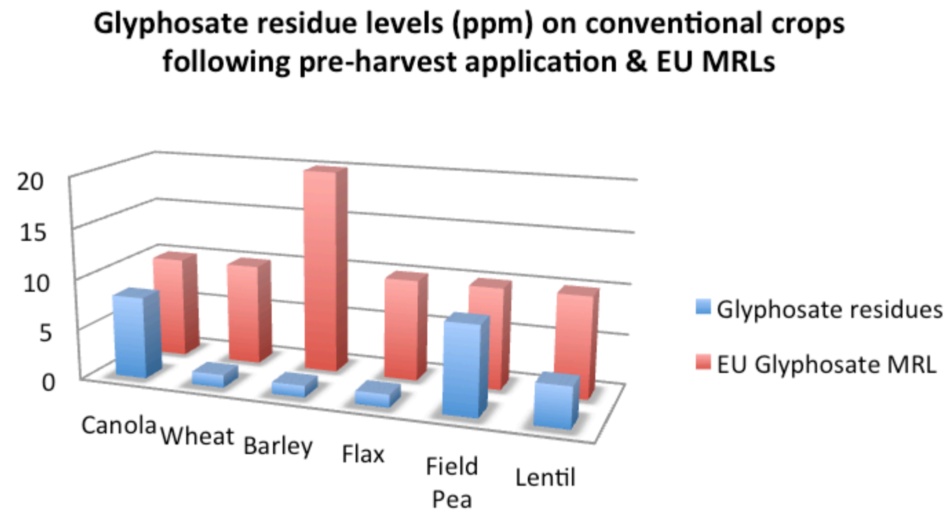
1.4 Glyphosate Maximum Residue Limits (MRLs)

To limit the potential for inadvertent consumption of glyphosate by humans or animals, Maximum Residue Limits (MRLs) have been set for glyphosate for many kinds of conventional crops. Established for individual crops and set by countries semi-independently,[7] MRLs are not to be confused with toxicology thresholds. MRLs are put in place to provide a quality assurance measure for international trade, as follows: when glyphosate is used in accordance with approved label instructions and good agricultural practices, MRL levels for glyphosate residues on crops will not be exceeded. To date, no MRLs have been set for organic commodities by any country (See Section 2.1).

For example, conventional wheat crops nearly ready-to harvest, with seed moisture of less than 40% (hard dough stage) can be sprayed at standard concentration levels of 1.7 kg (a.i.)/ha of glyphosate, resulting in glyphosate residue levels of about 4 ppm, below current wheat glyphosate MRLs set by Canada (5 ppm), the U.S. (30 ppm) and the EU (10 ppm) (Cessna et al. 1994; EFSA, 2012; Johnson, 2012, Scholz, 2013). Following current label recommendations for glyphosate as a pre-harvest management tool for a lentil crop should result in glyphosate residues on lentils that fall in the range of 0.1 ppm and 4 ppm, acceptable under the Canadian, U.S. and EU lentil glyphosate MRLs (4 ppm, 8 ppm and 10 ppm, respectively (Purcell, 2011; Johnson, 2012, Scholz 2013). Twenty years of data of shipped cargo from Canada has identified average glyphosate residue levels of 1.2-3.7 ppm for a variety of crops (Johnson, 2012). Research on the levels of glyphosate residues found on certain crops following pre-harvest application of glyphosate is presented in Figure 1, along with correspondent EU MRLs for these crops.

[7] Since 2004, NAFTA and other international trade agreements have influenced how MRLs are set and/or modified by different countries (Scholz, 2013).

Figure 1.[8]



Notably, in 2013, the European glyphosate MRL for lentils was increased 100-fold for lentil (from 0.1 to 10 ppm). This adjustment represented a pragmatic response to current glyphosate use practice. This use, which includes spraying glyphosate as a pre-harvest management tool on both glyphosate-resistant and non glyphosate-resistant crops, resulted in crop glyphosate residues on crops consistently greater than 0.1 ppm (Pulse Canada and USA Dry Pea and Lentil Council 2011; EFSA, 2012; Bøhn and Cuhra 2014). Raising of the EU's lentil glyphosate MRL removed a significant trade barrier for conventional lentils (Johnson, 2012). Certain MRL values for a number of different crops set by Canada and the U.S. have also been increased incrementally in recent years.

1.5. Typical Sources And Levels Of Glyphosate Contamination In The Environment

Extensive release of glyphosate into the environment leads to exposure of non-target areas primarily through two pathways: spray drift and soil-bound glyphosate being carried by wind and/or water[9]. Research findings with regard to glyphosate residue concentration levels associated with spray drift and dust mobility are discussed below.

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[8] Data compiled from Cessna et al., 2002 (canola); Cessna et al., 1994 (wheat); Cessna et al., 2002 (barley, flax and field pea), Purcell, 2011 (lentil) and EU Pesticides Database, 2014 (EU MRL values).

[9] A recent comprehensive study (Battaglin et al., 2014), not connected to the growing season presented data from samples taken from all over the U.S., showing detectable levels of glyphosate:

- in 71% of precipitation samples (60 of 85 samples) at median and maximum levels of 0.11 µg/L (0.0001 ppm) and 2.5 µg/L (0.0025 ppm), respectively; and
- in 91% of soil and sediment samples (41 of 45 samples) at median and maximum levels of 9.6 µg/kg (0.0096 ppm) and 476 µg/kg (0.476 ppm), respectively.

Spray drift—Spray drift is the most obvious—and perhaps the most significant—source of glyphosate contamination in the environment. According to Canadian experts consulted for this study, glyphosate drift impact (killing or damage) can be easily spotted in fields especially when spray clouds are dense/not dispersed by wind, conditions often favored during evening spraying. Partly because of the variable density of drift clouds, investigation of glyphosate drift on non-target field crops through residue analysis yields highly heterogeneous results.

Spray drift depends on wind direction and speed, and many other factors— including but not limited to: the kind of spray nozzle used, the droplet size emitted from the sprayer, the chemical composition of the sprayed substance, etc. (Deveau and Beaton, 2011). Some researchers suggest that drift-related exposure should be limited due to the fact that 90% of agrochemical applications in Canada are applied with low-level ground sprayers (Felsot et al., 2010). This viewpoint is considered to be overly optimistic by others interviewed for this report, who cite the increasing use of high-clearance tractors used by conventional farmers. The farmers do not always spray when wind conditions are ideal, given that they have a small window of time to cover enormous tracts of land.

Not all glyphosate exposure leads to lethal effects for plants. Glyphosate can be wind-dispersed and fall on non-target fields from the air or with rain at sub- or non-lethal levels for plants located far (miles) from the target field (Messing et al., 2011). Exposure risk (at lethal and non-lethal concentrations alike) has risen with the significant increase in glyphosate used throughout the growing season. Off-target application and subsequent sub-lethal exposure through drift are estimated to occur at 1-10% of the applied rate (Wolf et al., 1992; Roider et al., 2008) [10].

Soil-bound glyphosate—Stemming from the long-held perception that soil-bound glyphosate rapidly decomposes, dust in the air has often been discounted as being a likely source of (non-lethal) glyphosate exposure for crops (Speiser, 2012). By the mid 2000s, however, researchers began to quantify evidence that indicates that glyphosate persists in soils longer than previously believed. For example, in one study that measured total glyphosate deposition—as carried by wind bound to air-born dust particles and/or

[10] Research measurements made in the southern U.S. to track weekly composite levels of glyphosate in the air and rain during the 2007 growing season detected glyphosate in at least 75% of samples (Majewski et al., 2014). Glyphosate concentrations in that study showed that seasonal "flux" (deposition) of glyphosate by rain exceeded 100 μg/m^2, with greatest glyphosate air concentrations (of 0.006 mg/m^3, or 0.0009 ppm) detected in early spring months (Majewski et al., 2014). A study to quantify typical bulk deposition rates of agrochemicals from May to September in the Prairie Pothole region of North America identified glyphosate drift concentrations of 60 μg/m^2 at in about half of the study's samples (Messing et al., 2011). Another study investigating glyphosate deposition from drift found in bi-weekly samples of southern Ontario's surface waters detected glyphosate most frequently in spring and fall, with maximum concentrations in the 10-30 μg/L range (0.01 to 0.03 ppm) (Struger et al., 2008)[10]. These values are consistent with other studies of glyphosate deposition conducted across North America and elsewhere (Struger et al., 2008). For example, a study of air and rain samples collected weekly in central and southern regions of the U.S. during two growing seasons recorded glyphosate deposition at concentration levels that ranged from <0.01 to 9.1 ng/m^3 for air (0.000145 to 0.0014 ppm) and <0.1 to 2.5 μg/L for rain (<0.0001-0.0025 ppm) (Chang et al., 2011).

deposed in rainfall—analysis of rain samples collected at seven-day intervals throughout the growing season determined that deposition of airborne glyphosate is in fact most likely through dust particles being washed down with rain, rather than “free” glyphosate, sourced from spray drift, being dissolved in rain (Humphries et al., 2005). Even during a dry year in this study (when glyphosate spraying typically should theoretically decrease due to decreased weed pressure) glyphosate was regularly detected in amounts of up to 1.51 $\mu g/m^2$/day.

In summary, the mobility of glyphosate—through spray drift and dust-bound—presents a regular (constant), if modest risk for background exposure for non-target crops, especially in regions where glyphosate is sprayed regularly and where soil is exposed and/or disturbed with tillage.

1.6. Increased Use Of Glyphosate As A “Harvest Management Tool”

While glyphosate use has increased steadily with the adoption of Round-up Ready® and similarly resistant crops, the late-season, pre-harvest use of glyphosate merits special attention. Used to accelerate “harvest readiness” of crops as well as to kill weeds before seed set, this practice has become increasingly popular in recent years (Helander et al., 2012). Pre-harvest applications permit farmers to control and reduce the time interval between crop maturity and harvest, a.k.a. the pre-harvest interval (PHI). Glyphosate application for PHI control can also be especially helpful when prolonged rainy periods delay harvest, which carries the risk of reducing seed quality (Cerkauskas et al., 1982). Glyphosate used this way has been deemed to be a “good agricultural practice,”; as such, it has been the subject of many research reports and extension-type guidance documents Bovey et al., 1975; Jeffrey et al., 1981, Flaten et al., 2010; Thomas, 2012, Government of Manitoba 2012). Recommendations abound for how to best use glyphosate as “a harvest management tool” in order to facilitate and improve cash crop harvests. Such documents sometimes provide (creatively worded) advice for how to use glyphosate to kill and/or facilitate the harvest of non-glyphosate-resistant cash crops, in spite of the fact that glyphosate’s registered (authorized) label use is only for weed control (Flaten et al., 2010, Monsanto, 2009).

Glyphosate has been observed to be especially helpful in the harvest of indeterminate crops such as pulses (e.g., lentils, peas, and flax) (Cessna et al. 1999; EFSA 2012). This is because in indeterminate plants (e.g. pulses), flowers are produced at the bottom and continue to be produced all the way up as the plant grows. Seed pods also mature from the bottom up; glyphosate application when pods are dry at the bottom of the plant helps dry and even out the harvest of green material at the top of the plant (Thomas, 2012). The extent to which glyphosate has been pitched as being helpful in hastening crop readiness for harvest has led to common mischaracterization of glyphosate as a “desiccant” (EFSA, 2012). The use of the descriptive term “desiccant” for glyphosate is not technically correct: what glyphosate does is kill plants, not dry them; plants killed by glyphosate are dried by air (Flaten et al., 2010).

Due to improved levels of detection and increased application of glyphosate close to the crop harvest period, research studies and importer's lab analyses have identified that crops now regularly test at detectable levels for glyphosate residues (Speiser 2012). For example, in a two-year study, glyphosate residue concentrations of 0.18-19.70 mg/kg[11] were recorded in samples of mature canola seeds following normal (labeled) application rates of 1.7 L a.i./ha. These rates were observed on plants that were sprayed when seed moisture was at <25% (quite dry) at the time of application (Cessna et al., 2000), a time in the plant's maturity when it is thought that less glyphosate would be absorbed by the plants seed pods in particular. (In other words, the glyphosate residues detected were mostly likely surficial and not the result of systemic uptake by the canola plants.) Glyphosate application rates, the physiological maturity of crops crop at application, and possible rainfall wash-off will all affect the quantity of detectable glyphosate residues of crops in fields that receive glyphosate applications during the growing season.

PART 2. GLYPHOSATE RESIDUES & CANADIAN ORGANIC EXPORTS: AN OVERVIEW

In 2011, glyphosate residues were discovered on organic lentils imported into the EU, a finding that has since had far-reaching impacts on world trade of organic commodities. In response to its findings, the EU instituted a protocol of testing of glyphosate residues for both organic and conventional commodities imported into the EU. Until the EU MRL for (conventional) lentils was raised from 0.1 ppm to 10 ppm in 2013 (see Section 1.4), this testing protocol essentially brought trade in conventional lentils to the EU to a halt. The impact of this testing protocol vis-à-vis the Canadian organic export sector follows. This Part's content was gathered in large part through interviews and email queries with members of the Canadian organic sector who have had direct experience with this issue, including: 3 traders/brokers; a certifier; a farmer; 1 program director of an organic company that works with grains; 2 farm co-op/farm union representatives as well as a few academics familiar with glyphosate use, mobility and persistence in the environment.

2.1. Interest In Glyphosate Residue Testing Varies For Different Markets

To date, official MRLs for organic commodities have not set by any country. This is because of a fundamental belief held worldwide by the organic sector that residue testing cannot and should not be used to replace the "process-based" assurance of full adherence to organic production standards provided by third-party certification. Worldwide, "organic" brand recognition has grown in part based on consumer interest in buying organic products because they are perceived being "pure" or "free from" pesticides and herbicides used in conventional crop production. In other words, the organic marketplace tolerance threshold for any residues of substances prohibited by organic standards, including glyphosate, is generally at (or close to) zero.

[11] The unit mg/kg can also be expressed as parts per million (ppm).

The marketplace worldwide varies today with regard to buyers interest in using residue testing to demonstrate that organic commodities are not contaminated with prohibited substances. The buyer's country, "local" levels of supply and demand for the commodity to be imported and the product's country of origin all play a role a buyer's likelihood to insist on residue testing. In general, according to the people interviewed for this report, the U.S. organic import market, which sometimes uses a 0.04 ppm threshold for glyphosate, doesn't actually concern itself overly with regard to glyphosate (or other) residue levels of imports coming from Canada. Similarly, Japan, Canada's other major export market (notably for soybeans), has historically been more interested the farm production process as opposed to insisting on crop residue testing.

The EU import market has proven to be the most interested in testing for residues and restricting imports based on test results. By 2001, an "orientation value" testing guideline for single residues (including glyphosate) was established by Bundesverband Naturkost Naturwaren (BNN) (Arp, 2013). BNN is a German organic trade association that represents the economical and political interests of the organic food and natural goods sector (processors, wholesalers and retailers). Since the discovery of glyphosate residues on organic lentils in 2011, most German importers have opted to require potential sellers to submit samples for glyphosate residue testing; lot shipment acceptance is subject to refusal if glyphosate residues are detected above BNN's single residue threshold of 0.01 ppm +/- 50%. Germany is by far the largest European buyer of organic commodity imports, and most German buyers use the BNN orientation value, with many other buyers in other EU member countries following suit.

2.2. Impact Of Glyphosate Residue Presence On The Canadian Organic Export Market

Not all European buyers reject organic products that test at glyphosate residue levels above 0.01 ppm. The owner of a product with samples testing "positive" for product contamination is obligated, according to the BNN orientation value protocol, to prove that the glyphosate contamination is not due to non-conformance—unintentional (as in the case of drift) or intentional (fraudulent)—with organic standards. Along with retesting, buyers can insist on due diligence follow-up in the form of a certifier's affidavit that confirms that the farmer has demonstrated complete adherence to organic standards. For example, one broker interviewed for this report was familiar with situations where Canadian lentils with glyphosate residue levels of 0.04-0.05 ppm ended up being sold/marketed as organic via a BNN member because the farm's certifier was able to satisfy the buyer that that the farm was good standing, by providing soil analysis results and other documentation.

However, everyone interviewed for this report noted that many BNN members (and other European buyers) seem to incorrectly use and/or misinterpret the BNN orientation value of 0.010 ppm as being the "maximum allowable residue level" of glyphosate residue for organic imports. In other words, even with considerable efforts made to formally establish that products coming from Canada are fully compliant with organic standards, the imposition of regular glyphosate testing has significantly heightened the risk that Canadian organic products may be refused. Everyone interviewed for this report concurred that this misuse of the BNN orientation value has frequently resulted since 2011 in delays and/or rejection of organic product shipments from Canada. These delays and rejections involve significant associated costs for the owner of organic product in terms of retesting and storing product, of finding a new buyer and reshipping, if a new buyer is found. All in all, the increase in glyphosate testing in Europe has created considerable aggravation for Canadian and European parties trying to maintain long-term sales relationships.

Because Harmonized System (HS) codes have not yet been assigned to exports of organic commodities, the Canadian organic sector lacks annual, crop-specific data for Canadian organic exports. The lack of this data makes it difficult to precisely gauge the magnitude of the impact that glyphosate testing has had with regard to the flow of Canadian organic trade into Europe (and elsewhere). More than one trader mentioned that this issue has cost hundreds of thousands of dollars of annual sales in sales deals their business might have done with Europe prior to 2011. All the traders interviewed for this report concurred that the impact on their market flow of goods has been significant, affecting organic peas, beans, millet, quinoa and flax in addition to organic lentils.[12]

Variability in supply and demand across Europe was noted as being a determining factor in Europe's resistance to accept organic imports when they have been identified as being contaminated at low levels with glyphosate residues. For example, the certifier interviewed for this report provided an anecdote about a grower he certifies who had a supply arrangement to ship nine containers of a certain commodity for nine months (i.e., one container per month). Within a certain time frame that coincided with European harvest of this same crop, a container from this grower was held up due to glyphosate test results, when his previous shipments containing the exact same product were accepted without any concern over or special inquiry into glyphosate residues. A trader interviewed for this report also noted that Canadian organic mustard, which often tests above the BNN orientation value for glyphosate, is typically accepted without a problem by Northern European buyers because demand so significantly exceeds supply.

With lot shipment costs averaging at least $10,000 each, one trader interviewed for this report described how he has elected since 2011 to test every organic lot he plans to sell. He stated: "I have found that I can't afford [not to be proactive]. I won't send anything that isn't going to be accepted." This trader works extensively with European buyers to secure import approval based on the results of his pre-shipment sample tests, educating buyers on his sampling protocol, and having the tests performed in the lab of the buyer's choice.

[12] According to those interviewed for this report, at the present time, the other major organic commodities produced in Canada are used domestically or sold to the U.S. (in the case of corn) or Japan (in the case of soy), countries that have proven to be less insistent on glyphosate residue testing in trade relations.

Securing "pre-shipment" testing acceptance guarantees, however, does not always mean shipped product is accepted upon arrival. Sometimes, "pre-approved" product is still culled for re-testing after delivery to European ports. If evidence of glyphosate contamination is found at this point, the trader will be required to go back to the certifier to get an affidavit of authenticity for the product, as described earlier in this section. Attempts to mitigate risk through pre-testing will not prevent all lot rejections. Another trader interviewed for this report noted that not all buyers accept the use of pre-testing to for product acceptance.

As mentioned in the literature review, glyphosate residue testing is not cheap; a ballpark figure per test is $200-$500. Therefore (in a theoretical example), a Saskatchewan farmer with 10 lots of product to ship could easily face costs of $2000 (10 lots x $200/test) in residue testing costs on top of their certification costs. Furthermore, according to the certifier interviewed for this report, the current market reality for Canadian organic farmers (and sometimes traders) is that they bear the costs of multiple (rather than single) tests of their products; for example, one organic lot may be tested multiple times at the behest of different buyers, if a lot is divided for sale with a portion going to Germany, a portion going to France, etc.

According to those interviewed for his report, by 2012 Canadian sellers had begun to divert sales of affected organic commodities to destinations other than Europe. "Basically, we have made a decision to move on," noted one trader. "We could test a lot, but even with lots of testing, our shipments still run the risk of refusal and the risk isn't worth it," he said. More than one trader interviewed for this report cited using the U.S. as their default back-up market. "The U.S. generally pays more and requires less fees for shipping," noted one trader, adding that (though of course not true in every instance) he finds selling to American buyers a simpler process than dealing with the EU. Another trader has been trying to maintain his European clients by educating his buyers across Europe about the situation that he faces in Germany. When he finds that he can't get product into Europe, the U.S., or South America have become his target markets. Traders noted that diversion of organic commodities into conventional channels is also an option.

In the case of Canadian organic lentils specifically, those interviewed for this report differed in opinion with regard to the ease of penetrating alternate markets. Two traders and the farmer interviewed expressed not having much trouble finding another buyer outside of Europe (including the U.S.) while one trader noted that he'd seen lentils sitting in bins for two years, due to a glut in the North American market. All the traders agreed, however, that the glyphosate contamination issue has pushed some farmers away from growing lentils. Experts interviewed for this study noted that organic lentils, described as being the obvious and suitable money crop for certain regions in Western Canada are being replaced in some cases with peas in organic field rotations in part because of an anticipation that lentils will not be easy to sell.[13] One trader noted his unease with the current situation this way: "Letting market factors decide what organic farmers grow is not necessarily good for organic production systems."

[13] The farmer interviewed for this report also noted that shifts in climate/weather patterns might be another influential factor affecting rotations involving lentils.

More than one person interviewed for this report expressed finding it difficult to fully understand the European market's expectations and motivations behind their application of the glyphosate testing protocol using BNN's orientation value. Overall, interviewees expressed the feeling that BNN's orientation value was set in an arbitrary fashion[14] at a level that is not aligned properly with the current risk of organic crop exposure to glyphosate herbicide residues. From the perspective of those interviewed for this report, this issue negatively affected seller and buyer confidence, erecting an illegitimate trade barrier that prevents fully compliant organic Canadian farmers from obtaining their market share. As the farmer interviewed for this report noted: "All farmers are at risk with regard to glyphosate spray drift for sensitive crops; you hear about crop losses all the time. But for the organic farms [and glyphosate exposure] you aren't just talking about crop loss, you are also talking about market loss."

2.3. Spotlight On Sampling

As mentioned above, one trader interviewed for this report has decided since 2011 to manage the sales risk he faces in light of increased European product testing for glyphosate residues by pre-testing every lot he plans to sell. He arranges to send a representative sample for testing at the lab of a buyer's choice. A product that comes back negative for glyphosate residue is supposed to secure automatic shipment acceptance by the buyer.

Sample quality matters, and obtaining a representative sample of field crops is easier said than done. Field crop lots can be quite heterogeneous, especially when a farm field has been exposed to glyphosate drift. One trader interviewed for this reports takes the time to educate each farmer he buys from on how to take appropriate, representative samples. He uses the formula $\sqrt{n} + 1$ to determine the number of sample probes that need to be taken. For example: a lot shipment will have 800 bags, the number of probes he wants to have taken to make a representative sample is $\sqrt{800} + 1 = 30$ probes. The sampling rate for the example given (30 probes/800 bags)= 4% of bags sampled is less than Canada Grain Commission (CGC) standard guidelines, which probe 10-20% of lots and use minimum 1 kilo samples (Canada Grain Commission, 2013).

2.4. The European Perspective

European concern over glyphosate is based in part on the fact that when crops are sprayed directly with glyphosate (or when they are exposed through drift), the herbicide

[14] At the time the BNN orientation value of 0.01 ppm for single-value residues was announced, the Canadian certifier Pro-Cert analyzed the European data used to set the value. Pro-Cert found that BNN removed certain data from their data set, ostensibly to arrive at a clear, imposable value used to handle pesticide values on imports, an approach that is not sufficiently or solidly science-based (personal communication with Byron Hamm, June 20, 2014).

residue isn't something merely surficial (found on grain hulls)—it is taken up within/throughout the plant in a systemic fashion, an unsettling outcome for products intended directly for human consumption, especially in light of growing evidence of glyphosate's possible toxicity to living organisms (see Section 1.3). Several people interviewed for this report mentioned that the European market for organics is based on the perception that organic foods are/can be "pure" (that is, completely free from contamination), ignoring in effect, the reality that organic foods are being produced in an increasingly contaminated environment. A recent confidential European report suggested that glyphosate contamination of organic imports to Europe (all organic imports, not just Canada's) is most likely due to intentional or inadvertent post-harvest commingling and confounding of lot shipments (Speiser, 2012). In such an environment, establishing a regular glyphosate residue-testing protocol permits European buyers to root out what fraud and inadvertent lot confounding exists. Farm-level exposure of organic crops to glyphosate (including through fraudulent use) was cited in the European report as being less likely due to certification controls and the major deterrent of decertification risk.

2.5. Sources Of Glyphosate Contamination

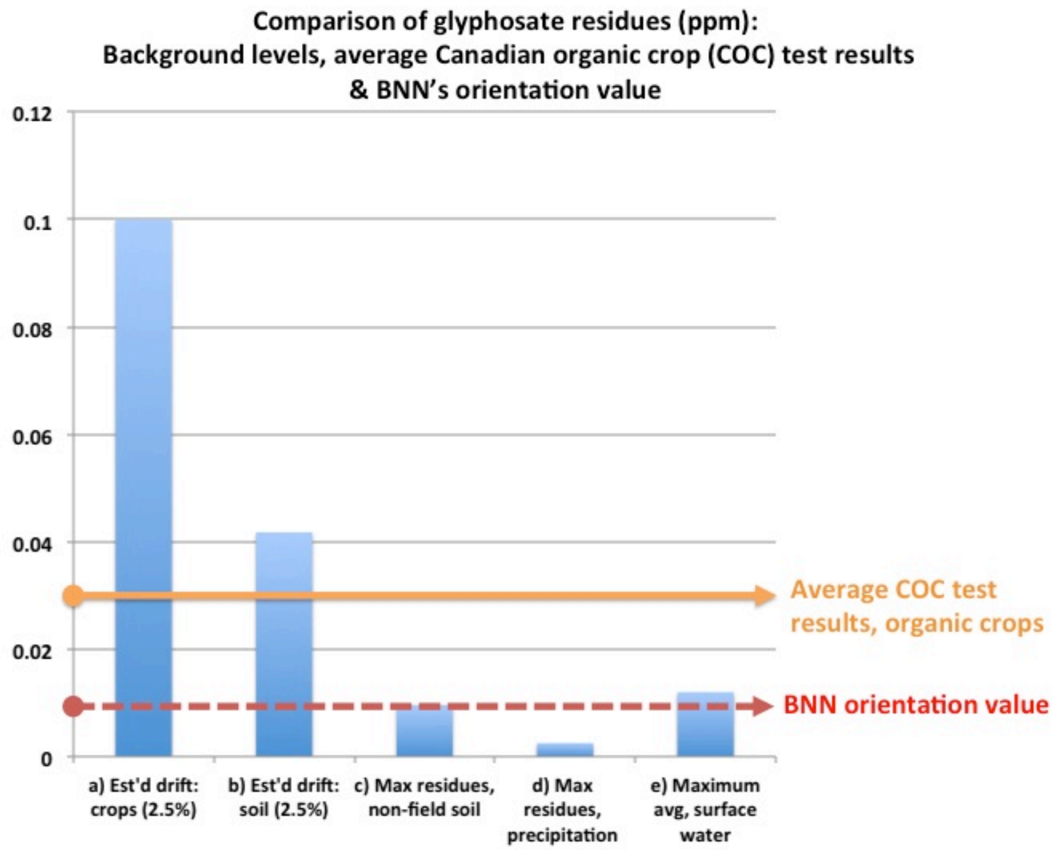
Contrary to the assessment of the European report, the consensus opinion of those interviewed for this report is that glyphosate exposure of Canadian organic commodities to glyphosate residues is taking place on-farm, rather than off-farm. Improved sampling/pre-testing protocols and lot preparation measures undertaken by Canadian farmers and traders since 2011 (see "Spotlight on sampling", above) should have reduced to nil the incidence of organic crop contamination with glyphosate residue due to off-farm factors. For example, one trader noted that he is confident that commingling and confounding of lots is not a problem source of glyphosate exposure for the products he sells, because his practice is to ship packed 25-kilo bags in locked, full containers of only organic product which are opened at the customer's door. While this trader expressed curiosity about whether other points in the supply chain—trucking and cleaning, specifically—were potential contamination points, the certifier interviewed for this report countered this idea, stating that a lot more organic crop samples would come back testing positive for glyphosate residue, were this the case.

So, what are the sources of glyphosate residues found on Canadian organic exports crops? The literature review, interviews and other content collected for this report indicate that background levels of glyphosate currently present in the environment due to drift and wide, regular dissemination of glyphosate throughout the environment are sufficient in quantity to explain the typical "positive" glyphosate residue test results associated with Canadian organic commodities (Figure 2).[15] Many uncontrollable variables—such as the timing of spraying, relative crop readiness for harvest on neighboring operations, wind speed and direction when neighbors are spraying substances prohibited by organic agriculture etc.—all factor into an organic farm's risk

[15] Lacking a truly comprehensive data set, a rough average of 0.035 ppm was calculated using available data to provide an idea of the typical glyphosate residues found on organic crops at or above the BNN orientation value (which range from 0.01-0.05 ppm).

for glyphosate exposure. If probed at the farm or directly from a bin before cleaning, it is possible that crops will be coated with dust, and possibly soil, if they are harvested during a wet period. This is especially likely for low-growing crops like lentils, which are not washed in order to preserve their low moisture content and prevent spoilage during storage.

Figure 2.[16]



[16] a) Represents a ballpark estimate for sub-lethal glyphosate concentrations on organic crops when a fall spraying event on a conventional farm drifts over to organic fields at
2.5% of the applied dose. Actual residue values may vary (and may be considerably greater) based on what the organic crop is, how mature the crop is during a drift event, and the concentration of the drift cloud when it falls. Calculated from data in Roider et al., 2008, Cessna et al., 1994, Cessna et al., 2000, Cessna et al 2002. b) Represents an estimate for glyphosate soil concentrations when a spraying event on a conventional farm drifts over to organic fields at 2.5% of the applied dose. The soil glyphosate concentration data used to generate point b was calculated from data on glyphosate in soil tested one week after spraying a conventional field at a standard concentration used for weed control. (Roider et al., 2008; Humphries et al., 2005). c, d) Represents background maximum glyphosate concentrations recorded in soil/sediment and precipitation (45 and 85 samples respectively) sampled across the U.S., tied to agricultural use (Battaglin et al., 2014); e) Represents weekly average maximum concentrations from an extensive number of surface water sites sampled during the growing season in Ontario (Struger et al., 2008) as evidence of the levels at which glyphosate is falling on non-target areas throughout the growing season. Weekly estimates of glyphosate residues in air and in wetland samples—detectable throughout the growing season—are not presented here because their concentrations are dilute (0.0002 ppm and 0.0008 ppm, respectively (calculated from Chang et al., 2011, Messing et al., 2011).

What it means for the organic sector, if glyphosate is ubiquitous at background levels in the agricultural environment, is that organic crops risk regular, if modest, exposure to glyphosate deposited from the air and precipitation. Because glyphosate persists in then environment longer than previously thought, especially when bound to soil or dust, detected residues cannot necessarily be traced back to a discrete spraying event, or even to the growing season in which they are discovered. In the perspective of one trader interviewed for this report, who deals in both organic and conventional crops, dust as a source of glyphosate contamination in Canada is much more likely to be a cause of crop contamination with glyphosate residues both pre- and possibly post-harvest than commingling. The bottom line is that extensive use of chemicals by conventional agriculture and their potential impact on organic systems, especially with glyphosate being sprayed so many times per year, can and should not be overlooked, especially since the levels at which they may be detected are close to (or above) the BNN orientation single-value residue limit of 0.01 ppm.

Why do Canadians perceive this issue being due to on-farm exposure, while the European report characterized glyphosate residue contamination as being a post-farm problem? Though published recently, the European article did not reflect a completely up-to-date understanding of the possibility of a prolonged persistence of glyphosate in the environment (see Section 1.3 of this report) contrary to previous belief. An awareness that glyphosate is being used in North America as a pre-harvest management tool to kill/manage main cash crops even though it is only authorized for use in weed control is also missing from the European report (Table 1 in Speiser 2012).

It should also be noted that Europeans are not as conditioned to the extensive use of glyphosate in Canadian conventional farming because the relative scale of farms and equipment is quite different. As one person interviewed for this report noted: "You're not going to see 640 acres being farmed in Europe with a high clearance sprayer. Or, an organic farmer who is surrounded on three to four sides by a conventional grower with 30,000-40,000 acres." In other words, though glyphosate use in Europe has also seen significant gains in recent years, land area use in Europe and Canada probably does not juxtapose conventional and organic field crops to the same extent.

For example, glyphosate-resistant canola has comprised more than 40% of the 6 million hectares planted annually in Canada to canola since 2000, reaching 93% in 2004 (Beckie, 2011, Upadhyay et al., 2006). According to the farmer interviewed for this report, in southeastern SK where a majority of Canada's organic lentil crops are produced, glyphosate-resistant canola comprises 20-30% of farm acreage. It is commonly the case that Canadian organic farmers who produce crops destined for export are often surrounded on many (or all) sides by conventional growers who rely heavily on glyphosate use. For large farms with many fields, it can be hard (or impossible) to know what substances neighbors are spraying, or where or when they are being used.

An overview explanation for glyphosate's increased role in Canadian conventional agriculture could be summed up as follows: Canadian conventional farmers, who deal each year with the constraints of tight profit margins, low commodity prices, and a lot of land area to manage, find themselves under ever greater pressure to achieve cost-covering yields. Essentially, economic pressure has sold conventional farmers on the idea that spraying with glyphosate regularly, including as a pre-harvest management tool to control pre-harvest intervals, is good economics whether or not such spraying is even necessary, appropriate, or legal according to registered label use.[17]

Intentional application of glyphosate (pre-emergent, post-emergent, pre-harvest and post-harvest spraying) should generate notably different residue testing results that can be used to distinguish whether organic product exposure has been active (fraud) or passive (unintentional). Available data provided upon request for this report on glyphosate "positive" residue test levels of organic lentils, flax, and mustard range from 0.010 mg/kg (ppm) up to 0.050 mg/kg (ppm).[18] According to the certifier interviewed for this report, all cases of lots deemed contaminated that he knows of were from entirely organic (not split) operations. The samples that tested "positive" were barely over the BNN orientation value limit of 0.01 ppm. Furthermore, to his knowledge of the situation more generally, not once has the detected residue contamination for a Canadian product been found to be due to intentional (fraudulent) use of glyphosate. If this has happened, the responsible Canadian certifying body would have had to take action, word of which would have been shared within the certifier community. He stated that nine out of ten shipments do eventually go through, either to the original intended buyer or to another buyer in Europe, with about a one-month delay on average.

This certifier stated that based on his experience that glyphosate residues detected at 1 ppm and higher would be likely to indicate intentional use within a crop. Meanwhile, detectable concentrations of up to 0.1 ppm (10 times higher than the BNN orientation value) could very well indicate non-intentional exposure (background-related) of organic crops (see Figure 2). Because glyphosate deposition via drift can be quite concentrated, organic crop residues may test positive for glyphosate residues levels above 0.1 ppm; a comprehensive effort to gather and review data is needed using cases in which organic fields have been determined to be exposed to glyphosate drift (e.g. residue testing levels and other indicators, such as plant damage), in order to generate a range value based on reality for use in interpreting glyphosate test results (see Recommendations, below).

[17] In an additional anecdote regarding the economic pressure faced by conventional growers, a person interviewed for this report familiar with trade in both organic and conventional commodities stated that conventional growers haven't been able to export much grain much since last year; a common speculation within his circle (of conventional and organic farmers) is that this is because conventional grain takes up a lot of train cars and shipping oil in recent months has been more profitable for rail companies than shipping grain. By comparison, organic farmers who typically only need one rail car to export their product have had no trouble shipping their product by railway over the past two years, to Europe or elsewhere.

2.6 Spotlight On A Farmer's Experience In Dealing With Glyphosate Residue Exposure

The SK-based farmer interviewed for this report has sent samples to a trader for testing for glyphosate residues since 2011 for European, Japanese and American markets. He has noted a fair amount of inconsistency in the lab results. So far, test results of his products have come back registering glyphosate concentrations of .018-.025 ppm. Glyphosate residues have been detected in 2-3 lots of his lentils, but not from all fields, and some of his golden flax has also been exposed to glyphosate. His wheat and other cereal crops have thus far been unaffected by this issue.

Though this farmer has experienced some loss in sales to Europe, it has not been hard for him to find alternative markets. He has long-term relationships with certain European buyers, however, and the issue of working through the BNN testing protocol in order to be able to conduct business then becomes a disruption in the flow of goods that is frustrating on all sides. "When I can't ship, my buyers don't always know where they can get alternative sources," he pointed out. "Is the organic sector prepared to start testing everything? No one [sellers or buyers] wants to do that."

This farmer is presently facing a hold-up of a product shipment because of glyphosate residue testing results that has required him for the first time to talk with his certifier to request a review and affidavit that will verify that his product is fully compliant with organic standards. The reality for this grower is that he has too many fields, in far too many locations, to be able to know or to monitor what his conventional neighbors may be doing or spraying. Where he farms, a lot of herbicide-resistant canola and wheat is grown. He worries about the new tank mixtures of herbicides that are now being recommended for conventional farmers in order to deal with increasing pressure of and prevention of super weeds resistant to glyphosate. He warns, "2,4-D is more persistent and active in the environment than glyphosate—it's going to become a serious issue."

PART 3. RECOMMENDATIONS

3.1. Glyphosate Contamination Is An Educational Opportunity For The Organic Sector

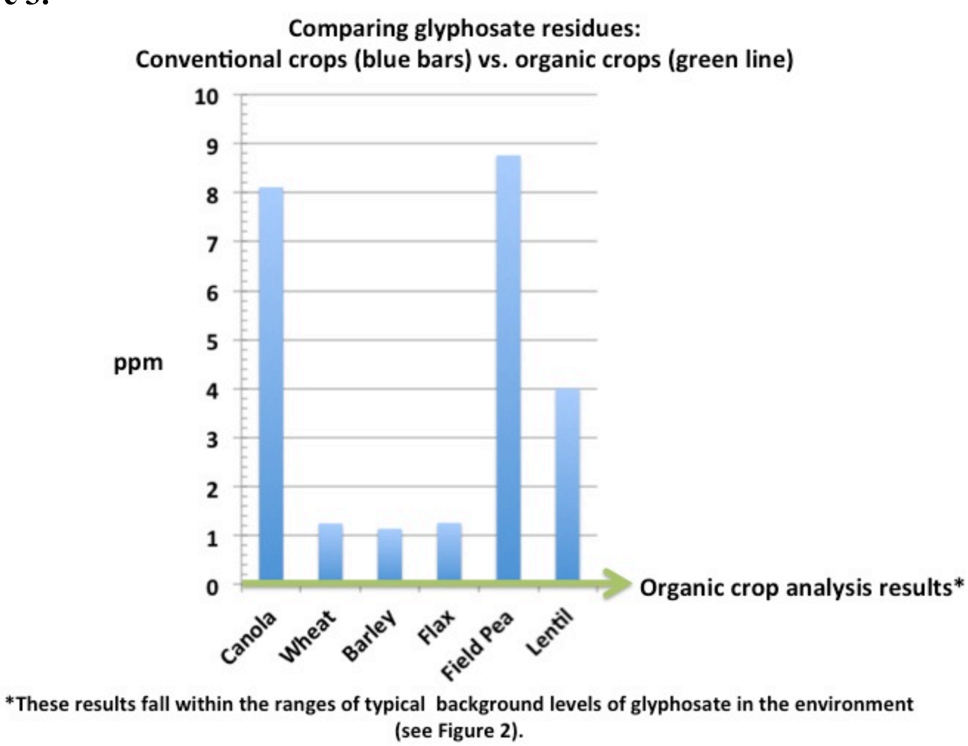
"This is an issue that needs bringing out into the open; farmers, markets, certifiers, consumers—everyone should know and be talking about it."

"No publicity is bad publicity."

Based on the information gathered fort his report, background levels of glyphosate present in the environment represent the most likely source of glyphosate residues detected on Canadian organic products destined for export. COTA should have a direct role in helping to inform the organic sector and other interested parties regarding the existence and significance of these low-level residues. COTA's efforts to generate better sector-wide recognition of this issue are essential for the development of the protocols that will provide a clear path forward for farmers, certifiers and traders when Canadian organic products test positive for glyphosate—or other—residues, thus avoiding further unnecessary hindering of sales and the flow of trade to Europe.

For example, COTA's communications should proactively and clearly provide the context necessary to understand the difference between glyphosate exposure on organic and conventional products (typically parts per billion versus parts per million, respectively)[19]. Glyphosate residue concentrations on fall-sprayed conventional crops (1 ppm) are likely to be at least 100 times greater (or more) than those found on organic crops, a convenient distinction in the effort to create messaging/provide perspective for a public audience. For example, analogies that relate 1 part to 100 (glyphosate residues expected on organic crops relative to conventional crops) include: one penny on a dollar; one paper towel in a whole roll; 1 seed from a dandelion puffball, etc. Plotting available data (see Research needs, below) shows the very low levels at which the incidence of glyphosate residues on Canadian organic crops occurs (Figure 3).

Figure 3.



COTA's messaging (to consumers, to buyers and other interested parties) needs to emphasize that glyphosate residues in organic products are essentially consistent with, and could even serve as a proxy for, the background contamination of glyphosate

[19] To provide an idea of the scale difference when talking about concentrations of ppm and ppb, the following analogy may be helpful: 4 drops of ink in a 55-gallon barrel of water would give an ink concentration of 1 ppm. 1 drop of ink in a 11,600-gallon tanker truck of water would give an ink concentration of 1 ppb. The current BNN single-residue orientation value of 0.01 ppm can also be expressed as 10 ppb.

presently in the (agro-)environment. COTA's proactive, informed approach will be useful for defusing the potential for overreaction by the public if/once the existence of this prohibited substance residue in organic food becomes "exposed." How the issue of the existence of glyphosate residues on organic products is handled could potentially influence where the organic sector goes as an industry. Currently, the organic pulse market is struggling because of an unwillingness to date to bring this issue forward more publicly. COTA should consider using its understanding of this issue to influence its organic sector partners that clear communication on this issue is less likely to cause blowback for the organic sector than keeping the information from the public eye.

"We have gone too far in letting the consumer believe that organics are free from pesticides when this is a) not true, since we live in a polluted world, and b) this is not what the organic standard is about," observed the certifier interviewed for this report. "Without proper messaging about what organic is, and what organic means, the consumer doesn't understand. And then in the context of this polluted environment we live in, we will have already lost the battle [concerning glyphosate residues]," he continued.

One person interviewed for his report suggested that there is an opportunity here for COTA to build on its messaging response strategy to the CBC's Winter 2014 pesticide report—data that showed that Canadian field crops had very low levels of prohibited substances. Essentially, an ongoing public education campaign is required by the organic sector that hammers home the value of organic products in being "produced without," rather than "free from," substances that are used in conventional agriculture but prohibited by organic standards.

If the standards haven't been compromised, then the issue of glyphosate residues on organic products is "a proof of documentation" situation.

Everyone interviewed for this report agreed that COTA should have a direct role in shaping and sharing that message. "It may seem like bad press to say organic has been exposed to or contaminated by glyphosate residues but at the end of the day, the organic system is strong enough to come out ok," noted the certifier for this report. A trader agreed, stating that "it's fine to uncover fraud [through residue testing] but when you have deliberate commingling (as in the case with Turkey) and compare that to the Canadian situation, what we have is opportunity here and avenue for selling our solid process that backs up/guarantees the integrity of organic products."

As part of informing and organizing the Canadian organic sector with regard this issue, COTA has a potential role to play in helping to educate the European market. As one trader one trader interviewed for this report pointed out, European buyers did not completely understand that any Canadian organic farmer's motivations to use glyphosate to control weeds, let alone for crop burn down, are basically non-existent. "If an organic farmer wanted to cheat by using glyphosate, it would be done at the beginning of the season to get rid of annual weeds, never as a pre-harvest management tool (cash crop burn down) and in any case with testing of all organic shipments this kind of fraud is highly unlikely to occur," he noted.

With comprehensive, recent data on glyphosate residue levels in organic crops in hand (see Research needs, below) some of COTA's efforts should be aimed at bringing BNN into full awareness of the common existence in Canada of glyphosate residues at background levels, including how to distinguish background noise from drift or intentional use in residue test results. This data should be compared with relevant European datawhich should, at least in certain countries/certain areas, be quite consistent. COTA can lobby BNN to: a) enforce the application its orientation value at its current level of 0.01 in a manner that is less discriminatory towards Canadian crops within the context of the changing flux of supply and demand; and b) modify the orientation testing value for glyphosate residues, probably from 0.01 ppm to 0.05-0.1 ppm +/- 50%. (see Research needs, and Outreach, below).

3.2. Research Needs Highlighted By The Issue Of Glyphosate Contamination:

a) As previously noted, there is a real need to identify realistic and reasonable glyphosate residue levels that make it possible to distinguish between fraudulent and non-fraudulent use, in a manner that takes into account the variability and non-reliability of low-level testing. To this end, COTA should solicit and compile glyphosate residue testing data generated by Canadian certifiers, farmers, and traders since 2011. Analysis of this data should involve consultation with Canadian experts in herbicide loading/stacking in the environment, such as Hugh Beckie (Government of Canada), Dave Humphries (Government of Alberta), Annemieke Farenhorst (University of Manitoba), Wally Hamm (Pro-Cert), and others.

Such a data set should enable the identification of (and justification for lobbying BNN with) a background-related glyphosate residue value for Canadian products. This residue value is likely to be greater than the current BNN orientation value of 0.01 ppm (probably in the range of 0.05-0.1 ppm). Similarly, this data set should/could be probed to identify the range in concentration identified through testing as being tied to: i.) drift, or ii.) intentional use (if any such data exists). Data collection efforts, likely to be constrained by funding availability, should focus on crops that have been most greatly affected and/or represent a significant Canadian organic export, such as lentils, wheat, mustard and flax. Other, more nuanced concepts that can be investigated with this data set should include: reasonable glyphosate levels to expect in a dry year or a wet year; whether certain crops (lentils for example) are more prone to showing detectable glyphosate residues (and other contaminants), the extent to which lots are subject to multiple tests, and residue testing variability, etc.

b) The existence and severity of market barriers due to the glyphosate residue issue for Canadian sellers of organic product is difficult to gauge because detailed organic commodities data (the amount and value of goods exported annually) don't exist. Being able to have data at hand, through the assignment of Harmonized System codes for exported organic commodities for example, would permit the analysis of related topics—

such as changes in organic rotations (for example, farmers switching from lentils to peas, diversion of commodities to other markets, transition rates in/out of organic farming in Canada, etc.—that would be of great value to the organic sector.

3.3 COTA Outreach Efforts

In terms of COTA's role in terms of coordinating the organic sector around this issue:

- As a first step, COTA will administer a survey (see Appendix), followed by a conference call to collect further information from affected parties and begin to organize the sector.
- Working with traders, COTA could help to solidify/standardize the sampling protocol used to create representative samples for glyphosate (and other residue) testing. Since documentation with the EU is a major point of concern, a standardized sampling protocol may involve pre- and post-cleaning samples, i.e., one on-farm test of product, followed by a test of a sample from bagged, ready-to-ship product.
- COTA should collaborate with government partners in Canada and worldwide (specifically Japan, the U.S. and the E.U) to identify how test cost burdens might be alleviated through the creation of a cost-sharing program and or cost-effective testing protocols.
- COTA should identify political partners to identify what support and/or action can be taken in regard to the fact that the practice of using glyphosate as a pre-harvest management tool for unauthorized purpose of crop burn-down (rather than weed control) has seriously compromised Canadian organic trade. One person interviewed for this report suggested following up with Ted Menzies (a former cabinet minister and current president/CEO of Crop Life Canada) regarding the investigation of political approach to this situation.
- COTA should work with AAFC and CFIA in crafting its approach of EU authorities if setting an import tolerance level for lentils and other organic crops—via the means of a "Special Notice"—is the desired path forward for the Canadian organic sector. David MacDonald, Director of Compliance Deputy Director Europe at AAFC was noted by one person interviewed for this report as being involved with this kind of work.
- Concerning the European trade sector: BNN has stated that "Public Statements" can be used to potentially modify the BNN orientation value of 0.01 ppm, specific to certain substances. As a first step, COTA should urge BNN to make a Public Statement that prevents outright shipment rejection and undue delays when residue testing detects glyphosate contamination of Canadian organic product above the orientation value. COTA's outreach to BNN should focus on bumping up, by as much as one order of magnitude, the orientation value for residue tolerance of glyphosate (to 0.1 ppm +/- 50%), via a Public Statement that applies not necessarily just to Canada but perhaps to the organic sector worldwide. Such a change would eliminate the double confounding that currently takes place of the 0.01 ppm orientation value with test variability and background levels of glyphosate in the environment.

3.4. An Expanded Role For Certifiers?

More than one person interviewed for this report expressed that certifiers, who have considerable on-site experience with regard to verifying which residue levels would be fraudulent, should play a larger role in helping the organic sector address this issue. For example, the development of an organic sector-wide science- and reality-based protocol that explains how to handle the existence of glyphosate background levels should take place with certifier involvement. The current nature of the farmer-certifier relationship is such that farmers are often fearful to approach their certifier to talk about glyphosate residue contamination—opening the dialogue feels like a potential path towards decertification, this farmer interviewed for this report said. He also mentioned anecdotally that he is aware of some cases in which spray drift led to farm decertification. A clear certifier protocol for dealing with glyphosate residues would serve to emphasize that organic certification is about organic standards being followed more than about outcomes possibly beyond a farmer's control, such as contamination exposure. Having such a protocol in place for consistent use by all certifiers would make it easier for farmers to approach certifiers with their concerns about glyphosate exposure and/or to obtain an affidavit that will let them finalize sales for product on which glyphosate residues have been found.

The traders interviewed for this report concurred, noting that certifiers are involved sort of after the fact (after glyphosate residues are found). Their perception is that certifiers seem somewhat unwilling to talk about this problem, and their feeling is that certifiers should be more at the forefront in terms of being clear about the protocol to be followed when glyphosate residues are found, and being more prepared to help (farmers and traders) with required documentation follow-up.

One trader suggested that the reluctance of certifiers to talk more about the issue of glyphosate residue contamination stems from trying to "hold the line" that organic foods are "pure" (i.e., free from contamination), in effect, refusing to get behind the reality of the situation (that organic foods are being produced in a contaminated environment). He stated that: "there is a feeling that certifiers are reluctant to get involved and take a leading role with regard to this this issue. Nobody wants to point out the reality of the contaminated environment for fear of bad press."

The certifier interviewed for this report provided a thorough perspective regarding his organization's approach when glyphosate residues are found. For example, if glyphosate residues are detected at levels that suggest drift exposure or intentional use, then the certifier must ask the follow-up questions of: Is the certified farm actually part of a split operation? What was taking place in fields adjacent to where the contaminated crops were grown? What were the buffers like—and were they actually in place in accordance with the farm plan?

A certifier asks these questions and others in order to assess the origin of the residue problem. In general, based on their work with farms, Canadian certification bodies should have an accurate idea of what levels of prohibited substance residues might be found in the environment/on organic farms dependent on what the substance is, how and at what time of the year it is used. When an organic field does turn out to show signs of drift, then the lot from that field can't be sold as organic and that field is subject to the 36-month transition process before its crops can be sold as organic.

The certifier stressed that in the case of background-level exposure or drift, it is not the case that whole farm that will be decertified. "We are focusing too much on the presence of very low glyphosate levels and therefore missing the point of the whole organic management system. We would not be spending these two years revising the [Canadian organic] standard if organic wasn't about a whole management system. Residue testing is simply one tool." Nine times out of ten, he noted, "if you do your job right as a certifier, then residue testing isn't even needed."

On the other hand, explained the certifier, if commingling is identified, or some other practice incoherent with organic standards, this is another story. Say, for example, a grower thinks they can do a burn off using glyphosate at any point in the season, thinking that nobody's going to know—in this case, if/when glyphosate residues are found, the certification body, in doing their assessment will be able to determine, with investigation into the source of elevated residue levels found on crops, that a farm has attempted to defraud the system. In this case a farm would (deservedly) lose its organic certification.

The certifier continued: "A certifier who is doing his/her job, has the training to know what to look for and conducts unannounced inspections, will find farmers who are attempting to commit fraud. It takes a year or two to build a solid case that cannot be explained away." He noted that while, in his opinion, most certifiers had sufficient knowledge and training to effectively assess situations involving glyphosate contamination, that deepening knowledge base on this issue among certifiers as a whole is also needed. He also commented that the Canadian system is problematic because "farmers suspected of fraud can [subsequently] go to other certifiers and make a case for why they should be certified- there is no mandatory time out, penalty or fine when fraud is detected."

Right now from a certification perspective, costs look great for organic products for 2014. As such, certifiers are currently on their guard, because with good prices, the incentive for fraud tends to rise—as the exception, however, according to the certifier and certainly not as the rule.

PART 4. SUMMARY

A market barrier due to glyphosate residue testing has hampered Canadian organic trade to Europe since 2011. Wide use in Europe of the trade organization BNN's low-level orientation value as a threshold to justify delay or rejection of Canadian organic product is at odds with the process-based, third-party verified assurance provided by organic standards worldwide. Meanwhile, market insistence in Europe (and elsewhere) that organic products are/should be free from contamination also undermines the process-based value of the organic production system, which operates in an increasingly polluted world. Future market/trade facilitation efforts should not attempt to provide guarantees of "pure" organic product through the use of residue testing.

The Canadian organic sector needs to achieve a wider understanding and recognition that, at this point in time, environmental exposure of organic product to low levels of prohibited substance is unavoidable. Consumers' low-residue expectations for organic products, generally a prevailing influence that encourages the growth of the organic sector, should not require unnecessary low-level testing of prohibited substances present at background levels in the environment, a costly burden that has shown to be harmful to trade of organic products and the growth of the organic sector worldwide. While everyone agrees that cutting back on fraud is good for the organic sector, the current European glyphosate testing protocol has the effect of unfairly disadvantaging Canadian sellers of compliant organic product.

Without the assignment of individual Harmonized System (HS) codes for organic commodities, the true impact of the European glyphosate residue-related market barrier on the Canadian organic sector cannot be known. Getting better comprehensive data on the volume and flow of Canadian organic exports is essential for dealing with this issue. Ironically, one negative impact of the discovery of glyphosate residues on organic lentils has been the potential reduction of Canadian organic acreage, which would increase the likelihood of the use of glyphosate and other substances prohibited in organic agriculture.

As science continues to push forward with greater precision in testing, what is to be done with better information about the presence of contaminants at low-levels in the environment? Better data on glyphosate exposure should permit differentiation of organic and conventional products. COTA can play a key role in: a) convincing BNN to adjust its glyphosate detection limits so that they more accurately reflect a reality in which glyphosate residues are detectable everywhere in the environment; and b) providing clear messaging with regard to the value of the whole organic production and third-party process in maintaining organic integrity. Moving forward, such efforts to handle the issue of glyphosate residue contamination should reduce unnecessary adversity in the global market and promote the development of Canada's organic sector.

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