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The Biology of *Solanum tuberosum* (L. (Linnaeus)) (Potatoes)

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1. General Administrative Information

1.1 Background

The Canadian Food Inspection Agency's Plant and Biotechnology Risk Assessment (PBRA) Unit is responsible for assessing the potential risk to the environment from the release of plants with novel traits (PNTs) into the Canadian environment. The PBRA (Plant and Biotechnology Risk Assessment) Unit is also responsible for assessing the pest potential of plant imports and plant species new to Canada.

Risk assessments conducted by the PBRA (Plant and Biotechnology Risk Assessment) Unit require biological information about the plant species being assessed. Therefore, these assessments can be done in conjunction with species-specific biology documents that provide the necessary biological information. When a PNT is assessed, these biology documents serve as companion documents to Dir94-08: *Assessment Criteria for Determining Environmental Safety of Plants with Novel Traits* (/plants/plants-with-novel-traits/applicants/directive-94-08/eng/1304475469806/1304475550733).

1.2 Scope

This document is intended to provide background information on the biology of *Solanum tuberosum*, its identity, geographical distribution, reproductive biology, related species, the potential for gene introgression from *S. (Solanum) tuberosum* into relatives, and details of the life forms with which it interacts.

Such information will be used during risk assessments conducted by the PBRA (Plant and Biotechnology Risk Assessment) Unit. Specifically, it may be used to characterize the potential risk from the release of the plant into the Canadian environment with regard to weediness/invasiveness, gene flow, plant pest properties, impacts on other organisms and impact on biodiversity.

2. Identity

2.1 Name(s)

Solanum tuberosum L. (Linnaeus)

2.2 Family

Solanaceae family

2.3 Synonym(s)

Synonyms for *Solanum tuberosum* include *Battata tuberosa* Hill, *Lycopersicon tuberosum* (L. (Linnaeus)) Mill., *Solanum andigenum* Juz. & Bukasov, S. (Solanum) *apurimacense* Vargas, S. (Solanum) *ascasabii* Hawkes, S. (Solanum) *boyacense* Juz. & Bukasov, S. (Solanum) *cardenasii* Hawkes, S. (Solanum) *chaucha* Juz. & Bukasov, S. (Solanum) *churuspi* Hawkes, S. (Solanum) *chocclo* Bukasov & Lechn., nom. nud., S. (Solanum) *coeruleiflorum* Hawkes, Solanum diemii Brücher, S. (Solanum) *cultum* (A.DC.) Berthault, S. (Solanum)*esculentum* Neck., S. (Solanum) *estradae* L.E.López, *Solanum goniocalyx* Juz. & Bukasov, S. (Solanum) *herrerae* Juz., S. (Solanum) *hygrothermicum* Ochoa, S. (Solanum) *maglia* Schltdl. var. (variety) *guaytecarum* Bitter, S. (Solanum) *leptostigma* Juz. ex Bukasov, nom. nud., S. (Solanum) *mamilliferum* Juz. & Bukasov, S. (Solanum) *molinae* Juz., S. (Solanum) *oceanicum* Brücher, S. (Solanum) *ochoanum* Lechn., S. (Solanum) *paramoense* Bitter, S. (Solanum) *parvicorollatum* Lechn., S. (Solanum) *phureja* Juz. & Bukasov, S. (Solanum) *rybinii* Juz. & Bukasov, S. (Solanum) *sanmartinense* Brücher, S. (Solanum) *sinense* Blanco, S. (Solanum) *stenotomum* Juz. & Bukasov, S. (Solanum) *subandigenum* Hawkes, S. (Solanum) *tascalense* Brücher, S. (Solanum) *tenuifilamentum* Juz. & Bukasov, S. (Solanum) *yabari* Hawkes, and S. (Solanum) *zykinii* Lechn. (Ovchinnikova et al. (et alii) 2011; USDA (United States Department of Agriculture)-ARS (Agricultural Research Service) 2014).

2.4 Common name(s)

Solanum tuberosum is commonly known in Canada as Irish potato, potato, white potato, yellow potato, red potato, and *pomme de terre* (USDA (United States Department of Agriculture)-ARS (Agricultural Research Service) 2014). The vegetable known as sweet potato (*Ipomoea batatas* (L. (Linnaeus)) Lam. var. (variety) *batatas*) belongs to a separate family (Convolvulaceae).

2.5 Taxonomy and genetics

Solanum tuberosum belongs to the *Solanaceae* family. This family includes, among 2000 other species, tomato (*S. (Solanum) lycopersicum L. (Linnaeus)*), sweet pepper (*Capsicum annuum L. (Linnaeus)*), eggplant (*S. (Solanum) melongena* L. (Linnaeus) var. (variety) *esculentum*), tobacco (*Nicotiana tabacum* L. (Linnaeus)), and petunia (*Petunia hybrid L. (Linnaeus)*). The genus *Solanum* is a polymorphous and largely tropical and subtropical genus containing more than 1000 species (Fernald 1970; Spooner and Knapp 2013).

Taxonomists have experienced difficulty in the ordering of species within the *Solanum* genus. Species definitions are confounded by a number of factors, including similar morphologies between distinct species, high levels of hybridization followed by introgression, and phenotypic plasticity in variable environments (Spooner and Berg 1992). *S. (Solanum) tuberosum* has been placed in the section *Petota*, which includes all of the tuber-bearing wild and cultivated potatoes. It is also informally classified in the Potato clade, which includes tomato and its wild relatives in section *Lycopersicon* as well as the closely related section *Etuberosum* (Bohs 2005; Weese and Bohs 2007).

One of the more widely used classifications identified seven species of cultivated potato: *S. (Solanum) tuberosum*, *S. (Solanum) curtilobum* Juz. & Bukasov, *S. (Solanum) chaucha* Juz. & Bukasov, *S. (Solanum) juzepczukii* Bukasov, *S. (Solanum) ajanhuiri*, Juz & Bukasov, *S. (Solanum) phureja* Juz. & Bukasov, and *S. (Solanum) stenotomum* Juz. & Bukasov (Hawkes 1990). However, this classification is not universally accepted. A recently updated classification suggests there are only four cultivated species: *S. (Solanum) tuberosum*, *S. (Solanum) ajanhuiri*, *S. (Solanum) juzepczukii* and *S. (Solanum) curtilobum* (Spooner et al. (et alii) 2007).

Domestic *S. (Solanum) tuberosum* are highly heterozygous autotetraploids ($2n = 4x = 48$); however some *S. (Solanum)* spp. (species) landraces cultivated primarily in South America are diploid ($2n = 2x = 24$), triploid ($3x = 36$), or pentaploid ($5x = 60$) (Andersson and de Vicente 2010). Continued self-pollination of *S. (Solanum) tuberosum* can lead to large inbreeding depression due to the fact that many characteristics are determined by non-additive genetic effects (Gopal and Ortiz 2006).

S. (Solanum) tuberosum is divided into two subspecies: *tuberosum* and *andigena*. The subspecies *tuberosum* is the cultivated potato widely used as a crop in North America andEurope. The subspecies *andigena* is also a cultivated species, but cultivation is restricted to Central and South America (Hawkes 1990; OECD (Organisation for Economic Cooperation and Development) 1997).

Taxonomic position (USDA (United States Department of Agriculture), NRCS (Natural Resources Conservation Service), 2010):
Kingdom: Plantae (plants)
Subkingdom: Tracheobionta (vascular plants)
Superdivision: Spermatophyta (seed plants)
Division: Magnoliophyta (flowering plants)
Class: Magnoliopsida (dicotyledons)
Subclass: Asteridae
Order: Solanales
Family: Solanaceae
Subfamily: Solanoideae
Genus: *Solanum* L. (Linnaeus)
Section: *Petota*
Subsection: *Potatoe*
Series: *Tuberosa*
Species: *Solanum tuberosum* L. (Linnaeus)

2.6 General description

Solanum tuberosum is a herbaceous plant that grows to 0.4-1.4 m (meters) tall and may range from erect to fully prostrate (Spooner and Knapp 2013). Stems range from nearly hairless to densely hairy and may be green, purple, or mottled green and purple. Leaves are pinnate with a single terminal leaflet and three or four pairs of large, ovoid leaflets with smaller ones in between (Spooner and Knapp 2013; Struik 2007). The blades range in size from 8-22 x 5-13 cm (centimetre) with the petioles ranging from 2-6 cm. They are medium to dark green, and like the stems, may range in hairiness from nearly hairless to densely hairy on both sides.

S. (Solanum) tuberosum plants produce rhizomes (often called stolons) that have rudimentary leaves and are typically hooked at the tip. They originate from the basal stem nodes, typically below ground, with up to three rhizomes per node (Struik 2007). Tubers, spherical to ovoid in shape, are swellings of the rhizome. The flesh of the tubers varies in colour from white to yellow to blue and the skin varies from white through yellow to tan and from red through blue. The colour of the flesh may or may not correspond to the colour of the skin. The texture of the surface may vary from smooth to netted or russetted (Spooner and Salas 2006). On the surface of the tuber are axillary buds with scars of scale leaves that are called eyes (Struik 2007). When tubers are planted, the eyes develop into stems to form the next vegetative generation.

The terminal inflorescences are cymes that are 5-11 cm (centimetre) long and generally found in the distal half of the plant (Spooner and Knapp 2013; Struik 2007). The inflorescences are usually branched and may contain up to 25 flowers. The peduncle is 0-22 cm (centimetre) long and the pedicels are 10-35 mm (millimetres) long in flower and fruit, spaced 1-10 mm (millimetres) apart. The pentamerous flowers, 3-4 cm (centimetre) in diameter, are all apparently perfect with styles of the same length (Sleper and Poehlman 2006; Spooner and Knapp 2013). The corolla may be a range of colours, including white, pink, lilac, blue, purple, and red-purple. The colour may be uniform or the pointed tips of the petal lobes may be white or there may be a second colour either stippled, in bands or in a star, and this may occur on either side of the corolla (Spooner and Knapp 2013). The petals are fused to create a tubular flower (Sleper and Poehlman 2006). The stamens have filaments that are 1-2 mm (millimetres) long and anthers that are 3-8 mm (millimetres) long (Spooner and Knapp 2013). The anthers form a cone-shaped structure through lateral joinings, serving to conceal the ovary (Struik 2007). They are typically bright yellow or orange with the exception of male-sterile plants in which the anthers are light yellow or yellow-green (Sleper and Poehlman 2006). The style is 9-13 mm (millimetres) by approximately 1 mm (millimetres) (Spooner and Knapp 2013).

The fruits are spherical to ovoid berries, about 1-4 cm (centimetre) in diameter. They are green or green tinged with white or purple spots or bands when ripe (Spooner and Knapp 2013; Spooner and Salas 2006). The berries may lack seeds or contain up to several hundred (Bailey and Bailey 1976). The seeds are ovoid and approximately 2 mm (millimetres) long. They are whitish to greenish when fresh and brownish when dry. The lateral walls of the testa are thick and "hair-like" and cause the seeds to be mucilaginous when wet (Spooner and Knapp 2013). Some cultivars may exhibit premature dropping of floral buds, male sterility, and/or inability to set fruit (Gopal 1994). The berries are toxic due to the presence of glycoalkaloids (Bailey and Bailey 1976).

3. Geographical Distribution

3.1 Origin and history of introduction

Solanum tuberosum ultimately traces its origin to Andean and Chilean landraces developed by pre-Colombian cultivators. These landraces exhibit tremendous morphological and genetic diversity and are distributed throughout the Andes, from western Venezuela to northern

Argentina, and in southern Chile. The wild species progenitors of these landraces have long been in dispute, but all hypotheses centre on a group of approximately 20 morphologically similar wild species referred to as the *Solanum brevicaule* complex (Correll 196; Grun 1990; Miller and Spooner 1999; Ugent 1968; van den Berg et al. (et alii) 1998).

The first record of *S. (Solanum) tuberosum* subsp. (subspecies) *andigena* outside South America was in the Canary Islands in 1567 (Hawkes and Francisco-Ortega 1993; Ríos et al. (et alii) 2007), and shortly thereafter in continental Spain in 1573 (Hawkes 1990; Hawkes and Francisco-Ortega 1992; Romans 2005). Forms of the introduced *S. (Solanum) tuberosum* subsp. (subspecies) *andigena* were adapted to the longer day lengths and climate of European latitudes through selection (OECD (Organisation for Economic Cooperation and Development) 1997). These converted forms are known today as *S. (Solanum) tuberosum* subsp. (subspecies) *tuberosum* (or *S. (Solanum) tuberosum*).

From Europe, *S. (Solanum) tuberosum* was transported to North America. *S. (Solanum) tuberosum* may first have been transported from England to Bermuda in 1613 and then from Bermuda to the North American mainland in 1621, a hypothesis favoured by Laufer (1938) and Hawkes (1990). *S. (Solanum) tuberosum* was present in India by 1610 and mainland China by 1700 (Sauer 1993). *S. (Solanum) tuberosum* was taken to New Zealand in 1769 by Captain Cook and gained agronomic significance for the native Maori by 1840 (Sauer 1993). Missionaries may have played a crucial role in the distribution of *S. (Solanum) tuberosum* from Europe throughout the world (Laufer 1938; Sauer 1993).

3.2 Native range

South America Argentina, Chile, Venezuela

3.3 Introduced range

Solanum tuberosum ranks as the world's fourth most important food crop, behind maize, rice, and wheat (FAO (Food and Agriculture Organization of the United Nations) 2014). It is cultivated worldwide in over one hundred countries throughout Africa, Asia, Australia, Europe, and North and South America (USDA (United States Department of Agriculture)-ARS (Agricultural Research Service) 2014). Landrace populations introduced in post-Colombian times are still maintained out of their natural range in Mexico and Central America, the Shimla Hills of India, and in the Canary Islands (Spooner and Knapp 2013). *S. (Solanum) tuberosum* is very rarely known to escape cultivation (Simon et al. (et alii) 2010).

Canada is one of the largest potato producers in the world, with production calculated at over 4.5 million metric tonnes in 2012 (Statistics Canada 2012). Potatoes are produced in every province in Canada with Prince Edward Island, Manitoba, New Brunswick, Alberta, Quebec, and Ontario having the highest proportion of production (Statistics Canada 2012). Potatoes are also produced on a small scale in the Yukon Territory and Northwest Territories (Statistics Canada 2012). *S. (Solanum) tuberosum* is reported as ephemeral (i.e. (that is to say) not established permanently in Canada, but recurring on a near-annual basis, usually as a result of volunteering from cultivation) in Manitoba, Ontario, New Brunswick, and Prince Edward Island (Brouillet et al. (et alii) 2013).

3.4 Potential range in North America

As previously mentioned, *Solanum tuberosum* is cultivated in every province in Canada as well as in the Yukon Territory and Northwest Territories (Statistics Canada 2012). It is also grown throughout the United States (Bohl and Johnson 2010). It can be grown wherever there is arable land, including in subarctic and even arctic regions, often with regionally adapted varieties (Dearborn 1957; Dearborn 1964; Dearborn et al. (et alii) 1953; Merzlaya et al. (et alii) 2008). Although *S. (Solanum) tuberosum* does volunteer, it generally does not persist outside of cultivation. There are only two reports of persistent populations of *S. (Solanum) tuberosum*, in the Republic of South Africa and Hawaii (Simon et al. (et alii) 2010). Therefore, although *S. (Solanum) tuberosum* can be cultivated throughout North America, it is unlikely to grow outside of cultivation.

3.5 Habitat

Solanum tuberosum rarely exists as a wild plant other than as a volunteer (Burton 1989; Simon et al. (et alii) 2010). *S. (Solanum) tuberosum* is cultivated around the world, although in the tropics it is grown in the cool highlands, typically at elevations over 1000 m (metres), and in the subtropics it is grown during the cooler winter, autumn, and spring seasons or at mid-elevations (Hijmans 2001). *S. (Solanum) tuberosum* grows best in cool climates, with higher temperatures favoring foliar development over tuberization (Haverkort 1990). *S. (Solanum) tuberosum* is not frost tolerant and will be killed at temperatures of -3°C (celsius) or lower (Li 1977). It can grow in a range of soil types, but is sensitive to drought stress and therefore can only be cultivated where there is adequate rainfall or the ability to irrigate (Bohl and Johnson 2010; Haverkort 1990). Differences in tolerance to frost and drought occur within the species. Thus, cultivars have been selected with greater adaptation to these stresses.

4. Biology

4.1 Reproductive biology

Solanum tuberosum is a perennial but is grown as an annual in Canada. The commercial crop is propagated vegetatively using tuber pieces or small whole tubers that are commonly referred to as seed or seed potatoes or through plant cuttings or plantlets. *S. (Solanum) tuberosum* may also be reproduced by botanical seeds, which are commonly referred to as true potato seeds or TPS (true potato seed). True potato seed production is practised in breeding programs under greenhouse or growth chamber conditions. Some programs have also used open pollination conducted outdoors. True potato seed production in the natural environment varies with cultivar and weather conditions. The degree to which flowering occurs, the duration of flowering, and the response of flowering behaviour to environmental conditions is greatly influenced by cultivar (Burton 1989). The environmental conditions that influence flower initiation and development include light intensity, quality and duration (day length), temperature, water supply, and available soil nutrients. Flowers of some varieties may abscise prematurely.

Tetraploid *S. (Solanum) tuberosum* is self-compatible, although most of the related diploid species are self-incompatible. Pollen sterility occurs frequently in *S. (Solanum) tuberosum*, and ovule sterility occasionally; many varieties do not produce any botanical seed.

Flowering starts on branches located near to the base of the plant and proceeds upwards. Each flower will typically remain open for 2 to 4 days, with the stigma being receptive and pollen being produced for approximately 2 days (Plaisted 1980). Fertilization occurs approximately 36 hours after pollination (Clarke 1940). Viable seeds require a minimum of 6 weeks to develop.

Figure 1: *Solanum tuberosum* field in bloom near Montebello, Quebec, Canada (Photo by A. Blain, CFIA (Canadian Food Inspection Agency)).

Tubers are storage organs that develop from swollen underground stems, and the eyes on the tubers are buds that can sprout and develop into new stems. New plants can be grown from whole tubers or pieces of tubers, and the number of stems produced from a planted tuber or tuber piece depends on the number of eyes and the physiological age of the tuber. The tuber acts as a source of nourishment for the new plant, and plants grown from tubers tend to have more early vigor than those grown from true potato seed (Hoopes and Plaisted 1987). Vegetative propagation may perpetuate diseases in successive generations.

4.2 Breeding and seed production

The majority of breeding with *Solanum tuberosum* involves crosses between tetraploid genotypes followed by phenotypic recurrent selection (Carputo and Frusciante 2011; Dean 1994). Parents are selected to be diverse in order to minimize homozygosity and inbreeding depression, and test crosses may be performed in order to determine which parent combinations are desirable. Selection is typically applied at the phenotypic level, although molecular markers are increasingly used (Bradshaw 2007; Carputo and Frusciante 2011). Due to the heterozygosity and tetraploidy of *S. (Solanum) tuberosum*, traits are expected to segregate in the F1 generation, and large populations are typically generated, on the order of tens of thousands (Carputo and Frusciante 2011; Howard 1978). From the F1 generation, tubers will be removed and planted, representing the first clonal generation. The clones will then be put through a series of field trials in an increasingly diverse range of environments over a number of years, and selection will be applied to reduce the number of clonal lines until only one or a few remain (Carputo and Frusciante 2011; Dean 1994).

Breeding may also be done using diploid lines. Maternal haploid lines can be made by crossing S. (Solanum) *tuberosum* with diploid clones of S. (Solanum) *phureja* (Carputo and Frusciante 2011). These can then be used in crosses with 2x tuber-bearing *Solanum* species. Direct crosses between diploid tuber-bearing *Solanum* species and tetraploid S. (Solanum) *tuberosum* may also succeed if the diploid can produce unreduced (2*n*) gametes, which is common for these species (Hoopes and Plaisted 1987). Other techniques such as mutagenesis, somatic hybridization, and genetic engineering may also be employed (Bradshaw 2007; Hoopes and Plaisted 1987; Karp et al. (et alii) 1987).

The main objectives of breeding include increased yield, improving quality characteristics of tubers such as skin and flesh colour, tuber size and shape, eye depth, nutritional properties, cooking/after cooking properties, processing quality, and introducing resistance to biotic and abiotic environmental stresses (Carputo and Frusciante 2011; Howard 1978). All *S. (Solanum) tuberosum* varieties must be registered before they can be grown for commercial use in Canada. Varieties not registered in Canada can only be grown for experimental purposes or for the purpose of registration. The maximum level of total glycoalkaloids allowed in potato tubers is 20 mg (milligrams) per 100 g (grams) fresh weight, and this is verified during the variety registration process (CFIA (Canadian Food Inspection Agency) 2012; Health Canada 2011).

Seed potato production often occurs in regions that are separate from those used to produce the crop for consumption. Precautions are taken during seed potato production to minimize disease incidence (Dean 1994; Hoopes and Plaisted 1987; Western Potato Council 2003). Insecticides and other insect control measures will be used to reduce aphid populations, which are the main agents for spreading viral diseases. Any plants showing symptoms of disease are rogued; rogueing may be supplemented with laboratory detection methods when symptoms may be poorly expressed. Management and sanitation practices will also be put into place to minimize the spread of disease through contact with machinery, tools or with surfaces encountered during transport and storage.

In Canada, Part II (2) of the *Seeds Regulations* under the *Seeds Act* specifies that seed potatoes must be certified before they can be sold commercially (Department of Justice 2014). The seed certification process ensures that the seed potatoes originated from nuclear stock, which means that they were produced from sterile tissue culture propagules and subjected to a number of tests that demonstrate it to be disease-free. The Canadian seed potato certification system relies on the continuous introduction of disease free material in the seed supply continuum and limits multiplication of seed potato stocks to a maximum of six field generations to minimize disease build-up. Further disease and varietal purity standards are ensured through additional field inspections, laboratory testing, post-harvest testing, and agronomic practices.

4.3 Cultivation and use as a crop

In Canada, the primary *Solanum tuberosum* cultivars grown include CalWhite, Ranger Russet, Russet Burbank, Shepody, and Umatilla Russet for French fries; Atlantic, Kennebec, Snowden and Superior for chips; and, Chieftain, Goldrush, Norland, Ranger Russet, Russet Norkotah, Sangre, Superior, Umatilla Russet, and Yukon Gold for table cultivars (Agriculture and Agri-Food Canada 2005; Agriculture and Agri-Food Canada 2007; Agriculture and Agri-Food Canada 2014).

Cool summer temperatures are ideal for potato production. The optimum temperature for growth is 21°C (celsius), and growth is restricted below 7°C (celsius) and above 30°C (celsius) (Western Potato Council 2003). Tuber formation in *S. (Solanum) tuberosum* is favoured by short days. It is also essential to have ample soil moisture for optimum yields. Deep, well-drained sandy or silt loam soils are ideal for growing *S. (Solanum) tuberosum*, with a soil pH (potential Hydrogen) between 5.5 to over 7.5 (Agriculture and Agri-Food Canada 2005).

Rotation with cereals, corn, forage, and/or canola is recommended for greater rooting depth, increased yield, improving soil properties, and contributing to pest control (Agriculture and Agri-Food Canada 2005; Atlantic Potato Committee 2007). Intervals of greater than 4 years is recommended between successive potato crops in order to reduce soil-borne pathogens and insect populations (Firman and Allen 2007; Western Potato Council 2003). Some herbicide residues can negatively impact *S. (Solanum) tuberosum* foliage development and tuber formation; field history should be reviewed carefully before planting (Western Potato Council 2003).

Tillage is generally applied in the production of *S. (Solanum) tuberosum*, but the type of tillage varies widely with soil type and availability of tillage implements (Western Potato Council 2003). The purpose of tillage is to incorporate crop residue, loosen the soil, and incorporate pre-emergence herbicides. Soil erosion is a major problem for potato production in Canada, and tillage should be planned to minimize soil loss (Atlantic Potato Committee 2007; Western Potato Council 2003).

In general, seed potatoes should have an average weight of 60 g (grams), with the majority of seed potatoes weighing between 35 and 85 g (grams) (Western Potato Council 2003). Seeding rate for *S. (Solanum) tuberosum* will vary depending on the intended end-use, but typically ranges from less than one to more than six tonnes per hectare (Firman and Allen 2007). Seed potatoes should be planted 10 to 18 cm (centimetre) deep, and spaced 15 to 46 cm (centimetre) apart in a row, with rows typically being 75 to 97 cm (centimetre) apart (Agriculture and Agri-Food Canada 2005; Western Potato Council 2003). In-row spacing will depend on the variety planted, the intended market, soil moisture, planting date, seed potato size and age, and cost (Western Potato Council 2003). Ideal soil temperatures for planting are 13-16°C (celsius), but should generally be at least 8-10°C (celsius) (Agriculture and Agri-Food Canada 2005; OMAF (Ontario Ministry of Agriculture and Food) 1979; Western Potato Council 2003). *S. (Solanum) tuberosum* may be planted before the usual date of the last killing frost. Although the foliage is only moderately tolerant of frosts, new shoots will emerge if the seed potatoes are still sound at the time of any frost damage.

Along each row of cultivated *S. (Solanum) tuberosum*, the soil is ridged up, a process known as hilling, to prevent exposure of the developing tubers to light. Tubers produce the alkaloid solanine and turn green when exposed to light, which renders them unfit for human or livestock consumption. For the same reason, tubers should be stored in a dark place after harvest. Hilling also enhances stolon development, minimizes infection with late blight, minimizes frost damage, improves drainage and facilitates harvest (Bohl and Johnson 2010; Western Potato Council 2003).

S. (Solanum) tuberosum withdraws a lot of nutrients from the soil, and applications of nitrogen, phosphorous and potassium are generally required to ensure adequate plant growth, tuber yield and quality, and to minimize susceptibility to diseases (Atlantic Potato Committee 2007; Western Potato Council 2003). Nitrogen is the most likely to limit potato production, but excess nitrogen can have negative impacts as well. Application of micronutrients is generally not required. Soil and, in some cases, tissue testing is recommended in order to determine the most effective fertilization rates (Atlantic Potato Committee 2007; Western Potato Council 2003). In areas where the soil is naturally acidic, such as in Atlantic Canada, agricultural limestone may be added to maintain pH (potential Hydrogen) within the desired range (Atlantic Potato Committee 2007).

Irrigation is often applied in potato production, since *S. (Solanum) tuberosum* is a moisture-sensitive crop and has a shallow active root zone. Water demand is highest during the tuber bulking stage of growth, and an inadequate supply will reduce tuber yield and quality (Western Potato Council 2003). Generally, *S. (Solanum) tuberosum* requires 400 to 500 mm (millimetres) of water, although this will depend on the variety, weather and soil type. In Manitoba, northern Alberta and parts of Saskatchewan, the primary source of moisture is precipitation and this will be supplemented by irrigation, while in southern Alberta and other parts of Saskatchewan, the majority of moisture comes from irrigation (Western Potato Council 2003). Little irrigation is used in Prince Edward Island and New Brunswick (Agriculture and Agri-Food Canada 2005).

There are many serious diseases that may be carried in seed potatoes, including late blight (*Phytophthora infestans* (Mont.) de Bary), early blight (*Alternaria solani Sorauer)*, and bacterial ring rot (*Clavibacter michiganensis subsp. (subspecies) sepedonicus (Spiekermann and Kotthoff) Davis et al. (et alii))*, as well as several viral diseases. The best protection against such diseases is to use certified disease-free seed potatoes. Crop rotations, the use of resistant cultivars, and proper sanitary practices are also important for reducing the incidence of disease (Bohl and Johnson 2010; Western Potato Council 2003). Fungicides may be applied to control fungal diseases, and the use of insecticides to limit the presence of aphids can help to minimize the spread of insect-transmitted diseases. In addition, a number of insects can attack the developing plant. Perhaps the most serious of these is the Colorado potato beetle (*Leptinotarsa decemlineata* Say), which can cause extensive foliar damage. Insecticides are generally required to control this insect, but a distance of 200 m (meters) between potato crops planted in successive years is strongly recommended as well (Western Potato Council 2003). Nematodes are another important pest of *S. (Solanum) tuberosum*. Fumigants can be used to control most nematode species, but they must be used with care as they are expensive, require specialized equipment, delay planting by 3 to 4 weeks if used in spring, and can contaminate tubers and groundwater (Atlantic Potato Committee 2007). Carefully planned rotations and the use of resistant potato cultivars can also help to minimize nematode populations. For a comprehensive list of organisms that interact with *S. (Solanum) tuberosum*, please refer to Section 6.

Weeds will compete with potato crops and should be managed until canopy closure. Weeds are less of a problem in fields with a uniform dense canopy (Western Potato Council 2003). Some weeds can also serve as alternate hosts for *S. (Solanum) tuberosum* pests, particularly nightshade weeds (*Solanum* species), and these should be controlled to help reduce pest populations (Bohl and Johnson 2010). There are few herbicides registered for *S. (Solanum) tuberosum* that are effective against Canada thistle (*Cirsium arvense* (L. (Linnaeus)) Scop.) and quack grass (*Elytrigia repens* (L. (Linnaeus)) Gould), two weeds that are problematic in potato fields, so other means of control should be considered for these, including field selection, crop rotation, and employing practices to prevent the entry of weeds, such as proper equipment cleaning. Pre-plant incorporated, pre-emergence, pre-emergence burn-off and post-emergence herbicide applications can be used to control weeds, as can cultural practices such as harrowing, cultivation and hilling (Western Potato Council 2003).

Integrated pest management is strongly recommended, with a combination of cultural and chemical approaches. Pesticides should only be applied when pest populations exceed the economic threshold and then only the affected area should be treated. If multiple pesticide applications are required, alternating between chemical groups will help to prevent resistance to a given pesticide.

S. (Solanum) tuberosum can also suffer from a number of physiological disorders that are caused by a combination of poor environmental conditions and poor management decisions (Atlantic Potato Committee 2007; Bohl and Johnson 2010; Western Potato Council 2003). Exposure of the tubers to low temperatures in the field or in storage can cause low temperature injury, while high soil temperatures can cause tuber deformities, as can nutrient and water imbalances. If there is insufficient oxygen supplied to internal tuber tissues, blackheart can occur, and if the tuber grows too rapidly, for instance in poor stands, hollow heart can occur. These disorders are mostly preventable using proper crop management and storage conditions.

Approximately 2 weeks before harvest, a vine killer may be applied as a harvest aid (Atlantic Potato Committee 2007). This is most commonly accomplished with a chemical desiccant. In addition to making harvesting easier, topkilling can reduce disease incidence, control tuber size, and reduce skinning of tubers. Vines can also be killed mechanically, sometimes in combination with a chemical desiccant. Flail beaters, rotary choppers, rolling vines with rubber tires or crowfoot packer wheels and fire are options (Bohl and Johnson 2010; Western Potato Council 2003).

Tubers should ideally be harvested when temperatures are between 7 and 15°C (celsius) to reduce shatter bruises, and before there is sufficient frost to cause damage. Another important consideration for deciding when to harvest is the chemical maturity of the tubers. Tubers are chemically mature when the amount of free sugars (sucrose, glucose and fructose) drops below a standard minimum level, which is important for their long-term storage and processing (Western Potato Council 2003). The acceptable amount of sugar differs with variety; for example, chipping potato varieties must have lower reducing sugar contents than French fry varieties (Western Potato Council 2003).

To conserve tuber consumption or processing quality during storage, it is important to prevent them from sprouting. A sprout inhibitor can be applied either in the field 2 to 3 weeks before harvest, or after the potatoes are placed in storage (Atlantic Potato Committee 2007; Western Potato Council 2003). Tubers may be stored for up to 10 months, but adequate storage conditions are important in order to maintain quality and prevent diseases. Tubers should be stored with adequate air movement at 3-4°C (celsius) for seed tubers, 4.5-5.5°C (celsius) for table tubers and between 8°C (celsius)-15°C (celsius) for processing tubers, depending on end market (Atlantic Potato Committee 2007). To prevent greening, tubers should be stored in the dark (Agriculture and Agri-Food Canada 2005; Atlantic Potato Committee 2007).

Proper storage facility insulation is important to reduce condensation as excess water can affect quality and increase the incidence of soft rots. Relative humidity of the air should be near 98 percent (Atlantic Potato Committee 2007; Western Potato Council 2003).

Of the potatoes produced in Canada, around 55% are processed, primarily into French fries, with 10-15% processed for chips and dehydration (Agriculture and Agri-Food Canada 2005; Agriculture and Agri-Food Canada 2007). This is typical of developed nations worldwide (Kirkman 2007). They may also be produced for the fresh market or for seed. Potatoes are also used as animal feed and for various industrial uses, such as the manufacture of starch and alcohol, but the proportion of Canada's potato production directed for industrial or non-food uses is minimal (Bohl and Johnson 2010; Dalton 1978).

4.4 Gene flow during commercial seed and biomass production

Solanum tuberosum is pollinated by a number of Hymenopteran insects, particularly bumblebees, including *Bombus impatiens* Cresson and *B. (Bombus) terrestris* L. (Linnaeus) (Eastham and Sweet 2002; Hawkes 1988; Plaisted 1980; Sanford and Hanneman 1981; Scurrah et al. (et alii) 2008; Teper 2004). However, it has been observed that bumblebees are more likely to visit plants at the edges of plots as opposed to their centres, allowing them to stay closer to their nests (Batra 1993; Free and Butler 1959; McPartlan and Dale 1994). Bumblebees will selectively visit different potato cultivars, preferring those with fertile pollen (Arndt et al. (et alii) 1990; Batra 1993; Sanford and Hanneman 1981). Bumblebees are most likely to forage within 500 m (meters) of their nest, although distances of up to 1750 m (meters) have been observed (Walther-Hellwig and Frankl 2000).

The pollen beetle species *Meligethes aeneus* Fabricius has also been observed to transfer potato pollen in Europe (Petti et al. (et alii) 2007; Skogsmyr 1994). The domestic honey bee (*Apis mellifera* L. (Linnaeus)) and the bumble bee species *B. (Bombus) fervidus* Fabricius do not visit *S. (Solanum) tuberosum* (Sanford and Hanneman 1981). *S. (Solanum) tuberosum* anthers have terminal pores and must be vibrated to release the pollen, known as buzz pollination (Buchmann and Hurley 1978; Plaisted 1980). Honey bees do not exhibit buzz pollination and it is likely for this reason that they are uninterested in *S. (Solanum) tuberosum* flowers (Sanford and Hanneman 1981). The role of wind in the pollination of *S. (Solanum) tuberosum* is likely to be minor (White 1983).

Outcrossing has primarily been observed to occur between adjacent plants and the rate of outcrossing decreases rapidly thereafter, with little observed beyond 4.5 m (meters) (Conner 1993; Dale et al. (et alii) 1992; McPartlan and Dale 1994; Tynan et al. (et alii) 1990). For instance, McPartlan and Dale (1994) measured outcrossing in the variety Désirée using the *nptII (neomycin phosphotransferase 2)* transgene as a selectable marker. They reported that only 2% of seedlings had the selectable marker at distances up to 3 m (meters), 0.017% of the seedlings had the selectable marker at 10 m (meters), and no outcrossing was observed at 20 m (meters). Tynan et al. (et alii) (1990) also measured outcrossing in the variety CRD (Chronic Respiratory Disease) Iwa using a gene encoding a chlorsulfuron-insensitive form of acetolactate synthase as a selectable marker. They found that within the trial, 1.14% of seedlings were resistant to chlorsulfuron, while between 0-1.5 m (meters) from the trial, 0.03% of seedlings were resistant. At a distance of 1.5-3 m (meters) and 3-4.5 m (meters), 0.05% of seedlings were resistant. No resistance was detected beyond 4.5 m (meters).

In contrast to the above studies, Skogsmyr (1994) observed much higher rates of outcrossing using the variety Désirée transformed with the *nptII (neomycin phosphotransferase 2)* and *GUS (D-glucuronidase)* marker genes as the pollen donor and Stina as the pollen receptor. Rates were 72% at a distance of 0-1 m (meters) and 31% at 1000 m (meters). The authors attributed the high rates of outcrossing observed in this study to the behaviour of the predominant pollinator species found in the plots, *M. (Meligethes) aeneus*, which tends to move together in large numbers and fly over large distances (Skogsmyr 1994). However, this study was reviewed by Connor and Dale (1996), who suggested that the high rates observed were the result of false positives during the PCR (polymerase chain reaction) analysis of the *nptII (neomycin phosphotransferase 2)* marker gene. Petti et al. (et alii) (2007) also found higher rates of outcrossing between the varieties Désirée and the male sterile British Queen. Using a microsatellite marker system, they found evidence of out-crossing at the furthest distance studied, 21 m (meters), where 4 berries produced true potato seed and the 23 seeds that germinated were all identified as hybrids.

4.5 Cultivated *Solanum tuberosum* as a volunteer weed

Solanum tuberosum volunteers, often referred to as groundkeepers, can reduce yields in subsequent crops through competition as well as perpetuate pests and diseases, which can be problematic for future potato crops grown on that site. If *S. (Solanum) tuberosum* volunteers are not removed, they can contaminate the harvest, which can potentially be hazardous since the plant and its berries are toxic (Lawson 1983; Makepeace and Holroyd 1978; Pérombelon 1975; Rahman 1980).

S. (Solanum) tuberosum volunteers may develop either from true potato seed or tubers that are left behind following harvest. The amount of true potato seed produced in a given crop will depend on the cultivar as well as environmental conditions, particularly photoperiod, temperature, plant density, and nitrogen supply (Askew 1993; Struik 2007). In Scotland, it was shown that true potato seed can survive for up to seven years in a potato field (Lawson 1983). However, the early growth of seedlings from true potato seed is slow compared to that of plants growing from tubers, and daughter tubers are generally smaller as well (Pérombelon 1975; Rowell et al. (et alii) 1986). Tubers are unlikely to persist as long as true potato seed, but due to limitations of harvesting equipment, there is a high potential for tubers to be left in fields after harvest (Rahman 1980). In some cases, more than 100,000 tubers/ha have been recovered following harvest, with the majority of the tubers being small in size (Lutman 1977; Pérombelon 1975). In areas with mild winters, it is estimated that *S. (Solanum) tuberosum* volunteers grown from tubers may persist for 4-5 years in most arable crops (Makepeace and Holroyd 1978). The handling and transportation of tubers also allow opportunities for escape.

In Canada, most production areas experience deep frost penetration in the soil profile and tubers are regularly purged from the soil environment as a result. The potential for frost to damage *S. (Solanum) tuberosum* volunteers will depend on soil type, the duration and severity of the frost and on the depth of the tuber (Askew and Struik 2007; Lutman 1977). Soil temperatures below -2.8°C (celsius) have been shown to result in significant tuber mortality (Boydston et al. (et alii) 2006). In addition, *S. (Solanum) tuberosum* is easily controlled with normal weed control practices (Rahman 1980). Thus, in areas where *S. (Solanum) tuberosum* is grown commercially, the measures required to control *S. (Solanum) tuberosum* volunteers do not differ from the cultural and pest management practices that are normally followed for the crop and succeeding crops in the rotation.

Outside of cultivated areas, *S. (Solanum) tuberosum* does not compete successfully and typically fails to establish (Love 1994). Despite its widespread cultivation worldwide in a variety of habitats, it is rare for *S. (Solanum) tuberosum* to escape into the wild. There are only two reports of persistent populations of *S. (Solanum) tuberosum* outside of cultivation: one in the Republic of South Africa and the other in Hawaii (Simon et al. (et alii) 2010). Even though volunteers occur periodically near animal feed lots, at waste disposal sites and in areas surrounding commercial production sites, there is no evidence that *S. (Solanum) tuberosum* can proliferate and become established as a weed under Canadian conditions.

S. (Solanum) tuberosum is not listed as a noxious weed in the *Weed Seeds Order* (Department of Justice 2005). It is not reported as a pest or weed in managed ecosystems in Canada, nor is it recorded as being invasive of natural ecosystems. In summary, there is no evidence that *S. (Solanum) tuberosum* has weed or pest characteristics in Canada.

4.5.1 Cultural/mechanical control

Improving the efficiency of the harvesters at separating tubers from soil would reduce the number of tubers left behind to potentially volunteer. Some harvesters have been developed for *S. (Solanum) tuberosum* that retain or crush tubers that would normally be lost during harvest, although such harvesters are not commonly used (Rahman 1980; Steiner et al. (et alii) 2005). Crushers can be used to destroy tubers, although their efficiency varies with soil type and environmental conditions, and they are not effective for small tubers of 1 cm (centimetre) or less (Rahman 1980).

Ploughing tends to bury tubers deeper, which will protect them from frost, allowing them to survive longer (Lumkes and Beukema 1973; Rahman 1980). Tubers at the surface may also be more prone to rotting and their earlier germination allows them to be controlled with pre-planting herbicides. Non-turning soil cultivation is therefore recommended (Lumkes and Beukema 1973).

S. (Solanum) *tuberosum* volunteers do not compete well in cereals and perennial ryegrass, but are a greater problem in vegetable crops, silage maize and subsequent potato crops (Lumkes and Beukema 1973). A proper rotation can therefore also contribute to minimizing the number of S. (Solanum) *tuberosum* volunteers in subsequent crops. Hand weeding during or after harvesting is an effective, although time-consuming, method for controlling S. (Solanum) *tuberosum* volunteers, and grazing has also been applied in some countries (Rahman 1980; Steiner et al. (et alii) 2005).

4.5.2 Chemical control

Sprout inhibitors are used to maintain tuber quality, and some sprout inhibitors are applied in the field and have the added advantage of reducing the potential for tubers to volunteer. The main sprout inhibitor applied in field is maleic hydrazide (MH). MH (maleic hydrazide) is applied to the plant 2-3 weeks after bloom, allowing it to be absorbed by the leaves and transported to tubers where it inhibits sprouting (Rahman 1980). Soil fumigants can also reduce the number of tuber volunteers, although soil type and environmental conditions have a large impact on their effectiveness (Boydston and Williams 2003; Rahman 1980).

It can be challenging to control S. (Solanum) *tuberosum* volunteers derived from tubers using herbicides because the food reserves in the tuber allow the plant to recover from herbicide damage that otherwise would have been lethal (Rahman 1980). The following herbicides can be used to kill or injure S. (Solanum) *tuberosum*, although tubers will likely resprout: oxyfluorfen, bromoxynil, ethofumesate, mesotrione, carfentrazone-ethyl, dicamba, 2,4-D, atrazine and fluroxypyr (Boydston 2001; Boydston 2004; Boydston and Seymour 2002; Boydston and Williams 2005; Rahman 1980). Glyphosate is also effective for controlling volunteer potatoes. Glyphosate is transported to below ground tissues, including the daughter tubers, effectively killing them; however, glyphosate will not kill unemerged sprouts on the parent tuber (Lutman and Richardson 1978; Rahman 1980).

4.5.3 Integrated weed management

There is no single method that is fully effective for controlling S. (Solanum) *tuberosum* volunteers, so an integrated weed management approach is recommended. Managing the potato crop is an important aspect to consider for reducing S. (Solanum) *tuberosum* volunteers, because a well-managed potato crop will set large, uniform tubers, making them easy to harvest and leaving fewer behind in the soil (Steiner et al. (et alii) 2005). Seedbed preparation, spacing, fertilization, irrigation, and disease management must all be carefully planned. During harvest, special considerations such as the depth of the blade, the primary chain gap size and the forward speed among others can also help to ensure optimal harvesting of tubers, reducing the number left behind in the soil (Steiner et al. (et alii) 2005). These practices should be combined with the cultural, mechanical, chemical, and biological control methods outlined in this document.

4.5.4 Biological control

The Colorado potato beetle has been investigated as a possible biological control for *S. (Solanum) tuberosum* volunteers, although its use should be combined with herbicides in order to effectively control volunteers (Boydston and Williams 2005; Steiner et al. (et alii) 2005; Williams et al. (et alii) 2004). This method has the potential to be detrimental to nearby potato crops, so it should be used carefully.

4.6 Means of movement and dispersal

Information on seed dispersal is lacking. Birds are unlikely to distribute true potato seeds because the berries are green and inconspicuous. Hawkes (1988) suggests that the distribution of berries by small (or perhaps large) mammals is possible due to their sweet and aromatic nature. However, there is no mention regarding the toxicity of the berries and whether this may impede browsing by animals. Potato tubers are most likely to be spread during handling and transportation.

5. Related species of *Solanum tuberosum*

There are more than 1000 species in the genus *Solanum* (Fernald 1970; Spooner and Knapp 2013). The *Solanum* genus is divided into several sections, and *S. (Solanum) tuberosum* belongs to the section *Petota*, which contains approximately 200 wild species that can be found from southwestern United States to Argentina and Chile (Spooner and Hijmans 2001). Wild relatives of *S. (Solanum) tuberosum* grow in a range of habitats, including semi-desert, subtropical and temperate regions, typically at altitudes of 1200 to 3800 m (meters), although they may be able to grow down to 800 m (meters) and up to 4000 m (meters) (Bradshaw and Mackay 1994; Hawkes 1990; Spooner et al. (et alii) 2004). Most of these are weedy and are commonly found in habitats that have recently been disturbed.

The three species in the section *Etuberosum* (*S. (Solanum) etuberosum* Lindl., *S. (Solanum) fernandezianum* Phil. and *S. (Solanum) palustre* Poepp. *ex* Schltdl.) are closely related to *S. (Solanum) tuberosum* and the section *Petota* (Andersson and de Vicente 2010). They grow in

Argentina and Chile, both in the mainland and on the Más a Tierra Island, in moist deciduous forests to upland dry scrub forests beside streams or near to waterfalls at elevations from 40 m (meters) to 2500 m (meters) (Contreras-M and Spooner 1999).

No wild relatives from the section *Petota* grow in Canada, nor do relatives from the section *Etuberosum*. The *Solanum* species that can be found in Canada include: from the section *Solanum*, S. (Solanum) *ptychanthum* Dunal *ex* DC, S. (Solanum) *nigrum* L. (Linnaeus), S. (Solanum) *interius* Rydb, S. (Solanum) *physalifolium* Rusby, S. (Solanum) *americanum* P. Miller, and S. (Solanum) *sarrachoides* auct. non Sendtner *ex* Martius; from the section *Dulcamara*, S. (Solanum) *dulcamara* L. (Linnaeus); from the section *Parasolanum*, S. (Solanum) *triflorum* Nutt.; from the section *Lathyrocarpum*, S. (Solanum) *carolinense* L. (Linnaeus); from the section *Androceras*, S. (Solanum) *rostratum* Dunal; from the section *Cryptocarpum*, S. (Solanum) *sisymbriifolium* Lam.; and from the section *Lycopersicon*, tomato, S. (Solanum) *lycopersicum* (Brouillet et al. (et alii) 2013; Government of Canada 2013).

5.1 Inter-species/genus hybridization

Hybridization is common among the tuber-bearing *Solanum* species (Bradshaw and Mackay 1994). However, endosperm breakdown has been observed following some crosses. This has led to the development of the endosperm balance number (EBN), which can be used to predict successful hybridization. An EBN (endosperm balance number) is assigned empirically to each tuber-bearing *Solanum* species and represents its "effective ploidy" (Andersson and de Vicente 2010). Crosses between species with the same EBN (endosperm balance number) are typically successful whereas if the species have different EBN (endosperm balance number), the cross is likely to fail. Many of the tuber-bearing *Solanum* species are also capable of producing unreduced (2*n*) gametes, which can allow that species to cross with another species that has double the EBN (endosperm balance number) (Andersson and de Vicente 2010).

Experimental evidence has demonstrated that S. (Solanum) *tuberosum* can cross successfully with S. (Solanum) *stoloniferum* Schltdl. & Bouché, S. (Solanum) *hougasii* Correll, S. (Solanum) *acaule* Bitter, S. (Solanum) *bukasovii* Juz., and S. (Solanum) *brevicaule* Bitter, although in some cases success is dependent on the ploidy of the S. (Solanum) *tuberosum* accession and the direction of the cross (Janssen et al. (et alii) 1997; Scurrah et al. (et alii) 2008). Representative results from Janssen et al. (et alii) (1997) are presented in Table 1.

Table 1. Results of experimental crosses between *Solanum tuberosum* and related species as reported in Janssen et al. (et alii) (1997)

Cross - Female	Cross - Male	Description

S. (Solanum) stoloniferum	*S. (Solanum) tuberosum* 2x	200 seeds from 95 pollinations
S. (Solanum) stoloniferum	*S. (Solanum) tuberosum* 4x	0 seeds from 322 pollinations
S. (Solanum) tuberosum 2x	*S. (Solanum) stoloniferum*	0 seeds from 39 pollinations
S. (Solanum) tuberosum 4x	*S. (Solanum) stoloniferum*	30 seeds from 76 pollinations
S. (Solanum) stoloniferum (as *S. (Solanum) fendleri*)	*S. (Solanum) tuberosum* 2x	13 seeds from 108 pollinations
S. (Solanum) stoloniferum (as *S. (Solanum) fendleri*)	*S. (Solanum) tuberosum* 4x	4 seeds from 199 pollinations
S. (Solanum) tuberosum 2x	*S. (Solanum) stoloniferum* (as *S. (Solanum) fendleri*)	620 seeds from 47 pollinations
S. (Solanum) tuberosum 4x	*S. (Solanum) stoloniferum* (as *S. (Solanum) fendleri*)	1 seed from 116 pollinations
S. (Solanum) hougasii	*S. (Solanum) tuberosum* 2x	1 seed from 121 pollinations
S. (Solanum) hougasii	*S. (Solanum) tuberosum* 4x	25 seeds from 50 pollinations
S. (Solanum) tuberosum 2x	*S. (Solanum) hougasii*	0 seeds from 65 pollinations
S. (Solanum) tuberosum 4x	*S. (Solanum) hougasii*	0 seeds from 49 pollinations

Many *S. (Solanum) tuberosum* cultivars exhibit reduced fertility, and this may limit their ability to hybridize. Male sterility, premature flower drop and the inability to set fruit are common (Gopal 1994; Sleper and Poehlman 2006). Male sterility may result from deformed flowers with anthers that do not dehisce or produce shrivelled microspores. Pollen may not form at all or the pollen may be of poor quality (Sleper and Poehlman 2006). In a study of 676 tetraploid

S. (Solanum) tuberosum accessions from 25 countries, including 20 from Canada, it was found that in 20.4 percent of the accessions, flower buds dropped prematurely and 23 percent of the accessions were found to be completely male sterile (Gopal 1994).

S. (Solanum) tuberosum is unable to successfully hybridize with the non-tuber bearing relatives outside of the section *Petota* (Conner 1994; Love 1994). Crosses between *S. (Solanum) tuberosum* and closely-related species in the section *Etuberosum*, *S. (Solanum) palustre* (as *S. (Solanum) brevidens*) and *S. (Solanum) etuberosum*, failed to produce any seed, although parthenocarpic berries were occasionally formed when *S. (Solanum) palustre* was the female parent (Hermsen and Taylor 1979). However, crosses between diploid *S. (Solanum) tuberosum* and all three species in the section *Etuberosum* resulted in the production of viable diploid hybrids when a combination of rescue pollinations and embryo rescue were employed (Watanabe et al. (et alii) 1995).

Outcrossing with two common weeds of potato fields, *S. (Solanum) dulcamara* and *S. (Solanum) nigrum*, has not been observed, either in the field or following hand crosses (Conner 1993; Dale et al. (et alii) 1992; Eijlander and Stiekema 1994). *S. (Solanum) tuberosum* pollen was able to germinate on *S. (Solanum) nigrum* styles and pollen tubes were observed to reach ovaries. However, mature berries were not formed due to poor fertilization, early embryo abortion and drop of the berry in the first week after pollination, likely related to the smaller size of the seeds and delayed development (Eijlander and Stiekema 1994). Hybrids could be obtained using embryo rescue, but were sterile and did not produce tubers. In addition, *S. (Solanum) nigrum* pollen outcompeted *S. (Solanum) tuberosum* pollen when a mixture was used to pollinate *S. (Solanum) nigrum* plants (Eijlander and Stiekema 1994). In crosses between *S. (Solanum) tuberosum* and *S. (Solanum) dulcamara*, *S. (Solanum) tuberosum* pollen rarely germinated on *S. (Solanum) dulcamara* pistils, and when it did germinate, the pollen tubes did not penetrate the stigmas well and did not grow into the style (Eijlander and Stiekema 1994).

Crossing barriers can be overcome by use of protoplast fusion, and successful hybrids have been formed with closely related species with incompabtible EBN (endosperm balance number) as well as with relatives outside of the section *Petota*, including species found in Canada (Austin et al. (et alii) 1985; Binding et al. (et alii) 1982). A summary of studies in which *S. (Solanum) tuberosum* hybrids have been created through protoplast fusion can be found in Table 2.

Table 2. Reports of somatic hybridization between *Solanum tuberosum* and related species

A. Intrasectional hybridization between species with incompatible EBN (endosperm balance number)

Hybridization	Description	References
S. (Solanum) tuberosum (4x) + *S. (Solanum) bulbocastanum* Dun. (1EBN (endosperm balance number))	Polyethylene glycol-mediated protoplast fusion; from 105 calli, 37 regenerated shoots but only 7 of these were phenotypically normal; hybrids were fertile	(Austin et al. (et alii) 1993)
	Polyethylene glycol-mediated protoplast fusion; 23 calli produced shoots; 17 hybrids were confirmed originating from 4 calli; hybrids were fertile	(Helgeson et al. (et alii) 1998)
S. (Solanum) tuberosum (2x) + *S. (Solanum) pinnatisectum* Dun. (1EBN (endosperm balance number))	Protoplast electrofusion; from 4 fusions with different *S. tuberosum* lines, 155 hybrids were recovered; hybrids formed tubers.	(Menke et al. (et alii) 1996)
S. (Solanum) tuberosum (2x) + *S. (Solanum) commersonii* Dun. (1EBN (endosperm balance number))	Protoplast electrofusion and polyethylene glycol-mediated fusion; from 2000 calli, 25 produced shoots from which 57 clones were established.	(Cardi et al. (et alii) 1993)
S. (Solanum) tuberosum (4x) + *S. (Solanum) acaule* (2EBN (endosperm balance number))	Protoplast electrofusion; using two different *S. (Solanum) tuberosum* lines, a total of 518 calli were formed, of which 17 produced shoots; hybrids produced tubers and seeds.	(Rokka et al. (et alii) 1998)

B. Intersectional hybridization

Hybridization	Description	References
S. (Solanum) tuberosum (2x) + *S. (Solanum) nigrum*	Polyethylene glycol-mediated protoplast fusion; 6 fusions resulting in 2,705 clones capable of producing shoots.	(Binding et al. (et alii) 1982)
	Polyethylene glycol-mediated protoplast fusion; 191 hybrids were isolated using 2x *S. (Solanum) tuberosum*, 0 hybrids using 4x *S. (Solanum) tuberosum*; 121 hybrids	(Horsman et al. (et alii) 1997)

	showed vigorous *in vitro* growth with 38 also vigorous when grown in greenhouse.	
S. (Solanum) tuberosum (2x) + *S. (Solanum) palustre* (as *S. (Solanum) brevidens*)	Polyethylene glycol-mediated protoplast fusion; from 70 calli, 53 were able to produce shoots; hybrids produced tubers and showed evidence of fertility.	(Austin et al. (et alii) 1985)
	Polyethylene glycol-mediated protoplast fusion; 32 putative hybrids were isolated; some tuber production was observed; some hybrids developed flowers and parthenocarpic fruit but no hybrids produced functional pollen.	(Barsby et al. (et alii) 1984)
S. (Solanum) tuberosum + *S. (Solanum) chenopodioides* Lam.	Polyethylene glycol-mediated protoplast fusion; 167 hybrids were isolated using both 2x and 4x *S. (Solanum) tuberosum*; 62 hybrids showed vigorous *in vitro* growth with 1 also vigorous when grown in greenhouse.	(Horsman et al. (et alii) 1997)
S. (Solanum) tuberosum + *S. (Solanum) americanum*	Polyethylene glycol-mediated protoplast fusion; 282 hybrids were isolated using both 2x and 4x *S. (Solanum) tuberosum* and diploid and hexaploid *S. (Solanum) americanum*; 160 hybrids showed vigorous *in vitro* growth with 21 also vigorous when grown in greenhouse.	(Horsman et al. (et alii) 1997)
S. (Solanum) tuberosum + *S. (Solanum) villosum* Mill.	Polyethylene glycol-mediated protoplast fusion; 121 hybrids were isolated using 2x *S. (Solanum) tuberosum*, 0 hybrids using 4x *S. (Solanum) tuberosum*; 30 hybrids showed vigorous *in vitro* growth but none were vigorous when grown in greenhouse.	(Horsman et al. (et alii) 1997)
S. (Solanum) tuberosum (2x) + *S. (Solanum) lycopersicum*	Polyethylene glycol-mediated protoplast fusion; 85 hybrids were isolated; 70 hybrids showed vigor equal to that of the parents *in vitro* with 31 also vigorous after transfer to soil; 28 hybrids produced tubers; most hybrids were sterile with 1 plant producing viable pollen and 1 plant able to set seed.	(Jacobsen et al. (et alii) 1992)

5.2 Potential for introgression of genetic information from *Solanum tuberosum* into relatives

Solanum tuberosum is not able to hybridize with any of the non-tuber bearing *Solanum* species outside of the section *Petota* (Conner 1994; Love 1994). As the *Solanum* species found in Canada do not belong to the section *Petota*, there is little potential for introgression of genetic material from *S. (Solanum) tuberosum* into related species in Canada.

5.3 Summary of the ecology of relatives of *Solanum tuberosum*

Solanum ptychanthum and *S. (Solanum) triflorum* are native to Canada and several other *Solanum* species are introduced (Brouillet et al. (et alii) 2013). Of these, *S. (Solanum) nigrum*, *S. (Solanum) ptychanthum*, *S. (Solanum) sarrachoides*, *S. (Solanum) dulcamara*, *S. (Solanum) carolinense*, and *S. (Solanum) rostratum* are considered to be weeds in Canada. *S. (Solanum) nigrum*, *S. (Solanum) ptychanthum*, *S. (Solanum) sarrachoides*, and *S. (Solanum) dulcamara* are nightshades that grow in disturbed areas as well as in cultivated fields, gardens, and along roadsides and railways (Alex and Switzer 1977; Bassett and Munro 1985). *S. (Solanum) ptychanthum* will grow in fields of soybeans, oats, barley, sweet corn, tomatoes, and sugar beets in southern Quebec and Ontario while *S. (Solanum) sarrachoides* is a weed in fields of tomatoes, corn, oats, millet, other grains, and alfalfa. The nightshades reduce the value of crops and also cause problems during harvest. *S. (Solanum) carolinense* is primarily limited to southern Ontario, where it can be found in corn, grain, and tomato fields as well as in waste areas and occasionally in gardens, while *S. (Solanum) rostratum*, found in disturbed sites, is more broadly scattered across Canada (Bassett and Munro 1986). Both *S. (Solanum) carolinense* and *S. (Solanum) rostratum* can act as alternative hosts for several crop pests and both are poisonous. Only *S. (Solanum) carolinense* is listed as a prohibited noxious weed in the *Weed Seeds Order* (Department of Justice 2005).

6. Potential Interaction of *Solanum tuberosum* with Other Life Forms

Solanum tuberosum is known to interact with a wide variety of fungi, bacteria, nematode, and insect species, many of which are important pests and disease-causing agents. Several publications provide extensive reviews of fungal and fungal-like (Forbes and Landeo 2006; Platt and Peters 2006; Termorshuizen 2007), bacterial (Lebecka et al. (et alii) 2006), virus and viroid (Jeffries et al. (et alii) 2006; Valkonen 2007), insect and nematode (Abdelhaq 2006; Mugniéry and Phillips 2007; Radcliffe and Lagnaoui 2007) pests of *S. (Solanum) tuberosum*. A list of species known to interact with *S. (Solanum) tuberosum* in Canada can be found in Table 3.

Late blight is prevalent worldwide and has been one of the most significant diseases for potato production (Forbes and Landeo 2006). High pest pressure occurs regularly in British Columbia, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, and Prince Edward Island (Agriculture and Agri-Food Canada 2005). Other major fungal pathogens in Canada include early blight, pink rot (*Phytophthora erythroseptica* Pethybr.), *Fusarium* dry rot (*Fusarium* spp. (species)), *Pythium* leak (*Pythium* spp. (species)), black scurf (*Rhizoctonia solani* Kühn), and silver scurf (*Helminthosporium solani* Dur. & Mont.) (Agriculture and Agri-Food Canada 2005).

The actinomycete known as common scab (*Streptomyces scabies (Thaxter) (Waksman and Henrici))* is of prime importance for non-irrigated potato production in eastern Canada (Agriculture and Agri-Food Canada 2005). The causative agent of aerial stem rot and bacterial soft rot, *Pectobacterium cartovorum* subsp. (subspecies) *cartovorum (Jones 1901) Hauben et al. (et alii) 1999 emend. Gardan et al. (et alii) 2003,* often in association with several of the fungal diseases listed above, is important in Canada for its role in tuber decay. Significant progress has been made towards the eradication of bacterial ring rot in Canada over the past few decades.

Potato virus Y (PVY) and several other viruses contribute to mosaic disease in *S. (Solanum) tuberosum* in Canada, which can reduce yield and contaminate seed potatoes. Potato leafroll virus (PLRV) is another important virus that infects *S. (Solanum) tuberosum* in Canada and can reduce the quality of tubers (Agriculture and Agri-Food Canada 2005).

Major insect pests in Canada include aphids, tarnished plant bug (*Lygus lineolaris* (Palisot de Beauvois)), potato leaf hopper (*Empoasca fabae* (Harris)), potato flea beetle (*Epitrix cucumeris* Harris), European corn borer (*Ostrinia nubilalis* (Hübner)), Colorado potato beetle, wireworms, and flea beetle (*Epitrix tuberis* Gentner) (Agriculture and Agri-Food Canada 2005). In addition to causing crop damage, aphids and other insects can act as vectors for pathogens that infect *S. (Solanum) tuberosum* (Atlantic Potato Committee 2007; Radcliffe and Lagnaoui 2007). A number of viruses are spread through aphids, including PVY (Potato virus Y) and PLRV (Potato leafroll virus). The aster leafhopper (*Macrosteles quadrilineatus Forbes (fascifrons)*) transmits aster yellows, which causes potato purple-top wilt (Bohl and Johnson 2010). Insects can also vector bacterial diseases, although bacteria can only survive on insects for a few days (van der Wolf and De Boer 2007).

Nematodes feed on *S. (Solanum) tuberosum* roots and most do so without causing serious damage. However, some species are pests that can cause damage, either as a result of saliva that is toxic to *S. (Solanum) tuberosum*, root penetration and cell destruction during feeding, or by mediating damage done by other pests such as viruses or fungi (Mugniéry and Phillips 2007). Infection by the potato cyst nematodes *Globodera rostochiensis* (Wollenweber) Behrens and *G. (Globodera) pallida* (Stone) Behrenscan result in retarded growth, leading ultimately to tuber yield losses (Mugniéry and Phillips 2007). These nematodes penetrate the roots and migrate to the vascular vessels where they induce feeding sites referred to as synctia or giant cells. In addition, these two nematodes are often associated with the fungi *Verticillium spp. (species)* and black scurf, and this association can hasten the onset of disease symptoms (Mugniéry and Phillips 2007). Both species are considered quarantine pests in many countries and seed potato production is typically forbidden on any land found to be infested. In Canada, the major free-living nematode pests include the root lesion nematode (*Pratylenchus penetrans* (Cobb) and the northern root-knot nematode (*Meloidogyne hapla* Chitwood) (Agriculture and Agri-Food Canada 2005).

Table 3. Examples of potential interactions of *Solanum tuberosum* with other life forms present in Canada during its life cycle in a natural environment.

Fungi and Fungi-like

Other Life Form	Interaction with *Solanum tuberosum* (pathogen; symbiont or beneficial organism; consumer; gene transfer)	Presence in Canada	Reference(s)
Alternaria alternata (Fr. : Fr.) Keissl. (brown leaf spot)	Pathogen	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004; Platt and Peters 2006)
Alternaria solani Sorauer (early blight)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Botrytis cinerea Pers. : Fr. (gray mold; teleomorph *Botryotinia fuckeliana* (de Bary) Whetzel)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)

Colletotrichum coccodes (Wallr.) S. (Solanum) Hughes (black dot)	Pathogen	Present	(Agriculture and Agri-Food Canada 2005; Platt and Peters 2006; Termorshuizen 2007)
Fusarium spp. (species) (dry rot, wilt)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Helminthosporium solani Dur. & Mont. (silver scurf)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Mycorrhizal fungi	Symbiont or beneficial organism	Present	(Dalpé 2003; Wang and Qiu 2006)
Phoma exigua Desm. var. (variety) *exigua* (thumbmark rot; pocket rot)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Phytophthora erythroseptica Pethybr. (pink rot)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)

Phytophthora infestans (Mont.) de Bary (late blight)	Pathogen	Present	(Atlantic Potato Committee 2007; Forbes and Landeo 2006; Termorshuizen 2007)
Polyscytalum pustulans (Owen & Wakef.) M.B. Ellis (tuber skin spot; skin spot)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Pythium spp. (species) (leak; watery wound rot)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Rhizoctonia solani Kühn (black scurf)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Sclerotinia sclerotiorum (Lib.) de Bary (white mold; Sclerotinia rot; Sclerotinia stalk rot)	Pathogen	Present	(Agriculture and Agri-Food Canada 2005; Platt and Peters 2006; Termorshuizen 2007)
Spongospora subterranea (Wallr.) Lager. f. sp. *subterranean* (powdery scab)	Pathogen	Present	(Platt and Peters 2006; Termorshuizen 2007; Western Potato Council

scab)			Potato Council 2003)
Synchytrium endobioticum (Schilb.) Perc. (wart disease; wart)	Pathogen	Present	(Agriculture and Agri-Food Canada 2005; Platt and Peters 2006; Termorshuizen 2007)
Verticillium albo-atrum Reinke & Berth. (potato early dying; Verticillium wilt)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)
Verticillium dahliae Kleb. (potato early dying; Verticillium wilt)	Pathogen	Present	(Atlantic Potato Committee 2007; Platt and Peters 2006; Termorshuizen 2007)

Bacteria

Other Life Form	**Interaction with *Solanum tuberosum* (pathogen; symbiont or beneficial organism; consumer; gene transfer)**	**Presence in Canada**	**Reference(s)**
Clavibacter michiganensis subsp. (subspecies) *sepedonicus* (Spiekermann and Kotthoff) Davis et al. (et alii) (bacterial	Pathogen	Present	(Atlantic Potato Committee

ring rot)			2007; Lebecka et al. (et alii) 2006; Platt and Peters 2006; van der Wolf and De Boer 2007)
Clostridium spp. (species) (Clostridium soft rot)	Pathogen	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Pectobacterium atrosepticum (van Hall 1902) Gardan et al. (et alii) 2003 [formerly known as *Erwinia carotovora* subsp. (subspecies) *atroseptica* (van Hall)] Dye (blackleg)	Pathogen	Present	(Atlantic Potato Committee 2007; Lebecka et al. (et alii) 2006; van der Wolf and De Boer 2007)
Pectobacterium carotovorum subsp. (subspecies) carotovorum (Jones 1901) Hauben et al. (et alii) 1999 emend. Gardan et al. (et alii) 2003 [formerly known as *Erwinia carotovora* subsp. (subspecies) *carotovora* (Jones) Bergey et al. (et alii)] (aerial stem rot; bacterial soft rot of tubers)	Pathogen	Present	(Atlantic Potato Committee 2007; Lebecka et al. (et alii) 2006; van der Wolf and De Boer 2007)
Pseudomonas fluorescens (Folsom and Friedman 1959) (pink eye)	Pathogen	Present	(Atlantic Potato

			Committee 2007; Lebecka et al. (et alii) 2006)
Soil microbes	Symbiont or beneficial organism	Present	
Streptomyces acidiscabies (Lambert and Loria 1989) (common scab)	Pathogen	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Streptomyces scabies (Thaxter) (Waksman and Henrici) (common scab)	Pathogen	Present	(Lebecka et al. (et alii) 2006; van der Wolf and De Boer 2007; Western Potato Council 2003)

Phytoplasma

Other Life Form	Interaction with *Solanum tuberosum* (pathogen; symbiont or beneficial organism; consumer; gene transfer)	Presence in Canada	Reference(s)
Candidatus Phytoplasma asteris (aster yellows)	Pathogen	Present	(Atlantic Potato Committee 2007; Radcliffe and Lagnaoui 2007)

Candidatus Phytoplasma trifolii (witches' broom)	Pathogen	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)

Viruses and Viroids

Other Life Form	Interaction with *Solanum tuberosum* (pathogen; symbiont or beneficial organism; consumer; gene transfer)	Presence in Canada	Reference(s)
Alfalfa mosaic virus (AMV)	Pathogen	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Potato leafroll virus (PLRV)	Pathogen	Present	(Atlantic Potato Committee 2007; Jeffries et al. (et alii) 2006; Valkonen 2007)
Potato mop-top virus (PMTV)	Pathogen	Present	(Jeffries et al. (et alii) 2006; Valkonen 2007; Western Potato Council 2003)
Potato spindle tuber viroid (PSTVd)	Pathogen	Present	(Atlantic Potato Committee 2007; Jeffries et al. (et alii) 2006; Valkonen 2007)
Potato virus A (PVA)	Pathogen	Present	(Atlantic Potato Committee 2007; Jeffries et al. (et alii) 2006; Valkonen 2007)
Potato virus M	Pathogen	Present	(Jeffries et al. (et alii) 2006; Radcliffe and

(PVM)			Lagnaoui 2007; Xu et al. (et alii) 2010)
Potato virus S (PVS)	Pathogen	Present	(Atlantic Potato Committee 2007; Jeffries et al. (et alii) 2006; Valkonen 2007)
Potato virus X (PVX)	Pathogen	Present	(Atlantic Potato Committee 2007; Jeffries et al. (et alii) 2006; Valkonen 2007)
Potato virus Y (PVY)	Pathogen	Present	(Atlantic Potato Committee 2007; Jeffries et al. (et alii) 2006; Valkonen 2007)

Insects

Other Life Form	Interaction with *Solanum tuberosum* (pathogen; symbiont or beneficial organism; consumer; gene transfer)	Presence in Canada	Reference(s)
Aeolus mellilus (Say) (wireworm)	Consumer	Present	(Benefer et al. (et alii) 2013; Radcliffe and Lagnaoui 2007)
Agriotes spp. (species) (wireworms)	Consumer	Present	(Benefer et al. (et alii) 2013; Radcliffe and Lagnaoui 2007)
Aphis nasturtii (Kaltenbach) (buckthorn aphid)	Consumer	Present	(Abdelhaq 2006; Atlantic Potato Committee 2007; Radcliffe and

			Lagnaoui 2007)
Aulacorthum solani (Kaltenback) (foxglove aphid)	Consumer	Present	(Abdelhaq 2006; Agriculture and Agri-Food Canada 2005; Radcliffe and Lagnaoui 2007)
Delia platura (Meigen) (seedcorn maggot)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Empoasca fabae (Harris) (potato leafhopper)	Consumer	Present	(Abdelhaq 2006; Radcliffe and Lagnaoui 2007; Western Potato Council 2003)
Epicauta spp. (species) (blister beetle)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Epitrix cucumeris Harris (potato flea beetle)	Consumer	Present	(Atlantic Potato Committee 2007; Radcliffe and Lagnaoui 2007)
Epitrix tuberis Gentner (tuber flea beetle)	Consumer	Present	(Radcliffe and Lagnaoui 2007; Western Potato Council 2003)
Hemicrepidius spp. (species) (wireworms)	Consumer	Present	(Benefer et al. (et alii) 2013; Radcliffe and Lagnaoui 2007)
Hydraecia micacea Esper (potato stem borer)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Hypnoidus bicolor Eschscholtz (wireworm)	Consumer	Present	(Benefer et al. (et alii) 2013; Radcliffe and

Eschscholtz (wireworm)			2013; Radcliffe and Lagnaoui 2007)
Leptinotarsa decemlineata (Say) (Colorado potato beetle)	Consumer	Present	(Abdelhaq 2006; Atlantic Potato Committee 2007; Radcliffe and Lagnaoui 2007)
Limonius spp. (species) (wireworms)	Consumer	Present	(Benefer et al. (et alii) 2013; Radcliffe and Lagnaoui 2007)
Lygus lineolaris (Palisot de Beauvois) (tarnished plant bug)	Consumer	Present	(Atlantic Potato Committee 2007)
Macrosiphum euphorbiae (Thomas) (potato aphid)	Consumer	Present	(Abdelhaq 2006; Atlantic Potato Committee 2007; Radcliffe and Lagnaoui 2007)
Macrosteles quadrilineatus Forbes (*fascifrons*) (aster leafhopper; six-spotted leafhopper)	Consumer	Present	(Radcliffe and Lagnaoui 2007; Western Potato Council 2003)
Melanotus similis (Kirby) (wireworm)	Consumer	Present	(Benefer et al. (et alii) 2013; Radcliffe and Lagnaoui 2007)
Meligethes aeneus Fabricius (pollen beetle)	Symbiont or beneficial organism	Absent	(Petti et al. (et alii) 2007; Skogsmyr 1994)
Myzus persicae (Sulzer) (green peach aphid; complex also containing *M. (Myzus) nicotianae* (Blackman) and *M. (Myzus) antirrhinii* (Macchiati))	Consumer	Present	(Abdelhaq 2006; Radcliffe and Lagnaoui 2007; Western Potato Council 2003)

Ostrinia nubilalis (Hübner) (European corn borer)	Consumer	Present	(Atlantic Potato Committee 2007)
Paratrioza cockerelli (Sulc) (potato psyllid)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Peridroma saucia (Hübner) (variegated cutworm)	Consumer	Present	(Abdelhaq 2006; Radcliffe and Lagnaoui 2007; Western Potato Council 2003)
Phyllophaga spp. (species) (white grubs, larvae of scarab beetles)	Consumer	Present	(Atlantic Potato Committee 2007; Radcliffe and Lagnaoui 2007)
Plagiometriona clavata (Fabricius) (tortoise beetle)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Pollinators (esp. (especially) *Bombus* spp. (species))	Symbiont or beneficial organism	Present	(Petti et al. (et alii) 2007; Sanford and Hanneman 1981; Scurrah et al. (et alii) 2008; Skogsmyr 1994)
Rhizotrogus majalis (Razoumowsky) (European chafer grub)	Consumer	Present	(B.C. (British Columbia) Ministry of Agriculture 2010; OMAFRA (Ontario Ministry of Agriculture and Food and the Ministry of Rural Affairs) 2013)
Selatosomus spp. (species) (wireworms)	Consumer	Present	(Benefer et al. (et alii) 2013; Radcliffe and

			Lagnaoui 2007)
Spodoptera spp. (species) (armyworms)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Systena frontalis (Fabricius) (red-headed flea beetle)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)
Trichoplusia ni (Hübner) (cabbage looper)	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)

Nematode

Other Life Form	Interaction with *Solanum tuberosum* (pathogen; symbiont or beneficial organism; consumer; gene transfer)	Presence in Canada	Reference(s)
Globodera pallida (Stone) Behrens(pale cyst nematode)	Consumer	Present	(Abdelhaq 2006; Atlantic Potato Committee 2007; Mugniéry and Phillips 2007)
Globodera rostochiensis (Wollenweber) Behrens(golden cyst nematode)	Consumer	Present	(Abdelhaq 2006; Atlantic Potato Committee 2007; Mugniéry and Phillips 2007)
Heterodera trifolii Goffart (clover cyst nematode)	Consumer	Present	(Agriculture and Agri-Food Canada 2005)
Meloidogyne spp. (species) (root-knot	Consumer	Present	(Atlantic Potato Committee 2007;

nematodes)			Mugniéry and Phillips 2007)
Pratylenchus spp. (species) (root lesion nematodes)	Consumer	Present	(Abdelhaq 2006; Atlantic Potato Committee 2007; Mugniéry and Phillips 2007)

Animals

Other Life Form	Interaction with *Solanum tuberosum* (pathogen; symbiont or beneficial organism; consumer; gene transfer)	Presence in Canada	Reference(s)
Birds	Consumer	Present	(Hirst and Easthope 1981; Martin and Guignion 1983)
Animal browsers	Consumer	Present	(OMAF (Ontario Ministry of Agriculture and Food) 2004)

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Date modified:
2015-05-24