# Growing with Bioplastics


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Canadian agriculture relies on plastic use throughout all stages of operation; from greenhouse covers, crop mulches and seedling trays used in growing; to labels, plastic wrap and containers used to package products for the consumer. In 2012, BC agriculture produced 3620 tonnes of plastic waste, with 51% of this being plastic film.[1] Recycling of this agricultural plastic is challenging, as it is often contaminated with soil and other organic matter. Local farmers, growers and producers must package their products in order to ship them to markets across Canada and the world are searching for ways to reduce plastic waste while ensuring that products find appropriate end-of-life facilities.

## Certified compostable packaging in agriculture

Food packaging presents a particular challenge as a variety of barrier, strength and durability properties are required for the vast range of agricultural products. Visibility and transparency are also essential in order to gain consumer attention.

The range of packaging options currently available are limited due to the material property constraints of most compostable plastics. Current plastics are more suited to the formation of rigid products, such as clam shells and berry containers. Paper packaging with transparent plastic windows made from cellulose can also be used. This compostable cellulose plastic is very brittle and is not sufficiently elastic to be used as a substitute for plastic wrap (Figure 1).[2] Mycelium-based materials are also starting to be utilized as compostable alternatives to foam packaging.[3]

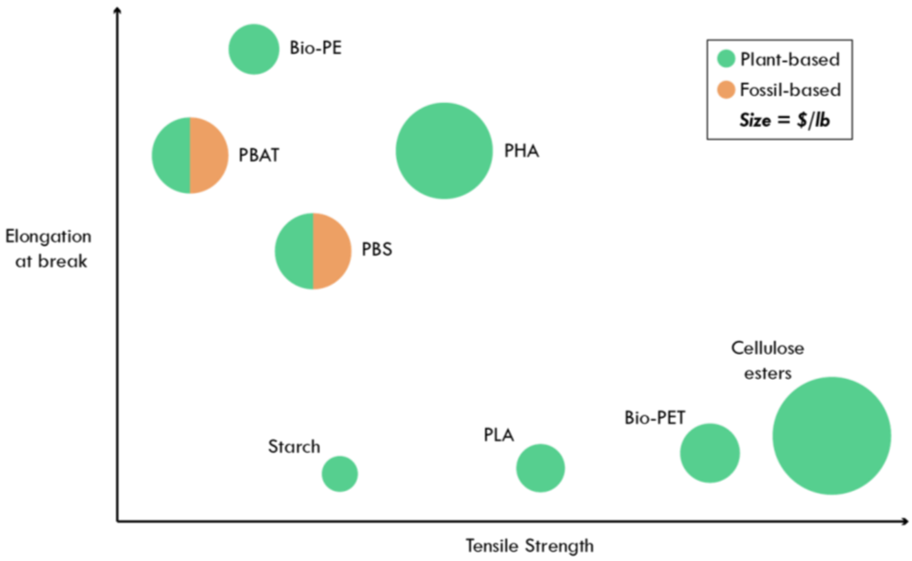


**Figure 1. Comparison of material properties and cost for common bio-based plastics. Adapted from reference 2.**

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[1] British Columbia Agricultural Packaging Waste Stewardship Study, June 2012 https://cleanfarms.ca/wp-content/uploads/2019/01/BC-Ag-Waste-Study-Dec-2012.pdf

[2] R. Shogren, D. Wood, W. Orts, G. Glenn "Plant-based materials and transitioning to a circular economy" Sustainable Production and Consumption 19 (2019) 194–215

[3] Ecovative https://ecovativedesign.com/mycocomposite

Many certified compostable products are targeted at single-use items in the food service industry rather than single-use plastics used in agricultural production. Because of the current niche market, certified compostable plastics have higher associated costs that must be reflected in consumer pricing. This higher price can make it more difficult for local agricultural production utilizing compostable packaging to compete with other options available on the market. These challenges are further exacerbated by the need for producers to sell to a variety of different markets and the requirement for local large-scale compost facilities to collect and degrade these materials. Rural farming communities also lack access to centralized compost operations, resulting in growers and producers attempting to break down the compostable plastics within their farm or home compost, where these materials are not certified to decompose.

**Soil degradable plastic use in agriculture**

Plastic mulches and coverings as well as bale twine, netting, and pots are currently used in Canadian agricultural practices to improve farm production. The plastic waste generated from these products can be challenging to successfully collect and recycle because of their contamination with organic residue (Figure 2). An agricultural waste characterization study performed in Alberta in 2013 showed that agricultural mulches are usually 2-4x more soil than plastic by weight and instead of recycling (23%), 27% of this waste plastic is burned and another 50% is landfilled (Figure 3).[4] For these applications, having a soil-biodegradable product would be useful where the product could be used for its intended application but then left in the fields to break down over time and add value back to the soil.


**Figure 2. Resin type and quality of commonly used agricultural plastics. Adapted from reference 5.**

[4] Alberta Agricultural Waste Characterization Study Final Report, August 2013 https://albertaplasticsrecycling.com/resources-education/agricultural-plastics/

[5] Plastics Recycling Conference 2014, Levitan, Cornell University

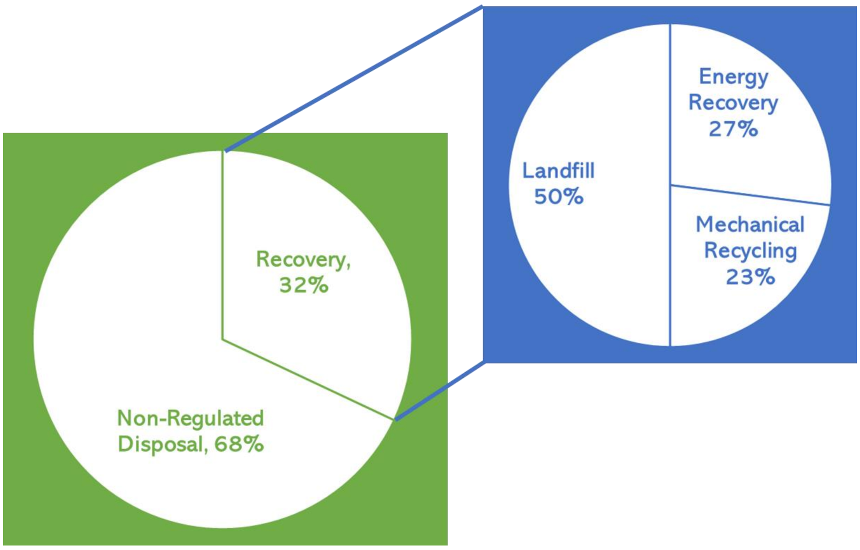


**Figure 3. End-of-life disposal of used agricultural plastics in Alberta. Adapted from reference 4.**

The impacts of conventional plastics on soil health are only beginning to be investigated, with the bulk of reports being published in the last five years. Some studies have stated that there may be 4-23 times more plastic in our soils than in the ocean.[6] [7] This wide range in possible contamination highlights the need for further investigation in this area.

Studies that explored soil contamination by plastics have shown that there is a potential impact on microbial activity and possibility for the spread of antibiotic genes through the adsorption of antibiotics onto microplastics that can persist in the soil for long periods of time.[8] Other potentially toxic chemical additives can also be transferred through soil ecosystems by way of microplastic transportation. Other studies have shown that different plant species are able to accumulate contaminated microplastics within their roots, stems, leaves, flowers and/or fruit, which could then be eaten by animals and humans to cause undetermined problems (Figure 4).[9]

[6] Liu *et al*., "Microplastics as contaminants in the soil environment: A mini-review." https://doi.org/10.1016/j.scitotenv.2019.07.209

[7] Zhu *et.al*., "Occurrence and Ecological Impacts of Microplastics in Soil Systems: A Review." https://doi.org/10.1007/s00128-019-02623-z

[8] Rillig *et. al.,* "Impacts of Microplastics on the Soil Biophysical Environment." https:// doi.org/10.1021/acs.est.8b02212

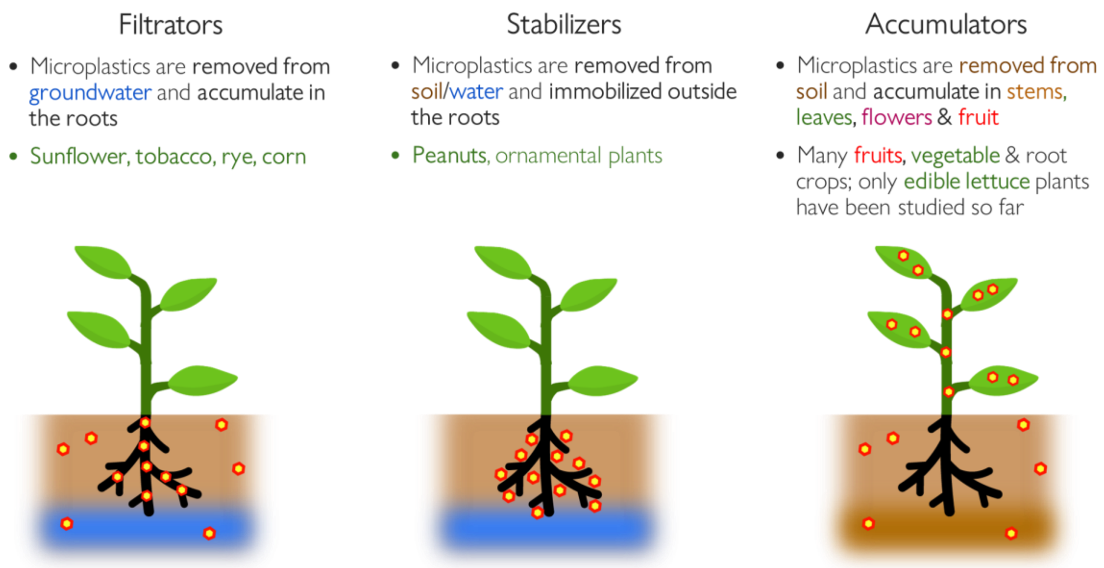


**Figure 4. Three mechanisms of microplastic uptake exhibited by plants.**[9]

Plastic mulch provides many benefits such as weed control, soil temperature moderation, and water conservation.[10] Biodegradable mulches are designed to be tilled into the soil after the growing season has been completed. International testing standards are available for biodegradable mulches only. In 2018, the EN 17033 standard was released, which regulates the requirements for biodegradable plastic mulch films.[11] In particular, this standard requires testing for: a) chemical composition (for regulated metals and hazardous substances),[12] b) biodegradation in soil, c) ecotoxicity (i.e., toxic effects on plants, invertebrates, microorganisms), and d) selected physical characteristics (e.g., thickness, tensile stress, light transmission). It does not apply to mulch films that are being removed from the fields after use. A major criterion of EN 17033 is the requirement of ≥90% biodegradation under aerobic conditions for the plastic (i.e., conversion of organic carbon into $CO_2$) in a natural topsoil from an agricultural field or forest at 20 to 28 °C within 2 years using a standardized test to measure $CO_2$ respiration. "TÜV Austria (formerly Vinçotte), developed an "OK biodegradable SOIL" label for plastics, to certify full biodegradability and the absence of ecotoxicity in soil. However, there are currently no organizations local to North America with a similar certification label.

The availability of stringent standardized tests for soil degradable plastics is an important step towards the adoption of biodegradable plastics in agriculture. However, there are significant limitations to these tests and there are still important questions that remain to be answered. Standardized tests are designed to be performed under ideal conditions. Test plastics are often ground to very fine particle sizes, with high temperatures and very specific soil types used in the degradation studies. Real-world soil environments are highly diverse between regions and across seasons.[13] Soil degradation standardized tests give an indication of the inherent ability for a material to biodegrade, however these must be coupled with field tests to ensure that changes in soil microbial populations and nutrients don't impact

[9] Ebere *et. al.*, "Uptake of Microplastics by Plant: A Reason to Worry or to be Happy?" https://www.researchgate.net/publication/334083970

[10] Hayes *et. al.* 2018, "Summary and Assessment of EN 17033:2018, a New Standard for Biodegradable Plastic Mulch Films." https://ag.tennessee.edu/biodegradablemulch/Documents/EU%20regs%20factsheet.pdf

[11] EN 17033: 2018, Plastics-Biodegradable mulch films for use in agriculture and horticulture. Requirements and test methods. European Standard, European Committee for Standardization, Brussels, Belgium, 2018. https://www.en-standard.eu/din-en-17033-plastics-biodegradable-mulch-films-for-use-in-agriculture-and-horticulture-requirements-and-test-methods/

[12] European Chemical Agency (ECHA) Candidate list of substances of very high concern, https://echa.europa.eu/candidate-list-table.

[13] Goldberger *et. al.* 2017, "Policy considerations for limiting unintended residual plastic in agricultural soils." http://dx.doi.org/10.1016/j.envsci.2016.12.014

the degradation process. Even if these plastics are certified to biodegrade within two years, there will still be a period of time where microplastics will accumulate in the environment. One study has observed that active biodegradation temporarily changes soil characteristics.[14] To produce microbial biomass, microorganisms need nitrogen. During active biodegradation, microbial growth reduces nitrogen content in the soil, which in turn can be detrimental to plant germination. Sustained changes in nitrogen content as biodegradable mulches are used and tilled into the soil may have unforeseen long-term consequences.

Use of compostable plastics and packaging has the potential to reduce the amount of organics-contaminated waste going to landfills from the agricultural industry. The compostable plastic industry is currently slow to develop materials for targeted use in agricultural settings. New products and processes are required before the full potential of these materials could be met. To further ensure that the application of these materials has the most positive impact on agricultural production, in-depth exploration into their short- and long-term impacts on soil ecosystems are crucial.

[14] Wilde *et. al.* "Environmental safety of biodegradation residuals of polymers". November 2016 www.open-bio.eu