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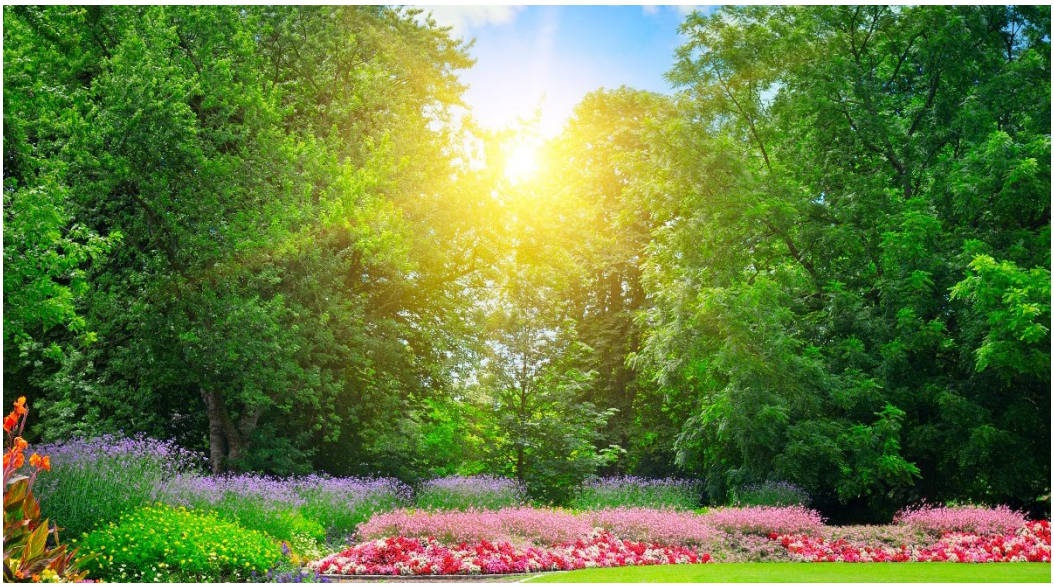
RESEARCH & INNOVATION CENTRE

# Ontario Horticulture Research Priority Report 2023



ONTARIO FRUIT & VEGETABLE GROWERS' ASSOCIATION

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# Introduction

Innovation and research can be a driving force that enhances growth, profitability and sustainability in any sector, including horticulture. To achieve the greatest impact from investments in research and innovation, there is a need for a coordinated, strategic approach that achieves a balance of both short- and long-term goals.

Horticulture is a unique and challenging sector due to its sheer diversity, with around 150 different fruit and vegetable crops, thousands of ornamental species plus mushrooms, maple syrup and honeybees. Defining research priorities for this large, diverse sector is a challenging task that requires coordinating input from many different groups.

As part of our commitment under the Canadian Agricultural Partnership, Vineland Research and Innovation Centre (Vineland) facilitates the compilation of the Ontario horticulture sector's research priorities. These are then used as input for OMAFRA's priority setting system, they are used to shape Vineland's own research strategy and they are provided to Agriculture and Agri-Food Canada (AAFC) and other research providers to assist them in meeting the needs of the Ontario industry.

Vineland's role in this process is primarily as a facilitator. The actual delivery of research projects will continue to include the University of Guelph, AAFC, Vineland and any other research providers.

## Approach

Priority setting is an evolving process for which Vineland has worked alongside the major sector organizations for more than ten years to develop a process ensuring the research needs and opportunities of the sector are identified.

One of the fundamental principles that has shaped this process is the need for narrowing the focus of the priority list. A shorter, more specifically-worded priority list is more realistically aligned to the level of available resources and provides clearer direction to funders and research providers.

The consultation process is focused on grower representation where sector groups are invited to nominate their own representatives to participate. In a few cases where sector groups are absent or otherwise lack the capacity to determine research priorities, OMAFRA crop specialists are nominated to represent the category. Wherever possible, a full value chain perspective is taken although it can be challenging to bring together disconnected or even competing groups within the sector.

Due to the diversity of crops, production systems and consumer markets, separate processes are used for the edible and ornamental horticulture sectors.

Participants in the process are encouraged to take a big picture view of the long-term growth and sustainability of their sector so that priorities become a balance of short- and long- term goals. In this context, "short-term" refers to a goal that can be achieved in one to three years for a single research project and "long-term" goals can take many years to achieve for multiple projects, grants and researchers involved. Specific topics for the

evaluation and registration of pesticide products are not considered in this process as they are covered by the Minor Use Pesticide Program.

As research priorities generally remain fairly consistent from one year to the next, formal priority setting meetings are held only every three to four years. In interim years, sector groups are given the opportunity to edit their priority list to reflect any new issues that may have arisen. This report is prepared and distributed each year to include the latest updates. The development of a research strategy or priority list is the first step to help provide focus and direction. Then, the implementation of these priorities requires leadership from both industry groups and researchers. Both need to collaborate to develop specific project ideas, matching funds and proposals to apply to research funding programs.

# Edible Horticulture

## Sector Consultation

A sector-wide research consultation was co-hosted by Vineland and the Ontario Fruit and Vegetable Growers Association in January 2017. This meeting allowed grower groups to discuss areas of common interest and share their approaches to decision-making and research-funding. The priorities identified by the individual associations and representatives for each crop category are included in this report and are updated annually.

Pest management (including pests, diseases and weeds) is a high priority need for virtually all horticultural crops and tends to be front of mind for many growers dealing with these issues on a daily basis. In order to maintain a balanced perspective and encourage big picture long-term thinking of a range of research topics, pest management is usually a stand-alone priority area with additional priorities categorized under 'other'. Grower representatives are invited to provide further details to identify specific pest problems and desired solutions for their crops. All priorities in this report are recorded as submitted by the designated representative with only minor adjustments made to ensure they align to the five-priority format. Numbering has been used where clear prioritization has been indicated, otherwise, bullet points are used to indicate non-ranked priorities.

## Edible Horticulture Research Priorities by Crop Group

### Pest Management Priority

All crop integrated pest management strategies for horticultural production systems that incorporate pesticides, alternative control measures, host resistance and/or take a systems approach to controlling pests, disease and weeds.

### Apples

**Pest Management**

Development and adoption of sustainable Integrated Pest Management (IPM) practices and resistance management for conventional and organic orchards. Research could include:

- Strategies for management of fire blight.
- Develop an integrated approach for difficult diseases and disorders. For example, but not limited to, the canker complex and replant disease complex.
- Evaluate the efficacy of sprayer application methods. For example, but not limited to, border sprays, alternate row spraying and the use of new equipment designs.
- Due to the loss of broad-spectrum crop protection products, evaluate management strategies and pesticide efficacy.
- Investigate new applications or IPM technology.
- Strategies for monitoring, intervention and management of invasive species and emerging issues. For example, but not limited to, BMSB, Spotted Lanternfly and Sudden Apple Decline (SAD).

**Other**

1. Technology, mechanization, automation and efficiencies: Increased production and post-harvest efficiencies using the latest technologies and precision agriculture that take into consideration the economic viability for apple growers. Research could include:
   - Labour efficiencies
   - Pest management and crop protection efficiencies
   - Weather risk mitigation
   - Water use efficiencies
   - Modelling (e.g. crop production and quality, pest degree day models, data analytics and pathology)
   - Remote sensing, software development and robotics
   - Technology in storage and packing efficiencies
   - Orchard design

2. Sustainable practices: Optimizing sustainable cropping practices for conventional or organic production according to variety and climatic conditions. Research could include:
   - Crop load management
   - Life cycle assessment (carbon sequestration/climate change mitigation)
   - Irrigation
   - Fertigation
   - Soil management
   - Nutrition

3. Maximizing quality and minimizing losses: Crop maturity management and postharvest storage conditions and treatment strategies with the goal of delivering a larger percentage of high quality fruit for the fresh market. Research could include:
   - Postharvest research developing storage regimes for in-demand varieties
   - Optimal harvest management and timing
   - Strategies to reduce storage disorders

4. Variety and rootstock development and evaluation: Variety and rootstocks development and selection according to consumer preferences and their performance in the different regions with the goal of achieving greater market share. Research could include:
   - New variety breeding and evaluation
   - Scion and rootstock evaluation (e.g. winter hardiness, drought efficiency)
   - Genomics
   - Consumer preference studies

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## Berries

### Pest Management

Berry growers are faced with several challenging insect and disease pests that have a serious impact on the economic viability of growing berries.

- Spotted Wing Drosophila (SWD) – New products have been registered but there continues to be a need for products with short harvest intervals. Research is needed on cultural management and education, as well as the feasibility for biological controls including predators and parasites of SWD.
- Anthracnose – Fungicide resistance to pyraclostrobin (FRAC group 11) fungicides has been documented in Ontario and there is a need for additional products to manage this disease. Disease-resistant cultivars and/or management techniques used for propagation could also play a role in managing this disease.
- Neopestalotiopsis –There are no products labelled in Canada for this disease and not much is known about management with fungicides. Research may include surveying and sequencing the disease.
- Cyclamen Mite – New products and alternative management strategies are needed to combat this challenging pest. Cyclamen mite control is critical for plant growers to supply the industry with clean plants.
- Bacterial diseases – Angular leaf spot is a bacterial disease that affects the leaves and calyx in strawberries. More research is needed on control options for this disease.
- Virus Complex – Recognizing and the management of virus are critical to surviving the impact from virus infections.
- Western Flower Thrips – The use of biological control needs to be evaluated and management protocols need to be put in place.
- Soil-borne diseases – Research is required to find tools to manage soil-borne diseases and increase general soil health.
- Pest management products:
    - There continues to be a loss of older broad-spectrum pest control products. For long-term viability of the berry industry, it is critical that these products have their registrations maintained or be replaced with effective materials. Resistance management is a real concern where in some cases, growers are limited to one or two products to control pests which lead to no opportunity of rotation to preserve the efficacy of these products. Resistance management via cultural control methods and grower education should be a priority. To be useful, these products must have workable pre-harvest intervals as well as re-entry intervals.
    - There is a need to continue to register new products and to harmonize these registrations with the U.S. to ensure we do not continue to be at a competitive disadvantage. There is an opportunity to limit worker exposure, reduce crop residues and increase efficacy using pest management treatments through drip irrigation. Registrants should be encouraged to continue to investigate these options.
    - Exploring options such as ozone, peracetic acid and UVC technology would also limit residues. The berry industry would benefit from the use of

macrobiological options and incorporating bee vectoring as a management tool.

**Other**

1. Production systems/robotics/labour
   The number one expense to berry growers is labour with the majority of costs being for harvest labour. Robotics, harvest aids and other labour-saving technologies need to be investigated and optimized for Ontario berry growers. Cultivation robots could be used to help growers with tillage, spraying, night-time application and more.

   There is an increased interest in new or alternative production systems including the use of artificial media, protected culture and season extension techniques. Interest has stemmed from soil health issues as well as the need to optimize labour and to take advantage of extended production seasons to market locally produced berries. It is critical to seek and test new production systems. OMAFRA staff should be encouraged to travel to find new technologies and have the opportunity to test and implement with growers in Ontario.

2. Breeding and evaluating new cultivars
   For the future of the berry industry there is a need for the development of varieties suited to Ontario conditions. Specifically, priority should be in developing new greenhouse strawberry varieties, early strawberry varieties that have excellent heat tolerance and disease resistance and machine harvest-ready cultivars. This can be accomplished by plant breeding in Ontario as well as evaluation of new cultivars developed in jurisdictions outside of the province. Research evaluations should include comprehensive testing on the four types of growing systems, field, plastic, tabletop and greenhouse. Continue to breed and evaluate new strawberry cultivars that the industry has invested research dollars and time.

   Growers need to have the knowledge of berry performance before investing in varieties that may not be suited to our conditions. Improved cultivars and a better understanding of management could lead to the expansion of the industry and increased profitability for growers as well as increased tax dollars with an expanded industry.

3. Product and quality marketing
   It is critical to continue to develop and expand the trend of buying local. The "Buy Local" movement is critical for the success of both on-farm marketers as well as wholesale producers. Price support for local will be critical in managing increased picking costs as a result of an increased minimum wage. Product quality at the wholesale level may be the most limiting factor to the expansion of the Ontario berry industry. Ontario growers need to supply quality fruit that stands the rigours of the wholesale marketing chain. Determining the most cost-effective method of storing and preserving the quality of fresh berries utilizing modified atmosphere technology and any other storage technologies for all the major berry crops is needed. This can also include the development of more environmentally acceptable packaging as well as

breeding cultivars that are suitable to Ontario conditions and meet the needs of the wholesale marketing system.

4. Fertigation/irrigation
   There is a need for modernization of benchmarks for irrigation and fertilization of berry crops grown under different growing systems. Growers would like recommendations that provide sustainable and efficient use of both fertilizer and water. New production systems including day neutral strawberries, fall bearing raspberries, protected culture and soilless media production need to be addressed. Fertigation scheduling for highbush blueberries grown under Ontario conditions needs refinement. A survey developed for knowledge transfer for fertigation and irrigation practices would benefit berry growers.

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## Bulb Vegetables

Including onions, leeks, shallots, garlic.

### Pest Management

- Insect and disease management – Growers of Allium crops are faced with multiple insects and diseases that can result in severe reduction in yield, and in some cases, total crop failure.
- Onion maggot management in onions – The loss of the broad-spectrum insecticide chlorpyrifos has severely impacted Ontario's bulb vegetable producers' ability to manage onion maggot. There are few registered, economic alternatives for onion maggot control and resistance management concerns are also of critical concern with this pest.
- Stemphylium leaf blight in onions – Fungus starts as yellow-tan, water-soaked lesions that develop into elongated brown to black spots which cause whole leaves to die back and reduce plant's photosynthetic ability and yield. Most pest control products are no longer effective against this fungus due to fungicide resistance. This is putting more pressure on the remaining effective fungicides.
- Virus complexes in garlic – Garlic is a vegetatively-grown crop, which means that bacteria, nematodes, fungi and viruses are more easily spread to the next generation and accumulate in the planting stock over time. In garlic, specifically *Music*, it is estimated that the yield drag from viruses is anywhere from 25 to 50 per cent. Access to clean planting stock of multiple cultivars is required.
- Fusarium basal rot of onion – Fusarium basal rot is a major concern for onion growers in mineral soils. Options for the management of fusarium basal rot could include: fungicide testing, irrigation water sterilization, modification of nitrogen rates and cultivar resistance testing.
- Fusarium on garlic – There are several fusarium species that attack garlic. The fusarium basal rots (*F. culmorum*, *F. oxysporum* and/or *F. roseum*) cause a different damage than the brown sunken lesions on the clove (*F. proliferatum*). Research aimed at Fusarium management in garlic could include fungicide testing, splitting/cracking/cleaning/sorting/planting methods to avoid bruising as well as curing and storage techniques.
- Stem and bulb nematode in garlic – This nematode can survive and overwinter in the soil but the main method of spread is through infected cloves. Currently only one nematicide is registered and resistance management is a concern. Alternative nematicides or management strategies should be investigated.

### Other

1. Improve storage quality
   Determine ideal environmental storage parameters for long-term storage of hardneck garlic cultivars in Ontario. Improve curing protocol to reduce cure time, improve quality and reduce pest pressure (mites, fusarium, larvae) going into storage.

2. Develop soil health and/or nutrient management strategies
   Research that leads to improved crop quality and/or environmental sustainability in bulb vegetables. Areas of research could include building soil organic matter, soil biodiversity, fumigation alternatives, intercropping options, cover crops for fall planted

garlic, interactions between applied nutrients and crop quality (including storage characteristics) as well as interactions between nutrient applications, soil type and water use. Research should address barriers to adoption as well as the long-term economic impact.

3. Production systems/robotics/labour
   Investigate efficiencies for the use of precision agriculture to improve planting, weed management, harvesting and sorting through automation and autonomous and semi-autonomous vehicles. Improvement of IPM modelling which would include forecasting pests and diseases, determine the ideal use of crop protection products while considering past, current and forecasted weather data.

4. Breeding and evaluating new garlic cultivars
   Develop new cultivars better suited to Ontario growing conditions and that last longer in storage. Once new cultivars are developed, improve tissue culture methods to make clean seed production more efficient.

5. Water management strategies
   Research focusing on the use of drip irrigation, fertigation and the impacts on yield and crop quality (including storage characteristics).

6. Product diversification
   Provide options for product diversification within the bulb vegetable sector. Projects should include a market analysis and consider consumer trends.

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## Brassicas and Leafy Vegetables

Including but not limited to: asparagus, broccoli, Brussels sprouts, cabbage, celery, cauliflower, lettuce, leafy herbs and vegetables, rhubarb, spinach.

### Pest Management

Brassica vegetable growers are facing a major disadvantage relative to other global regions due to re-evaluations and phase-outs of pest control products that have left growers without adequate options to manage pests or pathogens.

- Cabbage maggot on Brassica crops – The loss of the broad-spectrum insecticide chlorpyrifos has severely impacted producers' ability to manage cabbage maggot. There are few registered, economic alternatives for cabbage maggot control and resistance management concerns are also of critical concern with this pest.
- Alternaria on Brassica crops, especially Brussels sprouts, cauliflower and broccoli – Alternaria is a fungal pathogen that creates lesions on the heads, leaves and sprouts of Brassica crops. Fungicides are required to protect the crop against Alternaria infection. Broccoli heads with black beads and cauliflower heads with brown/black curds are not marketable. In Brussels sprouts, the entire field is abandoned, resulting in total crop loss if the percentage of infected Brussels sprouts are too high. Currently, a lack of available pest control products results in many days without protection against Alternaria and those products that are registered are under extreme selection pressure for Alternaria resistance.
- Aphids on Brussels sprouts – Effective aphid control strategies to replace the use of Admire™ systemic insecticide use.
- Stemphylium and rust of asparagus – Improving field management of Stemphylium and determining the genetic basis of Stemphylium and rust resistance in asparagus germplasm as well as understanding Stemphylium resistance in the relationship between the fern and spear.

### Other

1. Production systems/robotics/labour
   Investigate efficiencies for the use of precision agriculture to improve planting, weed management, harvesting and sorting through automation and autonomous and semi-autonomous vehicles. Improvement of IPM modelling which would include forecasting pests and diseases, determine the ideal use of crop protection products while taking into account past, current and forecasted weather data.

2. Breeding and evaluating new broccoli cultivars
   Most broccoli cultivars are not bred for the summer conditions in southwestern Ontario which can result in an uneven and unmarketable crown. Broccoli crowns that are uneven fail to shed water and are more likely to have issues with bacterial pathogens as well as physiological disorders like brown bead. Cultivars that have been developed for conditions like those seen in Ontario often lack traits (such as disease resistance), storability and/or are not as high yielding.

3. Breeding and evaluating new asparagus cultivars
   Develop high yielding, high quality, disease and replant resistant asparagus cultivars; identify the physiological basis of longevity in asparagus and assess genetic architecture for the trait and conduct field testing of potential new asparagus cultivars.

4. Develop strategies to improve Brassica crops and the leafy vegetable sector's resilience to extreme weather and climate change
   Strategies could include adaptations to changing season length and temperature patterns, new varieties that tolerate extreme conditions and/or longer seasons, models to predict vegetable harvest scheduling (like a degree day model, instead of days to harvest), adaptations to excess rain.

5. Develop strategies to improve soil and nutrient management
   Research should focus on phosphorus management in relation to Lake Erie water quality. Strategies should consider multiple interacting variables including nutrients, plant cultivars and soil type.

6. Food safety
   Improving food safety through surface sterilization, processing equipment material or through UV sterilization in the processing facility.

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## Fruiting Vegetables

Including but not limited to: solanaceous vegetables (eggplant, peppers, tomatoes), cucurbit vegetables (cucumber, pumpkin, melons, summer squash winter squash), legume vegetables (green/wax beans, succulent peas, edamame) and sweet corn.

### Pest Management

- Nematodes (common to many crops)
- Field tomatoes - Bacterial disease (primarily spot but including speck and canker), fruit rots, root health (disease, nematode, tired soils/replant issues), one-spotted stink bug life cycle on tomatoes, crop preferences and improved monitoring protocols, including pheromones lures
- Field peppers - Bacterial disease, fruit rots, including *Phytophthora capsici* (also bacterial soft rot, plus improved identification of causes), tarnished plant bug, *Colletotrichum scovellei* resistant pepper varieties, management, etc.
- Eggplant - Phytophthora (*P. capsici*), verticillium, mites, Colorado potato beetle, broadleaf weeds, grassy weeds
- Cucurbits - Downy mildew (cucumber and melon), powdery mildew (pumpkin and squash), insect-borne viral pathogens. Root diseases including phytophthora and fusarium (all cucurbits), cucumber beetle (striped and spotted).
- Vegetable legumes - Fusarium wilt (succulent peas), soybean cyst nematode (green/wax beans), white mould (beans), bean leaf beetle, aphids (all legume vegetables)
- Sweet corn - Lepidoperan insects (corn earworm, Western bean cutworm, armyworms, European corn borer), vertebrate pests (birds, raccoons, etc.), foliar diseases (northern corn leaf blight, tar spot)

### Other

1. Crop production systems research
   In particular, practices aimed at improving harvest quality. Research may include the analysis of the economic benefits of quality improvement practices at any point (or multiple points) along the fruiting vegetable value chain; analysis of existing data; developing new data through crop research; comparing production systems, harvest or postharvest practices. Research should develop best management practices for quality improvement that can be applied to Ontario.

2. Soil health
   Develop best management practices for improving and maintaining soil health in fruiting vegetables considering any or all of the following: short rotation, root health/soil-borne disease, cover crops, soil amendments, soil organic matter, soil biodiversity and resiliency. Research should include evaluation of barriers to adoption (reduce them) and the long-term economic benefits to growers and society as well as impacts on pest management factors such as soil-borne diseases.

3. Develop strategies for nutrient management
   Research should focus on maximizing crop production while minimizing the environmental impact in fruiting vegetables. Successful projects will emphasize phosphorus management in relation to a number of variables including runoff, fertilizer

application (method, timing, rates) and impacts on Great Lakes quality. Impacts on loss or use efficiency of other nutrients should be considered.

4. Develop irrigation and water management strategies
   Research should focus on achieving optimal crop quality and yield in fruiting vegetables. Variables of interest are water use efficiency, critical irrigation times, cut off times, fertigation, run off and management in extreme weather. Adaptation to both water shortages and to extreme rainfall events are of interest.

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## Ginseng

### Pest Management

Identify the cause and develop solutions to replant disease of ginseng, specifically including improving fumigation practice and timing, fumigator design, etc.

### Other

1. Identify the causes and develop solutions to skin diseases and disorders that affect the marketability of the root (preharvest and postharvest)

2. Improving pesticide efficacy and reducing residue for pesticide application

3. Improve ginseng seed viability and seed survival

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## Grape and Wine

**Pest Management**

- Spotted lantern fly
- Identification and mitigation for leafroll and red blotch (e.g. cover crop management for beneficial/vector management)
- Replacements for synthetic pyrethroids
- Quality improvement (e.g. canopy management, powdery mildew, black rot, fruit fly, Brown Marmorated Stink Bug, botrytis, downy mildew, etc.)
- Spotted Wing Drosophila (SWD), sour rot
- Spray programs strategies (rotation, feedback mechanism, alternatives to delisted sprays)
- Short- and long-term effects of viruses on plant performance

**Other**

1. Viticulture research:
   - Winter injury and mitigation technologies
   - Vitis certification (local vine propagation/supply)
   - Clonal and sub-clonal stability (assessing trueness to type)
   - New adaptative grapevine varieties
   - Extreme weather events recovery and strategy

2. Oenology research:
   - Clonal sensory evaluation
   - Post-frost picking strategy and must handling in the winery
   - Crop level vs. quality in light of climate change and weather patterns (e.g. colour, tannin development)
   - Sparkling wine, Icewine, Late Harvest
   - Operations of winery (e.g. filtration, yeast, nutrients)
   - Site selection (terroir)
   - How to remove/mitigate botrytis taint
   - How to determine optimal picking times
   - How to make dealcoholized (or low alcohol content) wine economically

3. Market research:
   - Sensory and consumer science
   - Sparkling wine profiles
   - Export/market development
   - Forecast of "winning" varieties and style of wine
   - Promoting local

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## Greenhouse Vegetables

### Pest Management

- Develop and modernize BMPs for IPM and biosecurity
- Efficacious novel fungicides and insecticides likely to become registered

### Other

- Efficacious resistant varieties (i.e. Tomato Brown Rugose Fruit Virus)
- On-farm energy conservation and optimization:
    - LED recipes specific to crop type
    - Climate optimization
    - HVAC systems
- Impacts of blended fuels in growing practices
- Impacts of blends and alternate energy sources on yield efficiency and plant productivity
- Environmental sustainability
- Market development:
    - Consumer interest and how their preference is anticipated to drive innovation and crop selection

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## Honey Bees and Pollination

### Pest Management

- Further development of effective IPM, diagnostic tools, nutrition and queen health recommendations, best management practices and food safety programs for controlling Varroa mites and other pests and diseases referred to in OMAFRA's list of existing/emerging bee diseases, including treatment-resistant pests and diseases.
- Investigate methods to improve bee immunity to pests and diseases on all levels.

### Other

1. Assess and improve queen quality, genetics and management in Ontario and promote utilization of Ontario bee stock. Investigate methods to improve queen viability and survival, early queen production and overwintering of queens.

2. Determine the risks and develop best management practices for bee colonies moved for pollination, for alternative pollinators and for new pollinator systems. This should include investigating:
   - The impact of pollination services on bee health and mortality
   - Methods to protect bees providing pollination services from the negative effects of pesticide application
   - Biosecurity and the effects of mixing managed pollinators
   - The effects of mixing managed pollinators with native bee species

3. Conduct a long-term survey of hive products (honey, wax, pollen, propolis, etc.) from honey bee colonies to investigate the extent of environmental chemicals (agrochemicals and agrochemical residues). Investigate the adverse effects of these chemicals, including synergistic effects on bee health, bee reproduction and the environment.

4. Investigate methods to increase pollinator forage and habitat in order to offset land use that has negative effects on pollinator populations.

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## Maple Syrup Producers Association

**Pest Management**

Asian Long-horned Beetle (ALHB) is currently the single most serious potential threat to maple trees in Ontario. Previous infestations have been controlled through fortuitous detection in a small geographical area. Development of tools and methods to educate the population on the identification of ALHB to observers throughout the province is a priority in increasing the likelihood of quick infestation identification.

**Other**

1. Develop an easy and rapid test to identify buddy sap prior to processing into maple syrup. Research is ongoing on this topic at Carleton University with some support from OMSPA but additional financial support is required to complete the project.

2. Determine how to best clean and sanitize storage barrels to prevent/minimize mould-damaged syrup.

3. Determine at what temperature and for how long it is required to preheat small glass bottles prior to hot-packing with maple syrup to prevent/minimize mould-damaged syrup. It is virtually impossible to remove all mould spores from maple syrup but syrup should be hot-packed into clean containers in conditions that are as hostile to mould growth as possible. Small glass containers seem to be the most problematic due to the high mass of glass and relatively small amount of syrup that cools quickly upon contact.

4. How to best prevent maple decline on acidic soils (Canadian Shield).

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## Mushrooms

### Other

1. Automation and other technology to address the high costs and availability of labour.

2. Analysis and validation of the nutritional value and potential health benefits of mushrooms, especially on immune system responses and the potential for treating or mitigating the effects of certain chronic health conditions.

3. Sustainability, both in production practices and packaging.

4. Peat alternatives and other input shortage solutions.

5. Improve energy efficiency and reduce the carbon footprint of mushroom production.

6. Value-added use of mushroom production by-products for functional food and nutraceutical ingredients.

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## New and Specialty Crops

The specialty crops sector consists of over 100 different commodities that are typically grown on small acreages in Ontario. These include, but are not limited to, sweet potatoes, peanuts, tigernut, okra and other specialty vegetables, specialty fruit including haskap, kiwiberries and pawpaw, medicinal herbs including cannabis, culinary herbs, lavender, hops, truffles, hazelnuts and other tree nuts.

### Pest Management

Field research on pest management including weeds under Ontario conditions (e.g. conventional and organic pest control products, pest identification, IPM, pesticide resistance management, product timing and rotations (including development of forecasting models), identification of pest-resistant germplasm). Examples of specific pest management needs include:

- Address the lack or loss of registered pest control products on specialty crops.
- Viruses in all specialty crops but especially hops, hemp/cannabis, sweet potatoes, specialty berries and tree nuts.
- Vertebrate pests in all specialty crops especially birds in haskap and tree nuts, squirrels in hazelnuts, mice and voles in lavender and root crops such as ginseng and sweet potatoes.
- Halo blight/Diaporthe of hops.
- Bacterial blight of cilantro.
- Invasive pests in specialty crops including spotted wing drosophila in specialty berries, European cherry fruit fly in haskap, brown marmorated stink bug in

hazelnuts and specialty field crops, spotted lantern fly in hops and other affected specialty crop hosts, Asian chestnut gall wasp in chestnut.
- Powdery mildew, plant bugs, scale, stink bugs, caterpillars in haskap.
- Boring insect species in woody and semi-woody specialty crops e.g. haskap and tree nuts.
- Downy mildew, powdery mildew, cone diseases, mites and leaf hoppers in hops.
- Black rot, grubs and wireworms in specialty root crops e.g. sweet potatoes.
- Bud mite and spongy moth in hazelnuts, Japanese beetles and weevils in all tree nuts.
- Diseases of tree nuts e.g. eastern filbert blight (hazelnuts), chestnut blight (chestnut), bacterial blight (most tree nuts).
- Downy mildew, powdery mildew, botrytis head blight, white mold and various insect pests in cannabis and industrial hemp.
- Four lined plant bug, garden fleahopper and Phytophthora root rot on lavender.
- Weed control in all crops.

**Other**

The following is a list of sector priorities in no particular order:

- Develop agronomic practices and efficiencies - e.g. pruning and pollination; fertility and water requirements; season extension; improving winter survival of certain perennial crops (e.g. lavender and hazelnuts) and harvesting methods/ postharvest handling and storage issues.
- Research on efficient production methods that impact labour, energy, greenhouse gas emissions, carbon sequestration and water requirements.
- Propagation of high-quality nursery stock for vegetatively propagated crops (e.g. lavender, hops, haskap, hazelnut, truffles) and the development of certification programs that include:
    - True to type nursery stock
    - Pest free (e.g. disease, virus)
    - Inoculated nursery stock (e.g. truffles)
    - Efficient propagation methods
- Germplasm development - Breeding/selection programs for new germplasm that is high yielding, high quality, adapted to Ontario growing conditions, resistant to key pests, consistent in germination and relevant to Ontario market preferences.
- Develop local supply chains for new and specialty crops by identifying emerging crop opportunities, identify sector partners and their needs (both generating data and analysis), understand purchasing and sourcing practices and accelerate technology adoption to meet market requirements. Additional areas of market development requiring research include:
    - Understand market requirements (quality, grades, packaging, consumer preferences, etc.)
    - Consumer education
    - Cost of production information
    - Access to processing facilities
    - Value-added opportunities

- Develop new edible materials and bioproducts (e.g. sugars, chemicals, biomaterials) from non-edible specialty crops, by-products, organic waste and residue streams for all specialty crops for a sustainable circular economy

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## Potatoes

**Pest Management**
Evaluate cultural, biological and chemical methods to reduce the incidence of soil-borne diseases and blight.

**Other**

- Identify and evaluate new potato lines that can help to provide a 12-month supply of high-quality potatoes to the Ontario fresh and chip processing industries through value-added traits such as early maturity, long term storage ability and nutritional potential, any of which would serve to enhance the competitiveness and profitability of the Ontario potato industry.
- Develop a breeding program that considers disease resistance, focusing heavily on common scab. Low N, P, K requirements and drought tolerance as priority traits.
- Identify selections and cultivars that are adapted to environments with lower fertility and water availability. Improve water use efficiency by altering timing and use of new irrigation technologies.
- Identify and evaluate tablestock lines for value-added traits that may have a positive effect on human health.

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## Root Vegetables

Including but not limited to: carrots, parsnips, beets, sugarbeets, rutabaga, turnip, radish, horseradish, sweet potatoes.

### Pest Management

Insect and disease management: root vegetable growers must manage a wide range of foliar and soil pests and diseases.

1. Cercospora leafspot on sugarbeet.

2. Nematodes on carrots – Many nematodes including root-knot, lesion and carrot cyst nematodes are a concern for many carrot growers in the province. Until recently, no nematicides were registered for control and growers have been reliant on fumigants. Other effective nematicides are recommended for resistance management.

3. Cavity spot of carrots – This soil-borne pathogen often creates multiple lesions on carrots, rendering the crop unmarketable. The registered products are not very effective in controlling the disease and there is concern the pathogen may be developing resistance to metalaxyl. Effective fungicides and identification of proper methods to apply these products are needed.

4. Cabbage maggot on brassica root crops – Cabbage maggot larvae cause extensive damage to root brassica vegetables, especially rutabaga. With the loss of chlorpyrifos, few products are available for control. Effective insecticides are needed for proper management and to reduce the risk of resistance development.

5. Downy mildew on brassica root crops – Very few fungicides are registered to control this foliar disease of brassica root crops. Under the right conditions, this disease can cause extensive foliar damage, reducing yields.

6. Fusarium root rot on sugarbeet – Root rot caused by Fusarium species is becoming more common in sugarbeet production and control options are very limited.

7. Cercospora leafspot on table beet – Potential for more control options could lead to possible label expansion to include table beets.

8. Rhizoctonia on table beet – More control options and label expansions needed.

9. Aphanomyces root rot on sugarbeet – This is an ongoing issue in sugarbeet production. It is a sporadic issue so research has been limited in Ontario.

10. Leafminers on table beets – Table beets have a very small toolbox when it comes to insecticides and fungicides. Research that can lead to label expansions are needed.

11. Leafhoppers on table beets – Table beets have a very small toolbox when it comes to insecticides and fungicides. Research that can lead to label expansions are needed.

12. Aphids on table beets – Table beets have a very small toolbox when it comes to insecticides and fungicides. Research that can lead to label expansions are needed.

**Other**

1. Develop soil health and/or nutrient management strategies that improve crop quality and/or environmental sustainability in root vegetables. Areas of research could include (but are not limited to): root health/soil-borne disease, soil organic matter, soil biodiversity, resiliency and fumigation alternatives; mitigation of soil compaction; intercropping options; interactions between applied nutrients; crop varieties and harvest date; interactions between applied nutrients; crop quality (including storage characteristics) and variety; interactions between nutrient applications, soil type and water use; best practices for soil amendments and/or cover crops, nutrient loss and nutrient use efficiency. Research should address barriers to adoption and long-term economic impact.

2. Develop strategies that improve product quality in root vegetables (including storage quality and percent marketable product).

3. Develop strategies and identify barriers to adoption for water management best practices in root vegetables that considers any or all of (but not limited to) the following variables: soil type, nutrient management, product quality and yield, irrigation system type, water sourcing, drainage, surface water management (note water management is not a high priority in sugarbeets).

4. Provide options for product diversification within the root vegetable sector. Projects should include a market analysis and consider consumer trends.

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## Tender Fruit

**Pest Management**

- Disease management tools and strategies for fire blight, black knot, bacterial spot
- Strategies to combat new invasive species such as Brown Marmorated Stink Bug (BMSB), Spotted Wing Drosophila (SWD) and Spotted Lantern Fly (SLF)

**Other**

1. Automation labour and operational efficiencies with improved processes and systems that reduce impacts of and/or costs for:
   - Pruning, thinning, harvesting and packing
   - Pest and disease management
   - Adverse weather management

2. New variety acquisition, development, best management and commercialization processes that result in:
   - Higher value varieties suited to Ontario growing conditions and marketplace needs
   - Varieties that can better withstand climate change pressures such as excessive heat and drought
   - An increase in organic production
   - Fast tracking of virus-free commercial production of promising varieties
   - Disease resistance, especially to fire blight, black knot and bacterial spot

3. Increase postharvest quality with a focus on optimal harvest, packing, cold chain management systems, treatments and practices to increase quality and shelf life

4. Irrigation, water and nutrient use by developing processes and systems to maximize efficiencies

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# Ornamental Horticulture

## Sector Consultation

A research priority list was originally generated from input provided at a broad industry consultation with the floriculture and nursery-landscape sectors held in January 2015. The list was updated and ranked in 2017 during a small group meeting of Landscape Ontario (LO) and Flowers Canada (Ontario) (FCO) representatives. In 2018, the LO and FCO research chairs reviewed the priority list and agreed to move the labour issue up to a higher ranking. For the current report, LO priorities have not changed from the 2022 report.

## Prioritization Criteria

- Size of opportunity or problem: What is the size or the reach of the research problem or opportunity for discovery? e.g. How much of the sector does it relate to?
- How many growers/businesses are affected and stand to benefit from the solution? How much potential uptake will it have?
- Economic impact: To what degree does research in this area improve the sector's market share, growth and enterprise profitability? e.g. Does it create a superior product, increase yields or reduce production costs in a significant way? To what extent will it improve the competitiveness of Ontario's sector?
- Socio-environmental impact: How will this research benefit the environment and/or broader society? e.g. Will it enable sector businesses to reduce their environmental footprint? Will it create jobs, reduce pollution or meet other societal needs?
- Probability of success: How likely is this area of research to succeed relative to the investments required? How do the risks weigh up against the possible returns?

## Ontario Ornamental Horticulture Research Priority List

(ranked)

1. Reduce water use by 20 per cent - Utilize water more efficiently in ornamental plant production with strategies that are economically viable and commercially practical.

2. Optimize nutrient use - Develop strategies to optimize the use of nutrients in plant production to reduce input costs, promote plant health and eliminate nutrient runoff.

3. Improve irrigation water quality - Develop strategies to improve irrigation water quality e.g. by optimizing source water, irrigation systems and/or storage and recirculation systems, managing algae growth.

4. Reduce labour costs - Identify issues and opportunities for driving down labour costs in the sector.

5. Improve energy efficiency - Strategies to reduce electrical, energy and fuel use that are economically viable and commercially practical.

6. Pest control - Research for more effective and sustainable control of insects, weeds and diseases in ornamental plant production and landscape maintenance. In greenhouse

floriculture the primary focus should be on biocontrol strategies.

7. Improve plant establishment and survival - Understand and improve plant establishment and survival in challenging environments, including: root growth in container nursery production and compacted soils; reducing low temperature injury; and soil amendments using wastes from other industries.

8. Supplemental lighting - Strategies to improve plant production with supplemental lighting.

9. Consumer research - Understand market trends, quantify environmental benefits, identify which plants to grow, when to supply them and how to present and market them.

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