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PLANT SCIENCE SCAN

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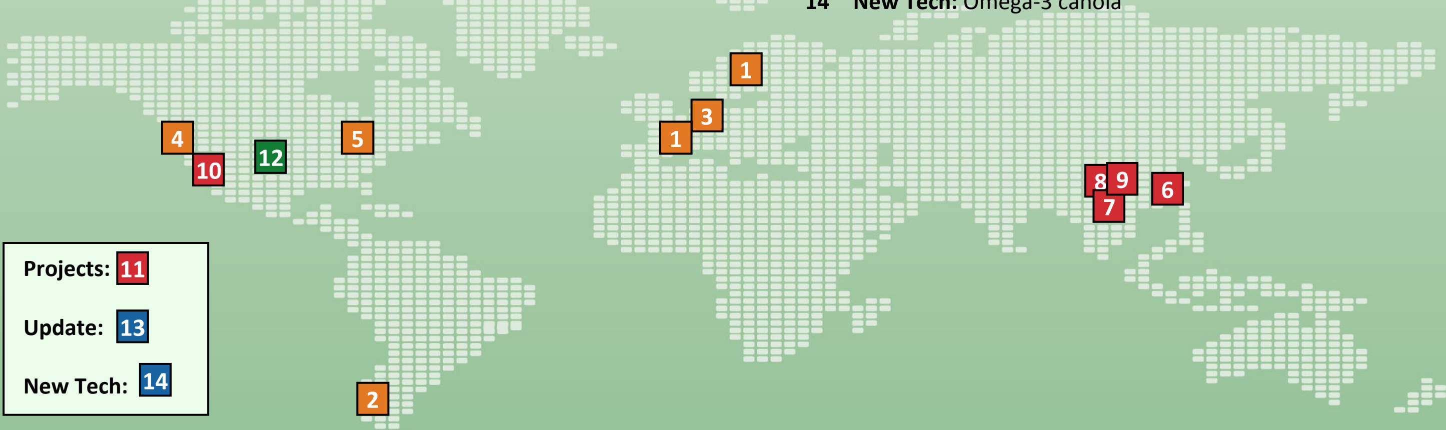
BACKGROUND: The Plant Health Science Division of the Canadian Food Inspection Agency routinely scans external sources to identify information that might be of possible regulatory significance or interest to Canada's national plant health. This Plant Science Scan report was prepared by the Canadian Food Inspection Agency's staff as a mechanism to highlight potential items of interest, raise awareness and share significant new information related to plant health.

Index of Articles



Numbered squares correspond to numbered articles above

Pathology

1 First Report: *Pseudomonas syringae* pv. *aesculi* in Switzerland and Finland

In 2011, *Aesculus hippocastanum* (horse chestnut) trees in a public park in Switzerland exhibited bleeding cankers. In 2015, the bacterium *Pseudomonas syringae* pv. *aesculi*, the causal agent of bleeding canker disease of horse chestnut, was isolated from bark samples taken from three affected trees. Pathogenicity tests and the fulfillment of Koch's postulates confirmed that the causal agent was *P. syringae* pv. *aesculi*. This is the first report of *P. syringae* pv. *aesculi* in Switzerland.

In Finland, dying horse chestnut trees were identified in the Tokoinranta park in 2015 and in Sibeliuspuisto park in 2016 in the city of Helsinki. Subsequent laboratory testing results confirmed the presence of *P. syringae* pv. *aesculi* in the wood and bark samples from the diseased trees. This is the first report of *P. syringae* pv. *aesculi* in Finland.

Pseudomonas syringae pv. *aesculi* infects *Aesculus* spp. (buckeye) and is also known to occur in other parts of Europe and India. It is not known to occur in Canada and is listed as a quarantine pest by the CFIA. This new finding expands on the known distribution of this pathogen in Europe.

SOURCES: Meyer, J. B., Brunner, M. and Rigling, D. (2016) First report of *Pseudomonas syringae* pv. *aesculi* on horse chestnut in Switzerland. New Disease Reports 33:19.

NPPO of Finland (2016) First report of *Pseudomonas syringae* pv. *aesculi* in Finland. EPPO Reporting Service No. 7

2 First Report: *Phytophthora kernoviae* in Chile

During surveys for the presence of *Phytophthora* species in forest trees in May and December 2012 in Southern Chile, fallen leaves of *Drimys winteri* (Winter's bark) trees showing necrosis around the midrib were observed in a native evergreen forest near the city of Valdivia, Región de Los Ríos. Molecular analysis and pathogenicity testing confirmed that the causal agent was the oomycete *Phytophthora kernoviae*. This is the first report of *P. kernoviae* in Chile and in the Western Hemisphere.

Phytophthora kernoviae, the causal agent of beech bleeding canker, infects several tree and shrub species, including *Fagus* spp. (beech), *Magnolia* spp., and *Rhododendron* spp. It has also been reported from Ireland, the United Kingdom and New Zealand. It is not known to occur in Canada and a pest categorization concluded that this pathogen meets the definition of a quarantine pest as defined by the International Plant Protection Convention (IPPC).

SOURCE: Sanfuentes, E., Fajardo, S., Sabag, M., Hansen, E. and González, M. (2016) *Phytophthora kernoviae* isolated from fallen leaves of *Drimys winteri* in native forest of southern Chile. Australasian Plant Disease Notes 11(1):19.

3 First Report: *Monilinia polystoma* infecting cherries

Until recently, only three *Monilinia* species (*M. fructigena, M. laxa* and *M. fructicola*) were known to cause brown rot on cherries worldwide. During a 2010-2013 survey, *Prunus cerasus* (sour cherry) and *Prunus avium* (sweet cherry) fruits in commercial orchards in Poland exhibited brown rot symptoms. Morphological and molecular analysis, as well as the fulfilment of Koch's postulates, confirmed that the causal agent was the fungus *Monilinia polystroma* (synonym: *Monilia polystroma*). This is the first report of *Monilinia polystroma* infecting cherries.

Monilinia polystroma is the causal agent of Asiatic brown rot in *Malus* spp. (apple), *Prunus persica* (peach), *Prunus armeniaca* (apricot), *Pyrus* spp. (pear), and *Cydonia* spp. (quince). *Monilinia polystroma* has been reported from Switzerland, Italy, Croatia, Slovenia, the Czech Republic, Poland, Hungary, Serbia, China and Japan. It is not known to occur in Canada and is listed as a regulated pest by the CFIA. This new finding provides new possible pathways for the introduction of this quarantine pest.

SOURCE: Poniatowska, A., Michalecka, M. and Puławska, J. (2016) Genetic diversity and pathogenicity of *Monilinia polystroma* – the new pathogen of cherries. Plant Pathology 65(5):723-733.

4 First Report: *Grapevine fleck virus* in Canada

Grapevine fleck virus (GFkV) has been reported in Canada for the first time. The virus was found in a number of samples from British Columbia vineyards (Poojari et al. 2016), suggesting that it is not an isolated occurrence. GFkV is thought to be distributed worldwide (Wilcox et al. 2015).
GFkV has been associated with grapevine fleck disease, a disease caused by a complex of viruses. Symptoms include the development of translucent spots on leaves that cause wrinkled and twisted leaves, and in severe cases, stunting and poor rooting (Wilcox et al. 2015). *Grapevine asteroid mosaic-associated virus* and *Grapevine rupestris vein feathering virus,* two other members of the fleck complex, were also recently reported for the first time in Canada (Xiao and Meng 2016).
GFkV does not appear on the list of Regulated Pests for Canada.

SOURCES: Poojari, S., Lowery, T., Rott, M., Schmidt, A.-M., DeLury, N., Boule, J. and Urbez-Torres, J.R. (2016) First report and prevalence of *Grapevine fleck virus* in grapevines (*Vitis vinifera*) in Canada. Plant Disease 100(5): 1028.

Wilcox, W., Gubler, W. and Uyemoto, J. (2016) Compendium of grape diseases, disorders and pests. APS Press: St. Paul, MN. 232 pp.

Xiao, H.G. and Meng, B.Z. (2016) First report of *Grapevine asteroid mosaic-associated virus* and *Grapevine rupestris vein feathering virus* in grapevines in Canada. Plant Disease. DOI http://dx.doi.org/10.1094/PDIS-03-16-0413-PDN

5 First Report: *Geosmithia morbida* on ambrosia beetles emerged from thousand cankers-diseased *Juglans nigra* in Ohio

A recent study on *Geosmithia morbida* (causal agent of thousand canker disease of walnuts) reports the detection of this pathogen on two ambrosia beetles (*Xylosandrus crassiusculus* and *Xyleborinus saxeseni*) and one weevil species (*Stenomimus pallidus*). The authors suggest that the presence of *G. morbida* on ambrosia beetles could intensify disease symptoms in areas where the disease is already present (Juzwik et al. 2016). *Xyleborinus saxeseni* is known to be present in Canada. *Xylosandrus crassiusculus* has previously been reported from Ontario, however, it is unknown if this species has established in Canada (Douglas et al. 2013). *Stenomimus pallidus* is present in the United States but not reported from Canada (CABI 2016).

Geosmithia morbida is an important pathogen affecting *Juglans nigra* (black walnut) in North America. It has long been present in western United States but has more recently spread to eastern U.S. (Indiana, Ohio, Pennsylvania, Massachusetts, Tennessee, North Carolina and Virginia) (Jackson 2016). In association with its previously main known vector, *Pityophthorus* *juglandis* (walnut twig beetle), this disease restricts nutrient flow which causes yellowing of leaves, canker production and leads to tree death within three years (Aggarwal et al. 2016).

Geosmithia morbida is not a quarantine pest to Canada.

SOURCES: Aggarwal, T., Westbrook, A., Broders, K., Woeste, K. and MacManes, M. D. (2016) De novo genome assembly of *Geosmithia morbida*, the causal agent of thousand cankers disease. bioRxiv. CABI. (2016) Crop Protection Compendium. CAB International, Wallingford, UK.

Douglas, H., Bouchard, P., Anderson, R. S., de Tonnancour, P., Vigneault, R. and Webster, R. P. (2013) New Curculionoidea (Coleoptera) records for Canada. ZooKeys (309):13-48.

Jackson, L. (2016) Thousand cankers disease. [Online] Available: http://www.thousandcankers.com/home.php [July 18, 2016].

Juzwik, J., McDermott-Kubeczko, M., Stewart, T. J. and Ginzel, M. D. (2016) First report of *Geosmithia morbida* on ambrosia beetles emerged from thousand cankers-diseased *Juglans nigra* in Ohio. Plant Disease 100(6):1238-1238.

Entomology

6 Biocontrol: New species of emerald ash borer egg parasitoid is found in the Russian Far East

A new species of egg parasitoid, *Oobius primorskyensis* Yao & Duan n. sp., collected from the emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), near Vladivostok, Russia, has been described. The new species is a natural enemy of EAB in its native range and may be considered for introduction in North America. *Oobius primorskyensis* is reported to be morphologically different and has a different molecular profile compared to *O. agrili* Zhang & Huang, different enough to merit species status. The latter species, native to Northeast China, was released in Ontario last year as a biological control agent against EAB. Evaluation of its effectiveness is currently ongoing.

With respect to biology, it was found that when reared on EAB eggs at 25 ± 1.5°C, 65 ± 10% relative humidity, and a photoperiod of 16:8 (L:D) h, nearly 100% of *O. primorskyensis* diapaused at the second and third generations after parents had diapaused, whereas a majority (60–96%) of *O. agrili* did not enter diapause for 11 sequential generations. The drastic difference in diapause between these two species may reflect a difference in temporal risk-spreading in their native ranges (the Russian Far East versus Northeast China), and may have important implications for their establishment and efficacy for the biological control of EAB in North America. It could be that because of its greater tendency to diapause, *O. primorskyensis* may be a better biocontrol agent in the northern parts of the range of ash trees.

EAB is a non-native, highly destructive wood-boring beetle that feeds under the bark of ash trees. All North American species of ash are susceptible to attack. Since it was first identified in Michigan in 2002, EAB has killed millions of ash trees in Ontario, Quebec, and the United States. It poses a major economic and environmental threat to urban and forested areas.

SOURCE: Yan-Xia, Y., Duan, J.J, Hopper, K.P., Mottern, J.L. and Gates, M.W. (2016) A New Species of *Oobius* Trjapitzin (Hymenoptera: Encyrtidae) From the Russian Far East That Parasitizes Eggs of Emerald Ash Borer (Coleoptera: Buprestidae). Annals of the Entomological Society of America, DOI: http://dx.doi.org/10.1093/aesa/saw022 629-638.

7 Update: Seasonal changes in supercooling capacity of Asian longhorned beetle and mechanisms of cold hardiness during overwintering periods

There are two main cold hardiness strategies that overwintering insects have developed which are differentiated based on the supercooling point (SCP). Freeze-avoiding insects generally have a low SCP and will die if their body fluids freeze, whereas freeze-tolerant insects have a higher SCP and can endure freezing. A recent study by Feng et al. (2016) investigated the dynamic changes in the supercooling capacity of a natural population of Asian longhorned beetle, *Anoplophora glabripennis* (Motschulsky) (Coleoptera: Cerambycidae) in Northwest China. Larvae were collected every two months from August 2012-May 2013 during which time the mean monthly temperature decreased from 21.81°C in August to -6.8°C in December, before increasing to 18°C in May. The minimum temperature over the course of the study was -24.2°C which occurred in January. The results indicated that the supercooling point of overwintering larvae decreased initially before increasing consistently with seasonal changes in ambient temperature. The mean SCP was -9.38±0.70 °C, with values ranging from -18.6 to -5.2°C. Previous research has shown that the supercooling point of *A. glabripennis* larvae from New York can reach -25.80°C (Roden et al. 2008) and that it also differed significantly amongst five populations in China (Feng et al. 2014). These findings suggest that *A. glabripennis* larvae have a strong ability to adapt to local environments or that there could be intraspecific variation in cold-hardiness. Larvae collected in March were also used to determine the probability of survival after freezing, by placing them in perforated tubes and exposing them to 0, -5, -10 and -15°C for different cumulative times (8 h, 18 h, 16 days and 30 days). Almost all larvae were frozen and still survived after treatment at -5°C, -10°C and -15°C for 6 hours, suggesting that *A. glabripennis* larvae are freeze-tolerant insects capable of being frozen for a short time. The probability of survival began decreasing after 18 h exposure to these temperatures, indicating that the greatest abiotic threat to larval winter survival is the cumulative effect of prolonged exposure in the cold above the freezing temperature, rather than freezing.

Low molecular weight sugars and polyols are also often produced by larvae of overwintering insects in order to lower their supercooling point, thus enhancing cold hardiness capacity. Feng et al. (2016) found that as the SCP decreased during the overwintering period, the concentrations of glycerol, glucose and mannitol increased significantly in the haemoplymph of *A. glabripennis* larvae. All low molecular weight substances, with the exception of trehalose, were almost metabolized by early spring. The negative correlation between the SCP and the levels of low molecular weight sugars and glycerol indicate that *A. glabripennis* larvae likely reduce their SCP by increasing the concentration of these compounds. Levels of serine, phenylalanine, valine, leucine, proline, glutamic acid and alanine all reached their highest level in the colder winter months, indicating that increased levels of amino acids may also enhance cold hardiness in *A. glabripennis*. Together, the seasonal changes in cold hardiness capacity and physiological-biochemical materials of *A. glabripennis* larvae indicate that the overwintering process of this species is highly complex and involves numerous mechanisms.

SOURCES: Feng, Y.Q., Xu, L., Tian, B., Tao, J., Wang, J. and Zong, S. (2014) Cold hardiness of Asian longhorned beetle (Coleoptera: Cerambycidae) larvae in different populations. Environmental Entomology 43: 1419–1426.

Feng, Y., Wenbo, L., Xu, Z., Cao, M., Wang, J., Tao, J. and Zong, S. (2016) Seasonal changes in supercooling capacity and major cryoprotectants of overwintering Asian longhorned beetle *Anoplophora glabripennis* larvae. Agricultural and Forest Entomology 18(3): 302-312.

Roden, D.B., Haack, R.A., Keena, M.A, Kenney, D.W., Beall F.D. and Roden P.M. (2008) Potential northern distribution of Asian longhorned beetle in North America. USDA Research Forum on Invasive Species, Annapolis, Maryland, pp. 65-67.

8 Update: Orchard habitat and overwintering site preferences of Oriental fruit moth

At the beginning of the 20th century, oriental fruit moth, *Grapholita molesta* (Lepidoptera: Tortricidae), began spreading from its native distribution in China and the Korean peninsula to many temperate fruit-growing areas of the world. Today, the only commercial peach-growing area of North America that is free of the pest is British Columbia. The principal host is *Prunus* spp. (peach, nectarine, apricot, plum and cherry) though larvae often migrate to *Malus* spp. (apples) and *Pyrus* spp. (pears) orchards during the late-season where fruits are still available, and some populations that have specialised on non-*Prunus* hosts have also been reported. Diapausing larvae will then overwinter within silken cocoons in a variety of sites, including: loose tree bark scales, pruning wounds, soil beneath the tree, leaf litter, weeds, trash and fruit bins.

A recent study by Yang et al. (2016) investigated the overwintering sites of *G. molesta* in four peach orchards and adjacent pear and apple orchards in Northern China, to better determine the overwintering preferences of the moth. The results indicated that the late-maturing 'Shenzhou honey peach' orchard was the most preferred overwintering habitat, where more than 90% of the larvae were collected. This preference could be partially explained by the phenological stage of the fruit tree, as the harvest period for 'Shenzhou honey peach' occurs later in the season, ensuring the availability of fruit for mature larvae. The pear and apple orchards were also managed by fruit bagging, while the peach fruits were not due to their shorter stalk. Because of this, pear and apple trees provided little food, leading to fewer overwintering cocooned larvae in these orchards. Another significant finding from this study is that larvae began overwintering between August and October, with the peak period for entering diapause in mid- to late September. The main overwintering site was the host tree, and cocooned larvae were only very rarely found overwintering in the soil. Together, these findings provide a better understanding of the overwintering habitats and site preferences of *G. molesta*, which in turn will add valuable knowledge for how to effectively control this moth.

Grapholita molesta is a regulated quarantine pest for Canada, present so far only in southern Ontario and southern Quebec. Further knowledge of this pest's biology and overwintering preferences will help the CFIA continue to develop mitigation measures, especially preventing this pest from entering British Columbia, and in particular, the province's commercial peach-growing areas.

SOURCE: Yang, X-F., Fan, F., Wang, C. and Wei, G.-S. (2016) Where does *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae) overwinter in adjacent peach, pear and apple orchards? Bulletin of Entomological Research 106(1): 135-140.

9 Biocontrol: A new species of endo-parasitoid described from China parasitizing eggs of the invasive spotted lanternfly

The spotted lanternfly, *Lycorma delicatula* (Hemiptera: Fulgoridae), is an invasive plant hopper native to China, Japan, Vietnam and India.

It was first reported as an invader in South Korea, where it spread across the country in just over five years after its introduction (Park et al. 2009). The pest primarily infests *Ailanthus altissima* (tree-of-heaven), but is also known to feed on economically important ornamental and fruit tree species, including *Vitis vinifera* (grape), *Malus* spp. (apple), *Prunus* spp. (stone fruit), *Populus* spp. (poplar), *Salix* spp. (willow), *Quercus* spp. (oak), *Platanus* spp. (plane tree) and *Acer* spp. (maple). Adults and nymphs feed on sap from leaves and stems of host plants, causing sap to excrete from wounds which appear grey or black and can occur along the stems, branches or trunk of the tree. Wounds are also caused by honeydew buildup which can prompt fungal growth and lead to mould patches occurring at the base of the tree which can eventually cause death (CFIA 2016).

An international cooperative project to find natural enemies of *L. delicatula* was launched in 2011 between the Chinese Academy of Forestry, the Chinese Academy of Agricultural Sciences and the Rural Development Administration of Korea (Yang et al. 2015). During the survey, a new egg parasitoid, *Anastatus orientalis* Yang & Choi (Chalcidoidea: Eupelmidae), was reared from overwintering egg masses collected from four regions of Northern China (Beijing, Hebei, Shandong and Shaanxi). The authors suggest that the new species has a high potential as a biocontrol agent for suppression of *L. delicatula* given the observed parasitism rates of egg masses (30.4%) and individual eggs (40.2%), and a female to male sex ratio of 1.9:1.0. A mass-rearing experiment was subsequently conducted with substitute host eggs which determined that *A. orientalis* can complete 7-8 generations from April to December in a year under laboratory conditions.

In September 2014, *L. delicatula* was detected for the first time in the United States in a limited area of Pennsylvania. It is not yet known to occur in Canada; however, there is risk of it moving long distances through human-assisted transport of all life stages, especially egg masses. Education leading to early detection could be the most effective barrier to the pest's entry. For more information on the pest, please visit: http://www.inspection.gc.ca/plants/plant-pests-invasive-species/insects/spotted-lanternfly/eng/1433365581428/1433365581959

SOURCES: Canadian Food Inspection Agency (CFIA) (2016) Spotted Lanternfly – *Lycorma delicatula* [Online] Available: http://www.inspection.gc.ca/plants/plant-pests-invasive-species/insects/spotted-lanternfly/eng/1433365581428/1433365581959 [August 26, 2016].

Park, J.-D., Kim, M.-Y., Lee, S.-G., Shin, S.-C., Kim, J.-H. and Park, I.K. (2009) Biological characteristics of *Lycorma delicatula* and the control effects of some insecticides. Korean Journal of Applied Entomology 48(1):53-57.

Yang, Z.-Q., Choi, W.-Y., Cao, L.-M., Wang, X.-Y. and Hou, Z.-R. (2015) A new species of *Anastatus* (Hymenoptera: Eulpelmidae) from China, parasitizing eggs of *Lycorma delicatula* (Homoptera: Fulgoridae). Zoological Systematics 40(3): 290-302.

10 Update: The influence of host plant volatiles on the attraction of longhorned beetles to pheromones

Within the past decade, there has been a significant increase in the number of pheromone attractants identified for longhorned beetles (Coleoptera: Cerambycidae). Prior to this, mimics of naturally produced host plant volatiles (HPVs), such as α-pinene, turpentine and related chemicals, were the main attractants used alone or in combination with ethanol for conifer-infesting cerambycids. More recent studies have shown that HPVs may strongly synergize the attraction of cerambycid beetles to their pheromones, yet less is known about the possible role of angiosperm HPVs as attractants with pheromones. To explore the extent of this synergism, a recent study tested the responses of a cerambycid community to a generic pheromone blend in the presence or absence of chipped material from host plants, and also with reconstructed blends of oak and conifer volatiles (Collignon et al. 2016). The main objectives were to determine whether volatiles from fresh host plant material affected the attraction of cerambycids to their pheromones and to test blends of HPVs reconstructed using synthetic chemicals at various release rates with and without pheromones.

In the first experiment which tested the influence of chipped host tree material, results suggested that HPVs enhanced the attraction of conifer-infesting cerambycids to pheromone lures, while oak-infesting species were not influenced by oak volatiles and the attraction of some species was inhibited by odors from non-host conifer material. For the second phase of the experiment, reconstructed HPV blends were developed based on the volatiles collected from the same chipped materials used in the first round of assays. Again, the conifer-infesting species generally exhibited increased responses with increasing release rates of conifer volatiles, whereas the responses of oak-infesting species generally decreased with increasing release rates of reconstructed blends of both oak and conifer volatiles. When comparing high- release rate conifer blend with high-release rate α-pinene as a single component, species responses varied: *Asemum nitidum* was most attracted to pheromones+ α-pinene, whereas *Neospondylis upiformis* was most attracted to pheromones+ conifer volatiles and ethanol. For oak-infesting species in the subfamily Cerambycinae, neither synthetic oak blend nor ethanol increased attraction to pheromones, with the exception of *Phymatodes grandis* which was most attracted to pheromones+ ethanol. HPV release rates were also important with some high rates being antagonistic for oak-infesting species, but acting synergistically for conifer-infesting species. Thus, the choice of which HPVs to use for trapping a given species or subset of species requires careful consideration.

The CFIA's Plant Health Surveillance Unit is assessing the utility and efficacy of traps that target multiple pests. The option to survey for multiple target pests at a given survey site would facilitate a streamlined approach while minimizing survey resource requirements. Trap prototypes have been designed using green delta sticky trap for attraction of emerald ash borer, gypsy moth and other potential survey targets using pest-specific lures. There are also experiments underway with lures that are non-specific, but still attract a number of beetles that may be of concern. This has paid off, with a recent post-border interception of a new *Xylotrechus* species near warehouses. Research such as that outlined in this paper certainly help that process along, and provide new ideas for lures that can be tested.

SOURCE: Collignon, R.M., Swift, I.P., Zou, Y., McElfresh, J.S., Hanks, L.M. and Millar, J.G. (2016) The Influence of Host Plant Volatiles on the Attraction of Longhorn Beetles to Pheromones. Journal of Chemical Ecology 42(3): 215-229.

11 Projects: Sentinel research on a global scale

The International Plant Sentinel Network (IPSN) was developed as part of a European Phytosanitary Research Cooperation (EUPHRESCO) project to facilitate collaboration amongst institutes around the world. Since its launch in 2013, the IPSN has worked to establish a network of botanic gardens, arboreta, research and National Plant Protection Organizations (NPPOs) working collaboratively to carry out sentinel research and provide an early warning system for new and emerging pest and pathogen risks. A short communication written by the IPSN Coordinator, Ellie Barham, from Botanic Gardens Conservation International (BGCI), was recently published in the journal *Plant Biosystems* to highlight the objectives of the network and opportunities that exist through sentinel research (Barham 2016).

The following is a link to the ISPN website where more information can be found on the project and its participants:
http://www.plantsentinel.org/index/

CFIA is a member of EUPHRESCO - a network of research funders and program managers among countries with similar plant health research needs. The key function of EUPHRESCO is to facilitate international collaborative research projects on phytosanitary topics of mutual interest. Canada is currently involved in several collaborative projects through this organization and has access to research outputs which can be used by the plant health community to inform plant protection.

In addition, the CFIA's Plant Health Surveillance Unit has collaborated with Northeastern Forestry University (Harbin, China), the Chinese Academy of Sciences (Beijing) and the USDA Forest Service to develop a sentinel tree program in northeast China which monitors wood-boring insects that could be a threat to North America. This collaborative project assesses species-specific trapping systems with emphasis on testing different trap colours for *Agrilus* sp., attraction of ethanol to *Scolytoplatypus tycon* and *Pityophthorus morosovi* and rearing of potential pest species from standing trap trees and trap log decks reflecting host species significant to North America. As the volume of Asian imports increases, there is increased likelihood that additional wood borers will arrive in Canada through solid wood packaging material such as pallets, crates, skids, etc. used to convey consignments. The results of the sentinel tree program are used by Plant Health Programs and the Plant Health Risk Assessment Unit to improve foresight capabilities.

SOURCE: Barham, E. (2016) The unique role of sentinel trees, botanic gardens and arboreta in safeguarding global plant health, Plant Biosystems – An International Journal Dealing with all Aspects of Plant Biology 150:3: 377-380 DOI: 10.1080/11263504.2016.1179231

Botany

12 New pest: Japanese chaff flower spreading in the U.S.

Japanese chaff flower (*Achyranthes japonica* (Miq.) Nakai), a perennial herbaceous plant of the Amaranth family (Amaranthaceae), is emerging as an invasive plant threat in the U.S. Midwest and Upper South. Originating from East Asia, it was discovered in 1981 in Martin County, Kentucky and has quickly spread to about 50 counties in nine states. It is particularly prevalent along the Ohio River. Although not regulated at the U.S. federal or state level, it is being actively controlled in most states where present.

The environmental impacts of this species are causing concern. Unlike most invasive plant species, Japanese chaff flower potentially poses a greater threat to highly diverse natural areas than to disturbed areas. It grows in a variety of habitats, including forests and along the margins of rivers, floodplains, ditches and agricultural fields, in both

sunlit and deeply shaded sites, where it forms dense populations (70+ plants per m^2) and displaces many native species.
Japanese chaff flower was evaluated to be a "high risk" species in a USDA-APHIS weed risk assessment. Biological characteristics that contribute to its high invasive potential include prolific seed production (up to 16,000 seeds per m^2) and high seed viability, which lead to high propagule pressure and rapid spread. Dispersal of the fruits is facilitated by two stiff bracts that attach to clothing, shoes, feathers and fur; it is also readily dispersed by water. The plants tolerate browsing and mowing, and respond by increasing seed output. Furthermore, in addition to its environmental impacts, Japanese chaff flower is reported as a common agricultural weed in its native range.

Japanese chaff flower is of potential concern to Canada. It is estimated to be hardy to USDA plant hardiness zone 5, which in Canada includes significant areas of British Columbia, southern Ontario and Quebec as well as the Maritime provinces. Within these areas, there are likely habitats suitable for the establishment and spread of this invasive species.

SOURCES: Rathfon, R. and Eubank, E. (2013) Invasive plant series. Fact sheets. FNR-477-W. Japanese chaff flower *Achyranthes japonica* (Miq.) Nakai. Southern Indiana Cooperative Weed Management Area. Purdue University Cooperative Extension Service. 4 pp.

Schwartz, L. M., Gibson, D. J. and Young, B. G. (2016) Life history of *Achyranthes japonica* (Amaranthaceae): an invasive species in southern Illinois. Journal of the Torrey Botanical Society 143(2): 93-102.

USDA-APHIS. (2014) Weed Risk Assessment for *Achyranthes japonica* (Miq.) Nakai – Japanese chaff flower. USDA-APHIS-PPQ-CPHST-PERAL, Raleigh, NC. 15 pp.

Biotechnology

13 Update: Improving the stewardship of herbicide-tolerant crops

Herbicide-tolerant crops are widely planted in Canada. These crops allow growers to spray their fields with a broad-spectrum, nonselective herbicide (glyphosate, for example) – the crops live, the weeds die. Growers can apply herbicides when the crop is growing, reducing the need for tillage that can disturb the soil. Simpler management can save time, and herbicide-tolerant crops may mean growers can manage more acres. Growers can also control some weeds closely related to the herbicide-tolerant crop that would normally be difficult to kill without killing the crop itself.

The use of herbicide-tolerant crops can increase herbicide resistance in weeds. Currently, there are 250 species (145 dicots and 105 monocots) of resistant weeds worldwide (weedscience.org). Weeds have evolved resistance to 23 of the 26 known herbicide sites of action and 160 different herbicides. Factors that can increase resistance in weeds include the frequent or exclusive use of the same herbicides, limited diversity in weed control practices, and no mandated herbicide tolerance management program (Lamichhane et al. 2016). When growers are faced with weeds that are not controlled by herbicides as expected, they may increase the amount of herbicide applied or switch to herbicides with greater environmental impact. Lamichhane et al. (2016) suggest changes to strengthen integrated weed management and ensure sustainable deployment of herbicide-tolerant crops, especially in the European Union where these crops have yet to be widely planted.

The recommendations were developed by considering weed management in countries currently regulating herbicide-tolerant crops, including Canada.

Recommendations include:

- Incorporate multi-year crop rotations when developing best management practices
- Implement mandatory grower courses on stewardship
- Use regulation and legal means to maximize stewardship compliance
- Demonstrate the long-term profitability of integrated weed management
- Increase growers' awareness about the need to enhance biodiversity
- Foster awareness-raising programs
- Coordinate responses to resistant weed populations
- Provide incentives for research related to non-herbicidal integrated weed management practices
- Clarify the relationship between legislation for pesticides and plants with novel traits to avoid duplication and gaps

Recently, interest in managing herbicide-tolerant crops in an integrated weed management system has increased. Integrated weed management involves the use of multiple strategies to manage weed populations in an economically and environmentally sound way. Adoption and improvements to integrated weed management can result in benefits including reduced herbicide use and the delayed evolution of resistance in weeds. A recent special issue of *Weed Science* focuses on the socioeconomic, policy, and regulation of herbicide tolerance management (Open access: http://www.wssajournals.org/toc/wees/64/sp1).

This special issue will be a valuable resource as strategies to manage new weed issues are developed in Canada and to extend the durability of weed management technologies.

SOURCE: Lamichhane, J. R., Devos, Y., Beckie, H. J., Owen, M. D., Tillie, P., Messéan, A. and Kudsk, P. (2016) Integrated weed management systems with herbicide-tolerant crops in the European Union: lessons learnt from home and abroad. Critical reviews in biotechnology, 1-17.

14 New Technology: Omega-3 canola

Omega-3 long-chain polyunsaturated fatty acids (LC-PUFAs), like alpha-linolenic acid (ALA), docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), are essential dietary fats that support the normal growth and development of the brain, nerves and eyes in young children (Nutrient Function Claims 2016). PUFAs may also prevent fatal coronary heart disease, total coronary events and inflammatory disorders (FAO/WHO 2008). Marine oils are fantastic dietary sources of DHA and EPA, and plant oils can provide ALA. Unfortunately, Western diets are markedly deficient in these food sources and omega-3 PUFAs (Simopoulos 2006).

Industry has shown interest in developing and marketing crops with modified fat profiles. In Canada, Laurical™ Canola (1996), as well as Treus™ (2009) and Vistive Gold™ (2011) Soybean have all received regulatory approvals for unconfined environmental release, as well as for animal feed and human food. There are no crops in Canada that possess modified fat profiles with DHA and EPA, which would address our dietary PUFA deficiency. However, part of the reason for this is that until recently LC-PUFA fortification required 7 or more genes to be transgenically introduced into oilseed crops. A recent Nature Biotechnology paper has reported canola LC-PUFA fortification by an alternative approach which required the introduction of only 4 microbial genes – a far more manageable goal (Walsh et al. 2016).

Scientists at Dow AgroSciences identified microbial PUFA synthases and introduced them into canola. This enzyme class contains all the functional domains necessary to take primary metabolites and convert them directly to LC-PUFAs without generating any unwanted metabolic intermediates – an unfortunate by-product of algal pathway which contributes to off flavours and product instability. Remarkably, these PUFA synthases harvest cytosolic malonyl-CoA, a valuable metabolic resource that's available in modern canola and which had previously been used to make erucic acid in rapeseed. As a result, this bio fortification strategy seems to be uniquely suited for canola.

Dow's LC-PUFA fortified transgenic canola produced commercial levels of DHA (3.7% total oil) and EPA (0.7% total oil) and was agronomically comparable to the non-transgenic counterpart when grown in field conditions. Remarkably, the experimental lines – which weren't elite oilseed lines – accumulated enough LC-PUFAs to provide the FAO/WHO recommended dietary amount of total omega-3 PUFAs in a reasonable serving.
It is unclear when, if ever this DHA and EPA fortified canola variety will be seen by Canadian regulators for pre-market safety assessment. What is clear is that there are remarkable opportunities in agricultural spaces to address our dietary LC-PUFA deficiency through metabolic engineering.

SOURCES: Nutrient Function Claims (2016) [Online] Available: http://www.inspection.gc.ca/food/labelling/food-labelling-for-industry/health-claims/eng/1392834838383/1392834887794?chap=8#s16c8 [August 2016]

Joint FAO/WHO Expert Consultation on Fats and Fatty Acids in Human Nutrition (2008) [Online] Available: http://www.who.int/nutrition/topics/FFA_summary_rec_conclusion.pdf [August 2016]

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Walsh, T., Bevan, S., Gachotte, D., Larsen, C., Moskal, W., Merlo, P., Sidorenko, >, Hampton, R., Stoltz, V., Pareddy, D., Anthony, G., Bhaskar, P., Marri, P., Clark, L., Chen, W., Adu-Peasah, P., Wensing, W., Zirkle, R. and Metz, J. (**2016**) Canola engineered with a microalgal polyketide synthase-like system produces oil enriched in docosahexanenoic acid. Nature Biotechnology 34(8): 881-889.

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