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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.

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Pathology

1 First report: Grapevine flavescence dorée phytoplasma in Germany

The NPPO of Germany has reported the first record of Grapevine flavescence dorée phytoplasma on its territory. The pathogen was detected on November 1st, 2014 in grapevine (*Vitis vinifera* cv. Chardonnay/SO4) in a nursery that is officially registered for the production of grapevine plants, located in Rheinland-Pfalz (Rhineland-Palatinate). Diseased grapevine plants showed typical symptoms of flavescence dorée.

Investigations have been initiated to determine the possible origin of the infection. The lot included 4400 grafted plants. Scion and rootstock originated from Germany and an Italian nursery, respectively. The vector of the disease, *Scaphoideus titanus* (Hemiptera: Cicadellidae), is not known to occur in Germany.

Phytosanitary measures have been taken to eradicate the disease. The movement of plants grafted on rootstocks from the same origin has been forbidden and survey activities are on-going.

The pest status of Grapevine flavescence dorée phytoplasma in Germany is officially declared as: transient, only at one location in Rhineland-Palatinate, under eradication.

Grapevine flavescence dorée phytoplasma is a regulated pest in Canada.

Source: EPPO reporting service no. 11. 2014/202 First report of Grapevine flavescence dorée phytoplasma in Germany.

2 Interception: *Dickeya solani* intercepted in China on hyacinth bulbs imported from the Netherlands

A recent issue of Plant Disease reports the interception of *Dickeya solani* (a major potato pathogen in Europe) in China on imported bulbs of *Hyacinthus orientalis* from the Netherlands. The report states that the bulbs "gave off an offensive odour" and exhibited symptoms of internal rotting and brown discolouration. Researchers used the isolated strains from the hyacinth bulbs to infect potato plants. Infected potato plants showed typical symptoms of *D. solani* infection.

Dickeya solani is a bacterial pathogen that causes considerable damage to potato production in Europe. This report demonstrates that the importation of hyacinth bulbs from the Netherlands presents a potential pathway for the introduction of this pathogen to Canada.

Source: Chen, X.F., Zhang, H.L. and J. Chen. 2015. First report of *Dickeya solani* causing soft rot in imported bulbs of Hyacinthus orientalis in China. Plant Disease 99(1): 155. URL: http://apsjournals.apsnet.org/doi/abs/10.1094/PDIS-09-14-0916-PDN

Entomology

3 First Report: *Anoplophora chinensis* detected in Turkey

The citrus long-horned beetle, *Anoplophora chinensis,* (Coleoptera; Cerambycidae) has been detected for the first time in Turkey, arriving through ornamental trade. The detection occurred in a nursery in Istanbul on *Salix* and *Acer.* Although the reporting article does not state that the country considers the beetle to be established, photographs of exit holes on planted trees and adult feeding suggest it has been present for at least a couple of years.

This is a new record for this beetle which has a propensity for moving with international trade in ornamental plants. It has been intercepted once entering Canada, introduced on several occasions into Europe and detected in and subsequently eradicated from the United States.

The citrus long-horned beetle is a wood-borer that is native to Asia. It feeds on and damages a wide variety of hardwood trees, including many important species in Canada. Longhorned beetles (*Anoplophora* spp.) are regulated pests in Canada.

Source: Hızal, E., Arslangündoğdu, Z., Göç, A., and Ak, M. 2015. The new record for Turkish invasive alien insect fauna *Anoplophora chinensis* (Forster, 1771) (Coleoptera: Cerambycidae). Journal of the Faculty of Forestry, Istanbul University 65 (1): 7-10.

4 Review: Categorizing hosts of *Anoplophora glabripennis*

Conflicting information regarding the host status of species reported as hosts of the Asian longhorned beetle, *Anoplophora glabripennis*, (Coleoptera; Cerambycidae), has led to the publication of an EPPO Bulletin that categorizes 34 plant taxa, identifying those that are considered to be true hosts, i.e. supporting completion of the full life cycle. *Anoplophora glabripennis*-hosts were placed in four categories based on a literature search and communication with experts. The categories include: (I) plant species on which *A. glabripennis* has been reported to complete its life cycle (from oviposition to emergence of new beetles) under field conditions, (II) plant species on which *A. glabripennis* has completed its life cycle in laboratory or semi-field experiments (i.e. plants and beetles reared in cages), (III) plant species on which *A. glabripennis* has been reported to complete part of its life cycle and (IV) others.

The following genera were placed in category I: *Acer*, *Aesculus*, *Betula*, *Cercidiphyllum*, *Fraxinus*, *Platanus*, *Populus*, *Salix* and *Ulmus*. The species *Albizia julibrissin*, *Corylus colurna*, *Elaeagnus angustifolia*, *Fagus sylvatica*, *Koelreuteria paniculata*, *Malus domestica*, *Pyrus bretschneideri* and *Sorbus aucuparia* were also placed in category I, although records on exit holes were limited. These species may be poor or unattractive hosts on which *A. glabripennis* only incidentally completes its life cycle or the species may be rather uncommon in outbreak areas thus far and, therefore, not frequently attacked.

A document that was recently completed by the CFIA's Plant Health Risk Assessment Unit (2014-37.02 List of high risk host genera for the Asian Longhorned Beetle) is complemented by this bulletin. It may be of use when designing surveys for infested trees or removal of primary hosts from an infested area.

Source: Gaag, D. J. v. d. and Loomans, A. J. M. 2014. Host plants of *Anoplophora glabripennis*, a review. EPPO Bulletin 44(3): 518-528.

5 Pest List: Countries identified as 'risky' by EU

The European Union has published a list of trades (commodity/exporting country combinations) that are considered high risk due to the frequent interception of plant pests. The table is based on interceptions made by EU Member States and Switzerland in the notification system EUROPHYT from February 2014 – February 2015.

A country is listed if the number of pest interceptions is greater than 20, the number of pest interceptions with planting material is greater than five or the number of pest interceptions with a commodity is greater than five. A commodity is listed if the number of pest interceptions from the trading country is greater than five.

The list includes some significant trade partners for Canada. From China, for instance, 169 interceptions were made in 2014, 131 on wood packaging, of those nearly all were wood-boring beetles. India also exported many bark beetles to the EU (4th on the list), and while fruit flies and leaf miners together comprise most of the interceptions from elsewhere, other significant pests were also noted (e.g. weevils, false codling moth). While this list is heavily biased by EU importation sources, importation volumes and commodity, it supports the concern that many insects are still moving on wood packaging.

Source: European Commission. 2015. Non-EU Trade Alert List. Available: http://ec.europa.eu/food/plant/plant_health_biosecurity/non_eu_trade/alert_list/index_en.htm [March 13, 2015].

Botany

6 Pest List: New Species Listed under Ontario's Weed Control Act

Changes to Ontario's *Schedule of Noxious Weeds* under the provincial *Weed Control Act* came into effect January 1, 2015. The province de-listed nine weeds no longer considered a significant threat to agricultural or horticultural production, and listed nine new species considered new and emerging threats of concern to the province. The total number of weed species remains the same (25) and the full list can be viewed at: http://www.e-laws.gov.on.ca/.

The species removed from the Schedule are: Goat's beard (*Tragopogon* spp.), nodding thistle (*Carduus nutans* L.), Scotch thistle (*Onopordum acanthium* L.), wild carrot (*Daucus carota* L.), Johnson grass (*Sorghum halepense* (L.) Pers.), black-seeded proso millet (*Panicum miliaceum* L.,), yellow rocket (*Barbarea* spp.), Russian thistle (*Salsola tragus* L.; syn. *Salsola pestifer* A. Nels.) and tuberous vetchling (*Lathyrus tuberosus* L.). These species are no longer considered a threat in Ontario as they can be controlled by modern management practices; some have also been identified as having benefits as a food source for pollinators (e.g., bees).

The new species added to the Schedule are: smooth bedstraw (*Galium mollugo* L.), wild chervil (*Anthriscus sylvestris* (L.) Hoffmann), common crupina (*Crupina vulgaris* Cass.), jointed goatgrass (*Aegilops cylindrica* Host), kudzu (*Pueraria montana* (Lour.) Merr.), wild parsnip (*Pastinaca sativa* L.), serrated tussock (*Nassella trichotoma* Hackel ex Arech), tansy ragwort (*Senecio jacobaea* L.) and woolly cupgrass (*Eriochloa villosa* (Thunb.) Kunth). These are considered new or potential threats to the province. The listing gives weed inspectors the authority to control their movement, and to destroy or require the destruction of plants on both public and private land.

Several of the newly listed weed species are also regulated as pests by the Canadian Food Inspection Agency (CFIA) under the *Plant Protection Act*. As such, these changes bring Ontario's weed control legislation into closer alignment with the federal regulation of weeds and invasive plants in Canada.

Sources: Andrews, B. 2015. Kudzu joins old standbys like giant hogweed. Chatham This Week. [Online] Available: http://www.chathamthisweek.com/2015/02/12/kudzu-joins-old-standbys-like-giant-hogweed [Accessed February 24, 2015].

OMAFRA. 2015. Weeds in Ontario. Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA). [Online] Available: http://www.omafra.gov.on.ca/english/crops/insects/weeds.html. [Accessed February 24, 2015].

7 Pest List: Risk Assessment for Proposed Biofuel Crops: A White List Approach

The introduction of new biofuel crops presents a policy challenge as the traits that make species desirable as carbon sources for alternative energy production are often the same as those associated with invasiveness (e.g., high rates of establishment, rapid biomass accumulation, ability to thrive on unproductive land). Regulation of invasive species can have a significant impact on bioenergy companies, particularly if they make large investments in the development of new crops that are later deemed problematic by regulators. Risk assessment can be used to distinguish between low and high-risk species, but has traditionally been used to develop “black lists” which offer bioenergy companies few useful alternatives. In a paper recently released in the U.S., the authors propose an alternative “white list” approach; they offer a list of low invasion risk biofuel crops that could be used by both companies and government to fast track approval or reduce liability for producers using low risk species.

To generate the list, they created a database of 120 vascular plants identified in the literature as potential or actual feedstock crops for bioenergy production. They then used results from the Australian Weed Risk Assessment (WRA) system to divide species into low risk, high risk, or undetermined (“evaluate further”) categories. The WRA system is widely recognized and has demonstrated accuracy (>90%) in predicting major invaders across a range of geographies. The authors automatically included all native taxa (24 of 120) on the white list to encourage the selection of native feedstocks wherever possible. They then included all non-native species that had low risk results from the risk assessment (25) and excluded those that received high risk or indeterminate scores, or that were listed as Federal Noxious Weeds in the U.S. The resulting white list includes 49 species with low invasion risk status and favourable agronomic properties for much of the U.S., or in more specific “niche” habitats (e.g., agave in the arid southwest). The list also includes sources that mention the bioenergy potential for each taxon, to help identify those with the most potential for government support and returns on investment.

This white list offers a starting point for bioenergy companies and for policy development at the federal and/or state levels in the U.S., and has the potential to reduce conflict among agencies that support bioenergy and those that regulate invasive species. A similar approach could be considered for Canada.

Source: Quinn, L. D., Gordon, D. R., Glaser, A., Lieurance, D. and Flory, S. L. 2014. Bioenergy feedstocks at low risk for invasion in the USA: a “white list” approach. BioEnergy Research DOI 10.1007/s12155-014-9503-z.

Biotechnology

8 Survey: Herbicide resistant kochia weed, *Kochia scoparia* L. Schrad., now found in Saskatchewan and Manitoba

Glyphosate is a herbicide of choice for many producers as it controls a broad-spectrum of weeds in glyphosate-resistant crops such as canola (*Brassica napus* L.), corn (*Zea mays* L.), soybean (*Glycine Max* L. Merr.) and sugar beet (*Beta vulgaris* L.). This herbicide is mainly used in (i) chemical-fallow fields, (ii) pre-seeding in zero-tillage systems and (iii) pre- and post-harvest control in glyphosate-resistant crops. Frequent glyphosate use, without other management practices, increases the selection pressure for resistant weed biotypes. Previous surveys have documented the occurrence of glyphosate-resistant (GR) kochia in southern Alberta in 2011 and 2012. The resistant populations mostly originated in chemical-fallow fields, but some populations were also found in non-crop areas such as ditches and railway right-of-ways adjacent to agricultural areas. The GR kochia populations identified in these surveys were also resistant to ALS-inhibiting herbicides (i.e. group 2 herbicides). As kochia is an abundant weed in the neighbouring provinces of Saskatchewan and Manitoba, similar surveys were necessary to determine the geographical extent of this GR weed. Thus, in the fall of 2013, surveys were conducted across southern and central regions of Saskatchewan and across southern Manitoba, to determine the distribution and abundance of GR kochia. Similar to Alberta GR kochia populations, the majority of the Saskatchewan GR kochia populations originated in chemical-fallow fields, while some were found in cropped fields (wheat, *Triticum aestivum* L.; lentil, *Lens culinaris* Medik.; and canola) and non-cropped areas (oil well sites and roadside ditches). Whereas in Manitoba, two GR kochia populations were found in fields cropped to GR corn and GR soybean, because chemical-fallow practices are much less frequent in this province in comparison to the other two Prairie Provinces. However based on the surveys, GR kochia is strongly associated with chemical-fallow, which questions the justification for including fallow in the rotation. The Saskatchewan and Manitoba GR kochia populations were also ALS inhibitor-resistant, but are susceptible to dicamba, an increasingly important auxinic herbicide (i.e. group 4 herbicide) used for control of this multiple-resistant weed biotype.

The CFIA conducts risk assessments for the unconfined environmental release of plants with novel traits (PNTs). For PNTs that express a herbicide tolerant trait, a herbicide tolerant management (HTM) plan is required. HTM plans are designed to delay weeds and species related to a herbicide-tolerant crop plant from developing tolerance to herbicides. In addition, HTM plans are designed to address the occurrence of herbicide tolerant volunteers and volunteers with resistance to multiple herbicides. Herbicide management plans together with production practices are essential to ensure continued efficacy of these herbicides and for reducing the selection pressure for resistance in other field sites.

Source: Beckie, H. J., Gulden, R. H., Shaikh, N., Johnson, E. N., Willenborg, C. J., Brenzil, C. A., Shirriff, S. W., Lozinski, C. and Ford, G. 2015. Glyphosate-resistant kochia (*kochia scoparia* L. Schrad.) in Saskatchewan and Manitoba. Canadian Journal of Plant Science 95: 1-5.

9 Review: Evolution of pest resistance in pyramided Bt crops

Pyramided *Bacillus thuringiensis* (Bt) crops are designed to delay the evolution of resistance by producing two or more distinct Bt toxins that kill the same pest. Although most cases of evolution of resistance involve single-toxin crops, some populations of *Helicoverpa zea* (Lepidoptera) in the southeastern United States have evolved resistance to pyramided Bt cotton (Tabashnik et al.

2008, 2013).

A recent review by Carrière et al. (2015) assessed the potential for pyramids to delay the evolution of resistance by analyzing data from 38 studies reporting the effects of Bt toxins used in transgenic crops. The authors' found that key factors affecting the durability of pyramids often deviate from the assumed ideal conditions used in computer simulation models to create resistance management strategies. In many cases, the crops' actual efficacy did not meet the assumption that if each toxin is highly effective on its own and two toxins act independently, the pyramid should kill at least 99.7% of Bt-susceptible pests. In addition, they found that selection for resistance to one toxin often causes cross-resistance to another toxin in a pyramid. Furthermore, by analyzing the three-domain structure of Bt toxins, the authors' identified a positive association between amino acid similarity of domain II and cross-resistance, and an increased likelihood of antagonistic effects between toxins with amino acid similarity of domain III.

Factors such as these are rarely considered in computer simulations and could assist in choosing more realistic values for key parameters, leading to more sustainable resistance management strategies. With the technology that is currently available, it is possible to swap domains and engineer Bt toxins with desired domain configuration. The information provided in this study could therefore also help the design of toxins used in pyramids.

Sources: Carrière, Y., Crickmore, N. and Tabashnik, B. E. 2015. Optimizing pyramided transgenic Bt crops for sustainable pest management. Nature biotechnology 33(2): 161-168.

Tabashnik, B.E., Brévault, T. and Carrière, Y. 2013. Insect resistance to Bt crops: lessons from the first billion acres. Nature biotechnology 31: 510-521.

Tabashnik, B.E., Gassman, A.J., Crowder, D.W. and Carrière, Y. 2008. Insect resistance to Bt crops: evidence versus theory Nature Biotechnology 26: 199-202.

10 First Report: Full crop protection against the Colorado potato beetle by expression of long double-stranded RNA

All currently authorized insect-resistant plants in Canada express insecticidal proteins derived from the soil bacterium *Bacillus thuringiensis* (Bt). The agricultural biotechnology industry has only recently begun to develop insect-resistant plants using RNA interference (RNAi). This technology relies on the interference or suppression of gene expression, initiated by double-stranded RNA (dsRNA). The application of this concept in plant protection is hindered by the presence of an endogenous plant RNAi pathway that processes dsRNA into short interfering RNAs. The article reports that long dsRNA can be stably produced in chloroplasts (termed a transplastomic plant), an organelle that appears to lack RNAi machinery. When expressed from the chloroplast genome, dsRNA accumulated to as much as 0.4% of the total cellular RNA. Transplastomic potato plants producing dsRNA targeted against the β-actin gene of the Colorado potato beetle, *Leptinotarsa decemlineata* (Chrysomelidae), a serious agricultural pest in Canada, exhibited a high degree of protection against insect feeding damage. Moreover, first instar larvae exhibited 100% mortality after 5 days of feeding. All transplastomic potato plants displayed no visible phenotype and were indistinguishable from wild-type plants, both under in vitro culture conditions and in the greenhouse, indicating that dsRNA expression in the chloroplast does not confer a phenotypic change.

Because Colorado potato beetle larvae and adults feed on leaves but not on below-ground tubers, only the leaves require protection against insect feeding. Non-photosynthetic tissues, such as tubers, express chloroplasts at much lower levels than leaves. Therefore, despite whole-plant transformation, dsRNA production in tubers, where accumulation of transgene-derived RNA is unnecessary and perhaps undesired by the consumer, was below or near the detection limit.

The CFIA and Health Canada are responsible for regulating the environmental release, livestock feed and human food uses of plants with novel traits (PNTs), including Bt crops. Given recent reports of resistance development to Bt proteins by certain pests, RNAi technology is becoming a promising future strategy for plant protection.

Source: Zhang, J., Khan, S.A., Hasse, C., Ruf, S., Heckel, D.G. and Bock, R. 2015. Full crop protection from an insect pest by expression of long double-stranded RNAs in plastids. Science 347 (6225): 991-994.

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