Illegal gene flow from transgenic creeping bentgrass: the saga continues

ALLISON A. SNOW
Department of Evolution, Ecology, and Organismal Biology, The Ohio State University, Columbus, OH 43210, USA

Ecologists have paid close attention to environmental effects that fitness-enhancing transgenes might have following crop-to-wild gene flow (e.g. Snow et al. 2003). For some crops, gene flow also can lead to legal problems, especially when government agencies have not approved transgenic events for unrestricted environmental release. Creeping bentgrass (Agrostis stolonifera), a common turfgrass used in golf courses, is the focus of both areas of concern. In 2002, prior to expected deregulation (still pending), The Scotts Company planted creeping bentgrass with transgenic resistance to the herbicide glyphosate, also known as RoundUp®, on 162 ha in a designated control area in central Oregon (Fig. 1). Despite efforts to restrict gene flow, wind-dispersed pollen carried transgenes to florets of local A. stolonifera and A. gigantea as far as 14 km away, and to sentinel plants placed as far as 21 km away (Watrud et al. 2004). Then, in August 2003, a strong wind event moved transgenic seeds from windrows of cut bentgrass into nearby areas. The company’s efforts to kill all transgenic survivors in the area failed: feral glyphosate-resistant populations of A. stolonifera were found by Reichman et al. (2006), and 62% of 585 bentgrass plants had the telltale CP4 EPSPS transgene in 2006 (Zapiola et al. 2008; Fig. 2). Now, in this issue, the story gets even more interesting as Zapiola & Mallory-Smith (2012) describe a transgenic, intergeneric hybrid produced on a feral, transgenic creeping bentgrass plant that received pollen from Polypogon monspeliensis (rabbitfoot grass). Their finding raises a host of new questions about the prevalence and fitness of interpigeneric hybrids, as well as how to evaluate the full extent of gene flow from transgenic crops.

Keywords: feral, gene flow, genetically modified organisms, hybridization, naturalized

Received 24 April 2012; revision received 26 May 2012; accepted 4 June 2012

To date, only a few other cases of spontaneous gene flow from transgenic crops to wild, weedy, or feral populations have been reported (e.g. Hall et al. 2000; Warwick et al. 2008; Schafer et al. 2011), although others are likely to follow when more species of transgenic crops are released near compatible relatives. For example, transgenic rice has been cultivated near weedy rice in the USA and China (where it is still regulated), and genetically engineered traits are expected to spread to conspecific weedy rice populations (Yang et al. 2011).

During 2003–2006, Zapiola et al. (2008) screened hundreds of in situ bentgrass plants and thousands of their progeny to test for glyphosate resistance. A glyphosate-resistant plant found inside the control area in 2005 produced a transgenic seedling that appeared to be a hybrid. Using a combination of nuclear and maternally inherited DNA markers, the authors identified this ‘off-type’ seedling as an intergeneric hybrid with rabbitfoot grass. The F₁

Fig. 1 Creeping bentgrass and rabbitfoot grass occur along canals and irrigation ditches within the designated control area near Madras, Oregon. Photo courtesy of M. L. Zapiola.

Fig. 2 A feral, glyphosate-resistant creeping bentgrass plant established along a ditch within the control area. Photo courtesy of M. L. Zapiola.
hybrid produced stolons, flowered without vernalization, and produced 14 viable seeds from 90 florets in bagged panicles. The current *Agrostis* study is noteworthy because:

1. This is the first report of spontaneous gene flow resulting in a transgenic, intergeneric hybrid;
2. It is a clear example of the otherwise poorly understood extent of spontaneous hybridization in *Agrostis* and *Polygopon* spp.;
3. In this context, herbicide resistance from a known transgenic event (ASR368) provided a powerful method for tracking and understanding gene flow in the *Agrostis* complex;
4. The study provides valuable information regarding gene flow in a naturalized, non-native, perennial, outcrossing species that is considered to be a weed in some crops and nonagricultural habitats in the USA and elsewhere; and
5. These results question the efficacy of the stringent procedures put in place for preventing unintended gene flow from field trials of regulated transgenic plants.

Public-sector researchers have been very resourceful in taking advantage of this ‘natural experiment’ in the face of miss-steps and ongoing eradication efforts by The Scots Company.

Previously, Monsanto Company and Scotts had described the potential for intergeneric hybrids with rabbitfoot grass in a petition to USDA for nonregulated status (Frellich et al. 2003), stating that ‘on the rare occasions that hybrids have been noted, the hybrids have been sterile (Björkman 1960)’. Low fertility is common in hybrids and is not surprising here given that creeping bentgrass and rabbitfoot grass have different chromosome numbers. However, spontaneous backcrossing and/or loss of extra-

References

Björkman SO (1960) Studies in *Agrostis* and related genera. *Symbi-
ieae Botanicae Upsalienses XVII*, 1, 1–114.

glass (*Agrostis stolonifera*) event ASR368 for determination of nonregulated status. http://www.aphis.usda.gov/brs/aphis-
docs/03_10401p.pdf.

Hall L, Topinka K, Huffman J, Davis L, Good A (2000) Pollen flow between herbicide-resistant *Brassica napus* is the cause of multi-

Mallory-Smith C (2011) Paper presented at the 64th Annual Meet-
ing of the Western Society of Weed Science, Spokane, WA, USA, March 8.

Perez-Jones A, Martins B, Mallory-Smith CA (2010) Hybridization in a commercial production field between imidazolone-resis-

Reichman JR, Waltrud LS, Lee EH et al. (2006) Establishment of transgenic herbicide-resistant creeping bentgrass (*Agrostis stolo-
nifera*) in nonagronomic habitats. *Molecular Ecology*, 15, 4243–
4255.


Watrud LS, Lee EH, Fairbrother A et al. (2004) Evidence for land-

Yang X, Hiu X, Wang F et al. (2011a) Transgenes for insect resis-
tance reduce herbivory and enhance fecundity in advanced gener-


doi: 10.1111/j.1365-294X.2012.05695.x

© 2012 Blackwell Publishing Ltd