Agriculture and Human Values (2006) 23: 27–31
DOI 10.1007/s10460-005-5863-5

COMMENTARY

Transgenic maize and Mexican maize diversity: Risky synergy?

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Abbreviations: FV – farmer crop variety; MV – modern crop variety; RMP – risk management process; TGV – transgenic crop variety

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The two articles that begin this issue of *Agriculture and Human Values* discuss different aspects of the debate about the potential effects of transgenic varieties (TGVs) of maize on the maize diversity of small-scale farming in Mexico. Bellon and Berthaud in their paper, "Traditional Mexican agricultural systems and the potential impacts of transgenic varieties on maize diversity," focus on ways in which transgenes may enter and move within maize populations. In her article, "Importing corn, exporting labor: The neoliberal corn regime, GMOs, and the erosion of Mexican biodiversity," Fitting investigates the larger social context of those farming systems with a case study from Puebla state. In this commentary we will try to bring these two perspectives together in a broader context for those not familiar with the topic, showing how the genetic, ecological, and social issues are integrated at farm, North American, and global levels. We will give some examples from Oaxaca, the state just south of Puebla that continues to be the center of the transgenic maize controversy in Mexico, and where we have done research.

The risk management process

The risk management process (RMP) is the primary method used in the US and internationally for regulating TGVs (NRC, 2002, 2004a), and includes the analysis of risk based on empirical data and the evaluation of risk based on subjective values. The RMP for TGVs is explicitly based on a preexisting system for invasive alien species (NRC, 2002), and there is recognition that genes as well as species can be invasive biological entities (Hindar, 1999). Seed flow is the first step in gene invasion, followed by pollen flow, hybridization (i.e., fertilization between transgenic and non-transgenic plants), and introgression (i.e., the gene is incorporated into the host genome and stably inherited). The entire process is also referred to as gene flow and depends on a number of variables including the rate of seed and pollen flow and the relative and absolute fitness of the hybrids, which are determined by the genetic, ecological, and sociocultural processes that form agricultural landscapes (Ellstrand, 2003; Cleveland and Soleri, 2005). Thus, Bellon and Berthaud's three models are included in the RMP.

The extent and effects of biological invasion are context specific. This is why many scientists believe the RMP for TGVs should be conducted on a case by case basis (NRC, 2002; Andow and Hilbeck, 2004; Snow et al., 2005). However, the US government sees its version of the RMP as "the standard" and promotes its extrapolation to other countries (USDA APHIS BRS, 2004). For example, the USDA is not mandated to include consideration of risk for locations outside of the US (NRC, 2002), yet the information it uses to accompany transgenic crop exports strongly implies that because they have been approved in the US, they are therefore without risk for the rest of the world (Cleveland and Soleri, 2005).

Because Mexican maize agriculture is so different than maize agriculture in the US, the US RMP will not be adequate. Key differences are:

Genetic and ecological

Modern crop varieties (MVs) are sown on a relatively small proportion of Mexican maize area – 21% nationally and approximately 10% in Oaxaca, compared with 99% in the US (Aquino et al., 2001; Aragón Cuevas et al., 2005). Farmer varieties (FVs) in Mexico are much more genetically diverse than the MVs that dominate in the US. They are grown under much more diverse growing conditions (Aragón Cuevas et al., 2005) and are characterized by high levels of gene flow (Pressoir and Berthaud, 2004).

Economic

Most maize in Mexico is produced by small-scale farmers with few or no subsidies from the government. They use relatively low amounts of external inputs, plant seed of FVs they save or obtain through the informal system, and depend on this maize for food, as described by Fitting in her case study. By contrast, most maize in the US is produced by large-scale farmers with large subsidies from the government (EWG, 2005). These farmers use relatively high amounts of external inputs (e.g., nitrogen fertilizer, fossil fuel) (Nadal and Wise, 2004); plant MVs they buy commercially; and sell all of their maize, of which only a small amount is consumed directly as a cereal by US consumers (i.e., 2%) (Baker and Allen, 2005).

Social

On Mexico's small-scale maize farms the functions of genetic resource conservation, crop improvement, seed multiplication, food production, and food consumption are all integrated within households and communities. In the industrialized maize agricultural systems of the US, by comparison, each of these functions is physically and institutionally distinct (Soleri and Cleveland, 2004). This has a profound effect on how these functions occur, who does them, and what their goals are.

Cultural

Maize has been a center of cultural values for most of Mexico's diverse ethnic groups for millennia, and today farmers and consumers value different varieties of maize for different growing conditions, foods, and ceremonies (Fitting, 2006; Perales et al., 2005).

Involving Mexican farmers

One of the keys to making the RMP adequate for Mexico is including Mexican farmers, who have been left out of this process, even though some community and farmer organizations have made statements (e.g., Gonzalez, 2005) and have even carried out their own research on transgene presence (ETC Group, 2003). At a meeting in Oaxaca, the discontent of local communities over being left out of the decision-making was evident, and it focused on farmers' rights with respect to their maize FVs (Nadal and Wise, 2004), reflecting a history of exclusion from decisions that affect their agriculture and lives.

For example, it has been suggested that an important way in which maize diversity could be reduced is if farmers reject FVs they believe to be contaminated with transgenes (Bellon and Berthaud, 2006; Ortiz-Garcia et al., 2005). However, very little is known about Mexican farmers' knowledge and attitudes. In surveys of farmers in four Oaxacan communities, we found that only 12% (20/168) had heard about transgenic maize (Aragón Cuevas, Soleri and Cleveland, ms under preparation). When it was described to farmers, most (57%, 91/158) found the idea of transgenesis *per se* to be acceptable, although this varied significantly between communities. However, asked to evaluate some of the potential consequences of transgenic maize for their farming system (e.g., reliance on the formal seed system, initially high but declining yields due to evolution of pest resistance to a pesticidal transgene) as depicted in a scenario, a significant majority (89%, 148/167) preferred non-transgenic maize.

While our results show that the common assumption held by TGV opponents – that the process of transgenesis is culturally unacceptable to all small-scale farmers – is not supported, neither is the common assumption held by TGV proponents that farmer acceptance of transgenesis is tantamount to acceptance of TGVs. Consequences acceptable in industrial agriculture, such as yields responsive to improved environmental conditions and reliance on the formal crop improvement and seed multiplication and distribution systems, are perceived differently by these farmers. In addition, significant variation between some communities further supports the need for a case by case approach.

The biggest threat to Mexican maize diversity

The biggest threat to maize diversity in Mexico is the synergy between micro level genetic processes and macro level regional and global economic processes, which creates a situation that is more than the sum of its parts. For example, if a recent report, showing no evidence for the presence of transgenes in maize FVs in Oaxaca (Ortiz-Garcia et al., 2005), is interpreted as evidence of their absence, this will be strong support for not worrying about transgenic maize in Mexico.

This latest volley in the debate over transgenic maize (Ortiz-Garcia et al., 2005) is from the same area where transgenes were first reported to have been found in local FVs in 2001 (Quist and Chapela, 2001). Even though the authors warn against extrapolating to other locations or into the future (Ortiz-Garcia et al., 2005), their results have been interpreted as proof that if the 2001 report is accurate, then transgenes have disappeared. *Science* magazine even declared that "Mexico's transgenic maize scare appears to be over" (Kaiser, 2005). Transgenic variety proponents see it not only as "positively confirming" the absence of transgenes in FVs in the state of Oaxaca, but as support for approving transgenic maize for all Mexican farmers (Prakash, 2005).

However, it is not clear how representative the sample used in the recent study of maize growing in the Sierra Juárez actually is. It was a small sample (relative to the sampling universe) taken from a portion of the Sierra Juárez – Northern Highlands maize region in Oaxaca, a region containing a small proportion (3.5%) of the maize FV production area in Oaxaca (calculated from Aragón Cuevas et al., 2005). Also, the main economic activities there are based on forestry, not maize production, and the region may therefore be atypical of maize growing in Oaxaca. The speculations of Ortiz-Garcia et al. about why transgenes might have disappeared include that TGVs and TGV × FV hybrids may be less fit due to natural or farmer selection. This suggests that there is no cause to worry about transgene flow into landraces because transgenes won't persist. However, as Bellon and Berthaud point out, little is known about the fitness of TGVs or transgenes in FVs (Cleveland and Soleri, 2005).

The idea that it will always be possible to eliminate transgenes from FVs is unfounded. It may be possible to eliminate food containing transgenes, as in the case of Starlink[tm] maize from the US (Bellon and Berthaud, 2006), though even this is disputed (Mora, 2005). However, this should not be confused with eliminating transgenes introgressed into crop populations. Selectively neutral transgenes may persist until lost by genetic drift at a rate dependent upon their frequency in the population. Selectively advantageous transgenes will be very difficult and, in many cases, probably impossible to eliminate (NRC, 2004b). Even if farmers wanted to eliminate a transgene from their FV populations, it may be difficult for them to discriminate genetic from environmental variation under their highly variable growing conditions (Louette and Smale, 2000; Soleri et al., 2000; Soleri and Cleveland, 2001).

Interpreting the "absence of evidence of transgenes" based on an unrepresentative sample from one small area of one Mexican state as evidence of their absence in FVs in all of Mexico is unjustified. It could provide support for the continued high level of maize grain imports from the US to Mexico with its negative effects on small-scale maize farmers (Nadal and Wise, 2004). As Fitting points out, an important question then becomes: can a migration/subsistence maize economy maintain maize diversity? Her case study adds valuable insights into larger economic analyses.

Such interpretations could also translate into the reduced likelihood of controls on maize grain imported into Mexico. For example, milling at the border, as recommended by the Commission for Environmental Cooperation for North America to prevent planting as seed (CEC, 2004), and could provide justification for ending the ban on commercial planting of transgenic maize. Should the ban be lifted, it would increase the probability of transgene introgression into maize FVs with unknown consequences. In addition, the development of new transgenic MVs adapted to the marginal conditions where FVs grow today could lead to the increased probability of transgene introgression into FVs, as well as into teosinte, the wild ancestor of maize, with potential for diversity loss (Gepts and Papa, 2003). The necessity for zero contamination of maize that some scientists feel is warranted in light of the new pharmaceutical TGVs being developed (Andow et al., 2004) may also be more difficult to implement.

As Fitting argues, the threat to maize diversity in Mexico may not be only, or even primarily, from transgene movement into FVs, but from the national and international policies that seem to be undermining the viability of small-scale maize agriculture in Mexico. However, these micro and macro processes are often synergistically linked and driven by assumptions that not only devalue the traditionally-based maize agriculture of Mexican farmers, but also allocate limited resources to developing agricultural technologies such as TGVs whose primary purpose is not to address the increasingly urgent needs of these farmers (Cleveland, 2001). As the reknown plant breeder Norman Simmonds noted about the Green Revolution, a preferable option would have been to explore "other possibilities which might accord better with social needs" (Simmonds and Smartt, 1999: 352). Therefore, it is necessary to think beyond the RMP, and beyond international trade agreements, and ask how TGVs or alterative investments could decrease the threats to the biological and social diversity of maize in Mexico – diversity that is a precious global resource as well.

Acknowledgements

We thank the Oaxacan farmers we have worked with, and our colleague Flavio Aragón for their insights and support. This work partially funded by the Wallace Genetic Foundation and NSF (DEB-0409984).

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