European Network of Scientists for Social and Environmental Responsibility
TWN Third World Network
VDW Vereinigung Deutscher Wissenschaftler e.V.

Advancing the Understanding of Biosafety

Latest scientific findings,

policy responses and public participation

Lecture

Native Maize Landraces, Transgenic Maize, Food Security and Cultural Conflicts in México

Antonio Turrent Fernández

Session

Key Note Lectures

Nagoya

7. - 9. October 2010

Prof. Antonio Turrent Fernández
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), Mexico
and Unión de Científicos Comprometidos con la Sociedad (UCCS), Mexico

ORIGIN OF MAIZE AND OF MAIZE LANDRACES

The most widely accepted hypothesis on the origin of maize indicates that the valley of the Balsas river in Mexico is the cradle of domestication, more than 6,250 years ago. Teosinte *(Zea mays* L. subsp. *parviglumis)*, a native grass would have been domesticated into maize in a single event (Matsuoka *et al.*, 2002). It took Mesoamericans some 5,000 years to develop modern maize from the early domesticate (as represented by relic ears excavated in the Guilá Naquitz caves of Oaxaca, dated 6,250 years ago). By the time of encounter of the two worlds, modern maize was already the main food crop of Mesoamerica. Developing modern maize was a product of interaction between humans and a highly diversified environment. Varied topography, climate, soil and biota interact in short geographical distances in Mexico, resulting in multiple discrete and very different ecological niches. Many of these niches were settled by some 62 ethnic groups who used the ecosystem´s natural resources for subsistence, and domesticated a number of crops. Maize, their main food cereal, was introduced to most human settlements by harnessing the natural diversity of the species that included frequent gene flow from teosinte.

A consensus, collective procedure to breed maize while used as food (Hernandez X. 1987, 1993) was developed as a long term process. This process is known as “Autochthonous Maize Breeding” (Turrent *et al.*, 2009) and has led to some 59 maize landraces with vast intra-racial diversity in Mexico (Sanchez *et al.*, 2000). Some landraces were adapted to high elevations; some tolerated or escaped severe drought, and some thrived in hyper acidic soils or hyper alkaline soils. Some had a large geographic domain; some were very early or very late maturing. The 59 landraces comprise a diversity of kernel colors, endosperm texture, protein and oil content, etc., that make them suited to pluricultural food preparations on an individual basis.

The 62 ethnic groups developed some 600 food preparations from “nixtamalized” maize plus some 300 types of tamales (Perez-Sanvicente, 2003). Nixtamalization or alkaline fermentation was invented as a means to improve maize nutritional value. Maize has been the staple cereal in Mexico for centuries. After colonization, failure of the “European conquistador” to appreciate nixtamalization, which at the time was a biotechnological breakthrough, led to the pellagra epidemic of Southern Europe in the XVII and XVIII centuries, as maize spread throughout and became the staple food of the poor. Unfortunately, pellagra continues to be a human threat in parts of Africa.

AUTOCHTHONOUS MAIZE BREEDING

This is a collective procedure of the 62 ethnic groups of Mexico that involves: 1) maintaining more than one landrace in the farm for satisfying traditional uses as separate entities; 2) interchanging seed among neighbours; 3) introducing allopatric (evolutionarily distinct) maize seed, making a seed mixture with own seed and producing hybrids; 4) planting progeny and judging performance; and 5) submitting the harvested ears to the process of seed selection in the granary by the homestead woman who selects only those seeds that are “typical” of the landrace. All together, this is an open system that seeks to enrich the landrace, and does so with new alleles that directly influence stability of yield and kernel quality accordingly to cultural consensus. Currently, there are some 1.5 million farming units that apply this process akin to parallel breeding, to maize landraces. Since the important traits of yield and kernel quality are quantitative in nature and are normally linked in specific regions of the chromosome space, many crossing-over recombinations are required so as to break those linkages and accumulate the more favorable alleles through selection. This procedure has been applied to the maize agroecosystem for 5,000 years. The sources of allopatric seeds have been from within Mesoamerica and as far as South America. However, evidence from the last 50 years has shown that public hybrids distributed in the maize agroecosystem have been used as allopatric materials in Autochthonous Maize Breeding of landraces. The seed-pollen route to gene flow has been central to such a process in the center of origin of maize, while the sole pollen route has played a secondary role.

FOOD SECURITY

The Mexican farming sector includes 3.8 million farming units that have a bimodal profile: either as campesino (individual, usually subsistence) or entrepreneurial (larger scale, commercial) farming. Sixty-six percent of all farming units are managed by peasants in units smaller than five hectares. Entrepreneurial farmers manage larger, modern and market-oriented farming units. The maize agroecosystem in Mexico covers 8.5 million hectares that are currently cultivated with non-transgenic technologies. There are currently two interacting sources of technology for maize in Mexico: pre-Columbian and classical agriculture. The campesino sector includes 62 ethnic groups, plus a majority of mestizo farmers and a small fraction of the creole farmers. They use pre-Columbian technology with elements of classical agriculture. The 59 maize landraces are grown mostly as a monoculture, usually with suboptimal rates of fertilizers, pesticides and herbicides. Collectively, landraces will typically adapt to any condition ranging from marginal to optimal in the maize agroecosystem. The 59 landraces are fundamental to rural food security and are the only source for the national requirements of maize as pluricultural food.

The entrepreneurial sector, on the other hand, follows the industrial agriculture model, growing non-transgenic hybrid varieties purchased annually from the private as well as public seed markets. This sector farms irrigated as well as rain-fed quality land. At present, only 25 percent of the maize agroecosystem is planted with annually purchased hybrid seed; 75 percent is planted with native landraces and improved open pollinated varieties. It has been shown that the maize agroecosystem of Mexico has the resources so as to increase its production to 57 million metric tons of maize annually towards the year 2025. Current apparent consumption is 33 million metric tons. However, Mexico has currently a growing dependency on the regional grain market that reaches 32 percent of apparent consumption. This deficiency explains the proclivity of the Mexican government to seek commercial planting of transgenic maize in the maize agroecosystem. Unfortunately, this strategy erroneously ignores the critical value of biodiversity that helps ensure self sufficiency.

TRANSGENIC MAIZE AND MAIZE LANDRACES

It is well known that modern recombinant DNA technology leads to a random insertion of the transgenic locus. Currently, at least 52 independent transgenic events in maize are available in the world's transgenic seed market. It is very likely that all or most of the 52 loci are dispersed throughout the chromosome space of maize. Because of this dispersion of transgenes, it should be feasible to accumulate them all in one genotype through sexual reproduction, unless there is a deleterious threshold of accumulation that is smaller than 52 loci. It is also known that commercial transgenic constructs are somatic and not designed to be regulated by endogenous DNA sequences. The transgenic promoter is permanently active and promotes transcription in the nucleus and translation of the transgenic genes in the ribosome where it competes for energy and other inputs and interacts with resident DNA. One could imagine that one or a few transgenes in one genotype would not produce a strong metabolic cost to the host organism; however, there could be a deleterious threshold of transgenes accumulated over time.

DISCUSSION

Coexistence of native maize and transgenic maize would be nearly impossible should transgenic maize be cultivated in Mexico on a commercial scale. The conjunction of at least four factors would lead to irreversible and progressive accumulation of transgenes in native maize: 1) autochthonous maize breeding; 2) a second wave of transgenic maize adapted to Mexico that would be used as allopatric genetic material; 3) reproductive biology of maize; and 4) the previously mentioned shortcomings of current recombinant DNA technology. In the long run (possibly 20 or more years), a deleterious threshold of transgene accumulation that would decrease native maize diversity would ensue. As maize landraces and their intra-racial diversity are critical to food security and to multicultural uses of maize as food, a limited list of non-transgenic and transgenic hybrids would hardly solve food security for all and would further impact the use of diverse maize types for multicultural uses as food. The Mexican government has recently granted permission to several multinational consortia to conduct 24 field experiments with transgenic maize in the Mexican states of Sinaloa, Sonora, Chihuahua and Tamaulipas, all located in northern Mexico. The area sampled by the experiments covers some 754,000 hectares of irrigated maize plus 284,000 hectares of rain-fed maize. This region is cohabited by five ethnic groups and is home to some 29 maize landraces. According to a law passed in the year 2005, adoption of transgenic maize should follow a three-stage process: experimental, pilot and commercial. Given the current drive for transgenic maize commercialization elsewhere, one could anticipate that the multinational seed companies wish to shorten the three-stage process to the limit and open the whole country to maize transgenic technology. Some sectors within civil society, legislature and the scientific community are very actively pursuing strategies for engaging in this process and examining the wisdom of transgenic maize introduction in the center of domestication. Who stands to gain and who pays the costs?

CONCLUSIONS

1. Transgenic maize technology is not necessary for maize food security for all and for multicultural uses of maize as food in México.
2. Native maize landraces are necessary for maize food security for all and for multicultural uses of maize as food in Mexico.
3. Autochthonous maize breeding harnesses maize genetic biodiversity and should be protected from interference or hybridization of transgenic maize.
4. For these reasons, cultivating and importing transgenic maize should be prohibited in Mexico.

REFERENCES

Hernández Xolocotzi, E. 1987. Experiences leading to a greater emphasis on man in ethnobotanical studies. Econ. Bot.41 (1): 6-11. http://www.springerlink.com/content/cu4h1814p6744207/

Hernandez Xolocotzi, E. 1993. La agricultura tradicional como una forma de conservar el germoplasma de los cultivos in situ. In: Biología, Ecología, y Conservación del género Zea. B.F. MBenz (comp). Universidad Autónoma de Guadalajara. Guadalajara, Méx. Pp: 243-256.

Matsuoka, Y., Vigourox, Y., Goodman, M.M., Sanchez, J., Buckler, E. & Doebley, J. 2002. A single domestication for maize shown by multilocus microsatellite genotyping. Proc. Natl. Acad. Sci. USA 99 (9): 6080-6084. http://www.pnas.org/content/99/9/6080.abstract

Perez-Sanvicente, G. 2003. Repertorio de tamales mexicanos, Núm. 15. Colección Cocina Indígena y Popular. Conaculta CNCA-DGCPI-Dirección General de Publicaciones. México. D.F. 264p. http://sic.conaculta.gob.mx/ficha.php?table=publicacion_dgcpi&table_id=107

Sanchez, J.J., Goodman, M. & Stuber, G.W. 2000. Isozymatic and morphological diversity in the races of maize of Mexico. Economic Botany 54 (1): 43-59. http://www.springerlink.com/content/vk00577864773685/

Turrent-Fernández, A., Serratos-Hernandez, J.A., Mejía-Andrade, H. & Espinosa-Calderon, A. 2009. Liberación comercial de maíz transgénico y acumulación de transgenes en razas de maíz mexicano. Rev. Fitotec. Mex. 32(4): 257-263. http://redalyc.uaemex.mx/src/inicio/ArtPdfRed.jsp?iCve=61011789001