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Mexican Corn:
Genetic Variability and Trade Liberalization

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It is now a well established fact that corn (*Zea mays*) originated in Mexico and that a great part of the evolution that may be observed in terms of this plant's genetic variability took place in this country.[2] As the plant's history unfolded, early forms of these races were taken by people into a wide variety of environments and ecological niches from which many distinct varieties developed in the relative isolation of these separated regions. Thus, Mexico also became a center of genetic diversity for corn, and its stock of germplasm has contributed in a decisive manner to global production of corn. Even the dented varieties of the U.S. Corn Belt are close descendants of the first Mexican landraces.

The germplasm resources that are deposited in Mexico's corn varieties, as well as in the wild relatives of this crop, are of prime importance for the world's food production system of the next century.[3] Corn germplasm of Mexican origin has played a critical role in improvements for corn cultivated in tropical regions in relation to yield increments, plague resistance, short growth cycle, drought resistance and increases of protein content of grain. It has also been instrumental in increasing yields in the case of corn produced in temperate regions at high latitudes. Mexican

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[2] Studies of prehistoric Mexico have revealed the existence of primitive and small cobs in caves in Tehuacán, central Mexico. These were dated by radiocarbon methods at about 5,000 years B.C. and confirmed that maize was domesticated in South Central Mexico. The evolutionary sequence, from these initial plants, to the precursors of today's racial complexes allow scientists to trace the history of how maize was originated and disseminated in Mexico several thousand years ago. Recent scientific analyses retrace the origins of corn to *teosinte*, a wild relative considered to be the wild ancestor of corn.

[3] According to the director of CIMMYT's germplasm bank (Taba 1995:10) "[e]lite germplasm sources identified since the initial collections in the Americas have been incorporated into breeding composites, groups, gene pools, and populations by the CIMMYT Maize Program and national maize breeding programs worldwide. These in turn have been used to develop improved varieties and hybrids. In temperate regions Corn Belt germplasm predominates and in the tropics Mexican white dents and Caribbean yellow dents and flints have been successfully utilized in (…) maize breeding programs."

varieties and their derivatives have been used to improve populations used in 43 countries in Latin America, Africa and Asia.

During the first half of the XXIst century, it is expected that most of the demand for corn will come from developing countries in these continents. Little additional land is expected to come under cultivation in these countries, thus production increments will have to come from greater yields. Mexican corn's genetic variability will have an important role to play in improving production, and combinations of Mexican corn germplasm with that of other racial complexes in South America and Africa may provide an unusual asset in meeting growing food needs.

However, in spite of the importance of Mexican corn's genetic variability, the North American Free Trade Agreement (NAFTA) is a serious threat for the ability of Mexican growers to conserve and develop these genetic resources.

Between 1992 and early 1993 Mexico negotiated the NAFTA with the United States and Canada. Probably the single most important element in the NAFTA was the inclusion of Mexico's most important crop, corn, which uses more than 60% of total cultivated surface and generates the country's most important staple food. Corn (*Zea mays*) is also a most sensitive crop given the fact that it's production involves roughly 20% of total active population.

Opening the Mexican market had been an objective of the powerful North American corn producers' lobby since the nineteenth century. Today, with an annual production of 240 million tons, the U.S. is the largest producer of corn in the world, and carries a critical weight in determining the international price of this basic commodity.

From the Mexican government's perspective, the rationale for including this crop in the NAFTA was to enable the economy tap its true comparative advantages by focusing in more labor intensive crops and to free precious fiscal resources previously required to subsidize inefficient corn producers. By purchasing corn from United States' growers who produce corn at roughly forty percent the cost of

Mexico's corn growers, efficiency gains would also be attained from the standpoint of consumer welfare as *tortilla* prices would fall.[4]

The central assumption behind this negotiation was that Mexico's corn producers are inefficient. Average yields at the national level have traditionally remained below the 2 tons per hectare level (compared with average yields in the U.S of 10 to 12 tons per hectare) and to maintain the country's growers in activity, it was deemed that a unjustified diversion of fiscal resources was required. Thus, trade liberalisation in corn was a logical consequence of more general fiscal policy considerations.

Equally important was the objective of ensuring a constant stream of cheap basic foodstuffs that would enable the Mexican economy to maintain low wages, contribute to control inflation and increase its capacity for capital accumulation. This is a shortsighted approach to overall development goals as the impoverishment of agricultural producers, especially for an economy which cannot absorb the surplus labor that will eventually migrate to urban areas, will eventually become an obstacle to growth. However, Mexico's ruling elite opted for the short term gains that this strategy would bring to them, and chose not to support the welfare of a larger number of people for a longer period of time. Arguments concerning Mexico's comparative advantages and consumer welfare were, in retrospective, mere rationalizations of a decision motivated by fiscal policy considerations and more generally, by a short term capital accumulation strategy marked by its doubtful capacity for sustainable growth.[5]

The NAFTA provided for an immediate conversion of the corn tariff system into a tariff-rate quota (TRQ) system to be phased out over fifteen years. A tariff free quota of 2.5 million metric tons of corn was granted by Mexico.[6] The starting point was set at 206.9% in 1994, to be reduced during the first six years of the agreement by 29.6%. The remaining tariff would be phased out linearly over the

[4] *Tortillas* are roasted corn pancakes which serve to accompany all dishes, or sometimes become the main course in the dinner table of Mexico's urban and rural poor. Tortillas are not the only manner in which corn is prepared and consumed in Mexico, but they are the most popular corn product.

[5] One plausible interpretation of the central underlying motivation to open the corn sector to U.S. imports is that this was a deliberate policy decision to hand Mexico's massive (and lucrative) *tortilla* market to these powerful industrialists. It should be noted that some of these industrialists were close friends with Mexico's top decision makers at the time, and continue to benefit from government handouts in the form of subsidies to prevent tortilla prices from increasing.

[6] This tariff-free quota expands at the compound rate of 3% *per annum* starting in 1995, leading to a tariff free quota for corn imports of 3.6 million tons by the year 14 of the agreement. The tariff rate quota system is to be phased out gradually over a transition period of fifteen years. See Nafta, Annex 302.2 in Schedule of Mexico, tariff item 1005.90.99.

following nine years until a zero tariff is reached for all imports. The central objective variable were domestic prices which would converge on international prices (plus the cost of introduction and transport to consumption markets) at the end of the fifteen year transition period.

It is important to note that in the NAFTA negotiations, yellow corn and white corn, two distinct commodities in the international market, were treated as one and the same commodity. Mexico's growers engage essentially in the production of white corn, while U.S. growers produce yellow corn, most of which is used as livestock feed (about 50% of that amount is used for cattle, hogs and poultry) and about a quarter of total U.S. production is exported, mainly to China, Japan Europe and, in growing quantities, to Mexico. In spite of significant price differentials, with white corn priced on average a full 25% above yellow corn in the international commodity markets, NAFTA treated these two varieties as the same commodity.

The entire complex of basic grains (including wheat, rice and sorghum) was subjected to a rapid process of trade liberalization. In the case of barley (*Hordeum spp.*) a TRQ system analogous to that of corn was established. In addition, a TRQ system was also set for kidney beans, *Phaseolus vulgaris*, a critical *leguminosa* whose production is closely related to strategies of corn producers in Mexico.

Since NAFTA's first year, corn imports have exceeded the tariff free quota established by the trade pact. In 1996 almost 6 million tons were imported, twice as much as the original tariff-free quota. In 1998 and 1999 corn imports, considering authorized and effective imports as of September, exceeded 5 million tons per year.

It is important to note that all corn imports since 1994 have been tariff free, with public officials justifying this as a requirement to cut costs and control inflationary pressures.[7] Instead of acting as a critical protection system for domestic producers during the transition period, the system generated its own perverse incentives to private importers. In addition, some of these importers in the industrialized *tortilla* market, received important direct subsidies. By failing to implement the tariff-quota system, the Mexican government destroyed whatever was left of the structure put in place for

the 15-year transition period for corn. It also unleashed an unbearable economic pressure on Mexico's own corn producers.

The tariff rate quota was not applied to the excess imports (over the tariff free quota) because, according to government sources, this would cause an increment in tortilla prices and accelerate inflation. In addition, fiscal policy-makers reiterated the notion that if these tariff rates were implemented, the price of tortilla would increase significantly and this would lead to renewed pressure to increase subsidies in order to keep tortilla prices stable. Thus, the official rhetoric stated that fiscal revenues associated to these tariffs on imported corn would be canceled out by the fiscal loss incurred through the additional subsidies. It is important to emphasize that *tortilla* prices increased by a factor of 5 since the NAFTA entered into force, while subsidies to the industrial flour industries (specially the two largest firms, MASECA and MINSA) increased and almost doubled during NAFTA's first five years. The official rhetoric proved to be a set of empty words.

This means two things. First, the Mexican government failed to live up to its commitments with Mexico's corn producers. Failure to implement the system of tariff rate quotas effectively eliminated all protection barriers for the corn sector. This is a key dimension of the manner in which the transition period was prematurely truncated. Second, as the Mexican government engaged in this maneuver it imperiled the livelihood of millions of corn growers and their families.

The effects of this extraordinary level of imports on corn prices has been rather strong. Corn prices have experienced a downward trend since 1982 for the two main agricultural cycles. Since 1990, the trend has been a constant in Mexico's economy, and in 1993, in anticipation of NAFTA's ratification this trend clearly accelerated. An adjustment was introduced in 1995 as inflation rose to 52%, but the trend resumed afterwards. As a result of a policy of increased tariff-free imports, corn prices have been cut in half over the past six years.[8] In addition, the income support mechanism initially established in 1994 and known in Mexico as PROCAMPO has lost half of its value in real terms.[9]

[7] Foregone fiscal revenues can be estimated at more than $2,000 million dollars, a figure comparable to fiscal appropriations for the entire agricultural sector for the relevant period.

[8] The issue is not only that imports have surpassed the level established for the tariff free quota. The key problem is that the corresponding tariffs have not been levied. Thus, the government's trade policy for corn has been that on january 1st 1994 the corn sector was totally and immediately opened to US producers. The rhetoric about a fifteen year transition period for corn is only that, rhetoric.

[9] PROCAMPO was designed in accordance to the new policy instruments for etc. Etc.

During this six year period the agricultural sector has experienced a reduction of public support in other key areas such as credit, infrastructure, R&D and technical assistance. The key public sector agency used to regulate support prices for basic agricultural commodities, CONASUPO, was dismantled in 1998, long before its role during the fifteen transition period could be accomplished. Thus, corn producers (as well as growers of other crops) face the stark reality of reduced prices as a result of competition from imported corn, in the context of a severe curtailment in credit, investment in infrastructure and the reduction of the remaining support mechanisms (PROCAMPO). Finally, the negative economic context has been marked by an accumulated rate of inflation of more than 140% over this period of time, sluggish growth rates for GDP and insufficient job generation in the entire economy.

From the point of view of the official studies hastily carried out to justify the inclusion of corn in the NAFTA, proof of the inherent inefficiency of Mexico's corn producers was thought to be found in the comparison between average production yields in Mexico (2 t/ha) and the United States (12 t/ha). This difference in productivity is explained by the very capital intensive agricultural experience in the U.S. which relies heavily on the use of heavy machinery, agro-chemical inputs, high yield varieties and, more recently, on the utilisation of transgenic seeds. The deep, well-drained soils of the midwestern plains, together with a very regular rainfall pattern, offer the ideal setting for the use of these inputs. This has led to a strong specialization in a limited number of breeds capable of high yields, with five or six lines dominating the corn producing landscape. The well-known vulnerability of this specialization was demonstrated in 1970 when the southern corn leaf blight epidemic wiped out a significant proportion of the corn crop in the United States.[10]

In sharp contrast, the vast majority of Mexico's corn growers rely heavily on a wide variety of land races as their only guarantee against risks. Producers of upland maize, or in the tropical humid and sub-humid agro-ecological environments encounter many sources of risk and uncertainty, and the most important technological asset at their disposal is the genetic variability of their corn.

[10] In the late 1960's a newly developed hybrid with yields 25% higher than average became widely used in the United States. This led to the narrowing of the genetic base and to increased vulnerability of the entire crop. Unfortunately, the fungus *Helminthosporium maydis* was discovered to be highly virulent on thus high-yield hybrid and in 1970 an epidemic of this fungus more than 25% of the U.S. crop was lost to the blight.

Every year, approximately two million corn growers in Mexico engage their undistracted attention and collective experience in the art of selecting seeds for the next agricultural cycle. The seeds are selected according to their ability to respond to needs which are, in turn, determined by the environmental and physical characteristics of the regions where they operate. Most of these planters grow their corn in mountainous areas and their plots are subjected to an irregular rainfed regime. Their plots are located in sloping terrain or in the intermountain valleys, and these upland production conditions frequently involve poor soils, strong winds, early frost, and diverse pests. In the lowlands, close to the coastal plains or in some big inland depressions, the tropical environment entails difficult production and post-harvest conservation conditions due to pests and poor soils.

The seeds selected by these growers are rich in gene-based mechanisms enabling them to resist pests of all kinds, from weevils to worms and fungi, or to grow even when the first rains are interrupted and plants are in their most vulnerable stage of growth. They are also capable of engendering fast-growing varieties maturing in a short period of time, a critical quality when planting upland corn due to risks of early frost. Some seeds bear plants which are well adapted to poor soils, either because of their acidic or high alkaline levels. Others have a hard pericarp (the protective coating surrounding the seed) which provide long conservation periods, an important quality under the tropical conditions.

The intense genetic-environment interaction displayed by corn enables the plant to adapt to highly contrasting environments. Mean growing season temperatures can exceed 26º C or may be as low as 12.5º, and corn can be cultivated at altitudes ranging between sea level and 4,000 meters above sea level. It can be grown in fully irrigated land, or in semi-arid land, with growing cycles varying between 3 to 12 months. Height variations are also quite marked with dwarf varieties below 65 centimeters and higher lines averaging four meters. Finally, corn can be well adapted to acid and alkaline soils, or to varied soil structures and textures that determine nutrient contents and drainage properties (from sandy to clay-rich soils). And this great capacity to adapt to widely differing environments found in Mexico's rugged topography, with its rich tapestry of varied ecological niches, make corn the perfect ally to minimize risks.

In Mexico's mountainous areas environmental heterogeneity results in a rich configuration of highly diversified productive spaces. Corn growers have learned to recognize the different parameters underlying this diversity of agroecological systems. In most places where corn production is undertaken, growers normally sow at least two corn varieties, one which is less productive but matures early and is capable of beating the onslaught of early frosts, and one which is more productive but slower to mature. But in the vast majority of places, growers sow more than two corn varieties. In the case of many communities, up to eight varieties are used in a reduced surface. The number of varieties depends on the type of risks of crop failure that defy producers every cycle. It also is a function of the type of final uses (dietary and ritual) that are reserved for the final produce by each community or farmer.

From the viewpoint of Mexico's corn growers, the most important determining factors underlying seed selection are the type of soil, drought resistance, wind resistance, response to inputs, critical period of vulnerability to weeds, optimum period of fertility, yields, different uses of maize (for sale, domestic or ritual uses), post-harvest conservation and dietary considerations (flavor, grain texture and color). Normally none of the selected cultivars shows high performance scores in more than one or two of these variables. Their negative correlation in these parameters offers the guarantee sought by Mexico's poor farmers who operate in a context of widely varying agroecological systems.[11]

Thus, every year, Mexico's corn growers perform a critical and unrecognized environmental service of vital importance as the curators of the rich genetic variability attained by corn in Mexico's environments. At the time of the NAFTA negotiations, this fact went unrecognized. In the noisy campaign with official propaganda surrounding the final negotiations on the agreement, the role of these corn producers and the critical importance that corn genetic variability entails for global food production during the next fifty years was carefully kept out of the big picture.

The fact that the best U.S. hybrid seeds would be outperformed by Mexico's landraces in most of the environments in which corn is produced in this country, was also cautiously concealed by official

[11] Ecological systems have been defined as topographical units of relative homogeneity in terms of soils, landforms, surface and groundwater, biota and topoclimates (Bailey 1996). Each system is susceptible to various forms of land management and agricultural practices, and this in turn defines an agroecological system. García Barrios et al (1991) coined the term agroenvironment to describe the geographical space in which ambient factors which act as constraints for agricultural production are relatively homogeneous from the viewpoint of producers.

government spokespersons. This capacity of local landraces to outperform modern high-yield hybrids is based on the plant's excellent adaptive features and this explains why penetration of hybrids in corn production has never reached the high rates obtained in wheat production.[12] Thus, it is not surprising to observe that in Mexico today use of hybrid varieties is restricted to about 25% of cultivated surface devoted to corn.

Another key aspect of corn production in Mexico is that growers relying on local landraces are usually the poorest producers, endowed with very small plots of land (averaging less than 2 hectares), little or no access to credit, limited or minimum use of chemical inputs and usually no employment of mechanical traction. The states where these producers operate exhibit the highest incidence of rural poverty. These producers are usually operating in the central and southern highlands, or in tropical and semi-tropical areas where high quality soils are very scarce, or in semi-arid regions. Their economic vulnerability is countered mainly through the use, conservation and development of corn's genetic resources. All told, these producers are the natural curators of the genetic resources embedded in corn's genetic variability.

The capacity to conserve, select and develop these genetic resources depends on factors at the household, social and institutional levels. At the household level, individual growers transmit from one generation to another the information required to select seeds for their use in different agroenvironments. The successful transmission of this sophisticated information is no easy task and requires a long term educational process that trains eye and touch to ably recognize different colors, sizes and textures for optimum variety selection. This has to be accompanied by the ability to identify how different seed varieties match different soil and agroenvironmental characteristics (humidity, texture, propensity to strong winds and early frosts, etc.).

This educational process requires both adequate living standards as well as the support of a strong institutional base. The social fabric that sustains this process is already being damaged through economic pressure, and the capacity to conserve and develop these genetic resources may be

[12] One reason for this is that improved hybrid varieties destined for commercial uses require to be of good quality and excellent outwards appearance (color and size) and they must be produced in Mexico by private companies under very good production conditions (high quality and well drained soils, irrigation, inputs). This undermines the potential of these seeds for use under the tougher environmental stress predominating in Mexico's highlands and semi-arid zones, or in regions endowed with poor quality soils.

irrevocably lost. Economic pressure in the case of Mexican growers stems from several critical sources. The first source of pressure stems from the loss of income due to the collapse in corn prices. The second arises from reduced off farm income generation. This in turn is the result of less employment opportunities in rural areas, a situation exacerbated as intermediate commercial farmers are forced out of business because of price cuts and restructuring of local and regional markets. Other sources of income, such as basket weaving or knitting are also affected by the drop in rural wages which further reduces demand of these goods. Thirdly, economic pressure also arises from the almost complete withdrawal of public support instruments as the new corn regime is implemented. These factors have been acting in the context of sluggish economic growth, inflation rates suppressed only through an overvalued exchange rate and contained effective domestic demand (through reductions in real wages). The regional and sector level distortions present in the Mexican economy have serious negative effects on the household economics of corn growers and their communities.

The survival strategy of corn growers will rely more on migration to areas with greater employment opportunities. Recent research has revealed that the propensity to migrate is stronger in areas where poor corn growers using local landraces operate.[13] As mid-sized producers are thrown out of the corn sector as they are affected by price reductions, poorer farmers will find less employment opportunities in the vicinity of their own plots and they will have to migrate to labor markets further away. Some studies have suggested that NAFTA's displacement effect would be limited because of the positive impact of public policy instruments that would help corn growers adjust to the new economic realities of trade liberalization (de Janvry *et al*, 1995) However, given the remarkable deficiencies of existing policy instruments this opinion remains at best an unfulfilled wish and migration will remain an important option in the survival strategies of Mexico's corn growers.

The situation of subsistence farmers requires special attention. All pre-NAFTA studies justifying the inclusion of corn in the trade pact assumed that subsistence growers would not be affected by the price reductions. It was assumed that because the crops of these producers are not marketed, price

[13] Salas (1997) uses a cluster analysis relying on four variables to estimate potential migration. The variables are labor income and rural population, productivity and local landraces, and these variables are linked with data on permanent migration. The results are straightforward: poorer corn growers, specially those operating in smaller land plots and using local landraces, are more prone to migrate.

cuts would leave them unaffected and, in fact, the reduction of *tortilla* prices would benefit subsistence growers which have a deficit in their corn accounts. However, this view ignored the fact that subsistence producers do not live in economic autarky and that many of their needs have to be satisfied through purchases of marketed commodities and this requires access to monetary flows. The typical pattern of subsistence production implies harvesting and storage for use during the year. Normally small fractions of the stored crop are sold in the local market to meet cash shortages.[14] In order to meet the normal expenditure constraints, these households need income which is obtained from various sources: cash receipts from household members hired in local labor markets, remittances from migrant workers, and, of course, through petty sales of grain. These petty sales take place in a buyers' market and are therefore marked by low prices. The grain thus sold must be replaced later, and that purchase takes place in a sellers' market which imposes higher prices.[15]

In situ conservation of genetic resources is a dynamic process in which farmers engage in conserving received germplasm complexes, but this conservation is also carried out in the context of exchanges with other farmers and communities. Experimentation with other varieties and breeding of new varieties is thus part of a dynamic process in which landraces are used, preserved and refined in multiple cycles through the flow of genetic material. But the capacity to carry out this process depends on the knowledge base of households and communities. As migration takes place, and as the pressure of poverty is endured, the capacity to conserve and develop these resources is severely diminished. This is confirmed by direct observation of seed selection processes (see Ortega Paczka 1997, 1999) and by data on the migration by age groups (Salas 1997). Poverty and migration conspire together to leave behind a deteriorated capacity to select seeds according to relevant criteria, and to identify the specific agro-environments into which each class of seeds can be productively inserted.

In many cases, it is not only a question of knowledge at the level of individual households and farmers that is required. Collective action by communities where social, family and ritual bonds are strong is frequently required to plant or harvest a crop. But this collective action becomes more difficult as the social base sustaining it is gradually deteriorated.

[14] These liquidity needs may arise from claims to debt or from the need to purchase other goods and services in the marketplace. Many subsistence producers use modern commercial inputs such as fertilizers.
[15] In addition, *tortilla* prices have not dropped as predicted.

Mexico's Federal program for biodiversity conservation has today 116 "natural protected areas" in Mexico. The total surface covered by these areas together reaches an imposing total of 12.6 million hectares. These parks or natural reserves are among the most well-endowed areas in biodiversity in the world. The variety of ecosystems covered by these protected reserves ranges from lush tropical or mountain forests brimming with wildlife and the richest variety of flora, to semi-arid and desert areas, abundant in diverse cacti and succulents showing extraordinary resilience in the desert's biome. The system of natural protected areas covers 6.4% of Mexico's surface and is the show piece of Mexico's government when it comes to biodiversity protection.

Mexico's status as a center of mega-diversity is well known and when the federal program of protected areas is displayed it gives a good impression of Mexico's environmental policies. However, the protected areas are surrounded by increasingly poor people, and the pressure on these lands and their resources is intensifying every year. The pressure is such that the viability of these natural protected areas is threatened and in the medium term, if recent trends are not reversed, most of the parks and reserves will be reduced to a drawing on a map.

REFERENCES

De Janvry, A., E. Sadoulet and G. Gordillo (1995)
"NAFTA and Mexico's Maize Producers", *World Development*, 23 (8). [1349-1362]