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Maize stover use and sustainable crop production in mixed crop–livestock systems in Mexico☆

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ABSTRACT

Mixed crop–livestock farming systems prevail in Mexico – typically rain-fed and smallholder systems based on maize and ruminants and spanning diverse agro-ecologies. Maize grain is the key Mexican staple produced for home consumption and the market. Maize crop residues (stover) are an important by-product, primarily for feed use, often through in situ stubble grazing and/or as ex situ forage. This paper explores maize stover use along the agro-ecological gradient and the potential trade-offs, particularly the widespread use of maize stover as feed against its potential use as mulch (soil cover) to manage soil health within the context of conservation agriculture. The paper builds on three case study areas in Mexico in contrasting agro-ecologies: (semi-)arid, temperate highland and tropical sub-humid. Data were obtained through expert consultation and semi-structured farmer group/community surveys. Although in situ grazing is found in all three study sites, it represented the bulk of stover use in only one site (70% of stover in the sub-humid tropics), with ex situ feed dominating in the other two sites (>80%). Maize stover commercialization is limited and mainly restricted to households with no livestock and often within the local context. Farmers are generally hesitant to adopt conservation agricultural practices that require the retention of stover as mulch, as this competes with their livestock feed needs and purchased feed is expensive. To reduce trade-offs, a portfolio of options could be adapted to these mixed systems, including partial residue retention, cover and feed crops and sustainable intensification. Promising but yet to be explored, are investments in the genetic improvement of maize stover feed quality.

1. Introduction: changing maize stover demands in Mexico

Mexico is the center of diversity for maize and farmers grow the crop in a variety of production environments in terms of altitude, temperature, moisture regimes, land, soil types and production technologies. Maize is Mexico's most important crop and continues to play multiple functions in farmers' livelihoods. It occupies the largest area planted to any crop in the country, and many small-scale farmers are engaged in its production (Barkin, 2002) mostly in rain-fed areas for self-consumption and to varying degrees for the market (De Janvry et al., 1995). Maize is a source of food, income, cultural identity, social status and part of a safety net (Perales et al., 2005). Maize plays a key role in local people's diets, not least the *tortilla* which is made from specially treated (*nixtamalized*) maize flour and which has been a staple food since pre-Columbian times. Poor consumers in both rural and urban areas register higher levels of *tortilla* consumption. Since the 1980s, Mexico has been increasingly dependent on imports, especially yellow maize imports for animal feed and industrial uses (Améndola et al., 2006).

The livestock sector is very important in Mexican agriculture. In 2004, Mexico produced 1.5 million tons of beef, making the country the world's ninth largest producer, and around 9 million tons of milk. Mexico is also the world's fourth largest producer of chicken (2.3 million tons) and ranks 17 in the world list of pig meat producers (1 million tons). The ruminant sector is dominated by cattle with 30.6 million head compared to 8.7 million goats and 6.1 million sheep (Améndola et al., 2006). Mixed crop–livestock systems span a wide agro-ecological gradient, including (semi-)arid, (sub-)humid and temperate/tropical highland areas, covering 18%, 8% and 7%, respectively, of Mexico's total land area of 2 million km^2. Of the mixed crop–livestock systems, grassland-based livestock production systems[1] comprise 38%, mixed crop–livestock

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[1] Thornton et al. (2002:17) defined grassland-based systems as follows: ">90% of dry matter fed to animals comes from rangelands, pastures, annual forages and purchased feeds and <10% of total value of comes from crops [. . .] i.e. high degree of importance of livestock in farm household economy".

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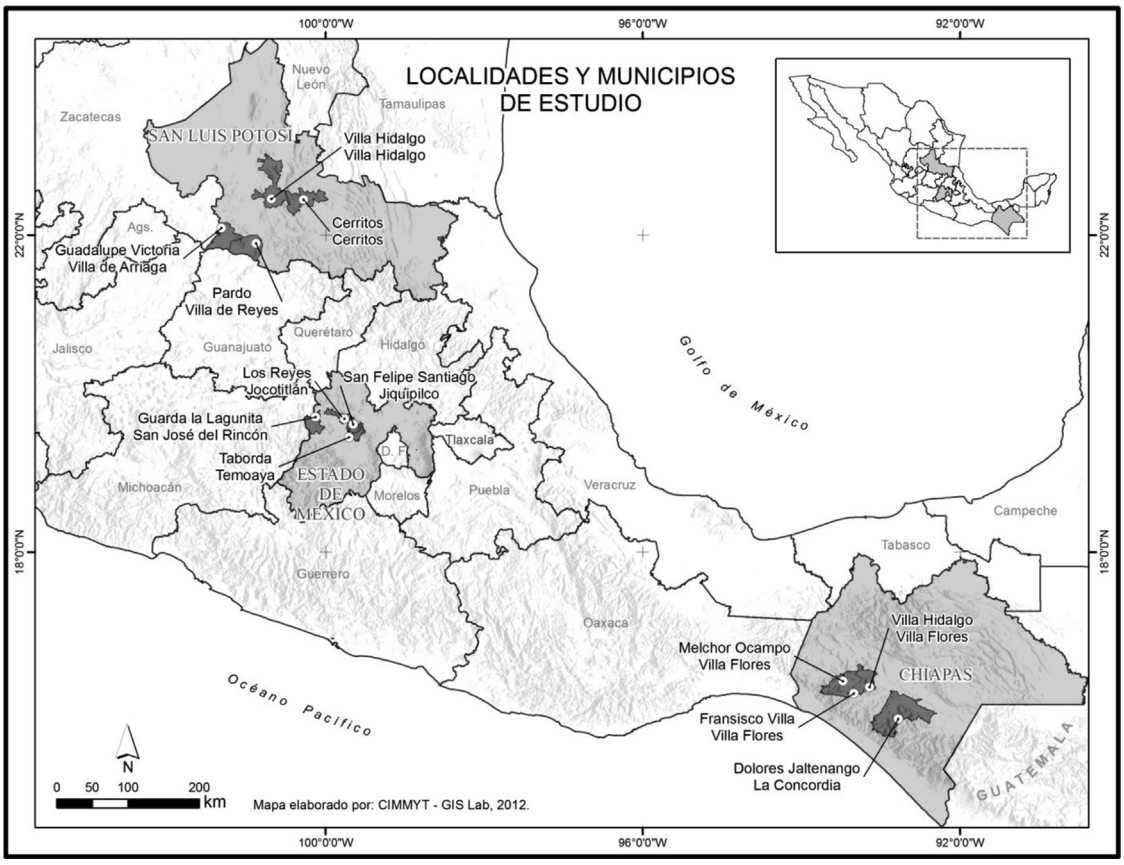

Fig. 1. Survey locations in Mexico.

systems[2] 33%, and other systems 29% (Thornton et al., 2002). The mixed systems are often based on maize and ruminants, with three-quarters being rain-fed (Thornton et al., 2002).

Commercial beef and dairy systems tend to use livestock feed based on cereals, sown and conserved forages, crop residues and industrial by-products. Especially in the semiarid north, pastoral use of land is widespread (Améndola et al., 2006). Mixed systems, typically small-scale family-based farms, tend to graze their cattle on crop residues and at roadsides, complemented with purchased concentrates, pastures and forage crops. Sheep production and goat production are usually extensive. Feeding is based on crop residues, grazing native grassland or along roadsides and there is limited use of supplementary feeding with chopped crop residues and maize grain during dry season (Améndola et al., 2006). Research from the south of Mexico (Yucatan) shows that mixed smallholder sheep farms are characterized by a large diversity, including different methods of feeding, varying intensity levels of crop and forage production as well as differences in infrastructure investments (Parsons et al., 2011).

Maize residues are a widespread source of forage especially during the dry season. They are the most important crop residue which is used as fodder (an estimated 48.1 million tons per annum), followed by sorghum stover (6.5 million tons per annum) and wheat straw (2.7 million tons per annum) (Améndola et al., 2006). Maize residues are often left in farmers' fields for in situ stubble grazing or are harvested for ex situ use and used as green or dry forage (with various degrees of processing and feed supplements). Arriaga-Jordán et al. (2005) found that in two rural communities in central Mexico, the main factor determining herd size was maize stover supply (collected and purchased). Maize processed into silage (fermented grain and green plant matter) is used as feed for livestock in high input systems. Maize residue use/market options and residue rights are interdependent, and the latter may vary from open access to common property to private property. However, although partly addressed in prior research (Erenstein, 1999), there has been no systematic assessment of these often informal and localized maize stover markets in Mexico.

Although the value of crop residues as fodder is widely recognized and relatively easy to assess, there is less understanding of the value of crop residues as a soil protection and improvement measure. Such an understanding is important in light of natural resource degradation. In traditional maize-based cropping systems of the central Mexican highlands and of the mid-altitude mountainous landscapes in the Southeastern part of the country, burning and grazing of crop residues, heavy tillage, and lack of crop rotations lead to soil degradation and erosion. Soil degradation is a major constraint to crop production, aggravating farmers' vulnerability to climate risks. State governments have progressively introduced laws banning the burning of crop residues and secondary vegetation along with environmental protection policies (e.g. creation of natural reserves). These have resulted in a decline of migrant slash and burn systems, leading to a shift to more intensive production systems.

This shift from relatively extensive to intensive production systems implies an intensification of natural resources management. Crop residue management in these production systems has become more critical especially in the case of (semi-)arid environments and/or in systems under low maize production levels where less than optimum soil cover can lead to soil and land degradation.

[2] Thornton et al. (2002:17) defined mixed farming systems as follows: ">10% of the dry matter fed to animals comes from crop by-products and stubble or >10% of the total value of production comes from non-livestock farming activities".