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The decline of the itinerant milpa and the maintenance of traditional agrobiodiversity: Crops and weeds coexistence in a tropical cloud forest area in Oaxaca, Mexico

Oscar Pérez-García, Rafael F. del Castillo*

Instituto Politécnico Nacional, CIIDIR-Oaxaca, Hornos 1003 Santa Cruz Xoxocotlán, Oaxaca 71230, Mexico

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ABSTRACT

The Mesoamerican *milpa* shifting cultivation (MS), characterized by slash-and-burn practices and long fallow periods, has being substituted by a semi-permanent system (SP), characterized by fire suppression, tilling, the application of synthetic fertilizers, and shorter fallow periods. We compared the composition, richness, and structure of crops and weed species associated with these two cultivation systems in a tropical montane cloud forest area in Sierra Norte, Oaxaca, Mexico. We studied how such changes are associated with crop species and varieties, weed life-cycle, and weed cover. We could detect three maize varieties of the local maize landraces (*Zea mays* L.) in MS, and only two in SP. The yellow variety was the indicator crop of MS, while the white variety was that of SP. In MS, maize density was lower but often intercropped with climbing bean species, whereas in SP, maize monoculture was common. The shift of cropping systems altered drastically the composition, richness, density, and cover of weeds. The plots of MS and SP were clearly separated in two clusters of weed species. In MS, the density of perennial weeds was higher, the total weed cover was lower, and the bracken-fern was the indicator species. Contrastingly, SP displayed a higher richness and density of annual weed species, a high weed cover, and several annuals, mostly Asteraceae, were the indicator species. We conclude that MS is a better reservoir of agrobiodiversity, and its substitution may accelerate the decline of climbing beans, maize varieties, and perennial weeds, by favoring maize monoculture and the infestation of the crop fields by annual weeds. Banning of shifting cultivation in indigenous communities can contribute to the decline of agrobiodiversity, reduce the nutritional apportionment of the crops to the local people, and favor land degradation by weed-infestation.

1. Introduction

Shifting cultivation is an ancient agricultural system currently practiced in marginal areas in the tropics (van Vliet et al., 2012). Compared with the modern shifting cultivation practiced by colonizers, the traditional shifting cultivation consists in the slash-and-burn of a small piece of forested land (Watters, 1971). The resulted ashes and soil organic matter are the main source of nutrients for growing food crops in polyculture, usually during few years (1–3 years). Weed infestation and soil depletion are indicators to leave the fields in fallow for decades for forest and soil regeneration (Watters, 1971; de Rouw, 1995). During the fallow stage, cultivation is started in other pieces of forest land to ensure the continuity of crop production. Traditional shifting cultivation is considered a sustainable agro-forestry system because it does not depend upon external inputs (Kleinman et al., 1995). Soil erosion and permanent deforestation tend to be less severe in comparison with more intensive agricultural systems. The *milpa* system is the most remarkable shifting cultivation in Mesoamerican tropical areas. This system harbor important landraces of maize (*Zea mays* L.), bean (*Phaseolus* spp.), and squash (*Cucurbita* spp.), which have been domesticated and diversified in this region (Watters, 1971). Indeed, maize diversification and the coexistence of important non-crop and non-timber species in the weedy vegetation appear to be closely associated with the *milpa* system (Ortega-Paczka, 2003; Finegan and Nasi, 2004). In contrast to modern cultivation systems, such weed species are usually of great value to the

* Corresponding author.
E-mail addresses: ospeg@yahoo.com.mx (O. Pérez-García), fsanchez@ipn.mx (R.F. del Castillo).

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farmers (Chacón and Gliessman, 1982), and seeds for the next cropping period are obtained by selection of locally harvested seeds (Ortega-Paczka, 2003). As such, the *milpa* system plays an important role in preserving agrobiodiversity.

The replacement of shifting cultivation by intensive agriculture practices and its expansion into tropical forest areas is a global trend (van Vliet et al., 2012). The consequences of such a substitution are expected to be multifarious. Agrobiodiversity, in particular, is expected to decline with such changes (Finegan and Nasi, 2004; van Vliet et al., 2012). The risk is higher for centers of origin and diversification of cultivated plants as has been demonstrated with the loss of several traditional varieties of rice in Southeast Asia (Rerkasem et al., 2009; Xu et al., 2009). In Mesoamerica, the *milpa* shifting cultivation (MS) is being replaced by more sedentary agricultural systems, but the effects of such a substitution in agrobiodiversity have been little explored in particular in tropical mountainous areas (van Vliet et al., 2012). The Sierra Norte, in the southern state of Oaxaca, Mexico is one of the regions were such a substitution is taking place (González, 2001; Ramos-García, 2007). MS is being gradually substituted by a more semi-permanent system (SP) of native maize production, hereinafter referred to as '*milpa* sedentarization'. SP consists in cultivation of maize on the same piece of land. In contrast to MS, SP requires soil tillage, weed hoeing, and the use of synthetic fertilizers. MS substitution by SP was implemented due to local regulations initiated in the early 2000s and motivated by government economic incentives purportedly to protect forest areas (Ibarra et al., 2011; Martin et al., 2011).

The shift of maize-based cropping systems presupposes important changes in the diversity of crops and weeds. The substitution of MS by SP has been slow in Sierra Norte in such a way that several plots managed under MS or SP are in close proximity to each other, and under the same ecological conditions. This mixture of farmlands with contrasting methods of cultivation provides a unique opportunity to explore how such changes affect the crops and the associated weeds. In this study we evaluate the effects of the *milpa* sedentarization on the varieties and species of crops, and the composition and abundance of the associated weeds.

2. Methods

2.1. Study area

The study was conducted in Juquila Vijanos municipality, Villa Alta District, Oaxaca State, in the Sierra Norte mountain range, Mexico (Fig. 1). The climate is temperate-humid influenced by the Gulf of Mexico moist winds. Rain is common throughout the year, but peaks during summer (June–September). The average annual precipitation ranges between 1500 and 2000 mm (INEGI, 2008). The average annual temperature at the nearest meteorological station (station 20145) is 18.7 °C (SMN, 2010). The soil lies on a bedrock of schist and slate from Cretaceous period (INEGI, 2008). Soils of maize fields are Inceptisols and those of forest areas are Entisols (Bautista-Cruz et al., 2005). The original vegetation is an upper tropical montane cloud forest (del Castillo and Blanco-Macías, 2007). The municipality total area is 62.93 km^2. The territory is steep (19–95%). Agricultural areas comprised 20% of the municipality area, whereas 78% of the territory is secondary forests of different development stages and primary forests (INEGI, 2008). This region is inhabited by Zapotecs, an ethnic group with its own

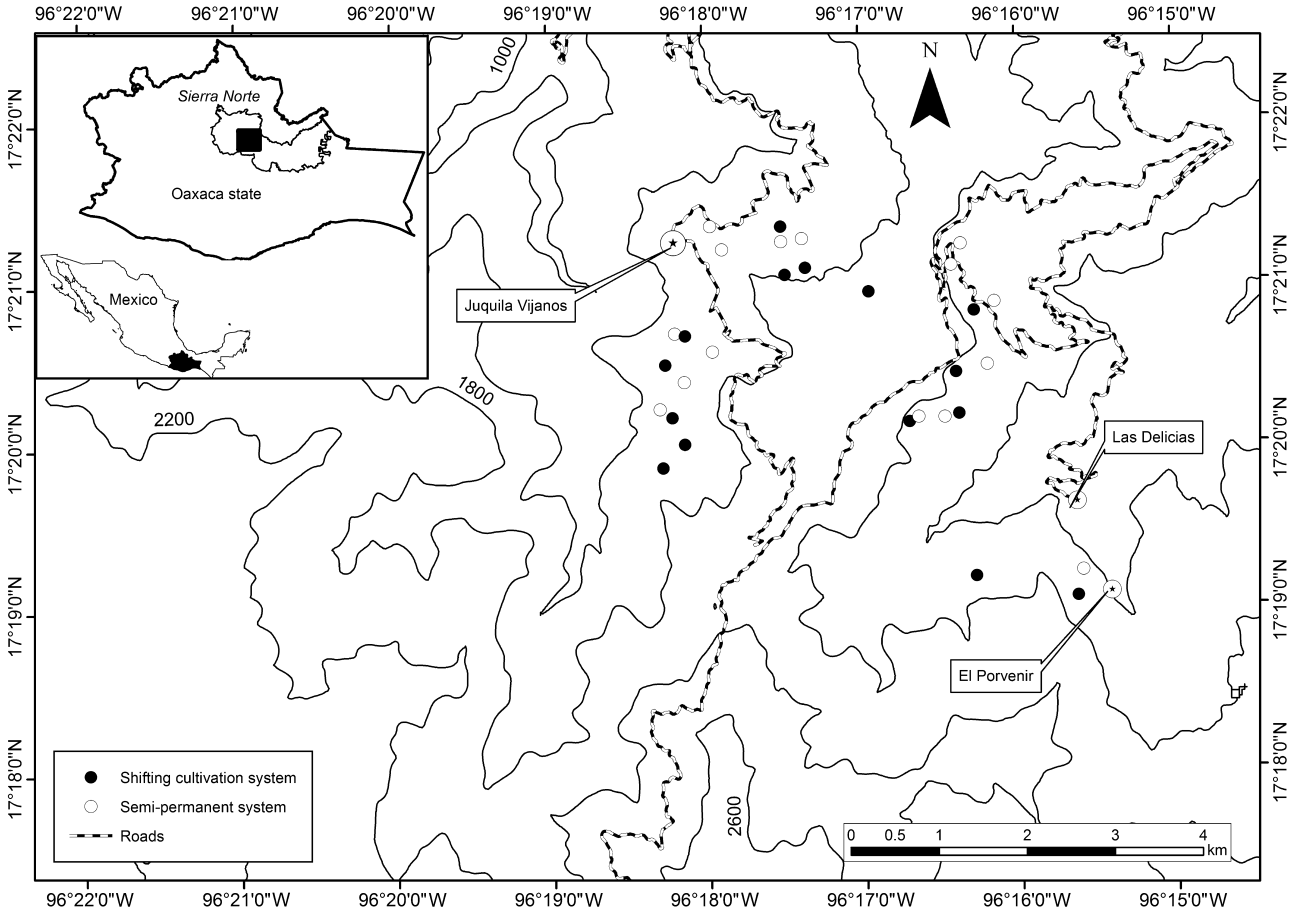

Fig. 1. Map of San Juan Juquila Vijanos, Oaxaca, Mexico and the plot location of the two cropping systems used for agrobiodiversity evaluations.