Intensification of Upland Agriculture – Development or Degradation?

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The large scale conversion of extensive swidden agriculture to intensive market oriented production of maize in upland areas of South East Asia is a cause of concern – both in relation to the environmental and socioeconomic impacts. This study investigates (1) the drivers behind intensive maize cultivation in an upland area of Northern Thailand (2) the effects of this intensification on soil quality; (3) the potential of Permanganate Oxidizable Carbon (Pox-C) as a fast, low cost indicator of soil quality and (4) the socio-economic impacts of maize cultivation.

Results

The area under active fields more than tripled from 2002 to 2010 (Figure 1). This development mainly took place in areas that used to be under old fallows. In 2002 all respondents cultivated upland rice in a fallow-based system, while maize was cultivated by less than 25%. In 2010, 55% of the respondents cultivated upland rice, whereas maize was cultivated by 90%. The total area under maize was more than five times larger than the area under upland rice.

Maize cultivation: CP888 was the most popular type of maize seeds used in the area. Fertilizers and herbicides were used by all respondents and a substantial amount was needed to purchase these inputs. 40% of maize production from Nan area was sold to the Chiang-Rai-Pattaya Group (CP).

Causes of Land Use Changes

The observed land use changes are driven by a combination of economic and political factors. Maize prices tripled from 2005–2011, and the favorable prices were mentioned as an important reason for cultivation of maize by all of the respondents. Governmental support programs, such as maize subsidies, were also mentioned as important incentives for focusing on maize cultivation. However, lack of alternative low investment cash crops capable of growing on the infertile upland soils was also frequently mentioned as a reason for the sole focus on maize.

Figure 1: Land Use Changes 2002-2010. Young fallows are < 10 years. Old fallows are > 10 years.

60% of the respondents started to cultivate maize after 2001 when the Thai Government launched a set of micro-credit programs. In 2011, almost 50% of the maize growing farmers relied on short term loans from the Bank for Agriculture and Agricultural Cooperatives (BAAC), and many stated the possibility of obtaining credit for maize cultivation as an important reason for continuing to grow this crop. The loans from BAAC had to be repaid after harvest - with interests rates of 8–12% yr⁻¹.

50% of the farmers reported accumulating maize-related debt due to harvest failure and decreasing prices. However, at the time of the study they all planned to continue maize cultivation due to the absence of alternative agricultural income sources, and the need to repay debts.

Methods

Surveys, Interviews and Participatory Mapping: Questionnaire surveys about agricultural activities, and perceptions of soil fertility were carried out in 2011 and 2012 (n=60). In 2013, households were revisited and interviewed about maize yields and constraining factors. Qualitative data was generated from in-depth interviews (n=20) and ranking exercises focusing on maize production, including information about indebtedness. Information about land use changes was acquired from participatory mapping and group interviews. Land use classification was done based on two high resolution, multi-spectral and pan-sharpened images from 2002, and 2012.

Plot selection and soil sampling: To investigate the effects of maize cultivation on soil quality, sampling plots were selected to represent a chronosequence of maize cultivation intensity (n=16). Soil samples were collected from four depths of three replicate profiles (60 cm) per site. Samples were analyzed for soil texture, pH of aqueous solution, total C and N, available P, K, Mg, Ca, Cu, Mn, Fe, Al, and available B using standard laboratory methods. Soil samples were also analyzed for soil moisture, pH (water), C, N, P, K, Mg, Cu, Mn, and Fe using standard laboratory methods. Soil samples were also analyzed for soil moisture, pH (water), C, N, P, K, Mg, Cu, Mn, and Fe using standard laboratory methods. Soil samples were also analyzed for soil moisture, pH (water), C, N, P, K, Mg, Cu, Mn, and Fe using standard laboratory methods.

Effects of maize cultivation on soil quality

A strongly negative correlation between land use intensity measured as years under maize and concentration of Pox-C in the upper 0.5 cm of the soil was found (Figure 2). On average, the concentration of Pox-C in the upper 0.5 cm of the soil declines with 40 mg g⁻¹ under maize. Based on these findings, it can be concluded that concentration of Pox-C in the upper 0.5 cm of the soil is sensitive to the land use intensity in the investigated system.

55% of the respondents stated that the soil in their active maize fields was either ‘bad’ or ‘very bad’. More than 70% ascribed low yields in the 2011–2012 cropping season to low soil quality, which was in most cases ascribed to successive maize cultivation.

Table 1: Correlations between selected indicators of soil quality.

<table>
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<tr>
<th>Soil Property</th>
<th>Years under Maize</th>
<th>SOC</th>
<th>pH</th>
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<th>Mg</th>
<th>Ca</th>
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<td>p</td>
<td>0.566**</td>
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<td>0.733**</td>
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<td>0.855**</td>
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<td>0.546**</td>
<td>0.593**</td>
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The abandonment of the traditional swidden agriculture system has been driven by a change in the cropping season to low soil quality, which was in most cases ascribed to successive maize cultivation. Maize cultivation is sensitive to the land use intensity in the investigated system. More than 70% ascribed low yields in the 2011–2012 cropping season to low soil quality, which was in most cases ascribed to successive maize cultivation.