Temporal changes in soil fertility and the attempt to maintain the land productivity under slash-and-burn cultivation in the northern Laos

Junichi Kashiwagi[1], Koji Watabe[2], Seiichiro Ishii[2], Maiko Tanahashi[2], Yukiyo Yamamoto[3], Ryuichi Yamada[3] and Yoichi Hujihara[4]

[1]Laboratory of Soil conservation, Research Faculty of Agriculture, Hokkaido University;
[2]Laboratory of Soil conservation, Graduate School of Agriculture, Hokkaido University;
[3]Japan International Research Center for Agricultural sciences, Japan;
[4]Faculty of Bioresources and Environmental Sciences, Ishikawa Prefectural University, Japan;

E-mail address of Junichi Kashiwagi: kashi@env.agr.hokudai.ac.jp .
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Slash and burn cultivation is a cropping system that is applied in the tropical region, the agricultural products as staple food have supported residents, who had no choice of intensive cultivation in the remote area. The productivity under this cultivation system is fully depended on the intrinsic soil fertility and the fallow biomass. Because there is no inputs into land except for the ash originated from the vegetation burned by farmers. Many studies [1, 2], affirm the assumption as showed in Figure 1 that crop yields decline when the length of fallow periods is reduced, have been conducted. On the other hand, Mertz (2002) [3] pointed out the lack of clear evidences and concluded that the shortage of fallow period does not necessary to lead the yield to decline.

Slash and burn cultivation is the predominant farming system in the mountainous areas of the northern Laos. This system is thought to be a sustainable cultivation method, which doesn't need fertilizer if farmers can plant in the traditional way based on their experiences. But the National Poverty Eradication Programme and the policy limiting access to land have enhanced the frequency of cultivation at the confined areas in Laos. The recent area of land farmers can cultivate has became half of that in 1980's and the average yield also has decreased form 1.2 t / ha to 0.6 t / ha because of the reduction of fallow period from 5 ~ 6 years to 2 ~ 3 years in the investigation village. Therefore, we should estimate the soil degradation quantitatively in order to propose the adequate land use plan, which can realize sustainable agriculture. In this research, we investigated the temporal change of soil properties from 2004 to 2010 at some fields according to the topographical situation and land use to clarify the degree of soil degradation. Furthermore, we estimated the effect of rain-fed lowland rice field on maintaining land productivities.

The studies were carried out in a village of Houayyen, which is located in the Xiengnguen District in the Province of Luang Prabang in the northern Laos. Utisols, Alfisols and Entisols were distributed along hill slopes. We have investigated soil profiles and collected the depth-incremental soil samples on the 4 sites as follows from September 2004 until October 2010. Corn field (CF): surrounded with irrigated lowland rice fields and continuously cultivated for over 10 years, Upland rice field (URF): located on the steep slope (30 degree) and regarded as typical land use system, Teak tree field (TTF): showed same topographical condition with URF and planted teak from 2008, Corn and rice field (CRF): located on the bottom of URF slope and continuously cultivated corn or upland rice from 2007.

The soil in CF originally had rich nutrients, particularly humus and calcium. Increase in pH and decrease in total carbon and nitrogen were recognized during 7 years. However another nutrients still had been maintained in top soil and the corn yield had been constant according to the farmer. This fertile soil was attributed to the seepage flow from upper paddy field area. The temporal changes of most soil chemical properties showed fluctuation influenced by farmer operations in other fields. The degree of the changes was relatively high in CRF compared with URF located on the upper slope. The nutrients stored in fallow vegetation were released by burning and easily flowed down along the slope. Therefore, the big increase recognized in CRF caused by the inflow containing soil materials and nutrients from upslope area. In contrast, soil nutrients declined by soil erosion during the crop season in URF. After 2 years fallow,

some properties except for phosphate and calcium were recovered. The soil in CRF has been kept in fertile condition in spite of continuous cultivation after 2007. The nutrients inventory in soil gradually decreased in TTF partly due to the uptake by teak. Because the teak that has absorbed some nutrients from the soil will be removed as harvest from the field 15 years after it was planted, the teak cultivation seemed to directly lead to the soil degradation.

We attempted the examination about the possibility of continuous planting based on the results mentioned above. The rain-fed paddy field without bank on the upslope side was introduced to the lowest production area at the same location with CRF. The 8 times yield compared with the slope site was also more than that of the outside surrounded paddy field. In the previous research, it was suggested that phosphate deficiency control the upland rice yield. The amount of available phosphate in paddy soil was almost constant though out the cultivation season in the first year, because of the supply from the upper slope area by soil erosion. Furthermore, soil water content in the paddy field was higher than that of outside. In the second season, the rice yield decreased to 65% and soil phosphate also decreased to 80%. We expected the phosphate in the paddy soil would be concentrated by inflow in the first season would fall below the state of slope soil just after burned after 4 seasons.

To maintain the rice product in the village, the land use plan based on the soil material movement and nutrients cycle in soil biomass system is indispensable

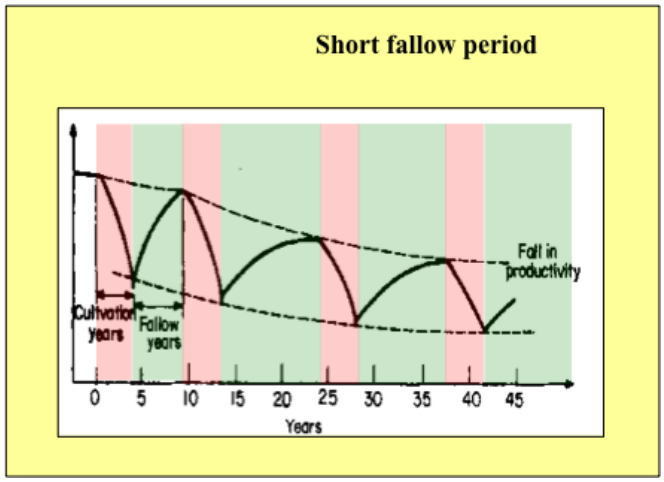

Fig. 1. A theoretical presentation of the relationship between soil productivity and fallow period in the case of short fallow period [4].

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