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Traditional skills and knowledge inherited from Japanese swidden cultivation: Toward restoration of degraded *Satoyama* forests

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Abstract: In this study, we examined the potential of swidden cultivation as a form of environmentally sustainable agriculture in intermediate and mountainous areas of Japan. In 2010, almost 1000 m^2 of scrub forest dominated by bamboo (*Sasa* sp.) was slashed and burned for swidden cultivation in the town of Yogo, Shiga Prefecture. After burning, half of the swidden field was plowed with hoe, and then the entire field was sown with turnip (*Brassica rapa*) seed. The fire left a layer of ash on the soil surface, which may have supplied sufficient nutrients to the surface soil for successful cultivation of the turnip crop. By mixing the ash with organic matter in the surface soil, surface plowing appeared to be very important for creating suitable conditions for crop growth. Plowing also appeared to help prevent ash runoff. In addition, almost no weeds were observed during the turnip cropping period, probably because of the intensive burning. About 3 months after sowing, approximately 350 kg of turnips were harvested, without the use of any fertilizer, chemical pesticide, or herbicide; the success of the crop was attributed to effects of burning and plowing. Swidden cultivation still plays an important role in food production in mountainous areas of Japan, and contemporary swidden cultivation has potential as an environmentally sustainable form of agriculture.
Key words: Burning, plowing, environmentally sustainable agriculture

Introduction

Traditional livelihoods and agricultural landscapes in Japan have changed drastically since the mid-20th century, mainly due to rapid economic growth, introduction of chemical fertilizers and fossil fuels, urbanization, and depopulation of rural areas. *Satoyama*, a land use mosaic composed of woodlands, paddy fields, crop fields, grassland, and settlements, is a typical agricultural landscape in Japan (Ichikawa *et al.*, 2006). In the woodlands, called *Satoyama* forests, people felled trees for timber and charcoal, cut shrubs for firewood, and collected litter for compost. However, the *Satoyama* forest environment has changed dramatically since these activities were largely halted in the 1950s (Morimoto and Yoshida, 2005). Consequently, most *Satoyama* forests have been abandoned and their ecological functions have been degraded. Recently, there have been many attempts by community-based organizations to restore the ecological functions of *Satoyama* forests. However, these efforts are not sustainable in the long-term because most of these activities depend largely on volunteers and are no longer tied to human livelihood.

In the intermediate and mountainous areas of Japan, swidden cultivation was widely practiced in the past. Secondary forests that recovered during the fallow period of swidden cultivation were utilized for collection of firewood and litter and functioned similarly to *Satoyama* forests. As noted by Sasaki (1972), the total area of swidden fields in Japan decreased sharply during and after World War II, from 77,000 ha in 1936 to 10,000 ha in 1950. Although the total area of swidden fields decreased sharply, the decrease in the number of households engaged in swidden cultivation was rather gradual; around 110,000 households were estimated to be engaged in swidden cultivation in 1950 (Sasaki, 1972). In some areas of Japan (e.g., Tsuruoka in Yamagata Prefecture, Miyama in Fukui Prefecture, Yogo in Shiga Prefecture, Shiiba in Miyazaki Prefecture), local people still engage in traditional swidden cultivation.

The environmental heterogeneity of the *Satoyama* landscape, created by the mosaic of land use, is a key factor in the biodiversity of these areas (Katoh *et al.*, 2009). Abandonment of traditional land use thus poses a major threat to biodiversity conservation (Kadoya and Washitani, 2010). Secondary nature, such as *Satoyama* forests or fallow lands that are maintained by human interference, may be more difficult to preserve than virgin nature as it is deeply related to human lifestyles (Morimoto and Yoshida, 2005). Because swidden fields and fallow lands were important components in creating heterogeneity in the *Satoyama* landscape (Kamada and Nakagoshi, 1997), it is useful to examine the contemporary significance of swidden cultivation in crop production and environmental conservation. The goal of this study was to examine the skills and knowledge inherited from traditional swidden cultivation in the town of Yogo, Shiga Prefecture, to evaluate the potential of swidden cultivation as a form of environmentally sustainable agriculture in intermediate and mountainous areas of Japan. In this paper, we particularly focus on the effects of burning and plowing in swidden cultivation. In addition, because slash and burn practices in swidden cultivation stimulate the regeneration of various plants during fallow periods, abandoned *Satoyama* forests may be rejuvenated by this practice. The ultimate goal of our research activity is to use the skills and knowledge inherited from traditional swidden cultivation to establish a model for forest management and local revitalization in intermediate and mountainous area of Japan.

Materials and Methods

The study took place in Yogo, in the city of Nagahama, Shiga Prefecture, Japan. Villagers living in Yogo still conduct traditional swidden cultivation. In 2010, almost 1,000 m^2 of scrub forest dominated by bamboo (*Sasa* sp.) was slashed and burned for swidden cultivation. According to villagers, this kind of scrub forest is typical of the vegetation traditionally opened for swidden fields. More than 40 people including local villagers, researchers, nonprofit organization (NPO) staff members, and media

representatives participated in the burning. After burning, half of the swidden field was plowed with hoe, and half was not plowed, and then the entire field was immediately sown with turnip (*Brassica rapa*) seeds. Most of the seeds sown in this study are local variety of turnips in Yogo. Mature turnips were harvested about 3 month later. The dates of these agricultural practices are listed in Table 1.

Table 1. Date of agricultural practices in the swidden cultivation

Date	Agricultural practice
25 and 30 July 2010	Opening (slashing) the scrub forest dominated by bamboo
19 August 2010	Burning the opened scrub forest
19 August 2010	Plowing the swidden field
19 August 2010	Sowing turnip seeds
13 August 2010	Harvesting turnips

Fig. 1. Scrub forest dominated by bamboo (*Sasa* sp.).

Fig. 2. The study site, after opening the scrub forest.

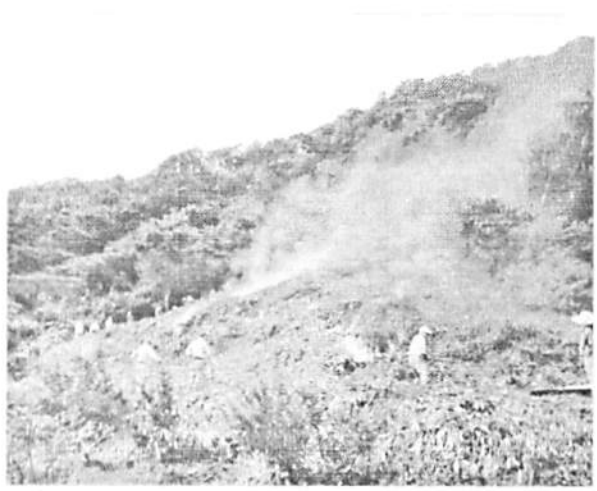

Fig. 3. Burning the study site.

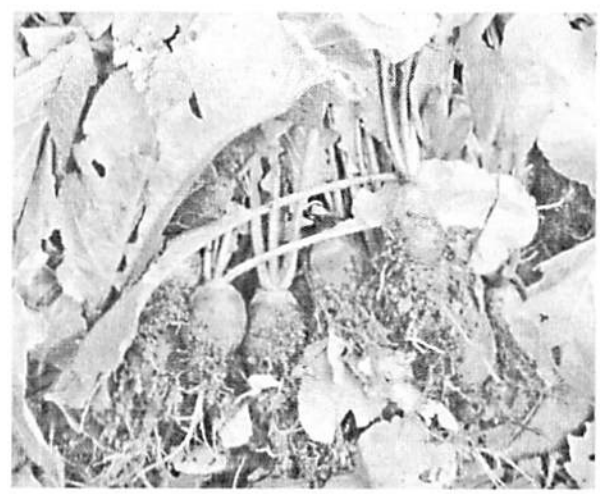

Fig. 4. Turnips harvested from the study site.

Results and Discussion

Effect of burning: The scrub forest was burned on 19 August. The fire intensity was quite high and almost all aboveground biomass burned completely. Many studies have reported that the slashing and burning of forests enriches soil nutrients due to the incorporation of ash from the burned biomass (Stromgaard, 1984; Andriesse and Schelhaas, 1987; Lessa *et al.*, 1996; Tanaka *et al.*, 2005). The burning of bamboo-dominated scrub forests has the particular advantage of supplying water-soluble K (Suzuki *et al.*, 2009) because bamboo accumulates more K than other base cations (Rao and Ramakrishnan, 1989; Shanmughavel and Francis, 1996a, 1996b; Mailly *et al.*, 1997), whereas tree-dominated forests accumulate more Ca (Kyuma and Pairintra, 1983). The burning left a layer of ash on the soil surface at our study site, suggesting that nutrients, especially water-soluble K, were supplied to the surface soil. In addition, slashing and burning enhances mineralization of organic N and P in soil by the "soil heating effect" (Stromgaard, 1984; Kyuma *et al.*, 1985). Thus, the intense burning observed at our study site may have enhanced the mineralization of these nutrients.

Field observations revealed an almost complete lack of weeds during the turnip cropping period, probably due to the intensive burning that occurred at the site. Fires of certain temperature and duration are known to be effective at killing buried weed seeds (Kato *et al.*, 1999). Furthermore, no pest damage was observed, whereas turnips grown in an adjacent upland field suffered from serious pest damage. It is also well known that sufficiently intense burning can prevent damage to crops from pests in swidden fields.

Effect of plowing: The swidden fields were plowed immediately after burning, as is commonly in Japanese swidden cultivation (Sasaki, 1972). In contrast, swidden fields in Southeast Asian countries are rarely plowed because plowing would lead to severe soil erosion in the rainy season.

In an interview survey conducted in Yogo, respondent indicated that surface plowing, by mixing the ash layer with organic matter in the surface soil, is very important to creating appropriate conditions for crop growth. Because the rainfall intensity after burning is generally not as high in Yogo as in Southeast Asian countries, plowing would not cause severe soil erosion. In fact, plowing the ash into the soil appears to aid in preventing ash runoff.

Field observations indicated that initial growth of turnips was much better in the plowed half of the field. In the unplowed half, seeds remained on the soil surface and seemed to dry up before germination. Summer 2010 was extremely hot in Japan, and almost no rain was observed after the sowing. The seeds covered by soil by plowing may have escaped desiccation.

The potential of Japanese swidden cultivation:

Approximately 350 kg of turnips were harvested in 2010 from our study field without the use of any fertilizers, chemical pesticides, or herbicides, probably owing to the beneficial effects of burning and plowing.

As mentioned in the Introduction, *Satoyama* forests have lost their biological resource production role because charcoal, firewood, and compost, which had been produced from *Satoyama* forest wood and litter, have been replaced by fossil fuels and chemical fertilizers. On the other hand, the role of swidden cultivation in food production has not been lost in mountainous areas of Japan. In particular, many varieties of turnips (*Brassica rapa*) are produced from swidden fields and are being sold at value-added prices. This suggests that contemporary swidden cultivation has high potential as a form of environmentally sustainable agriculture in intermediate and mountainous areas of Japan.

However, long-term monitoring of vegetation recovery after burning is necessary to determine the possibility of using swidden cultivation to restore degraded forests. Because our study site (scrub forest dominated by bamboo) was one of the typical of degraded forests in Japan, monitoring the vegetation recovery in this swidden field would be useful in evaluating the potential of using swidden cultivation to restore degraded *Satoyama* forests.

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