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Slash-and-Burn Experiments to Reconstruct Late Neolithic Shifting Cultivation

Introduction

The origin of agriculture in the Near East was in a region where the wild ancestors of the cultivated plants grew in a more or less open landscape. The spread of agriculture to the northwest into Europe covered forested landscapes and therefore required clearing to practise agriculture. According to older opinions, Neolithic agriculture was rather simple and hadn't developed sophisticated methods of manuring and tillage. Therefore people had to shift their fields regularly to avoid bad harvests (Childe 1929, 1952, 1960, Sangmeister 1950). But on the authority of later research the fertile soils of the loess belt in Central Europe, colonized during the Early Neolithic of Central Europe (about 5600 to 4300 B.C. cal.), allowed adequate yields for many years without manuring. Adequate yields in this case mean between five and eight dt/ha, as calculated for the Early Modern age three-field-system. Based on those yields are also quantitative models of Neolithic agriculture and nutrition (Jacomet and Schibler, 1985). For these reasons permanent fields and settlements were postulated (Modderman 1971, Lüning 1980 a, b). Neolithic agriculture was different from recent shifting cultivation in the tropics and also different from early modern age slash-and-burn agriculture on poor soils in mountains.

In the late Neolithic, between 4300 and 2300 B.C., people colonized fresh landscapes outside the loess belt, in the low-mountain region and in the former glaciated regions of the pre-alpine lowlands and those of northern Central Europe and southern Scandinavia. Pollen and macrofossil data from lake-shore settlements, peat and lake sediments of the northern pre-alpine lowlands indicate shifting cultivation and slash-and-burn agriculture (Rösch 1987, 2000) for this period. Obviously the Late Neolithic agriculture was different from the Early Neolithic agriculture in the loess belt. But it is not sure if this was a slash-and-burn system and under which circumstances and with which results this system worked. Therefore experiments are necessary.

Material and methods

To deliver new and different arguments to the discussion, we started 1994 with agricultural experiments to reconstruct Late Neolithic land use (Bauer 1998, Rösch 1998). Since 1998 these experiments have been carried out in Forchtenberg, northeast of Stuttgart, where the Forest department of Baden-Württemberg put an area of 3.5 ha with mixed deciduous forest at our disposal (Schulz 1999, Rösch et al. 2002a, b). The soil type of the area is Luvisol and Stagno-Luvisol according to WRB (FAO 1998); the climate is moderately suboceanic with an annual average temperature of about 9°C and an annual precipitation of about 850mm. The area has been forested for at least 200 years and is surrounded on all sides by forest. In the eastern part, where the best soils are located, Celtic fields indicate former agriculture.

The area was divided into 34 single plots with an extent of 30 x 30 m. Every year one or two plots are cleared for experiments. At the moment experiments are being carried out or succession processes after experiments are under observation on nine plots. The experiment is a multidisciplinary approach with the participation of different scientists. Data are collected concerning:

- burning temperature, charcoal and carbon circle
- archaeo-ergonomic data
- yields of different cereals
- soil biology and chemistry
- soil structure and morphology
- vegetation, seed bank and pollen precipitation

The normal cultivation procedure is as follows:

- Clearing of the forest in winter by cutting the trees. This is done partly with power saws, partly with copies of Neolithic stone axes to calculate the effort for clearing using original tools and technology.
- Removing the stems and wood with a diameter thicker than 10 cm

- Burning a part of the cleared area, between 50 and 150 m^2, using the remaining thin, dry wood as fuel. This is done in autumn to grow a winter crop or in spring to grow a summer crop. To burn the top soil and vegetation completely, a burning roller of wood is moved slowly over the area, using long hooks for pulling and feeding the fire permanently with wood (Figure 1). Burning an area of 100 m^2 demands the day's labour of a number of people.
- Sowing cereals a few days after burning, preferably after the first rain, in single holes made by a wooden stick. The holes are at distances of 16 cm and each contain ca. 8 grains. The resulting seed density is ca. 300 grains per m^2. As crops we use all cereals known from the Late Neolithic, *Triticum aestivum* (modern and old race) and *Triticum monococcum* as winter crops, *Triticum durum*, *Triticum dicoccon* and *Hordeum vulgare* (modern and old race) as summer crops.
- Removing tall weeds once in the autumn-sown crop and twice in the spring-sown crop.
- Protection of the yields from game by fences, from birds by nets, and from mice by special walls made of metal sheets.
- Harvesting the ripe cereals, partly by using copies of Neolithic harvesting tools.

Figure 1. Burning by moving the fire with hooks slowly over the ground

Apart from this standard procedure we also test a first growing season after clearing without burning and long-term agriculture at the same place without burning and fertilizing, but with tillage by hoeing. As far as animals are concerned, experiments to integrate livestock, especially goats and pigs, in the land-use system, have also started. The aim is to look for possibilities of weed regulation and tillage without fire or manpower.

Results and discussion

Important results of the experiment are:

- fire temperature in the soil shows a large variation, but normally at a depth of 1 cm the temperature is above 80°C and at 2 cm above 60°C. So nearly all weeds are suppressed (Figure 2).
- with burning the average yields of autumn-sown cereals are higher than 20 dt/ha on the poorer and more than 40dt/ha on the better soils (Figure 3). With spring-sown cereals the yields are about 1/3 lower, due to shorter growth time and higher weed pressure.
- without burning the yields are less than a ¼ on the poorer soils or less than ½ on the better soils compared with burning
- Growing cereals at the same place for several years without burning and fertilizer and growing cereals after clearing, but without burning and fertilizer, results in yields between nearly 0 (poor soils) and lower than 5 dt/ha (better soils).

- The main reasons for the high yields after burning are the mobilisation of nutrients, the rise of the pH, which makes nutrients better available, especially for wheat, and the suppression of weeds.
- These so called weeds are mainly not typical crop weeds but trees and shrubs, herbs of the forest floor or from clearings and forest fringes recovering from their root-stocks, or freshly germinating. Their development is very vigorous and makes growing on the same place in the following years very difficult and time-consuming.

Figure 2. A field burned and sown in autumn is here to see in spring. The wheat has well developed and the field is free of weeds. In the background *Anemone nemorosa* is flowering outside the burned area.

Figure 3. A burned field shortly before harvest. The wheat is in dense stand and more or less free from weeds, whereas in the surrounding tall thistles and other weeds cover the ground.

Conclusions

Assuming the availability of sufficient forest and wood, the slash-and-burn technology with shifting cultivation achieves higher yields compared with permanent agriculture and also compared with the usual agriculture with tillage and fertilizing on permanent fields as known from the iron age and medieval period. Clearing the forest is time-consuming, but the most important disadvantage is a lower total yield in a completely used landscape, because of much fallow land used to produce new wood for fuel during long-term fallow phases. Therefore a growing human population must substitute this type of agriculture by more sophisticated but even more lavish technologies. Whether long-term slash-and-burn agriculture with several cycles on the same place results in a deterioration of the system remains an open question for this long-time research project.

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