EVALUATION OF AN INDIGENOUS FARMING SYSTEM IN THE MATENGO HIGHLANDS, TANZANIA, AND ITS SUSTAINABILITY

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ABSTRACT The Matengo have cultivated steep slope fields for more than a century using their original soil conservation system. This system is a two-year rotation that includes a short-term grassland fallow. The field lies fallow without cultivation during the early rainy season at the first year. The grasses are cut down and the dry shoots are gathered up in lines forming a grid on the field that is then covered with topsoil in a square. The ridges form the grid, thereby producing many well-ordered pits over the whole field. The pit can function as a buffer and controls run-off by allowing rainwater to stand. Although the pit may break if the precipitation of an intense rain is beyond the capacity of buffer, the ridges are protected consistently because the water in pit can be efficiently led downward along the buried shoot bundles in the soil. At the beginning of the next rainy season, maize is sown on the ridges. Because the buried shoots are decomposed during this rainy season releasing nutrients of the maize, subsurface drainage is lost. The pit functions as a small sedimentation tank until the pit is filled with soil. Thereafter, because the field is covered with well-grown maize, the surface soil is again protected from runoff, thus conserving the topsoil and their fertility on steep slopes throughout a year. This area is also famous for coffee production, and the high cash income from coffee has economically sustained this farming system and the society

Key Words: Coffee; Grassland fallow; Matengo; Sedimentation tank; Soil erosion; Subsurface drainage.

INTRODUCTION

Soil erosion from agricultural practices is one of the most serious problems in mountainous areas where there are frequent heavy rains. Soil loss on slopes covered with vegetation is very little. However, with removal of the vegetation, surface soil can easily erode and if cultivated, erosion becomes even more serious. Therefore, when woodlands on slopes are cleared for cultivation, unless measures to stop soil erosion are taken, fertile surface soils may erode with heavy rain and the land becomes barren within only a few years (Kjekshus, 1977; Pratt & Gwynne, 1978; Pomeroy & Service, 1986).

Soil erosion on highlands with frequent torrential rain in southern Tanzania is a major factor influencing the period of time for cultivation. However, usually in Tanzania no measures are taken to conserve surface soils on slope farming. In the traditional slash-and-burn farming systems in Tanzania, the farming fields are utilized for two to three years after the forests are initially cleared, and then abandoned. The lands are then left until the original vegetation recovers. Because the roots of cleared trees can survive for several years, soil erosion can be minimal. However, if the land is cultivated, the roots die due to repetitive cultivation and burning, and the stability of the soil is lost (Pomeroy & Service, 1986).

To replace the traditional slash-and-burn farming systems, modernization of agriculture has been promoted in Tanzania, through introduction of intensive farming on permanent fields using fertilizers and pesticides. Because of a recent population expansion and the spread of chemical fertilizers, even the fields on steep slopes have been repeatedly utilized for many years. Consequently, the fertility of the topsoil has degraded and vast areas of arable lands on slopes have become irrecoverably barren (Pratt & Gwynne, 1978).

On the other hand, there are certain people who have successfully cultivated the slopes partly due to social constraint. The Livingstone Mountains are on the east coast of Lake Malawi, southern Tanzania. The south-end range of the mountains are called the Matengo Highlands where most of the farming fields are on steep slopes, susceptible to soil erosion due to frequent torrential rains. The Matengo people have lived in the mountainous lands for more than a century and a half, because of conflict with the Ngoni people who migrated from southern Africa to east of Matengo Highlands, now called Songea, in the middle of the nineteenth century (Willis, 1966; Shillington, 1989). They were obliged to stay only on the upper areas of mountains. Under these social constraints to survive in the highlands, the Matengo created a unique soil conservation farming system.

The Matengo farming system has already been reported by several researchers (Allan, 1965; Basehart, 1972; Basehart, 1973; Pike, 1938), but its agricultural significance has not been sufficiently discussed. This paper will explain this system and evaluate its agricultural significance and sustainability.

TOPOGRAPHY, PEOPLE, CLIMATE AND VEGETATION OF THE STUDY AREA

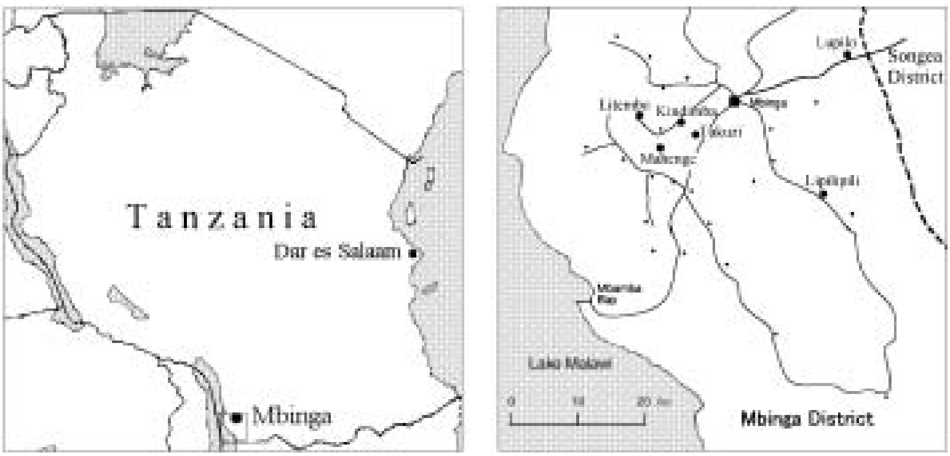

Fig. 1. Maps of Tanzania and Mbinga district. ● Main village, ● Research site

Table 1. Areas in Mbinga district.

Total	11,396 km^2
Lake	2,979
Land	8,417
Arable	7,150
Filed	1,132
Others	135

The Matengo territory is in the Mbinga district of the Ruvuma region of southern Tanzania (Fig.1). The highest peak in the area is over 2,000 m above sea level, although a large part of the district is in highlands between 900 m and 1,700 m. According to the data from DALDO (District Agricultural and Livestock Development Office) in Mbinga, 80% of the land is arable (Table 1) and is mainly composed of steep slopes, narrow plateaus and alluvial plains along the shore of Lake Malawi. The major inhabitants along the shore are not the Matengo, but the Nyasa people. Most of the Matengo live in the mountainous areas, in particular in the western highlands that were historically the political and economic center. The rolling hills in the eastern and southern parts of the district are still woodland and studded with small villages of immigrants from the western highlands.

A year is clearly divided into two seasons: a dry season from May to November and a rainy season from December to April, with annual precipitation of 500-1,200 mm (Fig. 2a, JICA, 1998). According to the data from rain gauges set at several vil-

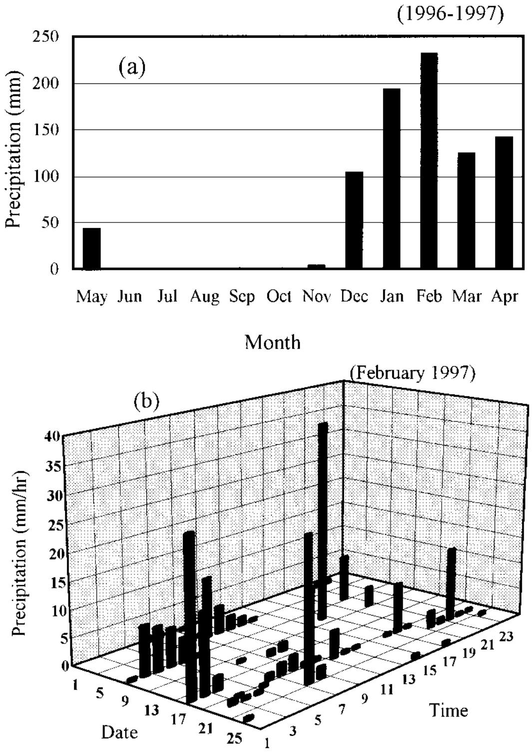

Fig. 2. Monthly precipitation (a) and intensity of rain (b) at Kindimba vollage (1,400 m above sea level).

lages since 1995, the rainfall is a torrential downpour of a short span, often raining more than 30 mm per hour (Fig. 2b). Generally, the temperature is cool throughout the year. Fig. 3 shows the average temperature for every ten days at Kindimba village (about 1,400 m above sea level) on the western highlands (JICA, 1997). The maximum temperature during the hot season from October to February is below

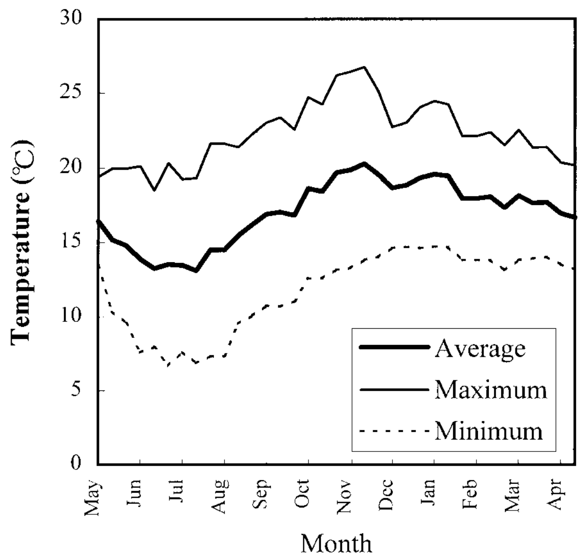

Fig. 3. Temperature for every ten days at Kindimba village in 1996-1997.

30˚C. The minimum temperature during the cold season from June to August is below 10˚C.

The vegetation on the rolling hills below 1,400 m are open woodland, called *miombo*, which is dominated with trees belonging to *Caesalpiniaceae*. The original vegetation in the highlands (1,400-1,900 m) was probably montane forest before being opened for cultivation. Now these trees are scarce. The highland tops around 2,000 m are rocky grassland that are not arable.

RESEARCH

I conducted this research during April 1993 and April 1994 while staying at the Sokoine University of Agriculture, Tanzania. The data were obtained by observation of cultivation practices in Mbinga district, interviews with the Matengo farmers in several villages, and later experiments in Japan.

NGOLO FARMING SYSTEM

The Matengo has a unique farming system for soil conservation in the mountain-

Fig. 4. *Ngolo* farming.

ous land where soil erosion is of major concern. A main feature of this system is that the fields contain a large number of pits (Fig. 4). This system has been referred to as “the Matengo pit system” in literature (Allan, 1965; Basehart, 1972; Basehart, 1973; Pike, 1938). As the pit itself is called *ngolo* by the Matengo language, I call

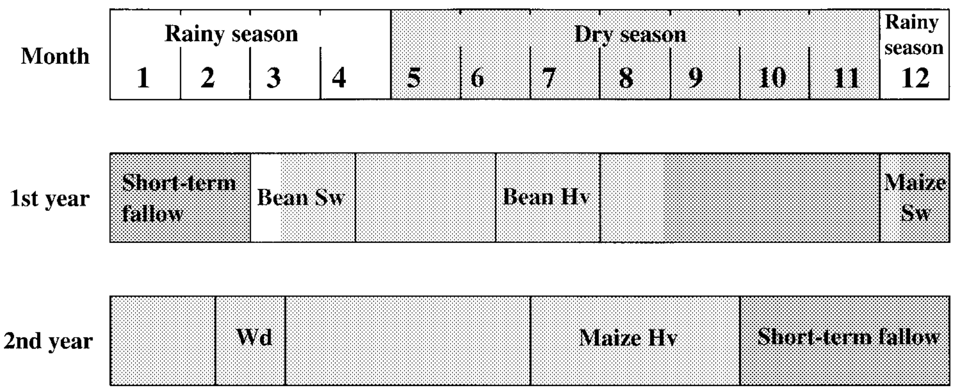

Fig. 5. Cropping system. Sw: Sowing, Hv: Harvesting, Wd: Weeding.

this system "*ngolo* farming" in this paper. *Ngolo* farming can be classified as a grassland fallow farming system, although cropping is usually repeated for many years without fallow. It is also combined with a two-crop-rotation system (Fig. 5), in which beans (*Phaseolus vulgaris* L.) are planted in the late rainy season of the first year and maize in the following year.

The *ngolo* system is also characterized by the land use in the early rainy season of the first year. Although in many Tanzanian farming systems the crops are sown at the beginning of rainy season, the farming fields in the *ngolo* system are left without cultivation until March. The fields in the early rainy season are left to grow weeds. A field with predominantly weeds called *malumba*, is considered fertile. Species included in *malumba* weeds vary slightly with the areas and the farmers, but in many cases they are *Conyza sumatrensis* and *Nidorella resedifolia*. *Malumba* is a general term for plants indicating the fertility of land. In contrast, *Pteridium* sp., called *lisilu*, generally indicate infertile or unsuitable land for cultivation.

In March men cut the well-grown weeds with their hand-made billhook. This work is called *ku-kyesa* and requires cutting as close to the ground as possible. The cut shoots are left for two weeks to dry. The farmers say that if non-dried shoots are buried into the ridges, the first crop of beans (*Phaseolus vulugaris* L.) will not germinate due to the heat from the green manure buried into the ridges. A test carried out at Utsunomiya University in Japan, using non-dried weed (*Digitaria adscendens* Henr.) shoots resulted in a markedly low germination rate, although the soil temperature did not increase. In Japan, a paddy field is customarily left for a week after green manure is plowed in and then irrigated for the purpose of removing toxic substances. In the case of *ngolo* system, the drying of shoots probably has the same effect. Because beans are sown just after burying the cut shoots into the ridges, the toxic substance to germination must be removed before burying.

The dry shoots are then collected and organized into lines using the billhook to form ridges of vertical and horizontal square grids of 1.5-2.0 m. The size of the square determines the plant population density. The work is called *ku-bonga* and is carried out by men as well. The well-ordered lines become a basic design of the *ngolo* field.

The shoot bundles forming the grids of the ridges are called *mabongi*, and all the weeds in the field and maize stalk residues are used. The *mabongi* measures 20-30 cm wide at most and 10-20 cm high. Extra shoots are heaped elsewhere in the field. This heap is called *tuta* (pl. *matutila*). This term is often confused with *tuta* in Swahili language which means ridge. The heaps are usually set on fire at the end of the dry season and finger millet (*Eleusine coracana* Gaertn.) or pumpkin (*Cucurbita* spp.) is planted in rainy season.

After finishing *ku-bonga*, women cover *mabongi* with small amounts of topsoil. This work is called *ku-jalalila*. Then they broadcast beans (*ku-lekalela ngunde*) on the small ridges and cover with soil. This work is called *ku-kulalila ngolo* (Fig. 6). A woman stands in the square, skillfully digs up and pushes the surface soil around her feet to the surrounding ridges using a hoe, forming an indentation at the center of the square (Fig. 7). Half of the cultivating time is spent on this work (Table 2). Although the surface soil is dark brown and rich in organic matter, the subsoil is very compact and reddish brown. When the subsoil appears, she stops digging fur-

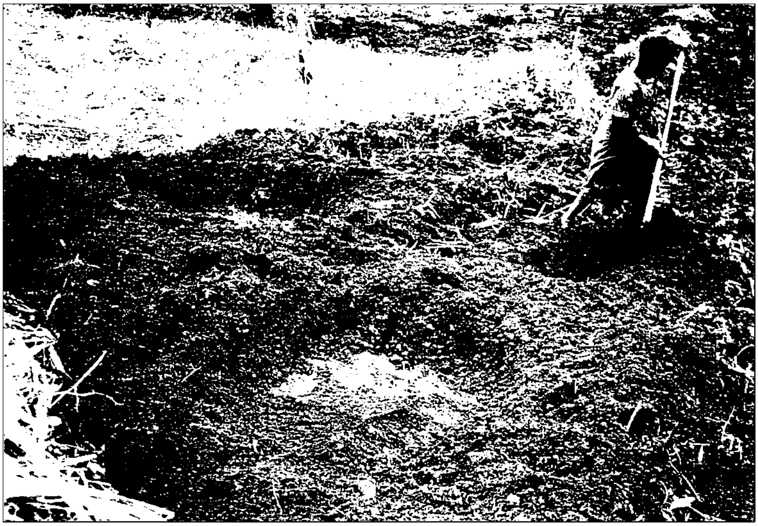

Fig. 6. Woman covering the bean seeds with topsoil in a square.

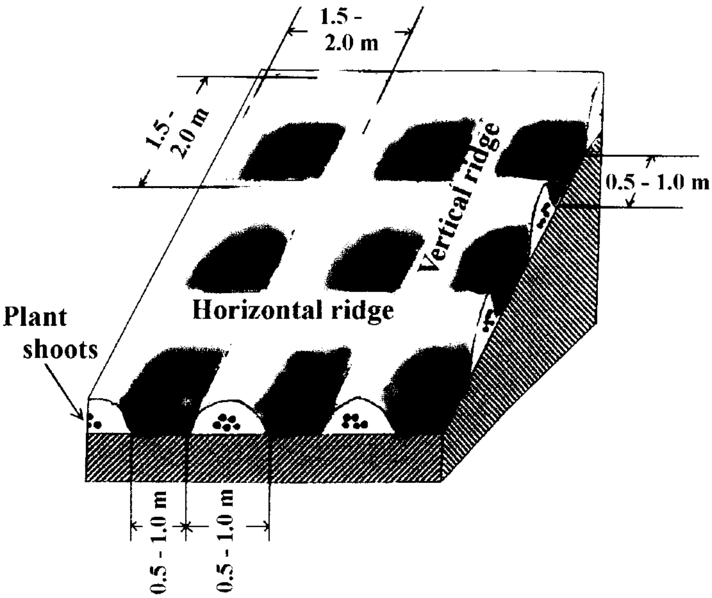

Fig. 7. A profile of *ngolo* ridge.

ther down. Workers divide into smaller units of work in terms of time and space. The work area is normally 0.1 to 0.2 ha thereby shortening the time between sowing and soil covering. Otherwise the field is exposed to the risk of erosion due to torrential downpours. The formers carry out several cycles of this work in a day.

Cultivation is basically women's work. Table 3 shows the area cultivated in one cycle, number of pits per area, and the time a skilled woman spent to cultivate the

Table 2. Time distribution of each work for *ngolo* cultivation by a woman.

Total	100.0%
Covering shoots with soil	33.9%
Sowing beans	15.5%
Covering beans with soil	50.6%

Note: a ratio of time taken to practice each work in a sequence.

Table 3. Area, number of pits and time which a farmer ciltivates in a *ngolo* farming cycle.

Area	(in a cycle)	173.6 m^2
Number of *ngolo*	(in a cycle)	33
Number of *ngolo*	(per hectare)	1882
Time to cultivate	(in a cycle)	2 hr 13 min*
Time to cultivate	(per hectare)	126 hr 44 min

Note: *not including rest time of five minutes.

area of one cycle. A homestead is usually composed of 0.5-1.0 ha fields that the family has to cultivate in a year. If three women cultivate the fields together for ten hours per day, the preparation can be completed in 2-4 days.

During the growing season the beans in the field do not require any management. The beans are harvested in the early dry season, from June to July. The whole plants with pods are pulled out and brought to a home garden for threshing. Throughout the dry season a *ngolo* field is left fallow, and at the beginning of the rainy season maize of local varieties is planted on the ridges where beans had previously been grown. The seeds are sown along the contour line as shown in Figure 8. It seems that space between plants in a *ngolo* field is narrower than that in a normal ridge, because the light competition among maize plants in a *ngolo* field is not a serious problem because of the slope and the open pit.

When maize reaches 20-30 cm in height, the sediment at the bottom of the pit is dug up by a hoe and the weeds are removed. This is the only management during the growing season of maize. Only dry ears are harvested in the middle of the dry

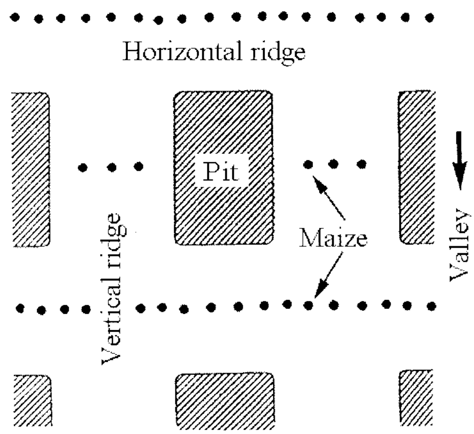

Fig. 8. Maize are mainly sown on the horizontal ridges.

season and stored. The shoots remain in the field. Although it begins to rain in December, the fields are left without cultivation to grow *malumba* and other weeds. In March men begin to cut the weeds again for *ngolo* cultivation.

Because *ngolo* farming system is repeated in a two-year cycle, and maize and beans are the main food crops for the Matengo, they need to own at least two fields. When the maize yield decreases, the field is fallowed for several years until it is fully covered with shrubs or tall grass.

Some people plant wheat or peas as well in *ngolo* field. Cassava is sometimes planted on the ridges at the time beans are sown and then harvested after the maize has matured the next year. Although cassava is an important starch crop, the yield is low due to the cool temperatures. Finger millet or pumpkin is sown at the spots where shoot heaps (*matutila*) are burned in maize fields during the early rainy season.

THE AGRONOMIC SIGNIFICANCE OF *NGOLO* FARMING SYSTEM

One of the characteristics of the *ngolo* farming system is that it involves a short-term fallow in its rotation cycle. In the early rainy season of every other year a field is left untilled to grow several different weeds. In general, the recovery of soil fertility in a grassland fallow system is attributed to an accumulation of organic matter in topsoil due to the repeated life cycle of annual herbious plants. In the short-term fallow of the *ngolo* system, the cycle is accelerated by cutting, drying and burying shoots. The manure must be a main source of nutrients for maize, evident from the fact that maize can be continuously harvested for ten years or more without application of any other fertilizers.

A farming system of the Fipa people in southwestern Tanzania involves making a compost mound called *intuumba* (Willis, 1966). Towards the end of the rainy season they create mounds by piling grass and weeds. At the beginning of the next rainy season, the mounds are broken down and finger millet is sown into the enriched soil. The purpose of this preparation is to accelerate the decomposition of the piled grass. In the *ngolo* system the buried residues may be expected to have the same effect.

The Matengo believe that the yield of maize in the *ngolo* field is higher than that in a normal ridge cultivation system. Allan (1965) reported the results of an experiment carried out in northern Tanzania where the yield of maize grown in *ngolo* field was significantly higher than that of maize grown in other types of fields. The reason for the high productivity in *ngolo* farming system needs to be studied further.

MECHANISMS OF SOIL CONSERVATION

I. Function of Subsurface Drainage

In the periods following the sowing of beans and maize, the *ngolo* fields are bared and directly exposed to rain apparently risking soil erosion. In general, soils in cultivated land easily erode compared to those of the non-cultivated land because soil cohesion weakens due to a break down of aggregated structure. However, the *ngolo* system prevents soil erosion, and as the literature and the Matengo explain by allowing the rainwater to stand in the pits.

However, the soil conservation system in a *ngolo* field cannot be entirely explained by this mechanism. As shown Figure 2b, it often rains more than 30 mm per hour in Mbinga district, whereas it seems that the water-holding capacity of the pit is not sufficient to reserve the large amounts of rainwater contributed by a torrential downpour. For example, assuming the size of one *ngolo* square, including ridges, is 4 m^2 (2×2 m) and it rains 30 mm per hour, one pit has to hold 120 liter of rain water. However, the actual capacity of a pit formed on a slope is less than this, and the steeper the slope, the less water-holding capacity of its pit. If heavy rain continues, the pits can overflow or the ridges may collapse. However, if the standing water can be successively run by some means, rainwater may be controlled. In fact, the pit does not overflow during heavy rains for several hours and the structure is maintained without a break in its horizontal ridge. This phenomenon is probably due to an effect of the ground on drainage, and may be one of the significant mechanisms supporting soil conservation in the *ngolo* farming system. I hypothesize that the buried shoots may accelerate the drainage of the pit, and the following experiment was carried out in Japan to assess subsurface drainage in *ngolo* fields.

Experiment: Effects of buried maize stalks on water drainage in a ngolo field

To evaluate the physical role of maize stalks buried into *ngolo* ridges, the infiltration rates in a pit with and without buried maize stalks were compared.

Methods

The experiment was carried out at the experimental field of Utsunomiya University in Japan in July 1994. The soils used were Andosols and the field had a moderate slope of about 7 degrees. Dry stalk bundles of maize (*Zea mays* var. Petercorn) were arranged in the form of a vertical and horizontal grid (1.5×2.0 m) on a bare slope and then covered with the surface soils from inside the square formed by the bundles (Fig. 9). A bundle was composed of seven stalks. The experi-

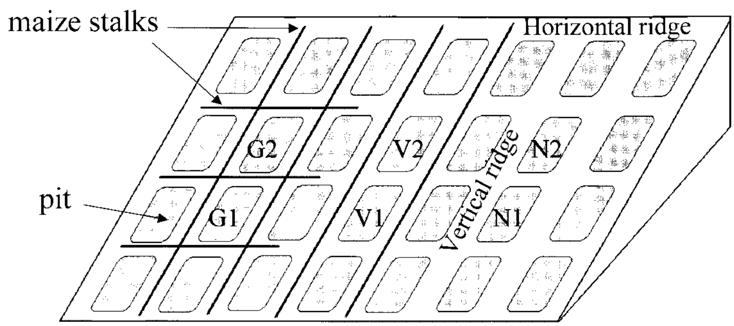

Fig. 9. Design of the experimental filed.
Maize stalks are buried into all the grids of the ridges (G), into the vertical ridges only (V), and into neither ridge (N).
1: First time, 2: Second time.

ment covered three designs: the stalk bundles were buried into all the grids of the ridges (G), only into the vertical grids of the ridges (V), and no burying (N). The pits were then filled with water and the decreasing water level was measured every minute. After thirty minutes, the pits were again filled with water and the measurements were repeated again for thirty minutes. Replicates were two.

Results and Discussion

After the initial filling, water in the pits of all treatments percolated into the ridges at a similar rate, for the soil was not saturated with water (Fig. 10). At the second filling test, however, the soil most probably became saturated with water and the rate of decrease in water level in N slowed down. In contrast, the water levels in G and V treatments decreased at a constant rate. These results clearly indicate that the buried maize stalk bundles account for the increased drainage in G and V treatments.

There was no difference between G and V treatments in the decreasing rate of water level in the experiment. The buried stalk bundles form continuous pores in the

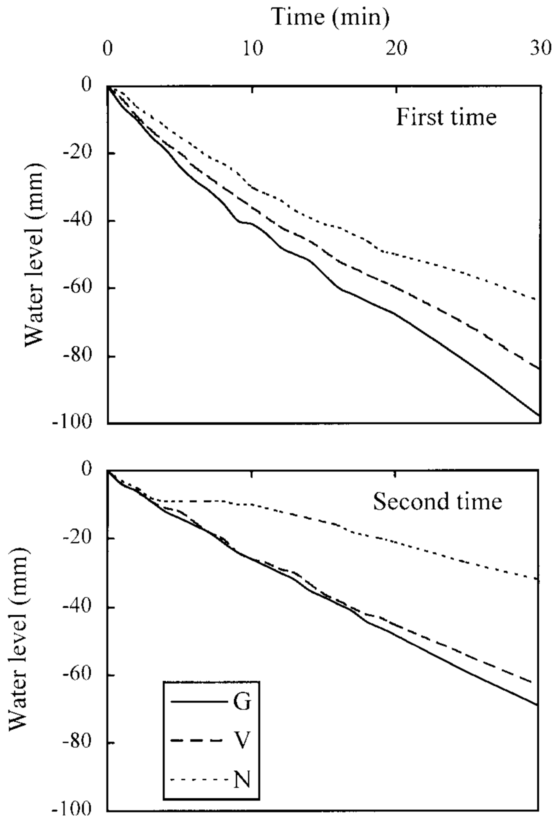

Fig. 10. Effects of maize buried stalks on drainage in pit.
First time: dry soil, Second time: closely water saturation.
Maize stalks are buried into horizontal and vertical ridges (G), into vertical ridges (V) and not into both ridges (N).

ridges and help drain the soil water. To note, in paddy fields, when there are cracks that are connected in soil layers, water moves through these cracks and is drained (Yamazaki, 1988).

In general, a subsurface drainage system is composed of both a lateral drain and a collecting drain. The lateral drain carries extra water in the soils into the collecting drain. The collecting drain leads the water from lateral drains to an outlet. Probably, the buried maize bundles in the *ngolo* horizontal ridges function as the lateral drain and the bundles in the vertical ridges function as the collecting drain.

In the case of a flat field, subsurface drainage itself has to be shunted toward an outlet. On a slope, however, drainage naturally flows downward along the slope. On a steeper slope the drainage is much more efficient. Although the pits in the *ngolo* fields are filled with rainwater during heavy rains even on the steep slopes, most of the standing water disappears immediately when the rain tapers. I often observed water left standing in pits formed on a flat plain. On a flat plain it seems that the subsurface drainage is not effective.

II. Function as Sedimentation Tanks

At the beginning of the rainy season maize is sown on the ridges in place harvested beans, and the configuration of the *ngolo* field is maintained throughout the dry season. This sowing without cultivation is also one of the characteristics of the *ngolo* farming system, and it apparently reduces raindrop erosion because of zero tillage. During the rainy season, however, the ridges begin to collapse gradually due to the rain, and the pits are filled with sediment by the middle of the rainy season. This is probably caused by a lack of subsurface drainage due to decomposition of *mabongi*. The decrease in permeability of water into the ridges may be ascribed to soil compaction. During the season, erodible surface soils are deposited in the bottom of the pit.

When a new farming field is reclaimed on slopes in Japan, measures are usually taken to control soil erosion. One of these measures is the use of a sedimentation tank, in which the collected run-off in the tank deposit soils on the bottom, allowing only the supernatant to run over. It is likely that *ngolo* pits in the early rainy season function similarly to sedimentation tanks. Even if the size of one pit is small, the number of pits formed all over the field may enhance soil sedimentation capacity by minimizing soil loss with run-off water.

III. Covering Field with Plants

The *ngolo* pits disappear completely in the late rainy season. However, maize grows thick by this time, with expanding leaves covering the field and the developed roots firmly holding the soils, retaining the surface soils.

Thus, the *ngolo* farming system conserves the surface soils sequentially on the slopes throughout the year by means of weeds, subsurface drainage, de facto sedimentation tanks, and field covering of crops.

CONCLUSION

The *ngolo* farming system has remained substantially the same for at least sixty years since Pike's report in the 1930's (Pike, 1938), despite the drastic changes in the social and economical conditions of Tanzania. The sustainability of the system has been based on the functions of the *ngolo* in terms of soil conservation and nutrition supply.

On the other hand, the social reason that the farming system has been kept must be due to its economical feasibility. Thanks to the cool climate in the district, high-quality Arabica coffee was introduced in the 1930's and its cultivation spread throughout the district. Nowadays, the distribution system of coffee beans and processing factories have been established and the Mbinga district is known as a major coffee producing area in Tanzania. Although most of indigenous farming systems in East Africa have been replaced by the commercialized farming systems, the Matengo was successful in combining their indigenous farming system for food with one for cash income. Coffee yields bring in high cash income from a small field, and may help the *ngolo* system survive.

The *ngolo* farming system is based on the division of labor between men and women. Boys and girls are directed towards specialized work from early childhood, and therefore they master each technique. The division of labor is complementary and involves cooperation between men and women (i.e. husband and wife or mother and son). If either labor is lost, it is difficult to maintain a *ngolo* field. In the past, there was a mutual aid system in Matengo traditional society, called *ngokela* (Ndunguru, 1972), where the people helped each other cultivating the fields. For example, a family in a homestead without enough labor would invite others to a special meal or beer so that they helped the land preparation. With the spread of a monetary system, *ngokela* has been replaced by a commission system, for example, ten Tanzanian Shillings might be paid for making one pit. Higher cash income derived from coffee facilitates this new day laborer system. Although a newly introduced farming system often competes with an existing farming system, in the case of Mbinga district, coffee cultivation has supported the *ngolo* farming system to remain economically viable.

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