Jpn. J. Trop. Agr. 42 (1) : 18—28, 1998

Indigenous Rice-Based Lowland Farming Systems of Nupe, Nigeria

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Abstract Gadza, a typical village where rice cultivation is carried out by the Nupe ethnic group (Niger State, Central Nigeria) was selected for the survey presented in this paper. Seven different land preparation patterns for rice cultivation were observed in the lowlands, i.e., Togogi kuru, Togoko kuru, Togogi naafena, Togoko naafena, Ewoko, Baragi and Gbaragi. Differences in land preparation patterns appear to be related to the microtoposequence and water regime. Each pattern was seasonally modified by displacing soil, with each sequence of pattern depending on rice and weed growth, water conditions and crop varieties. Moving the soil seemed to be effective for weed control, conservation of soil fertility and water retention. The biomass of weeds in a unit area under the five different land preparation patterns was less than 1/2 to 1/20 of that of the control area. Soil parts that were displaced showed larger amounts of exchangeable bases and lower amounts of exchangeable aluminum than soil parts that were not displaced. It was possible to put forward a hypothesis on the relationship between the microtopography and the seven land preparation patterns. It was suggested that instead of performing leveling and cultivation, the Nupe constructed ridges and mounds varying in shape and size in their traditional paddy fields for water control and land preparation.

Key words Indigenous farming system, Land preparation patterns, Mounds, Nigeria, Nupe, Ridges

ナイジェリア・ヌペ人の伝統的低地稲作農業システム 石田英子・上堂薗明・若月利之　島根大学生物資源科学部　〒690-8504　島根県松江市西川津町 1060

要　約 開発プロジェクトによる技術移転・導入を円滑に進める，すなわち，農民にとって受け入れ可能な技術開発のためには，現地の限定要因を反映し，それに適合されてきたと考えられる，現地農民による伝統的農業システムの研究，理解が必要である．調査は，ナイジェリア国ニジェール州ニェンクパタ川集水域中流部の Gadza 村を中心とした地域で，1994 年 8-11 月および 1995 年 6-10 月に行われた．この地域には，伝統的に稲作技術を持つヌペ人が居住しており，低地では雨期に稲作を，乾期には野菜を中心に栽培している．彼らが稲作システムのために低地に造成する栽培環境として，畦あるいはマウンドの存在の有無，また，畦の区画形態と大きさの違いにより，Togogi kuru, Togoko kuru, Togogi naafena，Togoko naafena，Ewoko，Baragi，Gbaragi の 7 形態が観察された．稲の生育状況，雑草の繁茂，水分条件，栽培作物種の変化により，7 形態各々において，各パターンで土壌が移動されることで，各々の区画形態が変化する．土壌を移動させる理由について，除草効果，土壌養分の回復，水分状況の保全との関係に着目した．各形態にコントロール区を設定し単位面積あたりの雑草のバイオマス量を計測したところ，7 形態中 5 形態でコントロール区の 1/2-1/20 となった．移動部分の土壌は，それより下部の土壌と比較して交換性塩基の量が高く，置換性アルミニウムの量が低かった．微地形的には，Togogi kuru は凸部あるいは標高が高く傾斜があるところ，Togoko kuru は高く比較的平坦なところ，Togogi naafena は凹部あるいは低く傾斜のあるところ，Togoko naafena は低く比較的平坦なところ，Ewoko は水条件の悪いところ，Baragi は何らかの理由で休閑したのち再耕作する場合，Gbaragi は常に湛水するところで観察された．ヌペ人の伝統的低地稲作農業システムでは，水田内の水分コントロールおよび地こしらえの方法として，彼らが形成する様々な形態および大きさを持つ畦あるいはマウンドが，「均平化」及び「耕耘」に代替する役割を果たしていると推察された．

キーワード 畦，地ごしらえの諸形態，伝統的農業システム，ナイジェリア，ヌペ，マウンド

Introduction

In developing countries, many studies and surveys on agricultural development are being carried out. The major objective of the development projects so far has been and continues to be yield increase. Although some projects seem to have been successful in the initial stages using large amounts of energy, resources, and funds, these high input technologies may not benefit local farmers in terms of sustainability. Past project assessments revealed that most of the capital-based technologies did not last beyond the project time, with the farmers reverting to their indigenous system. The technology in such development projects was not adequate under either natural or socio-economic conditions or both. In many development projects, farmers were not able to receive any benefit that such projects had intended to provide. It is therefore necessary to apply technologies which farmers can adapt to their ecological environment and socio-

Received Feb. 3, 1997
Accepted Nov. 7, 1997

economic conditions. The farmers' indigenous agricultural knowledge which reflects local limiting factors should be studied to develop technologies acceptable to farmers.

An agricultural indigenous knowledge system developed by a certain cultural or ethnic group aims at meeting subsistence goals in an ecosystem[15]. This information has been passed on through generations and therefore has become refined into a system compatible with natural resources and relevant ecological processes. The Center for Indigenous Knowledge for Agriculture and Rural Development, CIKARD, and other indigenous knowledge resource centers are trying to input such knowledge into a data base.[16, 22]

The most important characteristics of indigenous agricultural knowledge are as follows ; (1) indigenous agricultural knowledge has been developed to change the cropping systems and adapt them to agricultural soil potential, (2) yield is the second priority, (3) indigenous agricultural knowledge reflects problems and priorities in each cropping environment[11]. Indigenous knowledge is expected to offer new aspects for long term sustainable and suitable farming systems. Computer modeling was used to generalize folk expert systems for indigenous soil classification in the highlands of Peru. Indigenous soil erosion control system in relation to water and soil conservation and management methods were surveyed[3]. These models revealed that the major technical principle was rather the management of the accumulation of eroded soil than erosion control. However, small farmers in the highlands of Bolivia imitated the natural process to avoid soil erosion[26]. In Haiti soil conservation methods using agroforestry with perennial crops, *Zare, Sakle en woulo, Ramp pay, Kleonaj, Bit* were also reported[23].

In the Bida area, in Central Nigeria, the International Institute of Tropical Agriculture, IITA, carried out on-farm trials for the introduction of the Asian lowland water management rice cropping system, Sawah, from 1986 to 1989. Although Sawah produced higher yields and exerted beneficial effects on soil and water conservation[2,5,7,8,14], the Sawahs constructed at the benchmark site were not maintained by the farmers after on-farm trials carried out for three years. Although Sawah seemed very promising to solve food and land degradation problems in West Africa, the actual integration was not easy[20]. In a former report[9], the indigenous soil knowledge, evaluation, management and classification system had been characterized based on an ethnopedological survey for the Nupe people in the Bida area. In some benchmark sites around the Bida area, preliminary ethnopedological surveys on Nupe have been conducted[21]. In this paper, Nupe's indigenous rice farming and soil management systems were characterized to identify long-term sustainable rice based lowland farming systems through the crossing of culture between tropical Asia and Africa.

Materials and Methods

A typical Nupe village, Gadza was selected for the survey presented in this paper. The village is located in the middle of the Nyenkpata river basin, Niger State, Central Nigeria, West Africa (Fig.1). The major ethnic groups in this area are Nupe engaged in rice-based farming and Fulani cattle nomads. Around the Bida area, the Nupe were conquered by the Fulani in the middle of the nineteenth century. This historical situation has continued to reflect the relationship between the Nupe and the Fulani. The Nupe do not own domestic animals except for a few goats and several fowls. The Fulani are generally regarded as "farmers' enemy" by the Nupe, because Nupe's crops are eaten or trampled by Fulani cattle. Consequently, in the Nupe's fields animal manure is not commonly applied.

Vegetation in the Bida area belongs to Guinea savanna. Average annual rainfall is about 1100 mm. The bedrock that underlies the soils of the benchmark site is of Mesozoic (Cretaceous) origin, and it is generally designated as Nupe sand-stones of the Niger river through[17]. Nupe's upland farming is characterized by bush fallow and intercropping systems consisting of cereals, such as sorghum (*Sorghum bicolor*), pearl millet (*Pennisetum glaucum*) and maize (*Zea mays*), legumes, such as cowpea (*Vigna unguiculata*), ground nut (*Arachis hypogaea*) and bambara groundnut (*Vigna subterranea*), tubers, such

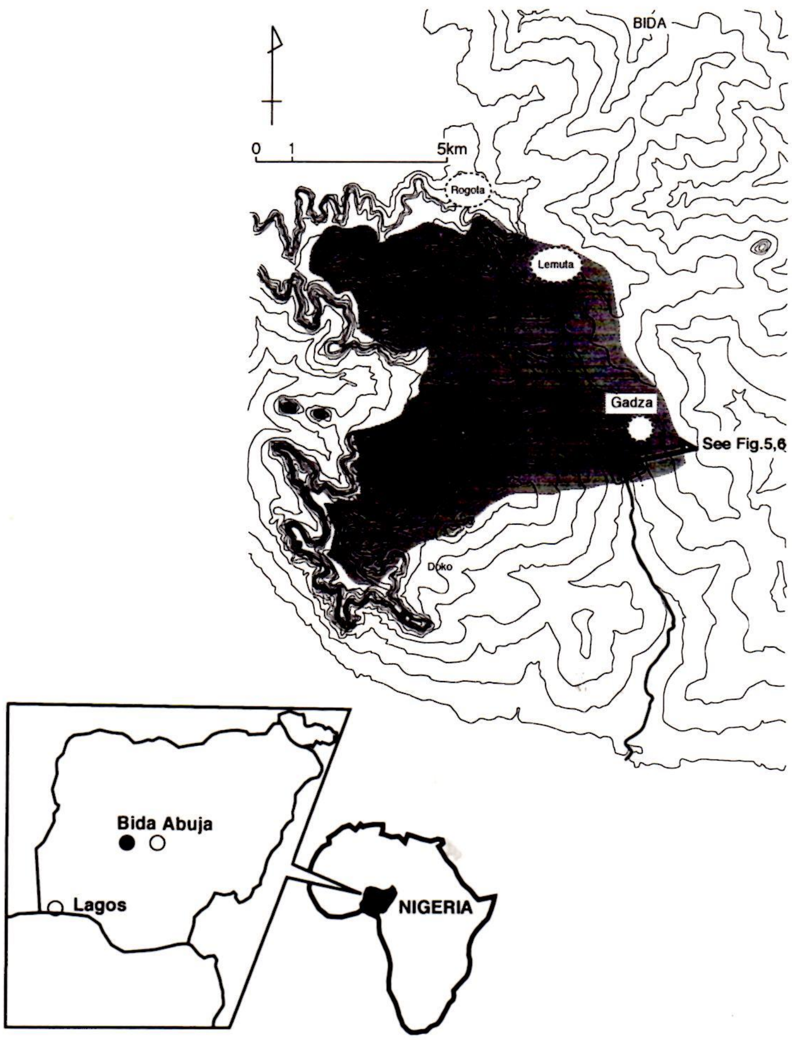

Fig. 1. Map showing the location of the research site.

as cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*) and yams (*Dioscorea* spp.), and vegetables, such as egsi melon (*Cucumis melo*), okra (*Abelmoschus esculentus*), red pepper (*Capsicum annuum*)[6], onion (*Allium cepa*) and *Amaranthus* spp. In the lowlands, farmers cultivate rice (*Oryza sativa*) during the rainy season and produce cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*) and vegetables, such as okra (*Abelmoschus esculentus*), garden egg (*Solanum* sp.), tomato (*Lycopersicon esculentum*), red pepper (*Capsicum annuum*)[6], and onion (*Allium cepa*) after harvesting rice, by forming various types of ridges and mounds. Sugar cane (*Saccharum officinarum*) is also produced in the lowlands throughout a year[6].

Ethnopedological surveys were conducted during the period August to December in 1994 and June to November in 1995. Information on rice-based lowland farming in Nupe language was collected from local farmers. Distribution of land preparation patterns for lowland rice and sequential changes of the patterns were partly observed in the field and partly sketched using the information given by leading farmers. The biomass and composition of weed species were surveyed. Soils were sampled from each of the land preparation patterns. Rice varieties were also surveyed in each farmer's field.

Soil samples were air-dried, ground and passed through a 2 mm sieve. Particle-size distribution was determined by the pipette method. Total carbon and nitrogen contents of the soil samples were determined by dry combustion using a Sumigraph NC-80 (Sumitomo Chemical Co. Ltd., Osaka, Japan), based on the same principle as that described for dry combustion using a Perkin-Elmer 240[13].

Available phosphorus content was determined by the method of Bray No.2[4].Exchangeable cations (Ca, Mg, K, Na) were first extracted with 1.0 N ammonium acetate and the concentrations of various cations were determined by Atomic Absorption Spectrometry as described[19]. Amounts of exchangeable Ca and Mg for some samples were determined by Inductive Coupled Plasma-Atomic Emission Spectroscopy (Shimadzu ICPS 2000). Exchangeable acidity was determined by first extracting with potassium chloride (1.0 N KCl) and titrating the extract with sodium hydroxide as described[12].

Results and Discussion

Nupe's lowland farming is characterized by the construction of various types of ridges and mounds. Seven patterns of land preparation were observed in the lowlands, as follows; Togogi kuru, Togoko kuru, Togogi naafena, Togoko naafena, Ewoko, Baragi and Gbaragi (Fig. 2). Figure 2 shows land preparation patterns at the onset of lowland rice cultivation. Black portions of the figure represent ridges or mounds. The rice planted by farmers is represented in the white sections except for Ewoko. Patterns of Togogi kuru and Togoko kuru appear like divided closed square blocks. There are also closed subdivided ridges inside the blocks. Size of a block determines the difference between Togogi kuru and Togoko kuru. The length of a side in Togogi kuru is about 2-3 m, while that in Togoko kuru is 5-15 m. Togogi naafena and Togoko naafena have hook-shaped ridges within each block. The area between hooks in Togoko kuru is wider than that in Togogi kuru. While height of ridges of Togogi kuru and Togoko kuru is about 40-60 cm, that of Togogi naafena and Togoko naafena is about 30-70 cm. Similar patterns of Togogi kuru, Togoko kuru, Togogi naafena and Togoko naafena had been reported[10] in Yayoi Age Ohuro Archeological site (2500 years before the present), Gunma Prefecture, Japan. Similar paddy or Sawah patterns of Togogi naafena and Togoko naafena were also observed[18] in Tapanuri, Sumatra, Indonesia. Ewoko is a mound about 40-60 cm in height and 0.5-1 m in diameter. Cassava, sweetpotato, cocoyam (*Colocasia esculenta*) and vegetables are grown on it. Baragi is a flat rice field without any mound or ridge. Gbaragi has linear parallel ridges, about 30-50 cm in height and 30 cm in width, and farmers plant rice on it.

Each pattern is seasonally modified, with each sequence of pattern depending on rice and weed growth, water conditions and rice varieties (Fig. 3). It is also a labor sav-

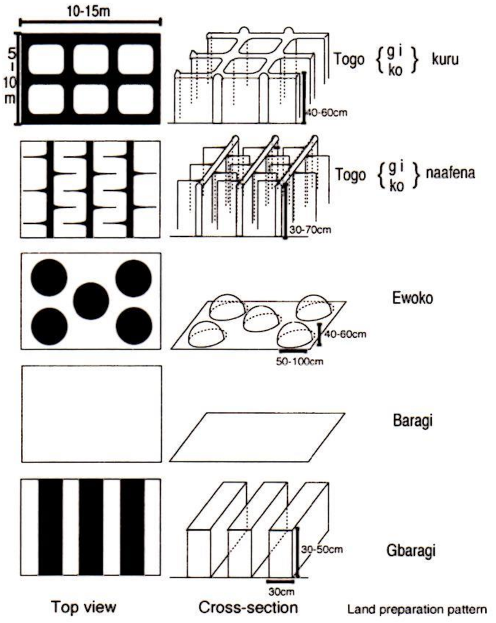

Fig. 2. Land preparation patterns at the onset of lowland rice cultivation.

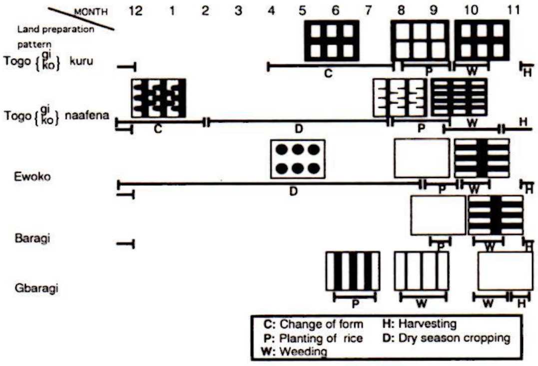

Fig. 3. Sequence of land preparation patterns for the cultivation of lowland rice.

ing method during the peak rice farming season, July to September. Time of operation changes according to each pattern. In this area the rainy season starts from April and most of the rain falls during June to early October. In the cases of Togogi kuru and Togoko kuru, wide closed square ridges are formed with collected surface soils (Fig. 3, C), then they are cut down and spread for preparation for rice planting (P). At the time of weeding, weeds along with soils are scooped up and turned over on the ridges using a hand hoe to make wider ridges (W). Almost the same ridge-forming methods are applied in Togogi naafena and Togoko naafena. In Togogi naafena and Togoko naafena, the dry season crops are planted on wide hook-shaped ridges. At the time of weeding, the fine hook-shaped ridges are closed and change to square ridges (W). Names also change to Togogi naatsuna and Togoko naatsuna. Ewoko is, however, broken down and leveled to be some flat for rice cropping in years with heavy rainfall (P). Baragi does not exhibit any mound or ridge by the time of weeding (P). Wide closed square ridges are formed in both Ewoko and Baragi at weeding. The changed of pattern of Gbaragi is completely different from any other pattern mentioned above. Though rice is planted on wide parallel linear ridges in Gbaragi (P), only rice is left after removing weeds and soils from ridges at weeding time (W).

In order to understand the reasons for moving the soil sequentially and the farmers' selection of the seven various land preparation patterns, the aspects which were emphasized are as follows; (1) the effect on the controll of weeds, (2) conservation of soil fertility, (3) water retention. All the weeds, excluding roots, were collected from unit areas under the seven observation patterns and from the controls in relation to each land preparation pattern. Sample weeds was air dried and weighed. The biomass of weeds in unit areas under the five patterns were less than 1/2 to 1/20 of that of the controls (Table 1). Table 2 shows the composition of weed species under each pattern and in the control. The "*"symbol represents the major weed species of inland valleybottoms and floodplains, and the "+"symbol indicates the weeds in the savanna vegetation[1]. Composition of weed species changed according to the water conditions. Based on the growing environment of Savanna type weeds and our field observations, Ewoko and Baragi were

Table 1. Comparison of weed dry weight, under different land preparation patterns.

Land preparation pattern	Dry weight* (kg)	Area (m^2)	Dry weight*/unit area (Kg/m^2)
Togogi naafena	2.62	17.48	0.15
Control	2.44	1.00	2.44
Sugarcane field	0.96	1.00	0.96
Togoko naafena	2.48	10.52	0.24
Control	1.12	1.00	1.12
Togogi kuru	1.52	6.24	0.24
Control	0.16	1.00	0.16
Togoko kuru	8.37	7.52	1.11
Control	2.35	1.00	2.35
Ewoko	0.27	2.80	0.10
Control	2.22	1.00	2.22
Gbaragi	0.80	1.00	0.80
Control	0.60	1.00	0.60
Baragi	0.28	1.00	0.28
Control	0.44	1.00	0.44

*Roots are not included.

Table 2. Composition of weed species collected under different land preparation patterns.

Land preparation pattem		Species
Togoko naafena		*Digitaria* sp.
		Panicum sp.
		Aeschynomene indica
		Tephrosia sp.
		Setaria pallide-fusca
	+	*Paspalum* sp.
Control of Togoko naafena	+	*Echinochloa* sp.
		Setaria pallide-fusca = *S. pumila*
	+	*Paspalum* sp.
Sugarcane field		*Vicoa leptoclada*
		Digitaria sp.
		Poaceae (*Graminea*)
		Oryza sp.
	+	*Cyperus distans*
		Tephrosia bracteolata
	+	*Paspalum* sp.
Togogi naafena	+	*Paspalum* sp.
		Setaria pallide-fusca
	+	*Cyperus tuberosus*
		Indigofera sp.
	+	*Echinochloa* sp.
Control of Togogi naafena		*Rottboellia cochinchinensis*
		Physalis angulata
		Commelina benghalensis
		Setaria pallide-fusca
Togoko kuru	+	*Paspalum* sp.
		Aeschynomene indica
		Vitex sp.
		Setaria pallide-fusca
	+	*Echinochloa* sp.
		Oryza sp.
		Ipomoea sp.
Control of Togoko kuru	+	*Paspalum* sp.
		Calopogonium mucunoides
		Aeschynomene indica
		Rottboellia cochinchinensis
		Setaria anceps
		Setaria pallide-fusca
Togogi kuru		*Fimbristylis* sp.
		Digitaria sp.
		Tephrosia bracteolata
	+	*Paspalum* sp.
		Brachiaria comata (?)
		Schwenckia americana
Control of Togogi kuru	+	*Paspalum* sp.
		Tephrosia sp.
	*	*Hyparrhenia* sp.
Ewoko		*Tephrosia* sp.
		Aeschynomene indica
		Digitaria sp.
	*	*Hyparrhenia* sp.
Control of Ewoko		*Andropogon* sp.
		Daniellia oliveri
		Markhamia sp.
Gbaragi		*Paspalum* sp.
		Digitaria sp.
		Brachiaria mutica
		Tephrosia sp.
Control of Gbaragi		*Andropogon* sp.
		Setaria pallide-fusca
Baragi	+	*Cyperus* sp.
		Digitaria sp.
		Alysicarpus sp.
	*	*Hyparrhenia* sp.
Control of Baragi	*	*Hyparrhenia* sp.
		Fimbristylis sp.
		Aeschynomene indica

+ indicates species in savanna vegetation.
* indicates species in inland valleybottoms and floodplains.

prepared at relatively higher microtopographical positions.

Table 3 shows that the soils of the lowland area were very sandy and contained low concentrations of total nitrogen and carbon. In the table, 0, −15 and −30 indicate the depth (cm) of sampling points. Sand contents of soil samples exceeded 70 % in both the upper and lower parts of the lowland area. The amounts of clay and total nitrogen contents of the soil samples were very low. The amount of available phosphorus in lowland soil was not appreciably low, compared with the other nutritional elements.

Soils under Baragi, Ewoko and Togogi kuru contained a larger amount of exchangeable Ca, K, Mg and Na than each of the respective control soils (Table 4). In Table 4, 70, 30, and 0 indicate the approximate height (cm) of the cut in the top, middle and the base regions of ridges in Togoko naafena, respectively. Fig. 4 shows the sampling depth (cm) of soils in each land preparation pattern. The soils of the ridges were seasonally moved. Soil parts that were moved showed a larger amount of exchangeable bases and a lower amount of exchangeable Al than soil parts that were not moved, i. e., subsoils, −10 and −30 below the base of ridges.

The amounts of exchangeable Ca, K, Mg and Na were generally very low in rice fields compared to sugarcane fields (Table 4). It was pointed out that potassium deficiency causes excess iron accumulation in rice plants grown in the lowlands[24]. Since termite mounds were often used for sugarcane fields, the fields were generally located at a slightly higher position (20-40 cm). In addition, farmers applied cow dung (from Fulani cattle) in sugarcane fields. Field observation revealed that mature in sugarcane field can conserve soil and trap eroded soils from the upland area, which may account for the relatively high fertility of sugarcane soil and also suggests another method of managing the soil.

The main reasons why Nupe farmers practice sequential land preparation methods by moving soils throughout a year were considered to be effective (1) for weed control (Table 1), (2) the maintenance of the soil fertility (Table 4) under the social and ethnical conditions in which the availability of chemi-

Table 3. Particle-size distribution, contents of total nitrogen, total carbon and available phosphorus in soils of the survey site

Sampling point	Soil depth (cm)	Clay (%)	Silt (%)	Sand (%)	T-N (g/kg)	T-C (g/kg)	C/N	P_2O_5* (mg/kg)
Upper part of lowland	0	8	4	88	0.07	1.39	20	6.32
	−15	8	3	89	0.27	3.32	12	9.45
	−30	7	2	91	0.16	0.68	4	4.07
Lower part of lowland	0	11	13	76	0.41	3.89	9	14.34
	−15	12	14	74	0.20	2.13	11	7.35
	−30	9	13	78	0.07	0.35	5	2.80

* determined by Bray No. 2.

cal fertilizer and animal manure is uncertain and limited, (3) for the retention of residual soil moisture for a longer period than when fields are left in a flat condition, which promotes the growth of dry season crops (Fig.3. D), (4) for the reduction of the effect of iron[24,25], (5) for saving labor as spreading of mounds enable to save about 40% of labor time compared to the flat tillage method[2].

Fig. 5 shows the distribution of rice varieties along the microtoposequence in Gadza village. *Egwazankpa*, ITA 306, *Chisadane, Farance* (FARO 14?), *Mars* (FARO 8) and *Manbechi* were identified. All these varieties except for *Egwazankpa* are high-yielding varieties and were released by IITA or NCRI (National Cereals Research Institute). *Egwazankpa* is assumed to be a local variety, because it did not correspond to any previously released line. Fig. 5 shows that ITA 306 was cultivated in the valley bottoms, while *Egwazankpa* was grown in the fringe between the upland and valley. As water was not sufficient for the rice crop in the fringe, yield response of varieties differed appreciably between fringe and valley bottoms[14]. Consequently, generally rice grown in the fringe produced significantly lower yields than that grown in valley bottoms. It was reported[14] that the yield of ITA 306 was the highest, 5392 kg/ha, followed in decreasing order by FARO 29, 4884 kg/ha, ITA 212, 3669 kg/ha, and local variety, 3475 kg/ha, in valley bottoms, while that of ITA 212 was the highest, 1332 kg/ha, followed by ITA 306, 1008 kg/ha, local variety, 921 kg/ha, FARO 29, 852 kg/ha, in the fringe. It appears that for each field position in the toposequence a certain variety is more suitable than others. The most preferred variety by farmers was ITA 306, because of its high yield[14]. Water is not usually sufficient to grow rice in the fringe. Therefore, if rice is to be cultivated, early maturing and drought-tolerant varieties should be identified in the absence of improved water management system.

Fig. 6 shows the relationship between the distribution of land preparation patterns and microtopography. Togogi naafena tended to be observed in lower and inclined positions. Togoko naafena seemed to be applied in depressed or lower positions, and on comparatively flat ground. Togogi kuru tended to be distributed in convex and inclined areas. Togoko kuru was seen on convex and flat surfaces. Ewoko was observed in areas where there is not enough ground water for rice growth. Baragi was used when farmers wanted to recultivate rice after fallow. Fig. 7 depicts the hypothesis put forward to explain why Nupe farmers selected each land preparation pattern. The Naafena was used in lower positions or bore some resemblance to dale. The hooks of Naafena were made so that water could flow down to fields located in lower regions. Since Kuru was used in certain convex positions, the field required on enclosure to retain the water. Togogi was used in inclined positions, so that many small ridges were required for water control. Togoko was distributed in a relatively flat areas. Consequently, fewer ridges were needed. Ewoko tended to be used

Table 4. Selected chemical properties of collected soil samples under different land preparation patterns.

Land preparation pattern	Soil depth (cm)	Exch.H (cmol/kg)	Exch.Al (cmol/kg)	Exch. Bases (cmol/kg) Ca	K	Mg	Na	eCEC (cmol/kg)	Base Sat. (%)
Togoko naafena	70	0.13	0.50	0.89	0.05	0.16	0.03	1.76	64.17
	30	0.13	0.38	0.91	0.06	0.16	0.03	1.67	69.77
	0	0.13	0.51	0.42	0.02	0.06	0.01	1.14	44.85
	−10	0.13	0.18	0.38	0.02	0.04	0.01	0.75	59.95
	−30	0.13	0.21	0.30	0.03	0.04	0.01	0.72	53.06
Sugarcane field	0	0.06	0.04	5.40	0.09	0.87	0.01	6.47	98.42
	−30	0.05	0.04	8.22	0.09	1.29	0.01	9.71	99.08
	−50	0.05	0.00	9.30	0.10	1.43	0.01	10.89	99.53
Togoko kuru	45	0.03	0.03	1.39	0.15	0.45	0.02	2.05	97.55
	30	0.05	0.05	1.42	0.18	0.42	0.04	2.16	95.33
	0	0.05	0.21	0.50	0.08	0.10	0.03	0.97	72.80
	−30	0.05	0.00	0.39	0.01	0.12	0.02	0.59	91.51
	−50	0.05	0.01	0.41	0.01	0.22	0.03	0.73	91.45
Control	0	0.05	0.04	1.46	0.07	0.34	0.03	1.99	95.56
	−30	0.05	0.04	0.73	0.01	0.11	0.02	0.96	90.88
	−50	0.05	0.04	0.19	0.01	0.04	0.02	0.34	74.52
Ewoko	45	0.05	0.05	4.05	0.10	0.62	0.02	4.89	97.93
	30	0.05	0.03	5.90	0.39	1.07	0.01	7.45	98.98
	0	0.03	0.03	6.10	0.13	1.06	0.02	7.36	99.31
	−30	0.03	0.03	1.44	0.06	0.52	0.02	2.09	97.58
	−50	0.09	0.42	2.06	0.14	2.46	0.04	5.22	90.13
Control	0	0.03	0.03	3.07	0.25	1.03	0.00	4.40	98.86
	−30	0.06	0.18	0.24	0.07	0.15	0.00	0.70	66.04
	−50	0.03	0.23	0.11	0.03	0.11	0.00	0.50	49.67
Sugarcane field	0	0.03	0.03	4.70	0.20	0.65	0.00	5.60	99.10
	−30	0.03	0.03	1.26	0.03	0.29	0.02	1.66	96.97
	−50	0.03	0.41	5.85	0.12	2.23	0.03	8.66	94.96
Baragi	0	0.06	0.19	0.42	0.07	0.13	0.01	0.87	71.30
	−30	0.05	0.08	0.13	0.02	0.05	0.02	0.34	63.01
	−50	0.05	0.00	0.05	0.01	0.03	0.01	0.15	65.96
Control	0	0.03	0.03	0.25	0.04	0.09	0.00	0.43	88.39
	−30	0.03	0.03	0.13	0.01	0.05	0.01	0.25	79.60
	−50	0.03	0.03	0.04	0.01	0.02	0.01	0.13	62.29

in a location where water is scarce and does not allow for rice production. The only reason why Ewoko was made was to save labor during heavy rainfall years. Gbaragi was found in a floodplain or in areas where water is constantly stagnant. Ridges of Gbaragi may contribute to the accelerating of germination of rice or to avoid washing out of rice seedlings.

For water retention in paddy fields, leveling is performed in Asian countries. Nupe farmers constructed ridges and mounds varying in shape and size in their traditional paddy fields for water control instead of leveling. Small blocks, such as in Togogi naafena, Togoko naafena, Togogi kuru and Togoko kuru, were made due to the slope gradient and soil texture conditions in cultivated horizon and/or under cultivated horizon. Particularly in the latter case, if the ho-

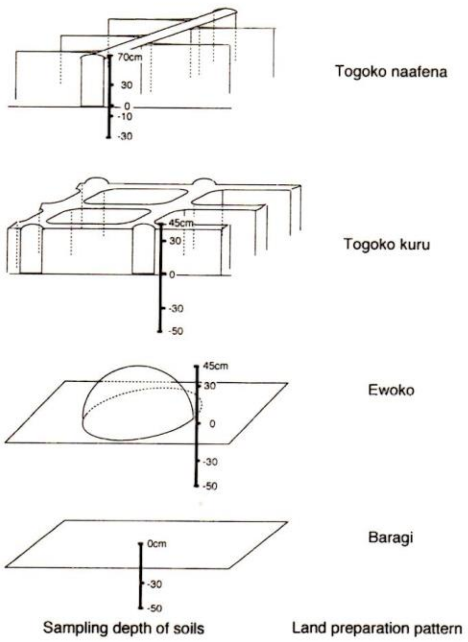

Fig. 4. Sampling depth of soils in each land preparation pattern.

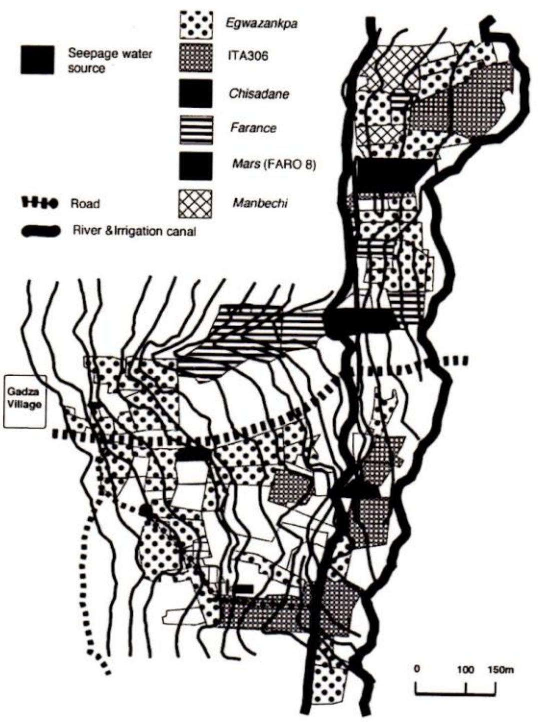

Fig. 5. Distribution of rice varieties. (Mapping position, see Fig. 1)

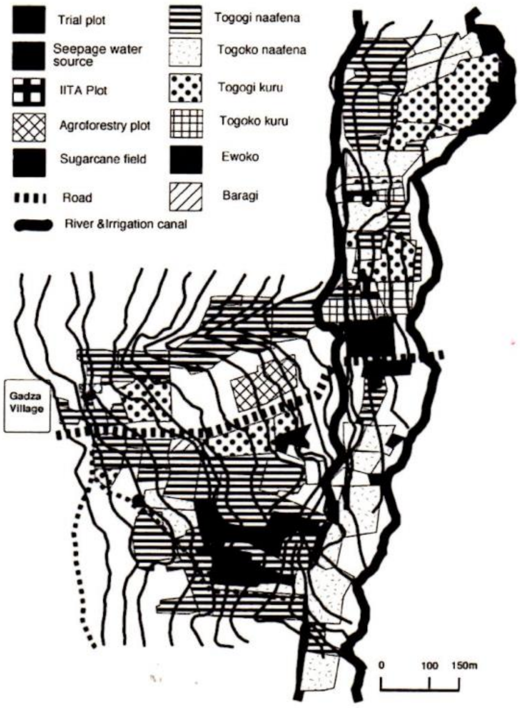

Fig. 6. Distribution of land preparation patterns. (Mapping position, see Fig. 1)

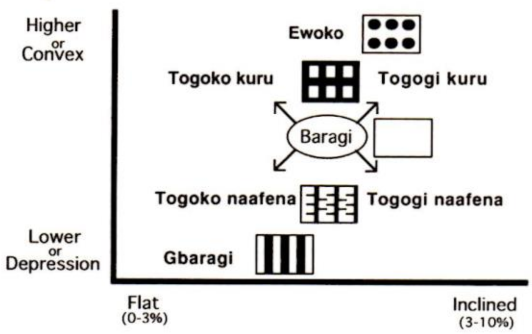

Fig. 7. Hypothesis on relationship between topograpy and seven land preparation patterns.

rizon contains a large percentage of sand, even if water is introduced, it will not be retained, because before water stagnated, it will flow to the subsoil rapidly. As a result, the small blocks reduce the loss of available water[10]. The changing patterns also seemed to play a role of cultivation.

Under these conditions, in which only hand hoe is available as tool, the sustainability of Nupe's indigenous rice-based lowland farming systems is supported by appropriate surface soil management including the utilization of weeds and collection of surface soil for mounds or ridges to supplement nutrition and to retain the residual water in soils. Although the rice yield under indigenous farming is still low[14], Nupe farmers do not recognize that soil fertility and water availability as limiting factors in Nupe land. Nupe's concept of soil and ecological environment should therefore be revealed.

Acknowledgement

We wish to express our gratitude to Prof. Shohei Hirose, Nihon University and Prof. Hiroyoshi Chujo, Chubu University. This research was supported in part by Grant-in-Aid for International Scientific Research Program: Field Research, FY 1993-95 lead by S. Hirose and a grant from Japan Society for the Promotion of Science, to which we are very grateful. We are most grateful to the International Institute of Tropical Agriculture (IITA), for providing the necessary support for field survey and soil sampling.

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