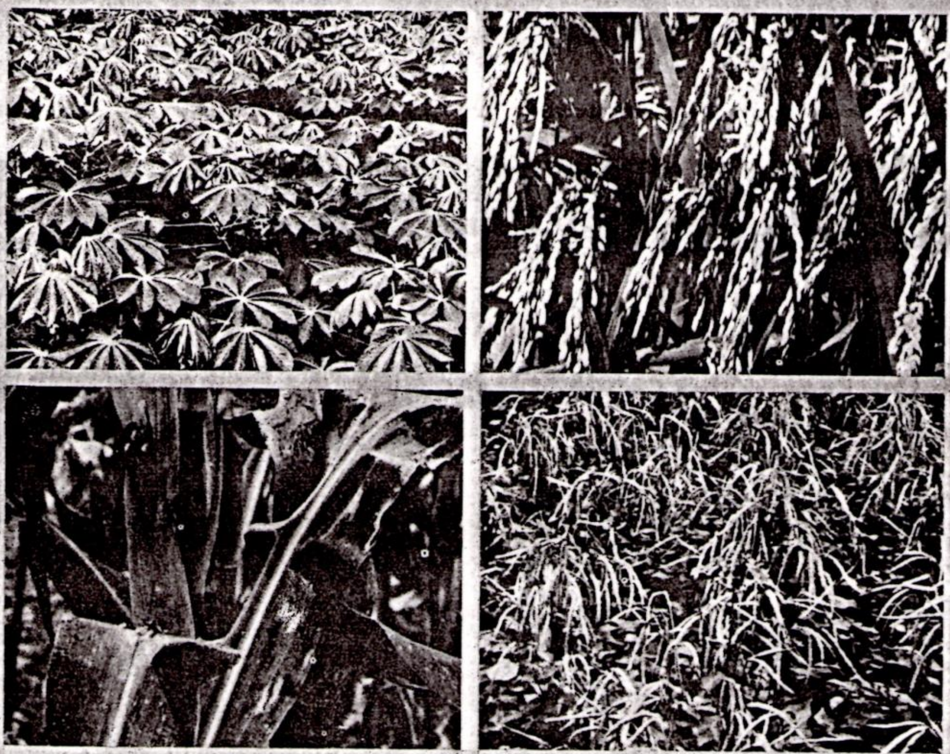
IITA

Resource & Crop Management Program

Annual Report

1986



INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE

The implications of these results are relevant to conditions of small-scale farmers. With hand planting, it is unlikely that the recommended plant population for soybeans (250,000 to 300,000 plant ha-1) can be conveniently achieved. In fact, low plant densities on farmers' fields appear almost deliberate, probably to maximize yield with limited available resources. Our results indicate that up to two metric tons of soybean grain can be obtained, on a land that has been left fallow for two years, without the application of phosphorus and zinc. **--M.P. Gichuru, K.E. Dashiell, and B.T. Kang.**

CHAPTER IV

WETLAND PRODUCTION SYSTEMS

Research on Wetland production systems during 1986 involved water management and hydrological studies conducted at Bida in Nigeria and Makeni in Sierra Leone in collaboration with the International Land Reclamation Institute (ILRI) in the Netherlands, Land and Water Development Division (LWDD) in Sierra Leone, the National Cereals Research Institute (NCRI) and the Bida Agricultural Development Project (BADP) both in Nigeria. Agronomic trials were also carried out on-station in Ibadan and off-site at Bida and Makeni. The objective of the studies is to develop suitable technologies of water, soil and crop management for more intensive use of small inland valleys in West and Central Africa.

Agro-economic surveys conducted in 1983 have revealed that the main problems limiting crop production in small inland valleys were inefficient use of available water, low soil fertility and iron toxicity problems, damage caused by pests (monkeys, birds, rodents, etc.), and labour shortage problems.

4.1 Water Management and Hydrological Studies

A. Makeni - Sierra Leone

A water balance model was developed in 1985 (IITA Annual Report). Field research was initiated in a small valley near Makeni in Sierra Leone in 1986 to verify and improve the model. A triangular, broad-crested concrete weir with an internal angle of 150° was built in the valley with a total catchment area upstream of 115 ha. A rainfall recorder and a water level recorder were also installed.

Piezometers were installed in five cross sections - two upstream and three downstream of the weir. Each cross section consists of four piezometers at 50 cm below surface level and four at 100 cm depth. The piezometers were placed in pairs: one pair on the upland, one pair near the valley bottom and two pairs at the fringes. In every cross section, an open groundwater well was installed. Data from piezometers and groundwater wells were recorded three times a week.

The preliminary hydrological data showed that the reaction factor is 0.20 which is larger than the value 0.038 used previously in the model. A larger reaction factor leads to a faster response of the basin to rainfall. The time between the start of the rainfall and the moment the hydrograph reaches its peak is very short (a few minutes). Approximately one day after a rain storm, 75% of the rain has already left the basin as runoff. This means that the rains during the peak of rainy season contribute little to crop water use. The early rains, however, are very useful to agriculture. Not only do they allow proper land preparation, they also replenish the soil moisture to field capacity. In the uplands, the mid-season rains keep the soil moisture at a level near field capacity. For the swamps however, they are mostly wasted. The late season rains have the same influence on the uplands as the early rains.

The study showed that the Makeni valleys have a ponded water table of less than 30 cm below soil surface for a period of 7 months a year. Only during April and May, does the ground watertable sink below 30 cm, but seldom deeper than 45 cm. This indicates that with proper water management, a 10-month growing season, i.e. at least two crops of swamp rice a year is feasible.

To test the hypothesis that lack of water control is among the major factors causing low yield of swamp rice in Sierra Leone, five contour bunds were constructed in the same valley near Rogbon. The bunds run perpendicular to the direction of waterflow. Every bund is 40 cm high, with an outlet in the middle (60 cm wide and a crest height of 15 cm). The elevation difference between the bunds is 15 cm. In this way, the five bunds create a cascade of paddies on a 1.6 ha area. It took 24 man days at a cost of about US $35.00 to construct the bunds.

The main purpose of these bunds is to spread the water over the valley, thus increasing the water level in the fringes, and allowing more efficient use of early season rainfall, and giving farmers the possibility of water control during the growing season. With the bunds it was estimated that the high-yielding swamp area with water depth of 12-14 cm was extended in such a way, that a 30% increase in total yield can be expected from the 1.6 ha area. Twenty three farmers in the Rogbon area are greatly interested in applying this technology next season **- A. Huizing and M. Jalloh, LWDD**

B. Bida - Nigeria

To study low-cost systems of paddy improvement, two small inland valleys, Gara and Anfani, near Bida, Nigeria were selected in 1984 as benchmark sites for the IITA/NCRI/BADP/Netherlands Wetland Utilization Research Project. Basic information on the soils, hydrology, and farming systems was collected. Detailed monitoring on the water, soil nutrients and land use dynamics started in 1986. Field trials to evaluate optimum paddy systems in small inland valley were also conducted.

Rainfall of 1085 mm in 1986 was similar to that of an average year (mean at Bida is 1180 mm and 50% probability is 1025 mm). A survey of land use in the valleys showed that the bottomlands are almost flat, about 3 kilometers long and mostly narrow (20-50m). They comprise about 10 ha at Gara and 15 ha at Anfani (Table 4-1). The valley fringes are also narrow (20-80m), straight to slightly concave, with slope between 2 and 8%. Rice fields cover between 70-75% of total areas of valley bottoms and only about 9% of the fringe area. Gara has three head dyke sluice and peripheral irrigation channels which were constructed by the farm community with assistance from BADP. This informal irrigation scheme covers about half of the valley. The Anfani valley has no informal irrigation scheme.

Table 4.1. Total area and area of paddy field (hectares) in fringe and valley bottom of two inland valley swamps near Bida, Nigeria.

		Gara Velley (Kunko)	Anfani Valley (Echin woye)
Total catchment area		800	1300
Upland area		755	1250
Fringes -	Total	35	35
	Paddy	3	3
Valley bottom -	Total	10	15
	Paddy	7	11

Source: Field survey, November 1986.

Figure 4-1 shows the 10 days rainfall-water discharge relationship in Gara valley between march 1986 and February 1987. Water discharge was measured using a triangular broad-crested weir with an internal angle of 150°. Water discharge data are expressed as mm/10 days for the total catchment area of 800 ha.

Rainfall started in March and stopped at the end of October. however water flow in the central stream started only in late July, and continued to the end of February. Traditional rice cultivation practices are well correlated with the water discharge pattern. Although the water discharge is only 13% of total rainfall over the 800 ha catchment area, it accumulates at the valley bottom. Since the total area of valley bottom is only 10 ha (Table 4-1), it received approximately 11520 mm equivalent of water which is sufficient for rice production (Fig. 4-1).

Thirteen transect lines at Gara and the eleven at Anfani were selected for detailed monitoring of water dynamics. Each transect has four to eleven plastic tubes 2m long and 2.5 inches in diameter for measuring the depth of surface and ground water. Tubes were positioned at each 50-100 cm differences of topographic height. Every two weeks, depth of surface or ground water were measured.

An example of the water dynamics is presented in Figure 4-2. The area within the thick broken lines represents the area of paddy from transplanting to harvesting. Along transect 1, the rice was continuously flooded for 100 days and more, except near the valley fringe. Paddies received water partly from the peripheral irrigation channel, the central stream, and from seepage. Along transect line VIII, the farmers planted mainly in the valley fringe. They had expected water from the peripheral irrigation channel and seepage. Unfortunately the rainfall in 1986 was not enough to flood the fringes, so most of the rice at the fringe area suffered severe drought stress.

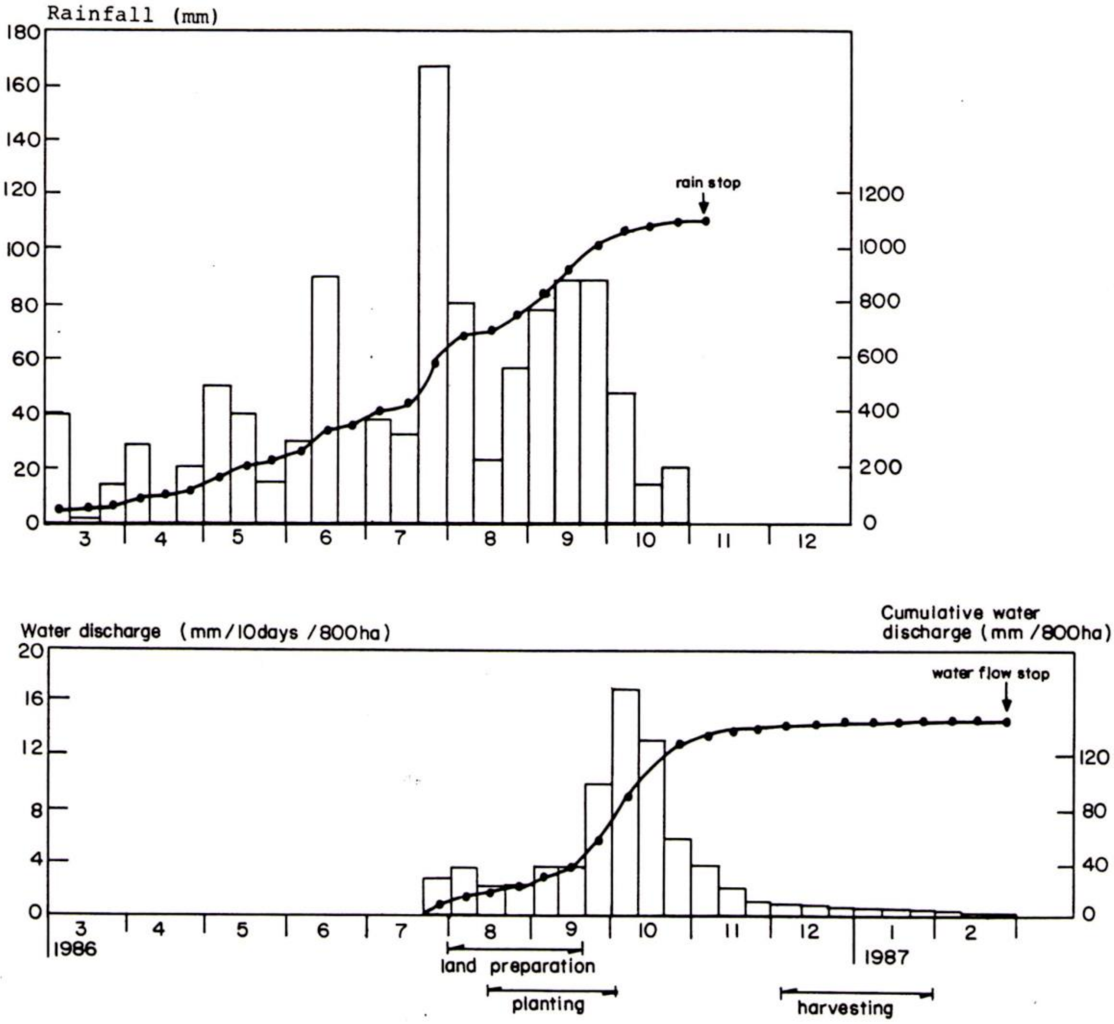


Fig. 4-1. Rainfall-water discharge relationship in Gara valley.

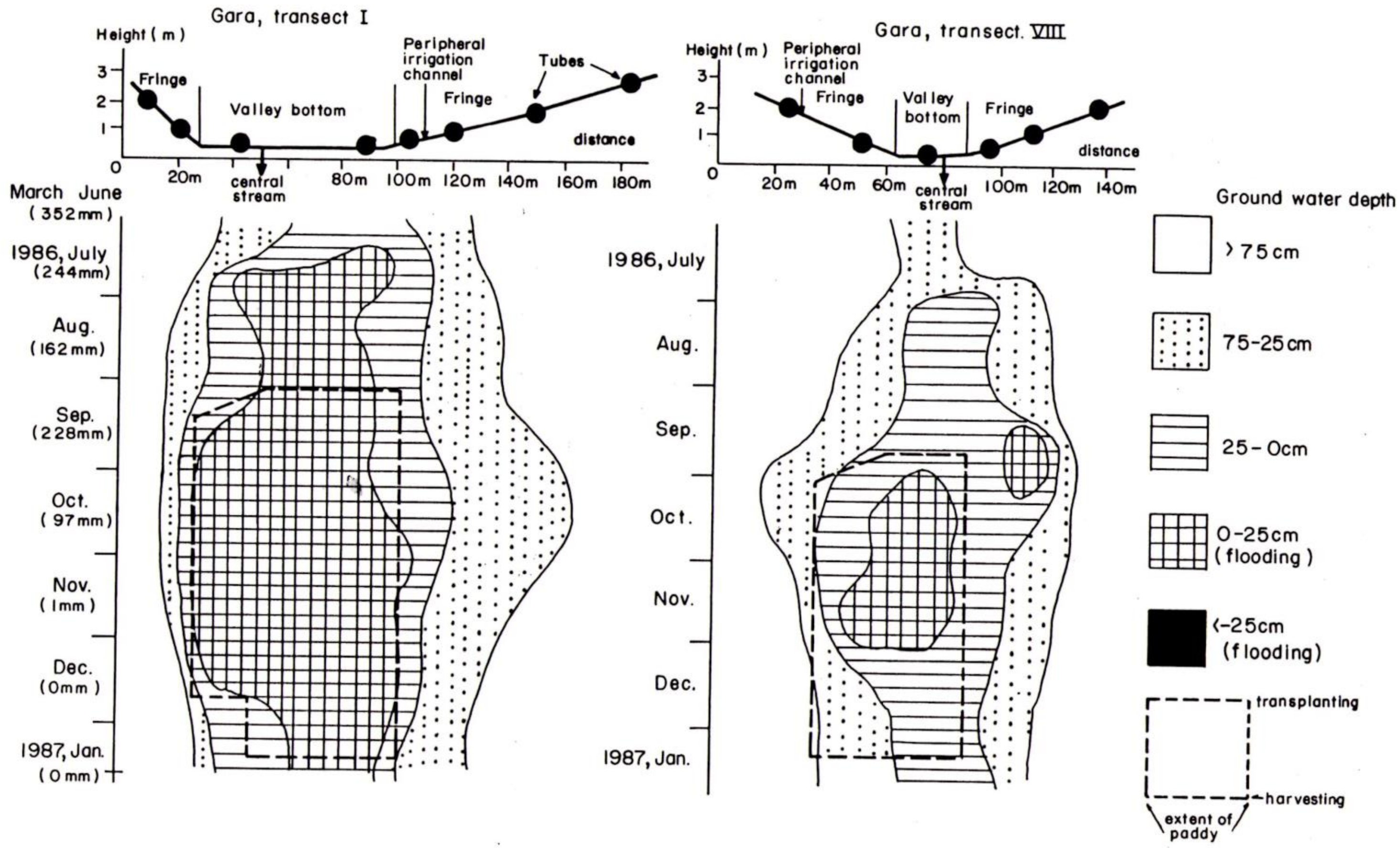


Fig.4-2. Fluctuation of ground and surface water, relation to topography and paddy distribution along transect I and VIII at Gara valley, from July 1986 to January 1987.

Based on dynamics of ground and surface water, water balances in the paddies were calculated and presented in Table 4-2. Tentatively three categories of water balance can be distinguished:- (a) paddies with more than 130 days of continuous flooding where it is possible to grow traditional long duration rice, (b) paddies with 100-130 days continuous flooding where early maturing varieties are more suitable; and (c) paddies with less than 100 days continuous flooding where rice cultivation is risky. Eighty-five percent of paddies in the valley bottom at Gara fall in the first two categories, but 75% of those in fring (or the "hydromorphic ecology") cannot expect sufficient water to produce a good crop of rice. Water balance of paddies in Anfani is less satisfactory. One third of paddies in valley bottom and more than 90% of paddies in the valley fringe will suffer drought stress. The difference of water balance of paddy between Gara and Anfani valleys is probably due to the positive effect of the head dyke and peripheral irrigation channels in Gara.

As commonly found in traditionally cultivated inland valley swamps in West Africa, the farmer's paddy units are small (10-70 m2), with weak sandy bunds (about 15 cm high and 15-20 cm wide). Water inlets and outlets are randomly arranged. As a result, waterways between peripheral channels and paddies are complex and not easily differentiated. Paddies at the valley fringe receive some seepage water.

Table 4-2. Percentage of area in Gara and Anfani valleys under different flooding regimes, July 1986-January 1987.

Days of continuous flooding[a]	Gara		Anfani	
	Valley bottom	Fringe	Valley bottom	Fringe
>130	44.3	3.8	34.8	0
100-130	40.7	21.2	30.5	9.6
<100	15.0	75.0	35.1	90.4

[a]If 30 days are added for seed bed preparation, the actual growing days will be > 160, 130-160, and <130.

An improved paddy system was constructed in a part of Gara valley. Improvements involved expanding the plots from 10-70 m2 to 100-270 m2. After rough leveling by hand hoes, the paddies were puddled by a turtle power tiller. Because of the coarse soil texture, larger bunds were made (30-40 cm high and 40-50 cm wide). Each paddy was given one water inlet and outlet. Because of these improvements water requirement for rice is calculated to drop from 190-240 mm/day to 67-71 mm/day in the valley fringe and from 71-150 mm/day to 21-30 mm/day in the valley bottom for the improved compared to the traditional farming system.

In researcher-managed trials established on two blocks in the improved paddies, seedlings from a nursery established on August 20 at a planting density of 100-150 g/m2, were transplanted at a spacing of 25 x 25 cm on September 18. Rice was harvested on January 13 and 14, 1987. One block received no fertilizer, while the second received NPK at 60-60-60 kg/ha applied in two equal doses before transplanting and at 40 days after transplanting, plus 30 kg/ha N as ammonium sulphate 70 days after transplanting.

Farmer-managed trials were also conducted in two blocks in the improved paddies and in two blocks in the unimproved paddies in the valley. One of the two blocks received only a basal dressing of 15-15-15 while the other received 90-60-60 applied in three doses as for the researcher-managed block. Each block was subdivided into five plots on each of which one of five rice varieties were planted (FARO 27 as local check, ITA 212, ITA 306, ITA 249 and FARO 29). The results of this preliminary trial are shown in Table 4-3. They indicate that improved water management resulting from the improved paddy system had a big effect on the rice yields and facilitated better response to fertilizer. **(T. Wakatsuki, Y.S. Chen, N.C. Navasero, A. Evers, M.C. Palada, O.O. Fashola, J. Musa).**

Table 4-3. Rice yields (ton/ha) in farmers traditional paddy compared to an improved paddy system in Gara valley, 1986.

Variety	Fertilizer (kg/ha NPK)	E①～⑦ Farmers paddy, farmer's management	A and D Improved paddy, farmer's management	B and C①～⑥ Improved paddy, researcher's management
Local	0-0-0	-	-	-
	15-15-15	1.7	3.6	4.7
	60-60-60	2.4	3.3	6.2
ITA 212	0-0-0	-	-	-
	15-15-15	2.2	3.2	4.4
	90-60-60	3.5	4.6	4.7
ITA 306	0-0-0	-	-	-
	15-15-15	1.8	4.9	4.6
	90-60-60	3.0	6.8	6.1
FARO 29				
	0-0-0	-	-	-
	15-15-15	1.7	3.1	4.6
	90-60-60	2.2	6.1	5.3
Mean	0-0-0	-	-	-
	15-15-15	1.9(0.2)	3.7(0.9)	4.6(0.1)
	90-60-60	2.8(0.6)	5.2(1.6)	5.6(0.7)

Figures in brackets are standard deviations.

Note: The position of E①～⑦, A and D, and B and C①～⑥ are described in newly added Fig. 6 in next page (Added by T. Wakatsuki in April 2014).

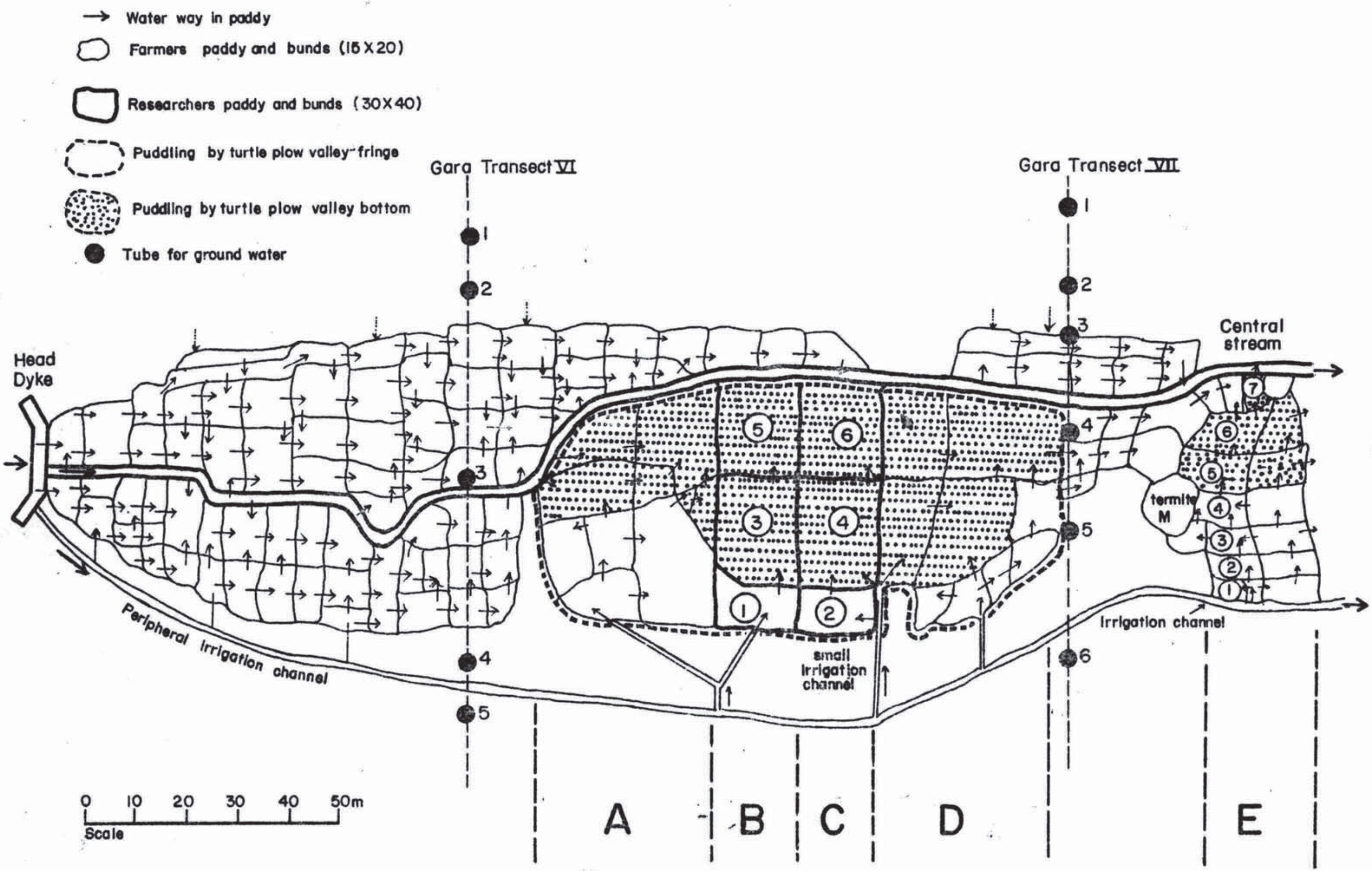


Fig. 6 Gara, Intensive on-Farm Research Site.
The figure shows the locations of yield data of Table 4-3 of page 86(Added by T. Wakatsuki in April 2014).
The site location maps at Bida area are shown in next three figures, which were cited from Chapter 6 by Wakatsuki from Hirose and Wakatsuki 2002 "Restoration of Inland Valley Ecosystems in West Africa"

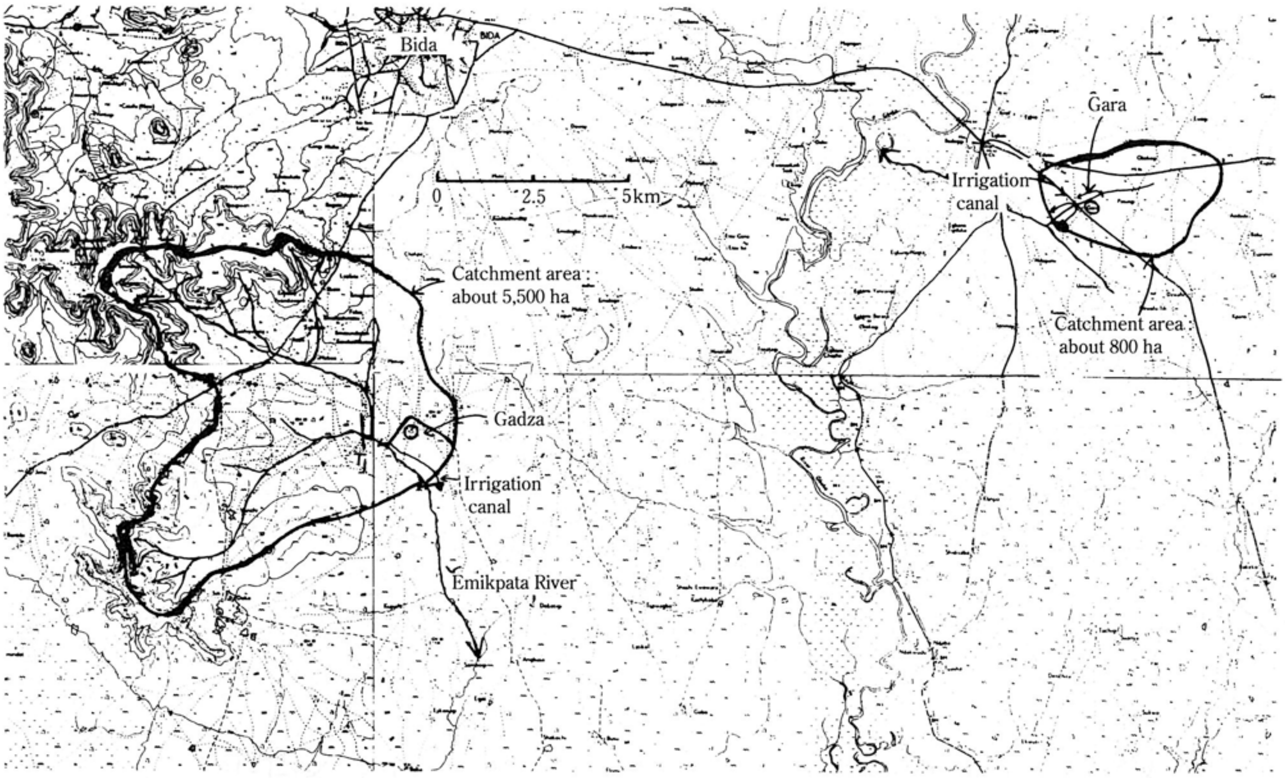


Fig. 6-5 Benchmark sites in the watershed of Gara and Gadza near Bida

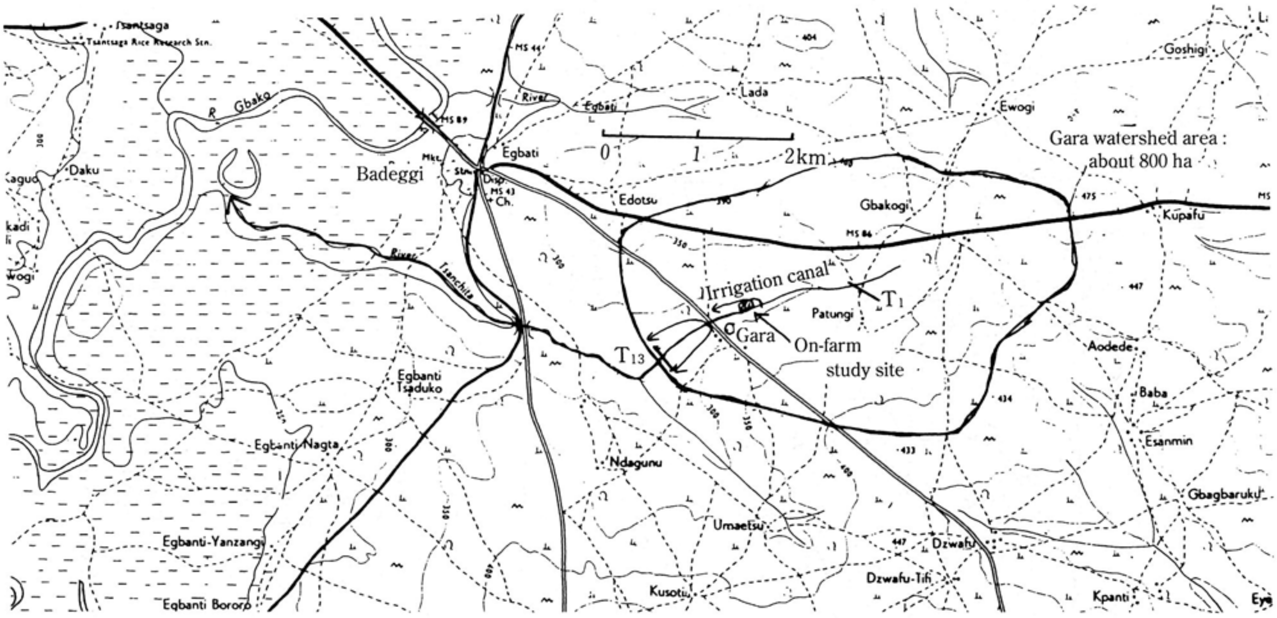


Fig. 6-6 Stream-flow inland valley watershed of Gara for the on-farm study

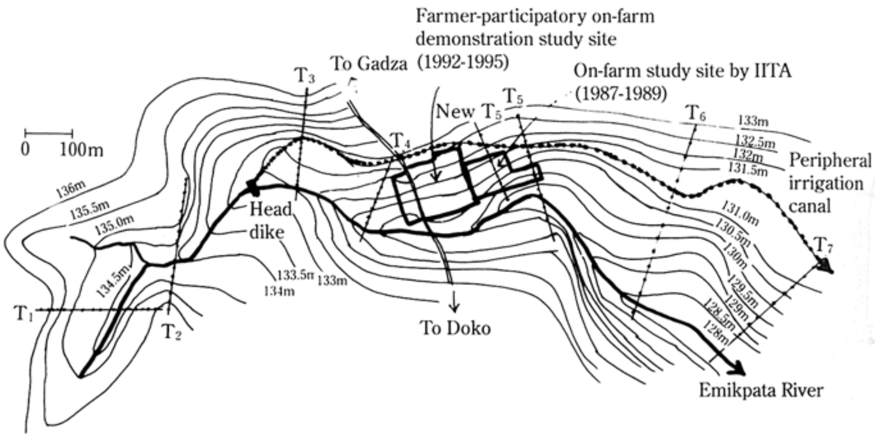


Fig. 6-9 Topographic features of the valley bottoms in a river overflow type inland valley and on-farm study sites in Gadza
(8-18 vinyl chloride ground water tubes were installed at T_1 to T_7.)

The site location maps at Bida area cited from Chapter 6 by Wakatsuki from Hirose and Wakatsuki 2002 "Restoration of Inland Valley Ecosystems in West Africa.