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Sawah Rice Eco-technology and Actualization of Green Revolution in West Africa: Experience from Nigeria and Ghana

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Abstract: The development and dissemination of sawah rice eco-technology in Nigeria and Ghana as prerequisites for the actualization of green revolution in West Africa were described. It showed that the neglect of the eco-technology and the overemphasis of the biotechnology have rendered the ineffective transferability of the green revolution process from Asia to Africa. The sawah eco-technology increases yield up to 5 t/hm^2 through bunding and the use of inlet and outlet connecting irrigation and drainage, which enhances effective water control and management, improves the efficiency of fertilizer, improves nitrogen fixation by soil microbes and algae, increases the use of wetlands, improves soil organic matter accumulation, suppresses weed growth, and enhances immune mechanism of rice through nutrient supply. The current experience has therefore established that the technology overcomes the constraints that have limited the realization of green revolution in West Africa.

Key words: sawah rice; eco-technology; green revolution; sub-Saharan Africa; rice production

Sub-Saharan Africa (SSA) is the only remaining region of the world where per capita food production has remained stagnant over the past 40 years (Sanchez, 2002), hunger prevalence is over 30% and the number of malnourished people is still increasing (Sanchez and Swaminathan, 2005). Increased agricultural productivity and food production is the key to combating hunger and to enhancing Africa's economic development in general. The expected transformation is always expressed as green revolution, a term which was first used to depict the spread of new technologies and other developments in the field of agriculture (Chapman, 2002). The green revolution that began in 1945 allowed food production to keep pace with population growth, which has continued as the result of programs of agricultural research, extension and infrastructural development. There have been numerous attempts to introduce green revolution into Africa but with less success, because of a number of reasons such as widespread corruption, insecurity, a lack of infrastructure, and a general lack of will on the part of the governments among other things.

The government of Japan has manifested strong support for increasing rice production in Africa as the most important agricultural support before and during the fourth Tokyo International Conference on African Development (TICAD 4) held in May 2008 in Yokohama, Japan. This is in a way to accelerate the long expected green revolution in Africa, because rice is a major staple in SSA, however, rice (paddy) yield remained almost stagnant from 1.2 to 1.5 t/hm^2 in SSA during 1960–2000 (WARDA, 2007). Evenson and Gollin (2003) reported that the green revolution has not yet taken place in West Africa while Otsuka and Kalirajan (2006) stated that contemporary SSA is similar to tropical Asia several decades ago with the attendant fear of famine. von Braun (2009) noted that recent food-price and economic shocks have further jeopardized the food security for developing countries and poor people, pushing the estimated number of undernourished people over one billion. Reasons adduced for the ineffective transferability of the green revolution process to Africa include low adoption rate of modern varieties and weak national agricultural and extension system (Evenson and Gollin, 2003; Otsuka and Kalirajan, 2006). In addition, a wide yield gap exists for the modern varieties between research's and farmers' fields (Becker et al, 2003), because fertilizer is often not available for farmers in SSA and when available, it is not timely for farm operations and

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usually very expensive. Farmers have reverted to the age-old practice of small-scale irrigation systems, which have been reported to be of growing economic significance in some regions due to the failure of large scale irrigation projects and river basins in SSA as a result of poor management, corruption and poor skills (Fu et al, 2010)

Wakatsuki (2009) stated that for the green revolution to be realized in SSA, there needed purposeful combination of biotechnological and eco-technology development. This has been confirmed through the sawah eco-technology rice production system in Nigeria and Ghana, which has led to increase rice yield from an average of 1.2 to 5.0 t/hm^2. The technology was based on the argument that the green revolution in Asia was feasible due to the combination of agronomy, breeding and eco-technology, however, in the case of SSA, eco-technology is missing.

The term sawah refers to improve man-made rice-growing environments with leveled rice field surrounded by bunding with inlet and outlet connecting irrigation and drainage. Fig. 1 shows the pattern of sawah in the inland valleys in Nigeria and Ghana. Sawah fields are the system adaptable to a lowland ecosystem but require eco-technological skills, including those for minimum changing of topographical and ecological features, such as both land leveling, bunding and irrigation/drainage systems. The eco-technological skills for sustainable water management based on the maintenance, improvement, and proper operation of the systems are also important. But in tropical Africa, this type of farming technology, which is essential to lowland use, has not been developed. This is why lowlands in Africa have mostly been left unused. In other words, rice and other crops have been grown at the cost of forests in uplands (Wakatsuki et al, 2001). Sawah is a sustainable rice cultivation system (Tabuchi and Hasegawa, 1995), consisting of land management and irrigation. The land management is leveling, bunding, puddling and transplanting. This technique leads to high yields and sustainable production, irrespective of fertilizer use (Asubonteng, 2001; Becker and Johnson, 2001).

In Nigeria and Ghana, rice is cultivated under three systems, namely, rainfed upland, irrigated, and rainfed lowland conditions in inland valleys. The numerous small inland valleys scattered across the country offer the best rice ecology. Inland valley bottoms and hydromorphic fringes cover about 50 million hectares in West Africa (Windmeijer and Andriesse, 1993), of which about 10 million hectares have potential for small-scale irrigated sawah based rice farming. In Ghana, potential area for small-scale irrigated sawah in Inland Valley Watershed is estimated at 700 000 hectares, which is 3% of total land area, and if floodplains are included, the total potential area for irrigated sawah may reach one million hectares in Ghana.

On-farm sawah demonstrations in Ghana and Nigeria

In Ghana, the project was carried out in the Ahafo Ano South district based on collaboration

Lowland before sawah   Lowland after sawah

Fig. 1. Lowlands before and after sawah in Nigeria.

among Japan International Cooperation Agency (JICA), Crop Research Institute of Ghana (CRI), Soil Research Institute of Ghana (SRI) and Inland Valley Rice Development Project (IVRDP) of African Development Bank (ADB), which has been the hallmark of the technology development and dissemination. The impact of the sawah intervention in Ghana can be clearly deduced from Table 1.

In Nigeria, the sawah system was introduced through on-farm adaptive research in the two research sites of Gara and Gadza inland valleys, located in Bida, Nigeria in 1986 (Hirose and Wakatsuki, 2002). On-farm adaptive research and participatory trials on Sawah system research were conducted on the research sites for four years (1986–1990) by Japanese researchers. In partnership with Watershed Initiative in Nigeria (2001), a Non Governmental Organization, Agricultural Development Project, Ministry of Agriculture, Niger State and National Cereals Research Institute (NCRI), the dissemination of the sawah technology took off in 2001 from villages previously identified in a diagnostic survey. The trend of the results of the activities is presented in Table 2.

Table 1. Paddy rice yields of 17 districts in Ashanti region of Ghana from 2001 to 2005. t/hm²

District	2000	2001	2002	2003	2004	2005
Amansie East	1.40	1.33	1.15	1.35	1.35	1.40
Amansie West	1.58	1.50	1.51	1.45	1.45	1.40
Ajura-Sekyedumasi	0.71	0.67	0.68	0.60	0.60	0.68
Sekyere West	2.14	2.00	2.03	2.33	2.33	2.50
Sekyere East	1.43	1.35	1.38	1.60	1.60	1.00
Afigya Sekyere	1.32	1.27	1.27	1.25	1.25	2.16
Ahafo Ano North	1.63	1.55	1.57	1.60	1.60	2.00
Ahafo Ano South [a]	5.44	5.17	5.22	5.25	2.25 [b]	5.30
Atwima	2.98	2.84	2.86	2.85	2.85	1.24
Ejisu Juaben	1.50	1.43	1.44	1.43	1.43	1.90
Bosumtwi-Kwanwo	1.50	1.43	1.44	1.44	1.44	1.20
Kwabre	1.31	1.29	1.29	1.00	1.00	1.80
Offinso	1.30	1.23	1.25	1.25	1.25	1.56
Adansi West	1.22	1.16	1.17	1.16	1.16	1.79
Adansi East	1.37	1.36	1.40	1.08	2.08	2.50
Asante Akim North	1.60	0.29	0.30	0.30	1.30	2.25
Asante Akim South	1.32	0.11	0.11	0.13	1.13	1.60

[a] District where sawah eco-technology was adopted; [b] Year of severe drought.

Source is from the Ministry of Food and Agriculture, Ghana.

Table 2. Trend of sawah technology adoption in Nigeria.

Year	Number of farmers	Average yield (t/hm²)	Field area (hm²)
2001	3	4.50	3
2002	5	5.00	5
2003	10	5.10	10
2004	30	5.00	30
2005	100	5.20	50
2006	200	5.10	100
2007	350	5.10	110
2008	500	5.00	150
2009	1000	5.20	200

Sawah eco-technology and rice yield

Soil and water management through bunding ensures that available water is maximally used through ponding within the bonds thus controlling water and preventing floods. For sustainable increase of rice yield and production, farmers have to control water in rice fields. If the degree of water control improves, sustainable rice yield will increase (Hirose and Wakatsuki, 2002; Ofori et al, 2005). Fasola et al (2006) reported higher yields of crops derived from sawah technology when compared to yields on other ecologies in West Africa. Sawah fields enhance the sustainability of intensive lowland sawah systems through nutrient cycling and geological fertilization processes. The sawah system overcomes the constraint of poor soil nutrient through the ponding of water, such with proper water management and efficiency of fertilizer application would largely increase yield and lead to high yield of rice (Hirose and Wakatsuki, 2002). The improvement of nitrogen fixation by sawah systems, such as 50–200 kg/hm^2 N per year, through the integrated management of water, soil microbes and algae, and the improvement of nitrogen fixation of rice plants has been reported on lowland soils in West Africa through various multi-functional mechanisms to enhance nutrient availability (Issaka et al, 1997; Abe et al, 2006). Similarly, Issaka et al (2009) reported that under sawah plots, soil pH and exchangeable cations increased over time. Asubonteng (2001) proposed that the sawah technique leads to high yield and sustainable production irrespective of fertilizer use, thus the problems of shortage of fertilizers can be overcome. Oladele and Wakatsuki (2008) noted that the use of wetlands for agriculture has increased because of the realization of the increasing benefit of hitherto neglected land and the efficiency of the sawah technology to profitably use flood prone areas for rice production. Furthermore, it contributes to the alleviation of global warming problem through the fixation of carbon in sawah soils (Wakatsuki and Masunaga, 2005). Issaka et al (2009) reported an increase in soil organic matter on sawah plots for a period of five years in Ghana. Consequently, the improvement of soil organic matter contributes to carbon sequestration. Effective water control enhanced by leveling of the area within the bunds helps to suppress weed growth, except for few water weeds. Generally, the cost of weeding is greatly reduced due to low weed infestation. The sawah system improves silicon and other nutrients supply to enhance immune mechanism of rice. The sustainable productivity of sawah is more than 10 times higher than upland rice fields. Because of geological fertilization processes and well-known bio-physico-chemical processes of inundated sawah soils as described by Kyuma and Wakatsuki (1995), sustainable productivity of 1 hm^2 of sawah fields is equivalent to more than 10 hm^2 of uplands fields. This value was estimated by assuming that the mean yield of upland rice without fertilizer application is 1 t/hm^2 and the mean yield of sawah rice without fertilizer application is about 2.0–2.5 t/hm^2. To sustain the yield, upland fields have to be fallowed (3-year cultivation and 12-year fallow, for example) while the lowland sawah rice can be cultivated continuously for several years. Thus, the sustainable productivity of sawah fields is 10–12.5 times higher than that of upland rice fields, i.e $12.5 = (2.5/1) \times (15/3)$ (Wakatsuki et al, 2009).

CONCLUSIONS

The intervention of Japanese researchers and institutions through the sawah technology had great impact on the transformation of the rice production in Nigeria and Ghana during the past years of operations, which contributes to the actualization of the green revolution in West Africa. However, the spread and intensity of the sawah technology has to be improved to develop enough manpower in the areas of effective water control, to exploit sawah plots on lowlands, to handle and manage power tillers, and to overcome the problem of land tenure. As farmers realize the increase in yield from adopting sawah technology, land owners either increase their rent on land or simple refuse to renew the tenancy periods on such inland valley (Oladele and Wakatsuki, 2009). The realities of sawah rice production technology by scientists and farmers in the region have been a major factor for its high rate of adoption, which will promote the use of more hectares of lowland into rice production within a short time. The sustainability of the sawah technology with high yielding is definitely the harbinger of the actualization of the green revolution in West Africa.

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