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Missing prerequisites for Green Revolution in Africa: Lessons and challenges of Sawah rice eco-technology development and dissemination in Nigeria and Ghana

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Abstract

This paper reviews past efforts to kick start Green Revolution in sub-Saharan Africa (SSA) with the emphasis that there are missing prerequisites for the actualization and realization of Green Revolution due to the absence of suitable growing environment for rice production on farmers fields in SSA. Sawah eco-technology was described in the paper as an established and proven solution for the actualization of Green Revolution in SSA. The paper examined the trend for the development and dissemination of sawah technology in Nigeria and Ghana, and consequently the benefits of the technology. Through sawah technology significant breakthroughs, which have always being the obstacle to high rice yield, include the ability to utilize the inland valleys and floodplain for sustainable rice production, effective water control for rice production in inland valleys for high rice yield and weed reduction, the use of sawah eco-technology to overcome the shortage of fertilizers through microbial nitrogen fixation and geological fertilization on sawah plots. Major challenges for up-scaling the technology are the issues of land tenure, cost of power tiller and trained manpower. The sawah rice production technology has afforded the awareness that more hectares of lowland can be put into rice production within a short time and still be sustained effectively and efficiently with high yield sufficient enough to herald the much awaited Green Revolution in West Africa.

Key words: Sawah, eco-technology, Green Revolution, SSA, rice production.

Introduction

The transformation of agriculture that began in 1945 allowed food production to keep pace with population growth. The associated transformation has continued as the result of programs of agricultural research, extension, and infrastructural development. The term "Green Revolution" was first used to depict the spread of the new technologies and other developments in the field of agriculture [1]. The take-off point was the Office of Special Studies in Mexico which in 1963 formally became CIMMYT, The International Maize and Wheat Improvement Center. This process was replicated in India through the adoption of IR8 - a semi-dwarf rice variety developed by the International Rice Research Institute (IRRI) that could produce more grains of rice per plant when grown with fertilizers and irrigation. In 1960, the Government of the Republic of the Philippines adopted the same process and annual rice production increased from 3.7 to 7.7 million tons in two decades. The switch to IR8 rice made the Philippines a rice exporter for the first time in the 20th century [2]. In May 19, 1971, the Consultative Group on International Agricultural Research (CGIAR) was established and co-sponsored by the FAO, IFAD and UNDP. CGIAR has over the years since inception added many research centers throughout the world and has responded to criticisms of Green Revolution methodologies [3]. Methods like agroecosystem analysis and farming system research have been adopted to gain a more holistic view of agriculture, while other methods like rapid rural appraisal and participatory rural appraisal have been adopted to help scientists understand the problems faced by farmers and even give farmers a role in the development process. The conventional process of Green Revolution was, however, still maintained and heavily funded [4].

There have been numerous attempts to introduce the successful concepts from the Mexican and Indian projects into Africa. These programs have generally been less successful, for 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. Yet environmental factors, such as the availability of water for irrigation, the high diversity in slope and soil types are also reasons why the Green Revolution is not so successful in Africa. Evenson and Gollin [5] reported that Green Revolution has not yet taken place in West Africa and SSA, while contemporary Sub-Saharan Africa is similar to tropical Asia several decades ago with the attendant fear of famine [6]. Recent food-price and economic shocks have further jeopardized the food security of developing countries and poor people, pushing the estimated number of undernourished people over one billion[7]. These increasing uncertainties raise critical questions about how to quickly, viably, and sustainably manage familiar risks and emerging new ones. Those who depend on food purchases, both in rural and urban areas, are highly vulnerable to market risks such as high and volatile agricultural prices, which peaked in 2007-2008. 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 [8], hunger prevalence is over 30% and the number of malnourished people is still increasing [9]. Increased agricultural productivity and food production is the key to combating hunger and to enhance Africa's economic development in general.

The green revolution package of high-yielding crop varieties (HYVs), irrigation and agrochemicals is often seen as mainly a technological intervention to boost food production, but there are socio-economic, political and environmental dimensions to it as agriculture is mainly based on natural resources. Many valuable lessons can be drawn from the green revolution experience in Asia which can hopefully help Africa to make strategic policy decisions for embarking on an agricultural revolution. The lessons can be used by Africa as inputs for considering strategies and approaches to food security. The entire range of lessons from Green Revolution in Asia, together with knowledge on existing potential technologies and systems in Africa, needs to be analysed and considered before any agricultural revolution is undertaken in Africa.

The most vital consideration may be about local agro-ecosystems and what they can offer, rather than applying technologies that are developed detached from the local system. Agro-ecosystem development may be more important than any revolution. Africa still has that legacy, which can be further improved with appropriate and people-based technology.

Otsuka and Kalirajan [6] reported that the main prerequisites of Green Revolution in Asia have been ineffective in the transferability of the green revolution process to Africa. Firstly, HYVs were fertilizer-responsive and irrigation system optimizes plant growth and fertilizer reaction. African farmers have widely adopted the first generation MVs with respect to rice since 1960s[6] though adoption rate of MVs was still lower in SSA than Asia [5] because national agricultural and extension system was much weaker [10]. Also, the impact of genetic improvement on rice has occurred disproportionately over rice ecologies in WA, high MVs adoption rates in irrigated wetlands and rainfed lowlands but low MVs adoption rate in the upland ecology [11]. Of much critical attention is the fact that a wide yield gap exists for the HYVs between research and farmers fields [12]. Fertilizer is often not available for farmers in SSA and when available, it is not timely for farm operations and usually very expensive. This has made the average intensity of fertilizer use in SSA to be less than 10 kg per hectare of cultivated land over the past 40 years, much lower than in other developing regions [13]. The failure of large-scale irrigation projects and River Basins in SSA due to poor management, corruption and poor skills has made farmers to revert back to the age-old practice of small-scale irrigation systems which have been reported to be of growing economic significance in some regions [14].

The scenarios described above have stressed the fact that the prerequisites needed for Green Revolution in SSA are actually missing and thus need for a solution. Fig. 1 depicts the anecdotal path for GR in SSA that has been researched and established.

Fig. 1 seeks to reverse the unfavorable environment for crop growth on farmers' fields which has rendered Green Revolution components ineffective and the introduction of sawah eco-technology which is an ecologically sound technology which modifies ecosystem functions and environment and can improve farmer's fields on a sustainable basis.

Rice is a major staple, increasingly eaten in SSA. However, rice (paddy) yield remained almost stagnant from 1.2 to 1.5 t ha^{-1} in SSA but showed remarkable increase from 1.8 to 4.0 t ha^{-1} in Asia during 1960-2000 [15]. It is obviously true that African Green Revolution is still far from the success, and efforts to increase the production of this major staple would not only make households to be food secure but will ease the pressure on foreign exchange that often goes to secure imports that are used to bridge the consumption demand-supply gap in many SSA countries. The government of Japan has manifested strong support for increasing rice production in Africa as the most important agricultural support before and during fourth Tokyo International Conference on African Development (TICAD 4) held in May 2008 in Yokohama, Japan. The plan of doubling rice production within ten years in African countries is a challenge which promotes suitable cropping, mixing lowland and upland rice based on climate condition and access to water. The declaration and the efforts for doubling was based on the obvious research reports of many rice researchers, mostly from Japan and African countries, that the potential actually exists and results of previous researches proved that it is attainable. This is in a way to accelerate the long expected Green Revolution in Africa. Support activities were implemented in conjunction with Japanese research institutes, universities, JICA, WARDA, IRRI and other NARS in many African countries.

In Nigeria and Ghana, rice is cultivated under three systems, namely, rainfed upland conditions, irrigated conditions, and rainfed lowland conditions in inland valleys. Production under rainfed upland conditions has been very low due to unreliable rainfall and shallow and erodible soils of low fertility. Also, production under the big irrigation scheme has not been successful. The numerous small inland valleys, scattered across the country where water control is the main problem, offer the best rice ecology. Inland valley bottoms and hydromorphic fringes cover about 50 million hectares in West Africa [16], 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, 1-3% of Guinea Savanna Zone and 3-5% of Forest Zone. If flood plains are included, the total potential area for irrigated sawah may reach one million hectares in Ghana. Applying sawah rice producing technology is one of the solutions [17]. Although, considerable progress has been made in addressing

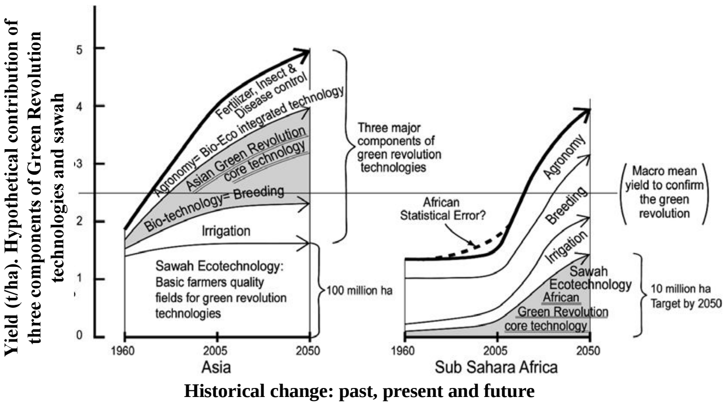

Figure 1. Schematic diagrams for the comparison of biotechnology-based rice Green Revolution in Asia with the sawah ecotechnology-based rice Green Revolution plan in Africa.

some of the researchable constraints, there is the need to devise simple and low cost and environmentally friendly system for managing the inland valleys that can be adapted by the resource poor farmers. The Asian experience in sawah development, which looks at not only the valley bottoms but also total watershed, has been applied through the sawah concept. The term sawah, originating from Malayo-Indonesian, refers to leveled rice field surrounded by bund with inlet and outlet connecting irrigation and drainage. The English term paddy or paddi, which refers to rice grain with husk in West Africa, also originates from the Malayo-Indonesian term, padi, which means rice plant. Most of the paddy fields in the Asian countries correspond to the definition of the term sawah. Paddy field is almost equivalent to sawah for Asian scientists. However, the term paddy field refers to just a rice field including upland rice field in West Africa. Therefore, in order to avoid confusion between the terms of rice plant, paddy, and the improved man-made rice-growing environment, the authors propose to use the term sawah [17]. Fig. 2 shows the pattern of sawah in the inland valleys in Nigeria and Ghana.

Lowland before sawah   Lowland after sawah

Figure 2. Lowlands before and after sawah in Nigeria.

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. However, 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 [17]. Sawah is a sustainable rice cultivating system [18], consisting of land management and irrigation. The land management is leveling, bonding, puddling and transplanting. This technique leads to high yields [19]and sustainable production irrespective of fertilizer use [20].

Field Experiments

In Nigeria, the study on development potential on sawah based rice production in inland valleys in Nigeria was conducted by Japanese scholars based on the fact that rice culture in the regions is basically upland cropping with the traditional method of bush fallow and shifting cultivation. In order to overcome the problems of low farming productivity and to realize a more intensive and sustainable agriculture, 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 [21]. Bida is 137 m above sea level and lies on longitude 6°01’E and latitude 9°06’N in Niger State of Nigeria with a clayey loamy, sandy soil, under the Guinea Savannah Ecology of Nigeria. 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 and IITA staff but there was generally poor adoption by farmers, however, improved varieties were readily adopted but other components of the system were marginally adopted and this led to the reassessment of the technology transfer methodology, which was incorporated in the new project that started in 2001 by Watershed Initiative in Nigeria (WIN 2001). The real efforts for dissemination took of in 2001.

Watershed Initiative in Nigeria (WIN 2001) - a Non-Governmental Organization, commenced the activities on sawah based rice production development in 2001 with funds provided by the Japanese Ministry of Education. WIN 2001 has a full collaboration with Agricultural Development Project (ADP), Ministry of Agriculture, Niger State, and with National Cereals Research Institute (NCRI). The dissemination of the sawah package took off in 2001 from villages previously identified in a diagnostic survey. Lowland rice farmers in different villages were contacted from where individuals show interest. Sawah based rice production development started with three individual farmers in three villages with 0.1 ha in total area in 2001 [22]. The establishment of a demonstration field (1.0 ha) at Ejeti village in 2002 galvanized the project. The trend of the results of the activities is presented in Fig. 3.

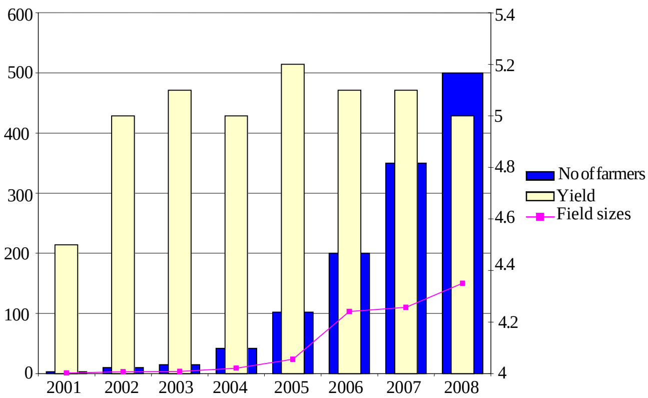

Figure 3. Trend of sawah technology adoption in Nigeria.

In Ghana, the project was carried out in the Ahafo Ano South district in Ghana. Ghana is located on West Africa’s Gulf of Guinea only a few degrees north of the Equator on Latitude 5°36’N, Longitude 0°10’ E. Half of the country lies less than 152 m (500 ft.) above sea level, and the highest point is 883 m (2,900 ft.). The coastline of 537 km (334-mi.) is mostly a low, sandy shore backed by plains and scrub and intersected by several rivers and streams, most of which are navigable only by canoe. Table 1 presents the 3 phases of the sawah development process in Ghana from 1997 till date and beyond 2009. The phases were described in terms of the duration, institutions involved, budget size and the target as well as the way to develop the inland valleys and enhance sustainable rice production. Central to all of the phases is the participation of farmers in order to ensure the continuity of the sawah development process. The collaborated study program of

Table 1. Features of the of sawah development phases in Ghana.

	Phase 1	Phase 2	Phase 3
The project name	Integrated Watershed Management of Inland Valleys in Ghana	Sawah project	Inland Valley Rice Development Project
Term	1997-2001	2002-2004	2004-2009
Conducted by	JICA – CRI	SRI – Shimane Univ., Kinki Univ.	MOFA – ADB
Budget size	$0.45 million	$ 0.17 million	$20 million
Main target 1	Training Ghanaian Agric. researchers	Study for sustainable sawah development	Nationwide sawah development, 200 km^2 in the country
Main target 2	Examining farmers' participated sawah development	Technical support and maintenance the machinery for farmers	Paddy yield 45 Mg/km^2, total production 80,000 Mg for poverty reduction in rural area
The way to develop	Employment for constructing sawah field/food for work	Food for work + 3 years support with financial aid	Group based loan + technical support
Sawah area developed	less than 10 ha	10-20 ha	Over 100 ha (Objective)
Main problem	Training farmers, especially the first year	farmers' incentive, sharing the production	site selection, no presence of machinery

JICA Japan International Cooperation Agency, SRI Soil Research Institute of Ghana, ADB African Development Bank, CRI Crop Research Institute of Ghana, MOFA Ministry of Food and Agriculture of Ghana

Japan International Cooperation Agency (JICA) and Crop Research Institute of Ghana (CRI) ran at the northern Ashanti region of Ghana. The sawah field development with the farmer's participation was proven (JICA). After the study collaboration had ended, the program was transferred to Soil Research Institute of Ghana (SRI). Afterwards, Inland Valley Rice Development Project (IVRDP) of African Development Bank (ADB) was planned, and now it is progressing [23]. The main goal of sawah projects in West Africa by Japanese institutions is the development of sustainable production systems of the whole watershed, which allows intensification and diversification of the lowland production system and stabilizing improved production systems on the upland. Furthermore, the projects would assist the development of a tool for land use planners and decision makers for integrated watershed development[24]. Table 1 presents the features of the 3 phases of sawah development process in Ghana.

The impact of the sawah intervention in Ghana can be clearly deduced from Table 2, which shows that farmers adopting sawah technology were able to obtain more than 4 t ha^{-1}.

Lessons

Significant breakthroughs which have always being the obstacle to high rice yield that was accomplished through sawah was the ability to utilize the inland valleys and floodplain for sustainable rice production, effective water control for rice production in inland valleys for high rice yield, the use of sawah eco-technology to overcome the shortage of fertilizers through microbial nitrogen fixation on sawah plots. Development and training of farmers, scientists and extension agents as well as government officials on the importance and capability of sawah rice production. The sawah farmers were also formed into cooperative and training groups to be able to take advantage of credits as a group and be trained collectively for improvement of their farming skills. In all, the socio-economic status of the sawah farmers had improved. Some farmers have secured more inputs for farming and other necessary household needs due to higher income.

Table 2. Mean paddy grain yield among farmers groups adopting sawah technology 2001-2005 in Ghana.

Farmers group	2001	2002	2003	2004	2005
Adugyama A	4.0	4.7	3.8*	5.0	4.5*
Adugyama B	4.4	4.8	5.5	5.5	4.8*
Biemso A	4.8	4.7	4.8	5.5	-
Biemso B	4.7	5.7	5.9	6.5	5.4
Biemso C	-	4.5	5.4	5.5	5.5
Mean	4.5	4.9	5.1	5.6	5.1
SE	0.18	0.21	0.36	0.24	0.24
Traditional system	0.9	1.0	1.0	1.1	1.1

* Fields partially destroyed by late floods.

Challenges and Conclusions

The intervention of Japanese researchers and institutions through the sawah technology no doubt had some profound effect on the transformation of the rice production in Nigeria and Ghana during the past years of operations but it was not without some shortcomings. Budgeted funds were not always targeted at the farmers and field facts. This affects the spread and the intensity of the sawah technology. The allocation of these funds was also given to multiple organizations working on the same purpose of improving rice production in SSA. Another major lesson is the realization of lacking manpower to effectively understand and disseminate sawah technology. The procedure for initiating and conducting research in the African setting also had to be carried on board for effective implementation.

One of the major challenges for sawah intervention project is the problem of land tenure. As farmers realize the increase in yield from adopting sawah technology, land owners either increased their rent on land or simple refuse to renew the tenancy periods on such inland valley [24]. Another is the need to develop from a fragmented holdings to a contiguous one, the continued waste of energy and time used in treking a long distance before getting to different rice plots can be reduced and more time could be available. Power tiller which is a major component in the sawah technology package is very expensive and availability is hindered by the agricultural implement importation policy in SSA. The sawah rice production technology has afford us the awareness that more hectares of lowland can be put into rice production within a short time and still be sustained effectively and efficiently with high yield sufficient enough to herald the much awaited Green Revolution in West Africa.

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