Full Length Research Paper

Enhancing farmers’ access to technology for increased rice productivity in Ghana

S. S. J. Buah1*, S. K. Nutsugah1, R. A. L. Kanton1, I. D. K. Atokple1, W. Dogbe1, Afia S. Karikari1, A. N. Wiredu1, A. Amankwah2, C. Osei2, Olupomi Ajayi3 and Kabirou Ndiaye4

1CSIR-Savanna Agricultural Research Institute (SARI), P. O. Box 52, Tamale, Ghana.
2CRS-Ghana, Tamale Office, P. O. Box TL 334, Tamale, Ghana.
3AfricaRice - Nigeria Station, P. M. B. 5230, Ibadan, Nigeria.
4AfricaRice-Senegal Station, St. Louis, Senegal.

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A two-year emergency rice (Oryza sativa L.) initiative was launched in 2009 in response to the global rice crises in 2008. The objective of this initiative in Ghana was to increase rice productivity in order to improve food security. Project activities included planning sessions, demonstrations, training courses and community seed production. The project made remarkable progress in enhancing access to quality seed and fertilizer for over 12,600 farmers while expanding knowledge of best-bet production technologies. Farmers produced 28,663 Mt of paddy which was 16,841 Mt above what they normally produced without project intervention. Average yield increased by 92% and also 4,093 women farmers constituting about 32.4% of the total number of participating farmers benefited directly from the project. Seed fairs, rural radios and audio-visual broadcasts on improved rice production technologies were used to reach non-participating farmers. The combination of methods that stimulated adoption of improved rice production technology was effective in achieving both increased paddy yields and household income. We conclude that investment in rice technology transfer and production efforts during the two-year period was well justified.

Key words: Technology-transfer, emergency, seed fair, improved-technology.

INTRODUCTION

Rice (Oryza sativa L.) is quickly becoming a major staple food for urban and rural consumers alike (Nwanze et al., 2006). However, domestic consumption of rice in Africa is significantly greater than domestic production, necessitating increased imports that drain large amounts of scarce foreign exchange. Currently, the demand for rice in sub-Saharan Africa (SSA) is double the rate of population growth and consumption is growing faster than production. Across Africa, local production has been unable to keep pace with the rate of increase in demand. In the past 50 years, rice production in Africa has increased to 14.60 million tons (from about 3.14 million metric tons), most of the increase in production has come from expansion in the area devoted to the crop rather than from increases in yields. During the same period, Asia has increased rice production on a much grander scale, to about 570 million tons (up from 200 million tons), with most of this coming from higher yields on existing farmland (Norman and Otoo, 2002; Africa Rice Center, 2007).

In Ghana, the total rice consumption in 2005 amounted to about 500,000 tons which is equivalent to per capita consumption of 22 kg per person (Tomlins et al., 2005; JICA, 2007). Ghana depends largely on imported rice to make up the deficit in rice supply. On average, annual rice import is 400,000 tons. The self-sufficiency ratio of rice in Ghana has declined from 38% in 1999 to 24% in 2006 (Andriesse and Fresco, 1991; Quaye, 2007). The rice import bill is estimated at US$500 million annually and has become a source of concern to government. In

*Corresponding author. E-mail: ssbuah@yahoo.com.
view of food security and foreign currency savings, increased production of domestic rice with higher competitiveness against imported rice is paramount to Ghana’s agricultural sector development (JICA, 2007). According to the Africa Rice Center, the limited growth of the aggregate productivity of rice in Africa is due to the large share of rain-fed rice and subsistence-based rice farming systems (Africa Rice Center, 2007). Improvement in rice productivity potential will therefore play a critical role in feeding the African population that is expected to double during the next two decades. Therefore, there is a need to support farmers to increase rice productivity rather than acreage cultivated, if Africa is to meet the short-fall in rice production. Among the challenges that national policies should address is access to and use of improved technologies. If the negative productivity effects are to be reversed, new and existing technologies must be quickly up-scaled and out-scaled.

Nutrient inputs from chemical fertilizers are needed to replace nutrients which are exported and lost during cropping, to maintain a positive nutrient balance. However, because of scarcity and high cost, most smallholder farmers in tropical Africa rarely use inorganic fertilizers on food crops including rice. Subsistence rice production in SSA is thus characterized by low external input, low yields, food insecurity, nutrient mining and environmental degradation (Stoorvogel et al., 1993; Rhodes, 1995; Mafongoya et al., 2006). Strategies must therefore be developed to restore soil fertility, to reduce erosion and environmental degradation in order to increase rice production and alleviate chronic hunger in the zone (Vagen et al., 2005). The limited amounts of fertilizer available need to be used judiciously for maximum benefit. Since a majority of these farmers have low income, technical packages to increase and sustain agricultural production must be affordable, profitable and applicable to ensure their acceptability. Experiences with periodic food shortfalls and impending population growth make scientists, politicians, governments, individuals and institutions aware of the fragile balance between food supply and food need. With globalization, while accessing food grain from the world market remains an option, the most promising way of sustaining food security in the face of rising population is the continuous growth in productivity through improved technologies. Research continues for more effective ways to develop and transfer useful technology for small-scale resource-poor farmers.

In an effort to boost rice production in four pilot countries in West Africa (Ghana, Mali, Nigeria and Senegal), in order to mitigate potential rice shortages in these countries, a two-year Emergency Rice Initiative Project (ERIP) was initiated in 2009. The emergency initiative aimed to boost rice production through enhancing farmer access to certified seed of improved rice varieties, mineral fertilizer and knowledge on best-bet actions. The emergency rice initiative was a short-term intervention launched as a direct response to the global food crisis and high rice prices experienced in 2008. The project was funded by the United States Agency for International Development (USAID) as a component of its Food Security and Crisis Mitigation Program. Globally, the project was led by the Africa Rice Center (AfricaRice, ex-WARDA) and implemented in Ghana by the International Center for Soil Fertility and Agricultural Development (IFDC), Catholic Relief Services (CRS), Council for Scientific and Industrial Research-Savanna Agricultural Research Institute (CSIR-SARI) and Ministry of Food and Agriculture (MOFA). IFDC focused on the demonstration of fertilizer best-bet practices among participating farmers and facilitated linkages with other projects that focused on access to mineral fertilizers using the voucher system, as well as training of farmer organizations and the private sector on agribusiness management and marketing. In Ghana, the project was implemented in northern Ghana (comprising Northern, Upper East and Upper West regions) and targeted 10,000 resource-poor farmers. The objective was to boost total domestic rice production among the participating farmers by 30,000 tons of paddy rice in the country in the short-term. The project also aimed at improving access for the 10,000 farmers to quality seed and fertilizer while expanding knowledge of appropriate and sustainable rice production technologies.

Methods to develop and adapt new technologies to actual farm situations and to communicate their advantages to farmers are among the most important factors influencing technology transfer. Various approaches have been used to disseminate improved technologies to farmers. Through the collaborative efforts among AfricaRice, IFDC, CRS, CSIR-SARI, MOFA and farmers, many technologies were transferred for adoption by farmers in the region, resulting in increased rice productivity. The project used several methods to promote the adoption of available rice technologies for increased productivity in Ghana. These methods included:

(i) Annual planning sessions,
(ii) Training courses and workshops,
(iii) Participatory on-farm demonstrations,
(iv) Seed fairs and seed vouchers to improve the availability and access to seeds of improved varieties for the most vulnerable rice farmers,
(v) Enhancement of exchange of ideas and technical experience among scientists and development agencies, and
(vi) Community outreach programs such as rural radio and video shows.
This paper summarizes the achievements of ERIP in disseminating improved rice technologies to farmers and the lessons learnt based on the two-year experience.

MATERIALS AND METHODS

The ERIP was implemented in the northern sector of Ghana comprising Northern, Upper East and Upper West regions. Based on climate and vegetation, Ghana is divided into six agro-ecological zones: Sudan and Guinea savanna zones (which form the northern savanna zone), the forest–savanna transition and semi-deciduous forest zones (which form the middle sector), and the high rain forest and coastal savanna zones (which form the southern sector) (Bonsu, 1996). The northern savanna zone is the largest ecological zone in Ghana. It occupies more than half of the country, covering 149,800 km$^2$ and constitutes the most extensive potential land area for rapid agricultural development.

The northern savanna zone often experiences hot, distinct dry and wet conditions. The characteristic unimodal rainfall regime starts from April or May and ends in October and ranges from 900 to 1,200 mm. The Sudan savanna has similar conditions but rainfall amounts are lower (900 to 1,100 mm) and the dry period is longer. The soils in the northern savanna have generally been described as savanna Ochrosols with underground laterite (poorly drained soils). The savanna soils are less leached and less acidic but mainly of pans, temporary waterlogging as well as lack of moisture in the long dry season are common features in the savanna. Small-scale farmers predominate, but such resource-poor farmers have few opportunities to intensify and commercialize their agricultural activities. For example, they have poor access to inputs, markets, low interest credit and poor extension services. Hence, there is little or no adoption of improved production technology and the low yields and rural poverty are further exacerbated.

The ERIP attached a lot of importance to promoting the adoption of improved technologies. The main methods used for the promotion of the adoption of available improved rice varieties and best-bet production technologies were annual planning sessions, participatory on-farm demonstrations on fertilizer management, training of trainers (ToT) courses and workshops, enhancement of technical experiences among scientists, extension staff and development agencies, promotion of community-level seed production schemes, and community outreach programs, such as rural radio and video shows. These methods are reviewed subsequently.

Annual planning sessions

The project adopted participatory approaches which consisted of a participatory diagnosis, a cyclic process of participatory planning, implementation and evaluation of activities, implemented by all relevant stakeholders. The focus was on the small-scale farmer, his environment and his problems.

Participatory Rural Appraisal (PRA) methods such as discussions in meetings, checklist for group interviews and visits to various communities were used to collect information from farmer groups. According to Theis and Grady (1991), PRA techniques are effective methods for a quick and systematic collection of information for needs assessment. Also, we conducted stakeholders meeting to reach a common understanding on reasons, aims, and methods of the project activities. It also included work plans, budgets reporting mechanisms and memorandum of understanding. In addition, we conducted stakeholders meeting to understand farmers rice production technology needs. Thereafter, we discussed the use of relevant methods, in support of the implementation stage. We then conducted capacity building activities such as training.

Furthermore, we agreed on a format for monitoring progress of project activities and also assessing achievements/prospects and challenges. At the end of the project, we documented lessons learnt by the project during the implementation stage. We then conducted capacity building activities such as training.

Training courses

The effectiveness of extension agents in encouraging technology uptake is limited by their inadequate training and knowledge on actual farm operations and problems. Thus, training was a very important component of the project. The project organized several training of trainers (ToT) courses and monitoring tours for annual planning sessions.
agricultural extension workers in an effort to promote technology exchange and transfer. The training programs included wealth ranking (also known as well-being ranking or vulnerability analysis) which is a technique for the rapid collection and analysis of specific data on social stratification at the community level. It refers to placing people on the different steps of the social ladder according to their own criteria. The purpose here is to find out the people of the village who belong to richest, middle income and poorest categories as perceived by the villagers themselves. Agricultural development must take into account differences in wealth among farmers in order to determine priorities for research and to develop interventions and technical packages that are relevant to and adoptable by majority of the farmers (Barbara, 1988). Wealth ranking is based on the assumption that community members have a good sense of who among them is more or less well off (Theis and Grady, 1991).

Other training programs included voucher system and seed fairs, integrated rice management (IRM) practices - including the importance of using quality seed, and key post-harvest issues (such as proper grain drying, conditioning and storage to improve milling quality, in order to guarantee premium market price of rice) and seed production techniques, inspection and certification. During the project, selected farmers across the three project regions were trained in the techniques of rice seed production, processing, storage and packaging with the objective of empowering them to produce good quality seed. The training curriculum on IRM included optimal planting time, appropriate plant density, water management techniques, earlier date of fertilizer application and the use of various fertilizers to improve soil fertility and rice paddy yields. The extension agents also received training on the field protocol on demonstrations and quality data collection procedures. In addition, input dealers were trained on the basics of agro-input business management, product knowledge and rice production. A second training was organized for selected input dealers, extension officers and the Diocesan Development Officers (DDOs) to sensitize them on the project’s objectives, the input voucher scheme and the terms of partnership, as well as agree on roles of stakeholders in the planning and implementation of the demonstrations.

On-farm demonstrations

To further improve scaling out of the improved seed and production technology and to increase impact, there was a need to set up collaborative demonstrations with MOFA and farmers at the district level. On-farm trials and demonstrations are important avenues to show the effectiveness of new technologies to farmers. Outstanding technologies identified from on-station and on-farm trials are often further evaluated in demonstration trials. The demonstrations carried out under the ERIP were an effective tool to showcase improved production technologies and to convince farmers to adopt them. They embodied the “learning-by-doing” principle and allowed the farmers to weigh the risks, costs and benefits of the new technology under their own circumstances. Demonstration plots were representative of the major rice ecosystems with the problem of concern and were generally located adjacent to the farmers’ fields for comparison purposes.

Additionally, the demonstrations were visible to other farmers in the community and included field days at different stages of crop growth. This approach enabled the researchers and extension workers to visit farmers’ fields and to obtain feedback on the performance of new technologies evaluated by the farmers. Apart from new varieties and improved seed, other technologies disseminated by the project included IRM practices (transplanting in rows, timing and rates of fertilizer application, deep placement of urea super granules, and cropping calendar).

Community outreach programs

Once appropriate technology is available and external factors make it profitable for the farmer, the next thing is the education and motivation of the farmer to adopt it. Community outreach programs included rural radio and video shows. These provided information and easy-to-learn ways of training. The videos were also translated into seven major local languages (Dagbanli, Gonja, Kusal, Kassim, Buli, Dagaari and Sissaii) in northern Ghana and effectively used by trainers to train and convey important extension messages to farmers.

The videos were also distributed to farmers, policy makers, local radio stations and MOFA district and regional offices in the three regions. The project partners also collaborated on developing radio scripts on improved rice production technologies in local languages, while calling attention to the availability of the rice videos.

Enhancement of exchange of ideas and technical experience among partners

Monitoring tours involving in-country regional teams were organized periodically to visit demonstration fields in each region. Concurrently, with monitoring tours, the ERIP Project Coordinator at AfricaRice and Project Manager for Nigeria and Ghana paid consultation visits to northern Ghana, to assess progress being made in the implementation of the approved work plan and to exchange expertise.

RESULTS

A constraint on the transfer of technology from the researchers’ fields to the farmer is the well known ineffective linkage between research and extension organizations in Ghana. However, the planning sessions have helped to strengthen the research-extension-farmer linkage by providing a forum that facilitated contributions from technical staff of the various participating organizations. During the planning process, technology gaps were identified and the researchers focused their efforts on filling the gaps.

Improving farmers’ access to quality seed

Across the two years of the project, the CSIR-SARI provided technical advice on seed production and also made significant positive impact on the availability of breeder, foundation and certified seed of improved rice varieties for the project (Table 1). In addition, the project improved access to 278.3 Mt of certified seed and 3,221 bags (1 bag weighs 50 kg) of quality fertilizer for 12,635 farmers (of which 4,093 were women) while expanding knowledge of current rice production technologies and best practices (Table 2). 32.4% of the registered rice farmers in the project were women as they are more vulnerable. Cumulatively, 9,494 farmers (representing 95% of the targeted 10,000 farmers) across the three project regions planted improved seed provided by the project (Table 3). The project promoted four improved techniques, earlier date of fertilizer application and the use of various fertilizers to improve soil fertility and rice paddy yields. The extension agents also received training on the field protocol on demonstrations and quality data collection procedures. In addition, input dealers were trained on the basics of agro-input business management, product knowledge and rice production. A second training was organized for selected input dealers, extension officers and the Diocesan Development Officers (DDOs) to sensitize them on the project’s objectives, the input voucher scheme and the terms of partnership, as well as agree on roles of stakeholders in the planning and implementation of the demonstrations.

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Recognizing the fact that agronomic recommendations are variety and location specific, the ERIP encouraged the cultivation of Jasmine 85 (released as Gbewaa rice by CSIR-SARI) under irrigation. Gbewaa rice was therefore recommended to farmers with irrigation or other dependable water sources, especially those at the Tono and Vea irrigation sites in the Upper East region.

In general, the project afforded beneficiary farmers the opportunity to verify and validate the performance of quality seed and improved production technologies under different environmental and socio-economic conditions. The introduction of quality seed of improved rice varieties also served the purpose of publicizing the varieties and related production technologies available in the country. By and large, the release and cultivation of early maturing and high yielding lowland and/or upland rice varieties have aided the movement of rice into new frontiers, especially drought-prone areas such as the Lawra district in the Upper West region, and have resulted in the increased rice productivity observed in Ghana in the last two years. Several maize and sorghum farmers in the Upper West region have become rice growers and most

Table 1. Quantities of breeder, foundation and commercial seed of rice produced by the Emergency Rice Initiative Project in Ghana, 2009-2010.

<table>
<thead>
<tr>
<th>Year</th>
<th>Breeder seed (t)</th>
<th>Foundation seed (t)</th>
<th>Certified/commercial seed (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>0.09</td>
<td>3.12</td>
<td>125.00</td>
</tr>
<tr>
<td>2010</td>
<td>0.07</td>
<td>2.60</td>
<td>103.30</td>
</tr>
<tr>
<td>Total</td>
<td>0.16</td>
<td>5.72</td>
<td>228.30</td>
</tr>
</tbody>
</table>

Table 2. Target project sites and number of registered rice farmers in Ghana, 2009 and 2010.

<table>
<thead>
<tr>
<th>Region</th>
<th>No. of farmers registered in 2009</th>
<th>No. of farmers registered in 2010</th>
<th>Total no. of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>1,630</td>
<td>3,102</td>
<td>4,732</td>
</tr>
<tr>
<td>Upper East</td>
<td>1,677</td>
<td>4,203</td>
<td>5,880</td>
</tr>
<tr>
<td>Upper West</td>
<td>914</td>
<td>1,248</td>
<td>2,162</td>
</tr>
<tr>
<td>Total</td>
<td>4,221</td>
<td>8,553</td>
<td>12,774</td>
</tr>
</tbody>
</table>

Table 3. Target project sites and number of rice farmers who actually planted rice in Ghana, 2009 and 2010.

<table>
<thead>
<tr>
<th>Region</th>
<th>No. of farmers who planted in 2009</th>
<th>No. of farmers who planted in 2010</th>
<th>Total no. of farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>900</td>
<td>2,392</td>
<td>3,297</td>
</tr>
<tr>
<td>Upper East</td>
<td>1,067</td>
<td>3,447</td>
<td>4,514</td>
</tr>
<tr>
<td>Upper West</td>
<td>773</td>
<td>915</td>
<td>1,684</td>
</tr>
<tr>
<td>Total</td>
<td>2,740</td>
<td>6,754</td>
<td>9,494</td>
</tr>
</tbody>
</table>

Table 4. Improved rice varieties promoted by the Emergency Rice Project in Ghana, 2009-2010.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Days to maturity</th>
<th>Potential grain yield (t/ha)</th>
<th>Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digang</td>
<td>110-115</td>
<td>3-4.5</td>
<td>Hydromorphic/Lowland</td>
</tr>
<tr>
<td>Gbewaa rice</td>
<td>110-120</td>
<td>4-6</td>
<td>Lowland/irrigated</td>
</tr>
<tr>
<td>GR18</td>
<td>125-132</td>
<td>4-6</td>
<td>Lowland</td>
</tr>
<tr>
<td>CT 8837-1-17-1P</td>
<td>110-115</td>
<td>4-6</td>
<td>Hydromorphic/Lowland</td>
</tr>
</tbody>
</table>

rice varieties (GR 18, Digang, Gbewaa rice, and CT 8837-1-17-1P) adapted to the specific environment of farms and farmers (Table 4). The CT 8837-1-17-1P variety was introduced to farmers in 2009, only to meet the seed demand because GR 18 was in short supply.
farmers are prepared to pay for improved rice seed and fertilizer. These farmers now grow rice in addition to growing their usual maize and sorghum. Those who do not have lowlands prefer to grow upland rice.

In 2009, the mean paddy yield of non-project farmers was 1.25 t/ha as against a mean yield of 1.94 t/ha obtained by ERIP farmers. The mean paddy yield obtained by project beneficiaries across the three regions in Ghana increased to 2.40 t/ha in 2010, representing a 92% increase over the two years. Averaging across years and ecologies, unit production cost of rice decreased from GHS 0.46/kg for non-project farmers to GHS 0.24/kg (1 US$ = GHS 1.42) for project farmers, representing a decrease of 48%. Over the two years, farmers produced 28,663 Mt of paddy, which was 16,841 Mt above what they would have produced without the project’s intervention. This extra production was clearly more than the target of 7,500 Mt.

Training courses

The training of trainers’ courses organized for agricultural extension officers are presented in Table 5. Over the two years, 102 agricultural extension workers were trained on IRM, seed production techniques and farm management practices. More than 80 selected extension workers were trained on well-being analysis to enable them acquire skills to train other extension staff to grasp the notion of well-being, within the community and also prepare for effective vulnerability targeting, during farmer registration. This was necessary because of the concept of inequality/differences between rich and poor that are inherent in all societies. Thus, the skills acquired by the trained extension staff equipped them to differentiate between viable and vulnerable farmers in the community during the implementation of the project. Additionally, the well-being analysis tool was used to enable farmers to identify the poorest members of their own community, evaluate the social dimension of farmer-to-farmer

Table 5. Training courses organized by the Emergency Rice Project to promote technology transfer in Ghana, 2009-2010.

<table>
<thead>
<tr>
<th>Type of training/workshop</th>
<th>Output</th>
<th>Potential impact on technology transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production and editing of videos</td>
<td>6 SARI staff (1 female + 5 males) trained in the production and editing of videos to promote the transfer of technologies</td>
<td>Videos on key rice management practices from land preparation to harvest and post-harvest activities translated into 7 major local languages</td>
</tr>
<tr>
<td>Well-being Analysis</td>
<td>90 extension staff trained in well-being analysis to prepare for effective vulnerability targeting during farmer registration.</td>
<td>The skills acquired by the trained extension staff will enable them be better equipped to differentiate between viable and vulnerable farmers in the community</td>
</tr>
<tr>
<td>Train AEAs and farmers on IRM and demonstrate the use of fertilizer materials</td>
<td>102 AEAs trained on IRM including key post harvest issues including the importance of using quality seed, proper grain drying, conditioning and storage to improve milling quality in order to guarantee premium market price of rice. 30 demonstrations on ISFM and 12 nutrient omission trials planted across the 3 project regions for training purposes.</td>
<td>Facilitated the exchange of information on available best-bet rice production practices</td>
</tr>
<tr>
<td>Seed production, inspection and certification</td>
<td>36 SEEDPAG members trained on seed production certification and distribution</td>
<td>Facilitated the exchange of information on techniques of rice seed production, processing, storage and packaging</td>
</tr>
<tr>
<td>Training of input dealers</td>
<td>67 agro-input dealers trained on their roles in publicising the importance of mineral fertilizers through local mass media and demonstrations</td>
<td>Some input dealers supported demonstration in their respective operational areas</td>
</tr>
</tbody>
</table>
extension and measure the impact of extension interventions. The extension agents also acquired skills to lay out demonstrations and collect meaningful and quality data. The capacity of researchers was also built on well-being analysis and production and editing of videos.

During the project phase, 36 members of SEEDPAG across the three project regions were trained in the techniques of rice seed production, processing, storage and packaging with the objective of empowering them to produce good quality seed. The training program strengthened the capacity of selected farmers and seed producers to produce quality seed. Trained extension workers also worked with selected collaborating farmers in the selection of good quality seed by providing technical advice. A field manual covering all aspects of rice cultivation and post-harvest management for use especially by the agricultural extension staff was produced. Additionally, technical fact sheets and leaflets (e.g. on improved rice varieties, weeds and fertilizer management) were developed. Typically, the training courses and workshops organized by the project have improved the capacity of both researchers and extension workers to effectively disseminate new rice technologies to farmers.

During the project phase, the trained AEAs were able to train the 12,635 registered farmers on IRM. Furthermore, the farmers who attended the training sessions were encouraged to share their knowledge and experience with other farmers within their communities. The technologies which the extension staff had to sell definitely improved the well-being of the farmers and their families and were therefore accepted by them. The extension program was oriented to the small-scale farmer. Emphasis was placed on programs that focused on the farmer, his needs, aspirations, capabilities and resources. Over the two years, 67 input dealers, comprising 57 males and 10 females, acquired skills in agro-input business management, product knowledge and rice production. They were also provided with certified seed to start their business off. Agro-input dealers in the country revealed that the project had helped them to increase their clientele and the volume of their business as well as qualifying them for higher levels of credit from financial and business organizations.

**On-farm demonstrations**

Through the on-farm demonstrations, best-bet fertilizer management practices have been identified and such information has been shared among various partners, project beneficiary farmers and farmers who were not directly involved in the project. Two of the management strategies relied on better nitrogen (N) placement techniques and the use of controlled-release fertilizers, such as urea supper granules (USG), to improve nutrient use efficiency in rainfed lowlands. Farmers in the region have started inquiring about the availability and accessibility of USG because they found it to be effective in increasing paddy yields, as a result of increased N use efficiency. Another strategy is the integrated nutrient management to enhance crop nutrition and minimize fertilizer costs. The use of compound fertilizer containing macronutrients (NPK) as well as micronutrients (e.g. Actyva; NPK 23-10-5 +2MgO+3S+0.3Zn) has been found to increase paddy yields significantly, because it minimizes N losses and gives greater availability of soluble P to rice over a wide range of soils compared to other NPK and straight fertilizers. A more efficient N source also means a reduced loss of nutrients to the environment. For example, rice fertilized with Actyva produced rice plants that looked greener and had bigger panicles than unfertilized plants or those treated with NPK (15-15-15) fertilizer only. Moreover, results from 9 farmers across three districts in the Upper East Region showed that the application of fertilizers with micronutrients increased yields by 0.24 to 1.30 t/ha. The highest response was obtained when micronutrient was applied with macronutrients (NPK). Subsurface placement of both Actyva and NPK (15-15-15) gave a yield advantage over the broadcasting method of placement.

Soil moisture conservation and utilization have also improved, particularly at the irrigation sites and in lowland valleys. An excellent example of rapid small-scale farmer adoption of new technology is the remarkable acceptance of soil and crop management practices, especially in the Upper East Region where most farmers now bund their rice fields along contours to conserve water. Likewise, the method of crop establishment by broadcasting, which is often primitive and wasteful of seeds, has been revolutionized by planting directly in rows or raising seedlings in nurseries and transplanting 2 to 3 seedlings per stand at a spacing of 20 x 20 cm when the seedlings are 21 to 28 days old. Several farmers said that they did not know that 20 kg of improved seed is sufficient to plant 0.4 ha. Additionally, the farmers observed that planting in rows and at the recommended spacing minimized weed infestation. Prior to the project’s intervention, most of the farmers used 40 to 60 kg of seed to plant 0.4 ha by broadcasting.

**Community outreach programs**

Two hundred copies of the English version of videos on key rice management practices from land preparation to harvest and post-harvest activities were distributed to farmers and extension staff in the various regions. So far, over 3,500 farmers have watched the videos in northern Ghana. In the Upper West Region, the Dagaari version of the video was watched on a giant screen of the Ministry of Information’s mobile van by 319 farmers in the Kpongur...
delivery and it is important because the female extension staff would be available to meet with wives who, on religious grounds, may not be permitted to meet male extension officers. Through community outreach programs, such as rural radio and video shows, current rice production technologies are also reaching thousands of farmers who were not directly involved in the project. Four project beneficiary farmers received awards for being the best rice farmers at regional and district levels during the National Farmers’ Day celebrations in 2009 and 2010.

Enhancement of exchange of ideas and technical experience among partners

An important spill-over advantage of the project is the willingness among farmers to share useful information. For example, beneficiary farmers were ready to share seed and information on best-bet practices and some even exchanged or sold seed to other farmers who were not directly involved in the project. As one farmer in the Tolon-Kumbumgu district in the Northern Region put it, “I sold Digang seed to 30 non-participating farmers in my community and used part of the proceeds to expand my rice field (from 0.2 to 0.6 ha) and also purchased a bicycle. I think the project is good as it has increased my household income.”

Digang, an upland rice variety, and Gbewaa rice, an irrigated rice variety, are being vigorously promoted by other donor-assisted projects working on rice production in Ghana. Gbewaa rice is widely preferred by farmers and consumers, partly because of its high yield, tolerance of multiple stress conditions and aromatic trait. Similarly, cultural practices promoted by the ERIP have been tested and adopted by non-participating farmers. For example, project beneficiary farmers at irrigation sites in the Upper East Region received training on rice nursery establishment and management, as well as good water management techniques like bunding along contours. Several farmers at these sites who were not directly involved in the project have also adopted the technology. The periodic monitoring tours involving in-country regional teams provided unique opportunities to appraise in situ the efforts of each region and this has led to a culture of active sharing of ideas. This also contributed to the improvement of the capability of scientists working in the ERIP to generate and transfer technology. Other mechanisms that ensured technology transfer included publications and distribution of in-country project regional teams’ quarterly and annual technical reports.

The project also facilitated the establishment of linkages among stakeholders in the rice value chain that ensured the sustainability of the gains from the project. For instance, SEEDPAG and the Ghana Grains and Legumes Development Board (GGLDB) were linked to the project to produce certified and foundation seeds, respectively for the project. In addition, linkages were established between farmers on one hand and seed producers, agro-input dealers, credit providers, fertilizer suppliers, grain processors and grain buyers on the other. In linking farmers to output markets, we first and foremost identified farmers who had excess paddy to sell and then linked them to rice brokers, processors and NGO’s who normally buy local rice. We also organized advocacy and awareness creation meetings with government and private institutions -the government school feeding program, the World Food program and the Swiss Red Cross and other relief agencies - to make them aware of the project and how they could become partners. Through these linkages, AmSIG (an NGO that supplies rice to the school feeding program in the northern region) has been linked to project farmers in the Tolon Kumbungu district. The Single Mothers Association in Bolgatanga has also been linked to farmers in the Bongo district.

DISCUSSION

The ERIP was uniquely positioned to bring modern technologies to rice farmers thereby helping them to increase yields. The project has made remarkable progress in increasing farmers’ access to quality seed and fertilizer while expanding their knowledge of current rice production technologies and best practices in the region. Balasubramanian (1998) reported that adequate farmer training is needed to receive, process and effectively exploit improved rice varieties and related information, knowledge and technologies. Therefore, from the initiation of the project, emphasis was placed on the training of targeted farmers on IRM through both field training and information videos. Apart from ensuring access to quality inputs, the project has positively supported the promotion of technology exchange and transfer activities in the region. Project beneficiary farmers were willing to share useful information with non-participating farmers and this farmer-to-farmer information sharing has been one of the alternative measures to the conventional extension system taken to achieve a high rate of adoption of improved seed and production technology. In addition, farmer-to-farmer technology diffusion builds upon farmers’ traditional transfer methods.
farmers sharpened their decision-making abilities and were empowered by learning leadership, communication and management skills (van de Fliert, 1993).

Soil fertility maintenance, improved agronomic practices and post-harvest technology have received considerable attention throughout the two years. The improved rice introduced by the project varieties not only have the potential to raise paddy yields but increasingly have the ability to resist disease and insect pests and to tolerate adverse soil and climatic conditions. The varieties also have properties that satisfy different consumer preferences in terms of grain type, swelling capacity, and cooking time. The proper management of these varieties by farmers in the different ecologies would enhance increased rice production. By assuring adequate soil moisture, irrigation allows planting densities and fertilizer doses to be increased efficiently without increasing farmers’ risk. The availability of good quality seed has promoted rapid diffusion and adoption of the early maturing and high yielding varieties.

The speed with which small-scale farmers adopted the new rice varieties as well as the planting and better water management methods in northern Ghana over the two years is perhaps the best example of a rapid response to opportunities presented by new technologies. This reflects farmers’ willingness to change in reaction to a superior practice or system. Thus, farmers know when it is to their advantage to adopt something new and if the risk is not too high, they will accept and use new technologies. Furthermore, it shows that even farmers with the smallest holdings quickly become attuned to the guidance of the extension services and to the new technologies the extension staff can provide. Similarly, Imolehin and Wada (2000) reported rapid adoption of improved varieties of rice by farmers in Nigeria. The reasons mentioned by farmers for the adoption of the improved rice varieties are high grain yield, early maturity, desirable taste, increased income and ease of processing and storage. Women specifically mentioned that they appreciated rice varieties that are suitable for rice-based products, easy to thresh and have high milling recovery. Additionally, the women preferred rice that would swell when cooked. The new varieties are the core of a technology package readily acceptable to the smallest and poorest rice farmers, and one that they can use as easily as that employed by their large-scale counterparts.

Results of impact studies in northern Ghana clearly justified the investment in rice production and technology transfer by ERIP. For example, the use of quality seed doubled the income of the collaborating rice farmers and rice production activities alone contributed about 33% of the total household income. Moreover, there was a 92% increase in rice productivity and a 48% reduction of unit cost of production on project farmers’ fields when compared with non-project farmers’ fields. It is clear that existing rice technologies can substantially increase paddy yields per unit area and also reduce unit production costs. Generally, unit production costs can be reduced through declining real costs of the major factors of production and through technical change whereby physical input/output ratios improve. In this case, unit production costs reduced through technical change as farmers adopted improved seed and production technologies leading to higher paddy yields. Most project farmers attributed the yield increases to the improved seed and fertilizer they received from the project. Most farmers in this region hitherto were growing rice with little or no fertilizer input. Rice production to meet domestic demand could effectively be achieved if improved rice varieties, along with appropriate cultural and management practices, are utilized by farmers in all the ecological zones of the country. Emphasis on the promotion of improved rice production technologies gained a fresh momentum following the recent policy of rice import restriction and also warranted a need to equip extension agents with up-to-date information on crop production practices (Andriesse and Fresco, 1991; Tomlins et al., 2005). The constraints to a wider adoption of the improved varieties included farmers’ ignorance of the importance of quality seed of improved varieties and lack of information on these varieties. Consequently, most smallholder farmers continue to grow their own saved seed. Therefore, there is a need for closer interaction with farmers through the extension services and on-farm demonstrations to create and increase awareness of the importance of improved seed and other production technologies. Similar observations have been made by Balasubramanian (1998) and Imolehin and Wada (2000). In this project, the extension workers lived and worked in the target communities alongside the farmers and farmer contact was the extension workers’ primary means of influencing the rice growers.

To facilitate the effectiveness of adoption, it is necessary to develop appropriate linkages of research institutions with producers, extension services, NGOs, processors and marketers for agricultural produce. Linkage to credit was rather difficult and frustrating as many lenders are extremely wary of extending credit to farmers, fearful that they will inherit the risks inherent to farming. The goal of ERIP was to increase rice production in Ghana by increasing the adoption of improved rice varieties suitable for rainfed ecosystems and hence increase food (rice) security of the resource-
most importantly, to match the length of the growing season. For example, some farmers found the recommended early-maturing varieties not suitable for planting in deep valleys and therefore prefer to plant local cultivars that take over 150 days to mature in such valleys.

Realizing the importance of agro-biodiversity conservation; and its importance in ensuring food security and developing a sustainable agriculture, we created awareness about the rapid loss of useful local rice cultivars and the concept of conservation of agrobiodiversity. Thus, we encouraged those farmers still growing the local rice cultivars to conserve and use the cultivars in order to contribute to achieving food security. This “conservation through use” approach is particularly refreshing and is a much needed innovation. The rice varieties promoted by ERIP have contributed to increased rice production and productivity through the movement of rice into new frontiers. Furthermore, the project has stimulated national scientists to solve rice production problems with significant returns to investment in the rice program. Thus, the use of technology can achieve the higher crop yields the world needs from the land available in a sustainable way, balancing environmental and economic factors. To grow more food from less land we need to provide farmers with the innovation and the knowledge to use natural resources more efficiently. One secret of the resounding success of ERIP is the management structure. The project was managed by a Country Coordinating Unit (CCU). All partners were represented on the CCU. Over the two years, the CCU and the regional teams maintained good relations and worked together constructively. The idea of a coordinating unit as a decision-making entity had been in operation in other projects, but ERIP coordinating unit introduced a regional coordination system. Regional coordinators were therefore appointed for Northern, Upper East and Upper West Regions to support the Country Coordinator in the collective planning, implementation, monitoring and evaluation of project activities at all times in the respective regions.

Despite the success in improved rice production recorded in the region, the project was faced with the challenges of pushing up the rice yield curve. Moreover, access to fertilizer is still a problem for most farmers. Although rice production has increased in the country as a whole in the last decade, the modest production country – at huge expenses in terms of hard currency (Bam et al., 1998). In general, there is a wide gap between potential and actual crop yields among smallholder farmers in developing countries, mainly because of poor extension services, institutional and cultural constraints and the farmers’ long history of adaptation to traditional practices, which has limited their ability and willingness to fully adjust their input levels (Ghatak and Ingersent, 1984; Xu and Jeffrey, 1998). Therefore, one of the challenges for researchers is to reduce the yield gap between research and production. However, because new technologies require intensive management and information, farmers in developing countries with low literacy rates, poor extension services and inadequate infrastructure have difficulties in adapting to new technologies (Ali and Byerlee, 1991; Pingali and Heisey, 1999).

Imolehin and Wada (2000) observed that active extension service is a key in passing developed technologies onto rice farmers who are the end users and this led many farmers to adopt improved rice varieties with a resultant increase in national output in Nigeria. Furthermore, Kalirajan (1981) explained that in a south Indian state, extension workers’ limited contact with farmers and farmers’ misunderstandings of the technology were responsible for the difference between the actual and maximum yields among farmers. The research stressed the need for policy makers to focus on extension work in order to increase rice production and reduce inefficiency. In addition, Owens et al. (2001) investigated the impact of farmer contact with agricultural extension services on farm productivity in Zimbabwe and reported that access to agricultural extension services, defined as receiving one or two visits per agricultural year, raised the value of crop production by about 15%. Our experience over the last two years has led us to conclude that a multi-disciplinary systems analysis approach to prioritizing and removing rice production constraints in the country is of paramount importance. The most important challenge is putting in place policies that would provide enabling environments conducive to rapid adoption and utilization of sustainable technologies. We call on the government and policy makers in the country to seriously look into important policy issues relating to rice production. The intervention should consider inputs such as fertilizer, trade, marketing and product utilization if the full potential of rice is to be
need for increased emphasis on farmer participatory available to the growing population in SSA, there is a linkages established by the project among stakeholders in the rice value chain. In order to make adequate food intervention is assured through farmers producing their systems. Sustainability of the gains of the project's methods for the transfer of agricultural techniques and fertilizer, national rice initiatives (e.g. MOFA block scheme and Rice Sector Support Project) and the and extension services meet the real needs of the small-scale farmer. There is also a need for reinforced capacity building and international cooperation on technology transfer and technology sharing.

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REFERENCES
Commission, Bangkok, Thailand, 23-26 July 2002. International Rice
Commission.
Nwanze KF, Mohapatra S, Kormawa P, Shellemiah K, Bruce-Oliver S
68: 675-677.
extension on farm production in resettlement areas of Zimbabwe.
Economies, University of Oxford.
Pingali PL, Heisey PW (1999). Cereal crop production in developing
countries: past trends and future prospects. CIMMYT Economics
Program Working Paper 99-03, The International Maize and Wheat
Improvement Center (CIMMYT), Mexico.
Quaye W (2007). Food sovereignty and combating poverty and hunger
Rhodes ER (1995). Nutrient depletion by food crops in Ghana and soil
organic nitrogen management. Agric. Syst., 48: 101-118. DOI:
10.1016/0308-521X(95)93648-W.
nutrient balances in Africa at different scales. Fertil. Res., 35:227-
235. DOI: 10.1007/BF00750641.
Community Development: A Training Manual Based on Experiences
in the Middle East and North Africa. IIED, London, UK.
preference and sensory evaluation of locally produced and imported
Vagen TO, Lal R, Singh BR (2005). Soil carbon sequestration in sub-
Schools generate sustainable practices. A case study in Central Java
evaluating IPM training. Wageningen Agricultural University,
Netherlands Paper No. 93-3.
Xu X, Jeffrey S (1998). Efficiency and technical progress in traditional
and modern agriculture: evidence from rice production in China.
Agric. Econ., 18: 117-165.