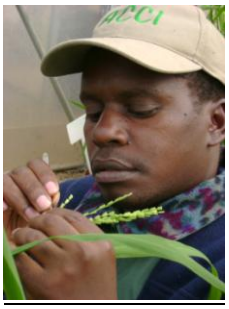

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Food Security in Kenya: Rice Research Agenda

The ever growing population is causing ripples among the world leaders not only because the productive resource base is dwindling, but also reality of real threats from climate change and variability. The global BioEconomy is threatened by competition between materials for industrial, read biofuel and demand to feed over seven billion mouths. This is really is huge global challenge that must be tackled by all both locally, regionally, continental wise and finally globally.

The real productivity must start with the stakeholder, using local systems and with external partnerships while giving prime consideration to environmental issues, socio constructs (gender mainstreaming, rural versus urbanites, youth versus older generation e.t.c). Thus, the synergy of multidisciplinary teams of experts driven by local priority issues and broad approach is the way out of this food and nutritional insecurity.

Here back in Kenya, rice is posed to play a key role in providing or meeting food and nutritional needs of her people. However, there are challenges to be overcome; among them, land degradation, growing population, climate change and variability, expanding consumption. All these have contributed to huge rice imports despite the fact that Kenya has the capacity to produce enough for her domestic consumption and even export to the region and overseas markets.

The above scenario is being addressed through various channels and pathways. Right from Ministry level, through the Rice Promotion Unit (RIPU) a brainchild of Japan International Cooperation Agency (JICA), World Bank through the regional mega project, East Africa Agricultural Productivity Project (EAAPP) covering Tanzania, Uganda, Ethiopia and Kenya. There are other important players among them Alliance for a Green Revolution in Africa (AGRA), International Rice Research Institute (IRRI), Africa Rice Centre (ARC), International Cooperation Center for Agricultural Education (ICCAE), Kenya Seed Company, Vibha Seed (Ke) limited, and other regional Institutions like ASARECA, and national Agricultural Research Systems like Kenya Agricultural Research Institute (KARI).

All these key players are working in tandem to ensure food and nutritional security is secured. The immediate overarching goals are to be achieved by addressing these basic objectives:

Objectives:

1) To develop and release to the farming community six improved rice varieties
2) To create linkages with consortiums relevant on issues to do with seed development and outreach to end users
3) To create awareness of new rice varieties to about 100,000 farmers who will act as catalyst to up scaling of rice production

Main Activities:

To come up with adapted and widely adoptable technologies there are a series of processes that must be undertaken. Some of these include;

i) On-station advancement of segregating populations to develop homozygous stable genotypes that are stable, uniform and distinct from any other variety being grown or under commercial production in the world
ii) Adaptability and acceptability test of promising genotypes through participatory variety selection with end user clientele
iii) Testing of new lines in on-farm trials and national performance trials for establishment of value of cultivation and use. This process really unlocks the establishment of the seed system for eventual commercialization

iv) Production of breeder and foundation; the breeder seed are the highest purity seed class that can ever be produced. These are used for other seed classes for commercialization

v) Development of linkages with seed companies; this outreach pathway is very important for popularization and up scaling of developed technologies

The research out puts are normally of various kinds and thus their packaging for presentation to end user clientele is again varied. This is exemplified below:

i. Release of normally 2 or more improved rice varieties that have preferred grain quality, and plant architecture
ii. Awareness creation of the new product to farmers and rice stakeholders,
iii. Production of normally 5kg of breeder seed to set in motion the certified seed production through foundation seed production,
iv. Use of organized farmers groups to produce rice seed, also seed may be availed by seed companies licensed to produce rice seed,
v. Primarily, farmers participate in variety demonstrations, field days and agricultural shows where showcasing of new technologies and production is at display and also for purchase
vi. The adoption is normally followed by monitoring the number of farmers planting new rice varieties

The expected outcome is increased farmer productivity, a vibrant enhanced capacity to develop improved rice varieties for farmers, an increase in farmer awareness of the improved varieties, better on farm productivity and eventually improved small scale farmers household food and nutritional security as well as incomes.

CURRENT SITUATION OF THE RICE SECTOR IN KENYA

Summary

Rice crop is a major cereal crop ranking third to maize and wheat in Kenya. However, despite its importance, the on-farm yields are low and range between 1-4 tons per ha depending on the level of management. The current production in Kenya varies between 43-80,000 MT while consumption is well above 300,000MT. This implies more than 80% of rice consumed in Kenya has to be imported, and this cost the country huge shanks of foreign exchange that could otherwise be used in other sectors of economy. The low productivity is attributed to lack of adapted varieties with the desirable traits for farmer acceptability. The low productivity is caused in part by limited information that is available to farmers through research since rice had previously been regarded an orphan crop. This situation lead to varietal degeneration arising from physical mixtures on farmers fields, natural mutations, and lack of a clear seed delivery system to ensure farmers access quality seed and thus better productivity. The demand for upland rice seed is huge as indicated by the requests made by farmers, farmer organizations and ministry of agriculture. The total basic seed requests are over 30 MT per year. This is a clear indication that a sustainable rice seed system should urgently be established, because currently only KARI-Mwea is producing 'standard' seed. Standard seed is produced under special authorization by the Kenya Plant Health Inspectorate Service (Kephis) when there is acute seed shortage. There is therefore a need to reverse this situation and undertake the breeder seed production of new released NERICAs to meet the immediate demand of certified seed supply.

In addition to the dissemination of NERICA varieties, a more sustainable and far-reaching approach is to develop, evaluate and release new improved varieties, promote new varieties to farmers, and link these activities to seed supply system either undertaken by registered contract farmers or seed merchants. The proposed project therefore aims to develop high yielding new varieties with acceptable grains quality to farmers, for both upland and irrigated ecologies, and initiate linkages necessary for commercialization of released new and already released NERICA varieties
The process of variety development normally involve farmer participatory approaches for fostering enhanced adoption of improved rice varieties for Kenya. The participation of farmers is very crucial, as they come to own the product and indicate areas of further improvement (Kimani *et al.*, 2011). The variety development process involves activities such as germplasm acquisition, evaluation for its adaptability, selection of promising parents, hybridization with local cultivars, on farm participatory trials, national performance trials, conducting, development of descriptors for elite lines (distinctness uniformity tests - DUS), and release of elite lines and linkages with seed companies.

Introduction

Rice is the third most important crop after maize and wheat and its consumption growth is about 12% per annum compared to 4% for wheat and 1% for maize (MoA, 2009). It forms an important source of food, employment and income for the small-scale farmers and business people. However, rice research has lagged behind other crops like maize and beans because it was regarded as an orphan crop and thus unimportant crop. It was therefore less researched on and consequently this has lead to the current state where the last irrigated varieties (Sindano and Basmati) were released before 1980s and these were accessions. There has been no local breeding program for rice in Kenya and therefore no locally bred varieties exist. In 2009, four NERICA varieties from the West Africa Rice Development Association (WARDA) were evaluated and released in Kenya. However the varieties have not been widely acceptance by farmers as they have not been widely tested nor were farmers aware or involved in the variety development process. Besides the varieties were developed without incorporation of the

local germplasm. Simultaneously, Kenya experienced a heavy outbreak of blast disease in 2007. This situation led to declined rice production for the last six years by about 26.6%, while consumption increased by 30.5% over the same period (MoA, 2009; Rosemary *et al.*, 2010). In the late 1980s Kenya was self sufficient in rice, but currently, rice production stands at approximately 45,00 – 80,000 metric tons (MT), while consumption is above 300,000 MT for 2009 (FAOSTAT, 2008; MoA, 2009). This creates a huge deficit (about 80%) that is too high to meet through imports.

There are two main rice production systems in Kenya, namely irrigated rice accounting for 95%, and upland rice contributing a paltry 5%. The area currently under rainfed rice production is 13,000 Ha against a potential of 1,000,000 Ha due to lack of appropriate high yielding, drought and cold tolerant varieties adapted to low fertile soil found in rainfed regions. Rainfed rice productivity is very low, being less than 1 MT Ha^{-1} compared to yield potential of up to 8 MT Ha-1. The situation is a bit different for irrigated rice which is managed by the National Irrigation Board (NIB). About 40,000 hectares out of 500,000 ha are under irrigation (Rudo and Jan, 1990), with optimal input, the average unit production for the aromatic variety is 4.5 T Ha^{-1}. For the non-aromatic varieties its about 6 T Ha^{-1} against a potential of more than 10 MT Ha^{-1} when improved varieties are used (FAO, 2006; NIB, 2008). The current irrigated varieties are low yielding and have lost their purity and original grain quality traits, mainly because the cultivars grown are unimproved (due to degeneration overtime and lack of proper seed system), and have now become prone to diseases and pests.

Rice production on farmers' fields is constrained by several factors among them lack of new improved and adapted varieties, low soil fertility, poor grain quality, lack of cold tolerant varieties, lack of awareness and promotion of rice farming agronomic activities in areas best suited to its production, lack of varieties resistant to diseases and pests in the various rice agro-ecological zones, lack of well organized seed systems and distribution networks, low volumes of irrigation water, lack of land suitable for irrigation, escalating fertilizer and input costs, and lack of credit facilities. This situation has been even more worsened by climate change and variability, which coupled by the fact that the current cultigens are not resilient and the fact that farmers have no coping mechanisms with adverse or favourable weather make the situation even grave. The lack of dissemination or outreach pathways and even lack of well packaged climate information to end user clientele is of great concern. There is therefore urgent need to development climatological and hydrological information as a mitigation measure against climate variability.

There is therefore, urgent need to develop locally adapted climate resilient new varieties that are high yielding with the desirable grain quality and can persist the local production constraints in the various ecological zones. These varieties should be tolerant to rice blast, white rice stem borers and rice yellow mottle virus (RYMV) diseases. The situation is even further compounded by damage caused by rice white stem borers (RWSB) that cause total yield loss, for both upland and irrigated rice, once the culms have been infected. Rice blast has actually become a major threat due to its rapid spread in areas that were traditionally not infected by the disease in Central Province, which is the major rice producer: where it causes major on-farm yield losses and serious quality deterioration in terms of white spots and broken grains that fetch low prices.

Aromatic rice, in particular, is very popular with consumers, and farmers refer to it as white gold, due to its high premium price in the market. The small-scale farmers have their livelihoods purely based on rice farming and any problems that occur, such as the recent rice blast outbreak, degeneration of existing varieties and other factors such as high input costs does affect their economic activities in a big way. This is because they lack the capacity to address these problems on their own, and thus provision

of new technologies to control low yields, diseases, pests and grain quality is paramount. The use of chemicals to control pest and diseases is costly and thus uneconomical and ecologically unsuitable.

Despite rice production for a very long time in Kenya, productivity has remained low, while consumption is on the increase, exacerbating the need to import rice or to find a solution in order to step up local production. Rice has a highly elastic demand due to urbanization and rising incomes, coupled with changes in eating habits of the rural populace. It is also gaining popularity due to its easiness, less cooking fuel use and flexibility during preparation of various recipes (FAO, 2006) especially for labour constrained households. In its effort to realize this aspiration, the Government of Kenya has projected that rice production needs to be increased by another 70% over the next 30 years in order to meet the growing food demand (GoK, 2002).

The varieties in production today were developed in the early 1980's, and over time they have degenerated mainly from admixture of different rice seed varieties, increased susceptibility to diseases and pests, slow natural mutations, and some limited cross pollination leading to genetic segregation. This situation has worsened with the liberalization of the rice sector where farmers now grow rice both within and outside (Jua Kali) the irrigation schemes managed by the National Irrigation Board (NIB). Majority of farmers use their home saved seed that is often recycled for many generations, either because they cannot afford to buy pure seed or there is no well organized seed system to meet all the farmers' requirement. The lack of or break down of the NIB credit facility system has not help the situation and this has opened a window where middle men exploit the small scale farmers. This scenario has forced farmers to continue growing their own on-farm saved seeds that are susceptible to a number of diseases and pests. It is only now that a rice seed certification process has been put in place at KARI-Mwea for rainfed rice, but the irrigated rice certification process is yet to be established and this has resulted to low farm productivity.

The area under rice production per province is; Nyanza (4,552 Ha), Western (702 ha), Coast (1,916 Ha), Central (15,750 Ha), North Eastern (186 Ha) thus the total area for the republic is 23,106 Ha (GOK, 2005). The major diseases are rice blast affecting both upland and irrigated rice in Central (10,000 ha) and 5,400 plot holders; western (2,778 Ha) and 1,260 plot holders (GOK, 2006). It has been envisaged that the irrigation potential is as follows; Tana (205,000 ha), Athi (40,000 Ha), Lake Victoria (200,000 Ha), Kerio valley (64,000 Ha) and Ewaso Nyiro (30,000 Ha). However, only 102,000 ha (19%) have been exploited, with 47,000 Ha, being under smallholder management; 13,000 Ha under NIB and 42,000 Ha under private firms management (NIB, 2008). Any increase in productivity on this land, say 1 tons ha^{-1} could significantly boost local yields towards self food sufficiency. These figures may be conservative, but according to the Vision 2030, a population of 494,000 (19,000 households with 5 persons) will be resettled on 4 acres (NIB, 2008). Thus the area under production will increase, though this will include other crops. The figure for Coast province are not well documented for rice, but the household and land area figure for rice growing districts are Kilifi (90,311 households grow rice in 4,779 km^2), Kwale (92,594 in 8,295 km^2), Tana River (36,177 in 38,466 km^2) and Taita Taveta (57,635 in 17,128 km^2) (GOK, 2006). The coast region has great potential for upland, lowland and irrigated rice. The occurrence of both disease, rice blast and RYMV has been reported but the actual yield loss resulting from these is not well documented, however, it is known that they do cause yield losses as was witnessed recently in Central Province where farmers reported that they were harvesting 5-8 bags instead of 25-30 bags due to rice blast disease (Munene, 2008). The factors that have contributed to high disease incidence are use of old and unimproved varieties with poor N use, poor crop husbandry, high relative humidity (RH), use of recycled seeds, and poor straw management after harvest.

There is therefore, an urgent need to develop, release and commercialize new varieties with the desirable traits, well suited to the production environment and that the farmers need access to released NERICA varieties urgently. These new varieties require to undergo the mandatory National Performance Trials (NPT) to determine the Value of cultivation and use, and distinctness uniformity and stability test (DUS) process for descriptor development for registration and certification purposes, before they can be released and commercialized.

There has been little rice breeding activities in Kenya and this has greatly hampered expansion of rice production. Probably this was because the government's emphasis was on major crops, such as maize, wheat, beans, Irish potato and others. Rice was among the 'orphan' crops and even its placement under NIB did not help much. However, it is only recently around 2003, when rice production was liberalized that the government realized the importance of the crop and made a bold step to place it in the national research system. KARI has had no full-time Ph.D rice breeder. Therefore, the breeding activities have been minimal but following AGRA training of John Kimani to the Ph. D level breeding work has started in order to develop new varieties that are well adapted to the prevailing production conditions. There is little work going on and aimed at developing high yielding varieties adapted to various production ecologies. This is because of constraint funding. KARI has supported at a low level maintenance of the breeding lines and breeding stock of NERICAs 1, 4, 10 and 11. These varieties are acquisitions from WARDA and were found to perform well, but there potential yields are yet to be realized through further improvement. These varieties are certified as standard seed and there is need to conduct the panicle to row tests in order to develop breeders seed for production of high quality seed with white label. They also need further improvement that may involve crossing them with local landraces and testing against major production constraints, such low yields, diseases and pests tolerance, drought tolerance, low temperatures, grain quality and general adaptability. There is also need to develop agronomic production kit for these new varieties in order to realize their production potential by the farmers.

Really a lot remain to be done, and all concerted efforts must be made to ensure global food supply is sustained and this is an aggregate of the local production.

FAO. 2006. FAOSTAT Database.

FAOSTAT. 2008. Statistics Database of the Food and Agriculture Organization FAO Publications, Rome, Italy.

GoK. 2002. Republic of Kenya, National development plan 2002-2008, Nairobi, Kenya.

GOK. 2005. Rice production, 2002-2006. NCPD and Department of lands, crops development and management. Government Printers, Nairobi, Kenya.

GOK. 2006. Statistical Abstracts. Central Bureau of Statistics. Ministry of Planning and National Development, Government Printers. Nairobi. 313pp.

Kimani, J.M., Tongoona, P., Derera, J. and Nyende, A.B. 2011. Upland Rice Varieties Development Through Participatory Plant Breeding. ARPN Journal of Agricultural and Biological Science 6(9):39-49.

MoA. 2009. National Rice Development Strategy (NRDS 2008-2018). pp 35.

Munene, G. 2008. Food Security: Rice shortage looms as fungi wreck havoc., Sunday Nation, Nation Media Group, Nairobi. pp. 17.

NIB. 2008. National Irrigation Board Strategic Plan 2008-2013: Ministry of water and irrigation, NIB. pp. 48.

Rosemary, A.E., Bibiana, M.W., Njuguna, N., Dominic, M.K. and Daniel, A. 2010. Rice value chain study report of Kenya. Ministry of Agriculture (MoA) and Kenya Agricultural research Institute (KARI). pp. 37.

Rudo, N. and Jan, H. 1990. Commercialization of Rice and Nutrition: A Case Study from Western Kenya. Ministry of Planning and National Development Report, Nairobi.