Report on Calibrating and Validating an ICT-based Decision Support System for Nutrient Management for Rice in West Africa

AfricaRice & Syngenta Foundation, 2014-16

Background

Since 2013, the Syngenta Foundation has engaged in rice production initiatives in Ghana, Senegal, Ivory Coast, Mali and Burkina Faso. Their aim is to improve the profitability and resilience of smallholder rice production. The initiatives particularly focus on good agronomy and farmers' inclusion into remunerative value chains.

Surveys and metric assessments of production methods, input use, yields and profitability examined the major constraints, cost drivers and bottlenecks. They revealed that, amongst others, fertilizer accounted for a large proportion of overall production costs. In Senegal, it represents 21% of costs ($142/ha). This figure rises to 26% in Mali ($126/ha), 29% in Ghana ($194/ha) and 30% in Ivory Coast ($200/ha). No data are available for Burkina Faso.

In addition, site visits often indicated poor nutrient management strategies. Insufficient or inappropriate fertilizer use led to reduced yields (Senegal, Mali) and nutrient run-off (e.g. Ghana).

To help address these issues, the Syngenta Foundation initiated a collaboration with AfricaRice to test, calibrate and validate RiceAdvice, an ICT-based nutrient management tool.

Based on existing Syngenta Foundation engagements, two project areas were identified for joint calibration and validation trials, namely the Senegal River Valley (Senegal) and the lower Volta basin (Ghana). Activities started in April 2014; calibration and validation were completed in October 2015. The Syngenta Foundation has subsequently performed further verification studies in Senegal and Mali.

This report summarizes the findings of the initial work and the subsequent studies.

The Tool

RiceAdvice is a decision support system for fertilizer applications. It provides guidance on quantity and timing. Originally developed by IRRI, it incorporates agro-ecological specifications of rice production systems as well as local farmer practices. Using farmers' answers about their production practices, the tool calculates tailor-made recommendations. These feature a cropping calendar, recommendations on fertilizer amounts and timing, as well as estimates of expected costs and income when following the recommendations. RiceAdvice is also designed to allow farmers to achieve maximum profitability, by taking into account local fertilizer supply, pricing and farmers' budget. The tool is Android-based and can be freely downloaded through Google Play. Originally developed in Benin, Nigeria and Senegal, it now covers a variety of major irrigated rice production systems in West Africa, as well as East Africa and Egypt.

Results

AfricaRice and the Syngenta Foundation collaborated on calibration and validation trials in Senegal and Ghana. The Foundation performed follow-up studies in Senegal and Mali. The three locations represent major rice growing systems and focus areas of existing Syngenta Foundation engagements. Results are provided below.

Senegal

Large-scale RiceAdvice validation trials ran in the dry season 2015 with 136 farmers on a total of 93 hectares. Interviews provided insights into yield and crop management in previous seasons. This enabled assessment of the potential impact of RiceAdvice fertilizer recommendations. Changing to RiceAdvice customized nutrient management increased average rice yields by 1.2 t/ha (21%). 112 farmers (76%) achieved higher yields than in previous years. Table 1 shows yield increases in relation to previous farmer performance.

Range of yield increase (t/ha)	Number of Farmers	Mean recent yield (t/ha)
X<0	27	7.5
0<x<1	30	6.1
1<x<2	24	4.8
2<x<3	10	5.1
3<x	21	4.1

Table 1: Distribution of yield increase (x) relative to farmer numbers and previously reported yields.

Intriguingly, the biggest yield increases were observed for farmers reporting low average productivity in previous seasons. This points to an opportunity for RiceAdvice both to help close overall yield gaps and even out the often vast differences between farmers in the same producer group. These differences occur despite farmers following the same production protocols, using the same inputs and working under similar agro-ecological conditions. Interviews revealed that most farmers (92%) were very interested in using RiceAdvice in subsequent seasons. (Of those few not interested, almost half had simply decided not to grow rice again). A parallel study by the Syngenta Foundation in the 2015 dry season compared RiceAdvice fertilizer protocols with farmer practice. This confirmed the initial findings. Average yields were 1.6 t/ha (27%) higher on plots farmed to the RiceAdvice nutrient management protocol; all farmers (n=17) reported an increase (Table 2 and Figure 1).

Range of yield increase (t/ha)	Number of Farmers	Average yields of farmer practice plots (t/ha)
X<0	0	
0<X<1	4	6.8
1<X<2	9	6.1
2<X<3	2	5.6
3<X	2	7.0

Table 2: Distribution of relative yield increase (X) using RiceAdvice recommendations, compared to standard farmer practice.

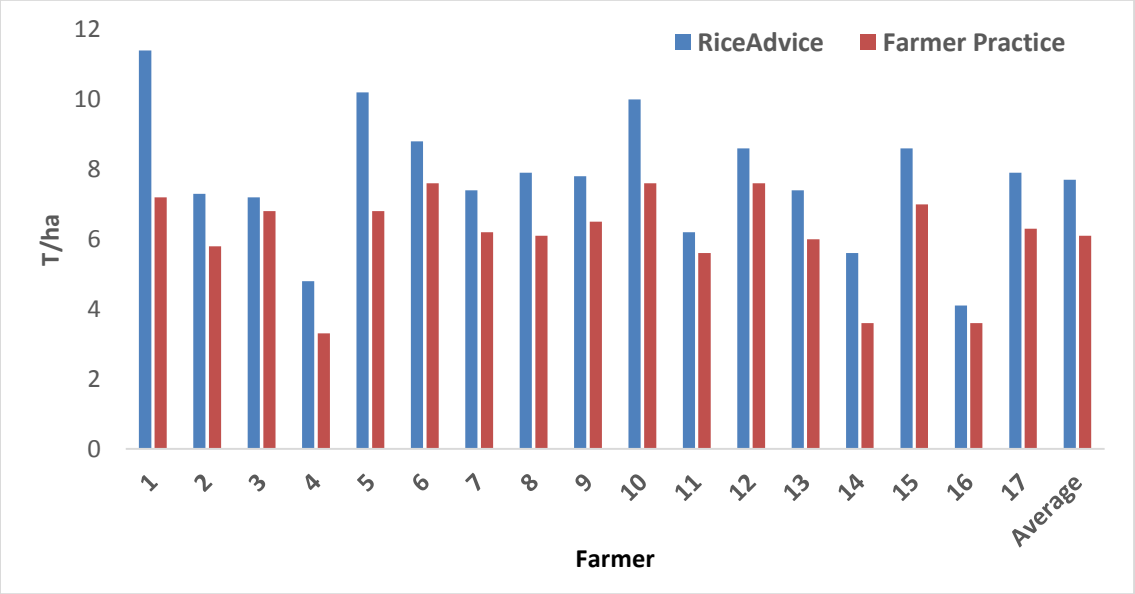

Figure 1: Yield obtained through either following RiceAdvice recommendations or current farmer practice (2015 dry season). The last bars on the horizontal axis depict the average for all farmers (n=17).

Similar results were obtained for the main season 2015/16. Average yields were 1.2 t/ha higher when farmers used RiceAdvice recommendations instead of previous fertilizer protocols (n=112, Figure 2).

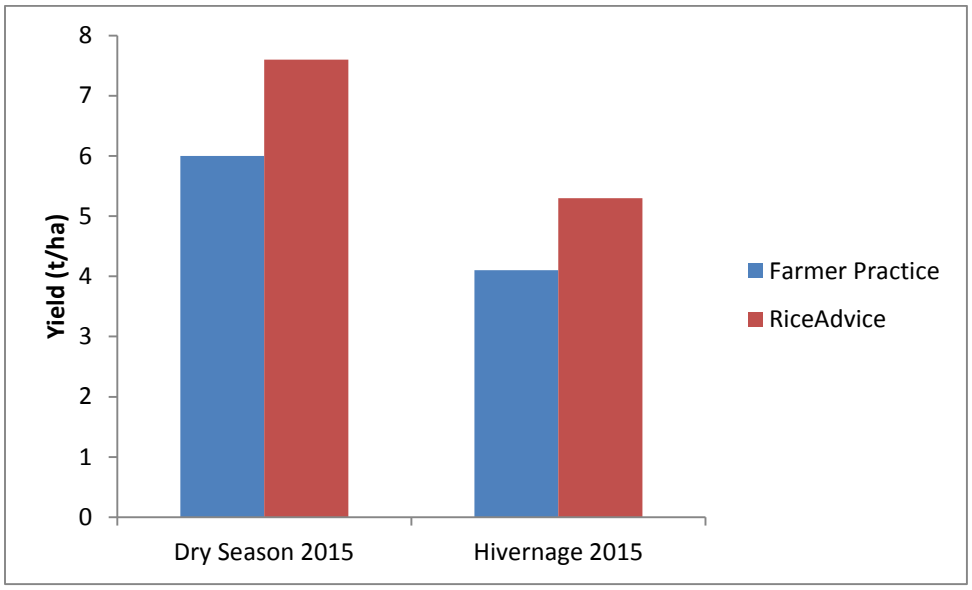

Figure 2: Comparison of average yields between RiceAdvice and traditional fertilizer practices at Union Pont Gendarmes, Senegal River Valley (n=17 for dry season and n=112 for *hivernage*/main season).

Potassium-containing fertilizers were only available in 10-10-20 mixes. This has led to high overall volume of fertilizer use. The lack of subsidies means that input costs are therefore very high. As a result, the increase in farmer profitability was only limited (but still significant): 33,748 FCFA per ha (approx. $55, Table 3). Appropriate fertilizer blends would shift costs and profits significantly.

	N (kg/ha)	**P_2O_5** (kg/ha)	**10-10-20** (kg/ha)	**Paddy Yield** (t/ha)	**Fertilizer cost** (FCFA/ha)	**Paddy Income** (FCFA/ha)	**Relative Profitability** (FCFA/ha)
Farmer Practice	274	98	-	6.1	61,870	762,500	700,630
RiceAdvice	172	-	834	7.7	228,122	962,500	734,378

Table 3: Fertilizer application, paddy yield, fertilizer cost, paddy income and relative profitability between Farmer Practice and RiceAdvice in one season in Pont Gendarmes, Senegal.

AfricaRice and the Syngenta Foundation concluded that the RiceAdvice protocol would increase yields independently of the use of potassium-containing fertilizers. We are therefore now planning to scale up using this adapted protocol. However, we anticipate feeding our results into an initiative to change current fertilizer subsidy and credit policies. The aim would be to allow farmers access to appropriate potassium fertilizer blends for sustainable intensification of production. Initial joint activities are currently under discussion.

Ghana

Calibration and validation trials ran in the wet season 2014 and dry season 2015, on 25 and 41 farm respectively. RiceAdvice increased average yields by 0.6 t/ha (14%) compared to current farmer practice. 78% of farmers experienced higher yields when using the tool (Table 4).

Range of yield increase (t/ha)	Number of Farmers
X<0	11
0<X<1	22
1<X	17

Table 4: Distribution of relative yield increase (X) following RiceAdvice recommendations instead of standard farmer practice. Data depict average yield increase over two consecutive seasons.

Notably, this was achieved despite decreasing average nitrogen inputs by 25 kg/ha and maintaining the supply of other macronutrients (P and K) at constant levels. In line with these observations, farmer profitability increased by an average of 800-1100 GHC/ha (approx. $200 at the then exchange rate). 62% of farmers increased their profitability by over 500 GHC/ha (Tables 5 and 6).

	N (kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)	Paddy Yield (t/ha)	Fertilizer cost (GHC/ha)	Paddy Income (GHC/ha)	Relative Profitability (GHC/ha)
Farmer Practice	151 (89-286)	43 (19-86)	43 (19-86)	4.3 (2.5-6.6)	982 (597-1700)	4625 (2623-7057)	3642 (1780-6037)
RiceAdvice	126 (65-190)	44 (0-112)	44 (0-112)	4.9 (3.1-7.0)	866 (418-1559)	5295 (3304-7514)	4429 (1745-6527)

Table 5: Fertilizer application rate, paddy yield, fertilizer cost, paddy income and profitability following either Farmer Practice or RiceAdvice over two seasons in Kpong, Ghana. Values in brackets depict data range within the sample size (n=50).

Range of profitability increase (GHC/ha)	Number of Farmers
X<0	15
0<X<1000	12
1000<X<2000	30
2000<X	3

Table 6: Distribution of relative profitability increase (X) following RiceAdvice recommendations instead of standard farmer practice. Data depict average profitability increase over two consecutive seasons.

Mali

The Syngenta Foundation ran preliminary verification tests with eleven growers in the main season 2015/16. These indicated an average yield increase of 0.6 t/ha when using RiceAdvice (5.86 t/ha compared to 5.23 t/ha). Eight of the growers raised their production (Table 7).

Range of yield increase (t/ha)	Number of Farmers
X<0	3
0<X<1	4
1<X	4

Table 7: Distribution of relative yield increase (X) following RiceAdvice recommendations instead of standard farmer practice. Data depict average yield increase for the main season 2015/16.

Fertilizer costs rose from FCFA 74,500 to FCFA 117,800 as a result of changed input recommendations. However, overall relative profitability also rose, because yield increases when following RiceAdvice recommendations outweighed the additional input costs (Table 8).

	DAP (kg/ha)	Urea (kg/ha)	10-10-20 (kg/ha)	Paddy Yield (t/ha)	Fertilizer cost (FCFA/ha)	Paddy Income (FCFA/ha)	Relative Profitability (FCFA/ha)
Farmer Practice	78	196	32	5.2	74,500	650,000	575,500
RiceAdvice	146	105	226	5.8	117,800	725,000	607,200

Table 8: Fertilizer application rate, paddy yield, fertilizer cost, paddy income and profitability using standard Farmer Practice or RiceAdvice over one season in Kouroumari, Office du Niger, Mali.

Conclusions and Outlook

Calibration and validation of RiceAdvice in Ghana, Senegal and Mali showed considerable potential of this tool to increase farmer productivity and profitability. Comparison of current fertilizer practices and RiceAdvice recommendations revealed overuse of nitrogen in Ghana and a lack of potassium application for Senegal. The latter greatly limits potentially achievable yields; the former adversely affects the environment and soil quality, therefore likely limiting future yields.

Technology Dissemination within Syngenta Foundation Initiatives

The Syngenta Foundation is planning to use RiceAdvice at scale on 150-200ha with 200-250 farmers in the Senegal River valley in the dry season 2016. Similar scale-up is envisaged in Ghana, led by an appropriate partner such as CARI/WIENCO. In Mali (Office du Niger), separate JICAS-funded and Syngenta Foundation-led dissemination activities aim to reach at least 600 growers in the main season 2016.

Factors limiting the adoption of RiceAdvice

Bottlenecks in RiceAdvice adoption include:

1. Lack of on-ground capacity to set up and supervise RiceAdvice demonstration plots.
2. Farmers' reluctance to invest in new technologies upfront (ahead of a growing season) without suitable risk mitigation.
3. Lack of appropriate fertilizer blends in many areas of West Africa (e.g. K_2O in Senegal), or fertilizer certification in Mali.
4. Strict linking of credit schemes to fixed and often outdated agronomic protocols
5. Subsidy schemes that support inefficient use of inputs.

Addressing these constraints requires policy work to convince public bodies and financing institutions to adapt fertilizer recommendations and production protocols. This is important for nutrient management, pest/disease control and seed use. Additionally, input suppliers need to be convinced to provide new, improved fertilizer blends, and farmer cooperatives/aggregators to promote RiceAdvice as a tool to improve the sustainability and profitability of production systems.