

Studies on the **soil fertility** improvement technologies with use of indigenous resources in rice systems in SSA

A commissioned project of MAFF toward the CARD

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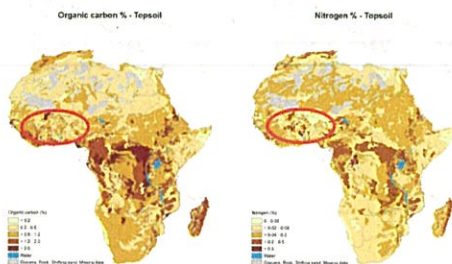


Goals of the project

- Development of technologies for soil fertility management/improvement in rice ecologies,
 - with use of indigenous resources
 - with affordability of local farmers and sustainability
- To contribute to
- The goal of CARD (Coalition of African Rice Development):
 - Double the production of rice in SSA in 10 years

Target site: West Africa

Which area in SSA should be prioritized?
Soil fertility is threatened more in **West Africa** among SSA



Target site: Ghana/West Africa

Which country is most suitable to implement this project?
Ghana for several reasons.

- Agro-ecological reason
 - Two major lowland rice ecologies

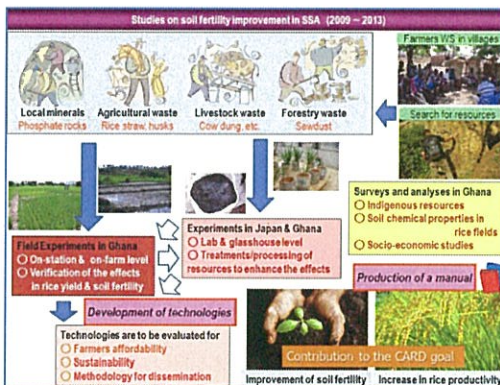
Rice system	Rain fed lowland	Irrigated lowland
Agro-ecological zone	Guinea savannah	Equatorial forest
Topography	Flood plain	Inland valley
Regions in Ghana	Northern region etc.	Ashanti region etc.



- Political reason
 - MOFA is very positive to expand the rice production.
 - One of the **1st** prioritized countries in NRDS of the CARD.

Roles of two counterparts: UDS & CSIR-SRI

- University for Development Studies
 - Based at Tamale in Guinea Savanna Zone
 - Field experiments
 - Socioeconomic survey
- Soil Research Institute
 - Based at Kumasi in Equatorial Forest Zone
 - Field experiments
 - Soil and plant analysis
 - Socioeconomic survey



Research activities for technologies

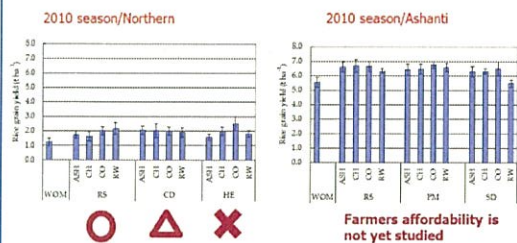
Activities	In Ghana	In Japan
	At Tamale, Northern (Guinea savannah) With UDS	At Kumasi, Ashanti (Equatorial forest) With CSIR-SRI
Inventory of local resources	Statistical survey Quality, quantity, & locality	Statistical survey Quality, quantity, & locality
Effect of organic matters (OM)	On-station, on-farm Rice straw, husks, cow dung, human excreta	On-station, on-farm Rice straw, husks, sawdust, poultry manure
Effect of phosphatic rocks (PR)	On-station, on-farm Direct application	On-station, on-farm Direct application
Effects of pre-treatment on seeds or seedlings	On-station Seed coating for direct seeding	Lab & Pot experiments for more dissolution Direct application & its mechanisms Composting process Calcination Simultaneous with OM
Socio-economic studies	Participatory work Farmers' view Affordability Cost-benefit analysis	Participatory work Affordability Cost-benefit analysis

Inventory of local organic resources (summary)

Plant	Rice	Straw	N	P ₂ O ₅	K ₂ O
Soybean		Husk	1.8	0.6	5.1
			0.7	0.1	0.3
Sum			2.5	1.0	5.5
Northern and Volta Rgn.		Cow	20.7	31.6	8.9
		Urine	21.1	0.2	23.6
Northern and Upper Rgns.		Pig	2.7	2.2	2.1
		Urine	0.4	0.1	1.1
Ashanti and Greater Accra		Chicken	5.8	3.1	2.9
		Urine			
		Goat	8.8	3.2	3.2
		Urine	4.6	0.2	6.1
		Goat	10.8	3.9	3.9
		Urine	5.6	0.2	7.7
Sum			80.5	44.5	59.2
			83.0	45.5	64.6
			In kilo tons per year		

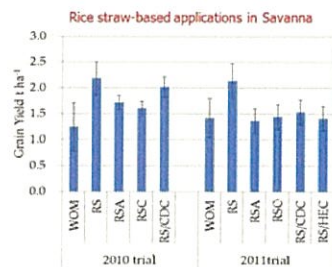
- If only 20 percent of these resources were utilized, it could replace the requirement for chemical fertilizer in rice cultivation system for the entire Northern region.

On-station results in organic matter applications (1)



Farmers affordability is not yet studied

On-station results in organic matter applications (2)



- Application of raw material of rice straw was most effective to rice grain yield.

On-station results in organic matter applications (3)

Amended Organic Materials	Application Rate
RS	1.71 a
RS/CDC	1.42 a
RS/HEC	1.41 a
RSA	1.32 a
RSC	1.29 a
WOM	1.29 a
LSD (5%)	0.438

- Combination of organic matter with small amount of chemical fertilizer enhanced the yield.

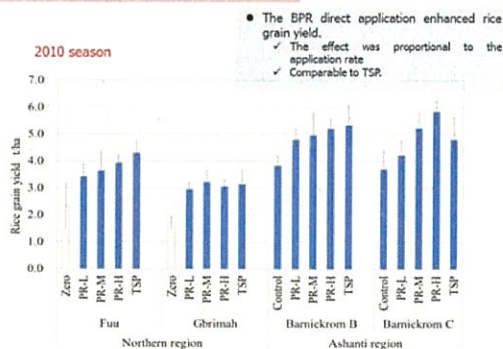
Effect of phosphate rocks



Justifications

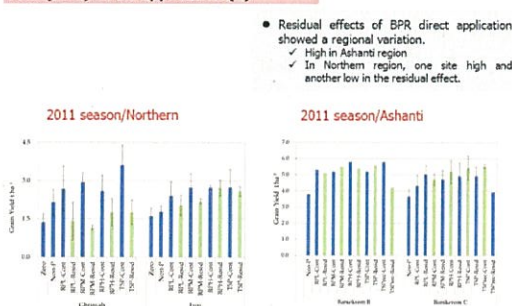
- Direct application of phosphate rocks (PR) is a cheap agricultural practice, due to minimum processing compared to expensive chemical P fertilizers.
- More than a hundred phosphate deposits in 31 countries in SSA.
- Unfortunately, no commercial activity of PR in Ghana.
- Burkina Faso PR (BPR) has potential in agronomic use inside the country and also neighboring countries.

On-farm results of Burkina phosphate rock (BPR) direct application (1)

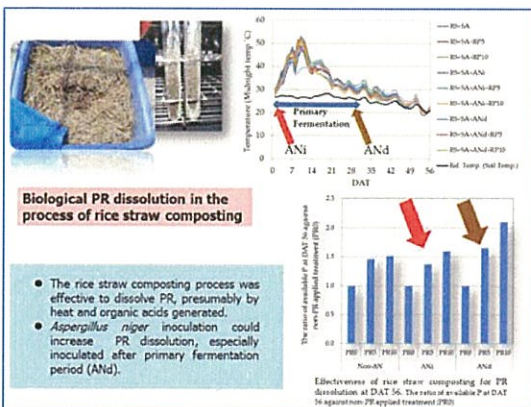


- The BPR direct application enhanced rice grain yield.
- The effect was proportional to the application rate
- Comparable to TSP.

On-farm results of Burkina phosphate rock (BPR) direct application (2)

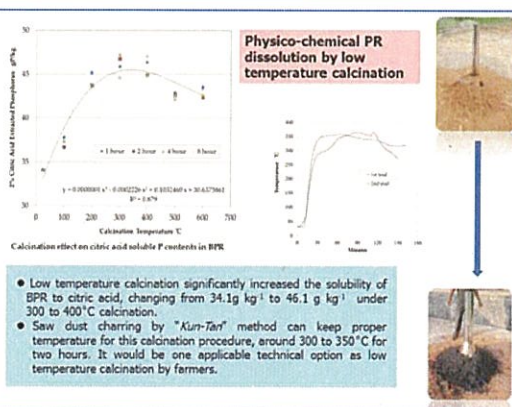


- Residual effects of BPR direct application showed a regional variation.
- High in Ashanti region
- In Northern region, one site high and another low in the residual effect.



Biological PR dissolution in the process of rice straw composting

- The rice straw composting process was effective to dissolve PR, presumably by heat and organic acids generated.
- Aspergillus niger inoculation could increase PR dissolution, especially inoculated after primary fermentation period (ANd).



Physico-chemical PR dissolution by low temperature calcination

- Low temperature calcination significantly increased the solubility of BPR to citric acid, changing from 34.1 g kg⁻¹ to 46.1 g kg⁻¹ under 300 to 400°C calcination.
- Saw dust charring by "Kun-Tan" method can keep proper temperature for this calcination procedure, around 300 to 350 °C for two hours. It would be one applicable technical option as low temperature calcination by farmers.

Fertilizer seed coating



Fertilizer soaking



Current and future activities

- Continuation of field experiments with more **emphasis on on-farm** to reproduce positive effects of technologies
 - ✓ BPR direct application & its residual effect
 - ✓ Local organic materials (sawdust & rice straw "kuntan")
 - ✓ P-enriched compost & "kuntan"
- Soil chemical properties to explain the rice yield
 - ✓ Locality in PR residual effect
 - ✓ Organic matter/PR antagonism?
- Farmers' **participatory** processing of materials
 - ✓ "Kuntan", composting
- Cost-benefit analysis
 - ✓ Data from on-farm practices
- Discussion on the **"technology manual"** as an outcome
 - ✓ Editorial committee, contributors
 - ✓ User, language, contents

Acknowledgements

- JIRCAS
 - Drs. Nagumo, Nakamura, Fukuda
 - Mr. Koide (new)
 - Director Dr. Toriyama as chief consultation
- UDS
 - Dr. Dzomeku as representative
 - Mr. Awuni & Mr. Avornyo
- CSIR-SRI
 - Dr. Issaka as representative
 - Dr. Moro Buri & Dr. Adjey
 - Dr. Anchirinah (new from CRIG)

Thank you for your attention!



1 October 2012

Concept note (first touch visiting to MOFA)

Dissemination of technologies for soil fertility improvement
For the final stage of the MAFF-commissioned project

1. The project: Studies on soil fertility improvement with use of indigenous resources for rice systems in SSA
 - 1) 2009-2013 (March 2014)
 - 2) MAFF-commissioned CARD-targeted project
 - 3) Contribute to the area of soil fertility management
 - 4) Targeted toward the technology development for lowland rice systems
 - 5) JIRCAS collaborating with Ghanaian institutions (UDS & CSIR-SRI)
 - 6) Experiments/trials in the levels from lab and glasshouse to on-station and on-farm fields
2. Proposed technologies
 - 1) Organic matters
 - ① Locality: Northern/Upper & Ashanti
 - ② Materials with farmers accessibility, acceptability and affordability
 - ③ Processing technologies for more effectiveness and sustainability:
Composting and charring
 - > Rice straw in Northern, poultry manure and sawdust in Ashanti
 - > To be finalized at the end of this fiscal year
 - 2) Phosphate rocks
 - As a regional resource for non-producing countries, like Ghana
 - As a local resource for producing countries, like Burkina Faso
 - ① Direct application to lowland field
 - ② Biological and physic-chemical dissolution technologies
 - Farmers' affordability examined through participatory studies
 - ③ Application of P-enriched manure or char
 - > To be listed at the end of this fiscal year
 - 3) Evaluated by the cost/benefit analysis

3. A manual as a project outcome

- 1) Existing manuals
 - ① MOFA's: soil fertility management specified?
 - ② JIRCAS's: to be improved through more inputs from this project
- 2) Manual to be produced in the project (still an idea)
 - ① Users: extension workers
 - ② Beneficiaries: local rice farmers
 - ③ Contents: technologies with descriptions on precise practices with pictures and illustrations, possibly separated in each technology
 - ④ Language: English first, French later (for neighboring countries)
 - ⑤ Distributing media: booklet of small size, movies?
 - ⑥ Contributors: JIRCAS, UDS, CSIR-SRI, MOFA including regional offices
 - ⑦ Editorial committee

4. Some notes

- 1) Consistency with MOFA's policy?
 - Chemical fertilizer: it's actually effective in combination with OM
 - Phosphate rocks from outside: need more propaganda on its effectiveness from research
- 2) Cooperation of MOFA and its regional offices, especially in the stage of technology transfer
- 3) Ghanaian MOFA and Japanese MAFF
- 4)

Memo of the meeting at MOFA on 08/02/2013

Purpose

To discuss about possible involvement of MOFA in the Soil Fertility Project toward the CARD goal

The Project

- ❖ Funded by MAFF (Ministry of Agriculture, Forestry & Fisheries, Japan) from 2009 to 2013, FY)
- ❖ Commissioned to JIRCAS after competition
- ❖ Technology development for soil fertility improvement in lowland rice ecologies in Ghana and neighboring countries
- ❖ Technologies shall be:
 - With use of indigenous resources
 - With local farmers affordability
- ❖ In collaboration with CSIR-SRI (Kumasi) and UDS (Tamale) scientists

Progress of the project

1. Surveys on the status of soil fertility in rice fields over Ghanaian Regions
 - ❖ P is the most deficient element followed by N.
 - ❖ P deficiency is very common. N status is better in the Forest zone than in the Savannah zone.
2. Surveys on the local resources available in two zones.
 - ❖ Forest zone: Rice residues, poultry manure, sawdust
 - ❖ Savannah zone: Rice residues, cow droppings, human excreta
 - ❖ Phosphate rock from Burkina Faso is characterized as a sub-regional resource.
3. On-station and on-farm experiments for evaluation of effectiveness of the resources
4. Farmers accessibility and acceptability of the resources
5. Examination of treatment/processing methods to enhance the effects
6. Some technology options are being proposed from the results of 3), 4) and 5).

Technology options to be proposed

Options (high priority is bolded)	Rice ecology	
	Northern and Upper Regions	Ashanti and southern Regions

	(Savannah zone)	(Equatorial Forest zone)
Organic matter application	Rice straw base <ul style="list-style-type: none"> ❖ Direct application or compost ❖ If applicable, small quantity of chemical fertilizer shall be recommended. 	Poultry manure base <ul style="list-style-type: none"> ❖ Quick effect by direct application ❖ Direct application of rice straw and sawdust causes N starvation in this ecology
Composting	Cow dung/Human excreta + rice straw <ul style="list-style-type: none"> ❖ Some farmers not acceptable 	Poultry manure + sawdust/rice straw <ul style="list-style-type: none"> ❖ Utilization of waste resources
Charring (Kuntan)	Soil physical/biological improvement, not direct effect on soil fertility improvement	
	Rice husks as material	Sawdust as material
Phosphate rock application	Phosphate rocks will appear in the market of Ghana in near future. Depends on <u>stakeholders and policy-makers</u> in Ghana. Applicable in neighboring PR-producing countries	
	Direct application <ul style="list-style-type: none"> ❖ Very effective in all area in the first year of application. Residual effects differed among fields. 	Direct application <ul style="list-style-type: none"> ❖ Very effective in all areas in the first year of application as well as residual effects at least 3 years.
	(At least) Burkina Faso PR is fine powder in texture, so spreading method shall be considered like mixing with mud	
Dual application of organic matter and phosphate rock	Optimization of quantity and timing of application <ul style="list-style-type: none"> ❖ Rice straw shall be incorporated into soil just after harvesting, to have better C/N ratio for the next season and to avoid unnecessary burning. ❖ Phosphate rock shall be applied at sowing or transplanting. 	
Pretreatment	Early growth of rice is enhanced by pretreatment with a small quantity of water-soluble P fertilizer	
	Coating of fertilizer with rice seeds <ul style="list-style-type: none"> ❖ Direct sowing 	Soaking of rice seedlings in fertilizer solution <ul style="list-style-type: none"> ❖ Transplanting
Azolla	N input to rice ecosystems is expected through N fixation by symbiotic bacteria	
	<ul style="list-style-type: none"> ❖ No Azolla is found in fields. Inoculation technique is 	<ul style="list-style-type: none"> ❖ Azolla is found. Its proliferation is enhanced by P addition in the

	considered.	glasshouse experiment.
Technologies for the enhancement of phosphate rock solubility	Useful for environments where the solubility of PR is lower, such as upland rice or crops.	
	(1) Incorporate of PR in the process of composting to make P-enriched compost	
	(2) Incorporate of PR in the charring process, expecting calcination in relatively low temperature, to make P-enriched char	
	(3) Utilization of cover crops between rice, expecting of root exudates to dissolve PR	

At this moment, cost/benefit analysis is on-going for each option with data from on-farm trials, to finalize the list of technology options.

How to disseminate the technology options?

❖ Production and distribution of **technology manuals**

- Beneficiaries: Local rice farmers through MOFA extension workers
- Contents: Technology options with verified effectiveness on the improvement of soil fertility in lowland rice ecology
 - ❖ Cover all technologies or emphasize only the outcomes of this project?
 - ❖ Include the phosphate rock technologies? -->Yes
- Images
 - ❖ Not a complete textbook, separate in each option with a few pages
 - ❖ Usable in the field: size? -->not small, laminated feature
 - ❖ User friendly: a lot of photos and illustrations
- Contributors
 - ❖ Japanese side: JIRCAS scientists
 - ❖ Ghanaian side: Scientists of SRI, UDS, extension workers of MOFA
 - ❖ Editorial committee: Representatives of each institutions plus MOFA-HQ
- Schedules
 - ❖ Feb 2013: Visits to all institutions involved and MOFA, accordance of manual production and their contribution, ideas of the manual
 - ❖ May 2013: 1st Executive meeting in Ghana, confirmation of each role,

estimation of necessary budget, commencement of script, request of illustrations to artists

- ✧ Oct 2013: Completion of draft, 2nd executive meeting, harmonization
- ✧ Nov 2013: Completion of the 2nd draft
- ✧ Dec 2013: Finalize the manuscripts of manual, printing in Ghana
- ✧ Jan 2014: Completion of manual for each option, compilation upon regions or farmers, distribution of compiled manuals
- ✧ 2014 season: Demonstration/transfer of technologies by JICA and MOFA
- Budget: to be estimated and requested to MAFF

✧ **Workshop in Ghana** to summarize the achievements of the project

- Featuring academic findings and new technologies
- Date and place: In October or around, at Accra (or other idea?), followed by a tour to Kumasi and Tamale for Japanese guests for interacting with key farmers
- Participants
 - ✧ Main contributors: Scientists of JIRCAS, SRI and UDS
 - ✧ Guest contributors: Expert of the associated JICA project, Scientists from International Institutes (IWMI and SARI)
 - ✧ MAFF officials, project evaluation team from Japan
 - ✧ MOFA officials of HQ (CARD focal points and Extension Office) and Regional Offices
- Publications: Abstracts (small) and the proceedings (complete book)
- Budget: to be estimated and requested to MAFF or JIRCAS

Discussion points breakdown

- ◆ Inclusion of phosphate rock-associated technologies (depends on Ghana's policy)
- ◆ Ideas on the manual: inputs from users are very important
- ◆ Nomination of personnel from HQ and regional offices to be involved in the manual production and distribution
- ◆ Personnel cost for MOFA (travel, per diem, etc.)

(by S. Tobita, JIRCAS)