OVERVIEW ON SOIL FERTILITY AND CROP PRODUCTION IN SSA

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Andre Bationo is a citizen of Burkina Faso and holds a PhD degree in Soil Chemistry from Laval University (Quebec, Canada).He is now the President of a newly created NGO (Action for Integrated Rural Development). He served as Director of Alliance for a Green Revolution in Africa (AGRA) West Africa, Senior Program Officer, and Soil Health Program and as Resource Mobilization at AGRA during the period. Prior to the position at AGRA, he was the Coordinator of the African Network for Soil Biology and Fertility (AfNet) of the Tropical Soil Biology and Fertility Institute (TSBF) institute of the International Center for Tropical Agriculture (CIAT) in Nairobi, Kenya. He has also served as Principal Soil Scientist seconded to International Crops Research Institute for Semi-Arid Tropics (ICRISAT) by the International Fertilizer Development Center (IFDC).

ABSTRACT

Only a fraction of Africa's 874 million ha is potentially suitable for agricultural production. Arid and semi-arid lands (ASAL) comprising about a third of the potentially suitable agricultural land are too dry for rainfed agriculture and have shortened lengths of growing period. The continent has a wide range of soils and climatic conditions. Soils range from stony and shallow poor soils to deeply weathered soils that recycle and support large amounts of biomass. African soils have inherently poor soil fertility because they are very old and lack volcanic rejuvenation. Inappropriate land use, poor management and lack of inputs have led to a decline in productivity, soil erosion, salinization and loss of vegetation. However, general fertility and organic matter status of soils differ from upland to lowland ecologies. Wetland soils in the inland valley system of West and Central Africa generally are better endowed with fertility, especially soil organic matter status than their upland relatives. They have potential for increased agricultural intensification through an integrated use of crop genoptypes adapted to the ecology. Supporting integrated soil fertility management with sound policy, financial and institutional support can stimulate the much needed increase in food production.

Overview on soil fertility and crop production in Sub-Saharan Africa (SSA)

Andre Bationo
Soil scientist and President , Action for Integrated Rural Development (AIRD)

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Outline

- Introduction
- Biophysical and socio-economic constraints
- Paradigm shift in soil research
- Extent of nutrient mining
- Integrated soil fertility management (ISFM) implementation
- Conclusion

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Africa member countries are largely known for….

Introduction 3

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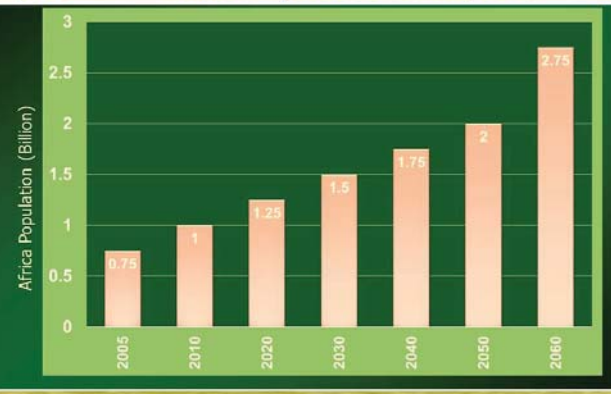
Africa is spending 50 billion dollars annually on food import



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The African Gloomy Situation

- 0ver 200 million people, 23% of the population are hungry.
- 40% of children under the age of five are malnourished.
- On the present trend, only 13% of food need s will be met by 2050.
- 3.3% of agricultural GDP lost every year.
- Only 4% of cultivated land is irrigated.
- Per capita arable land fell by about 76m² per year.

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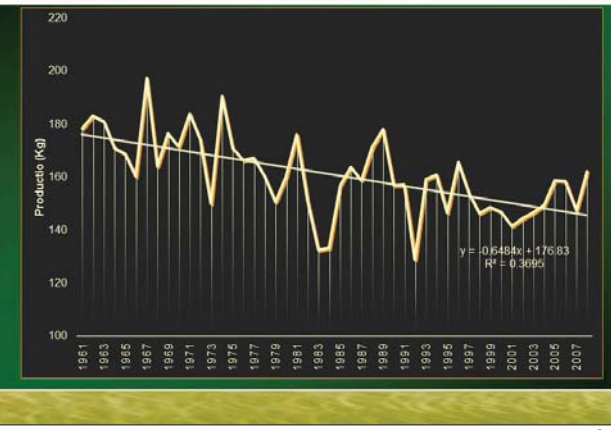
Cereal production per capita in SSA



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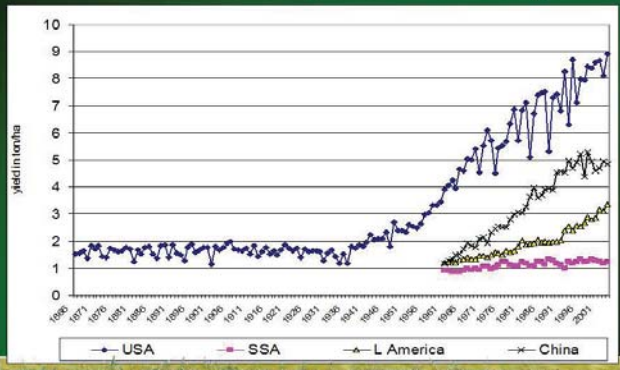
Growth in Yields

Low in Africa due to inhability of farmers to mitigate risks



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Fertilizer use and intensification in China

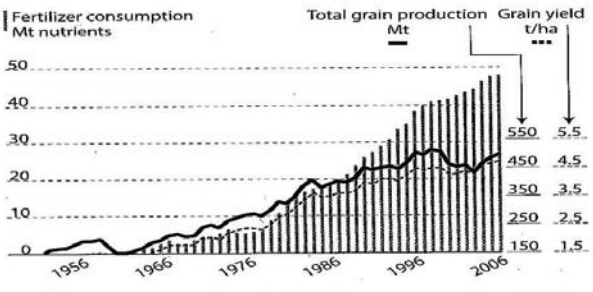

Figure 1-1 Trends in chemical fertilizer consumption, total grain production and production per unit area.

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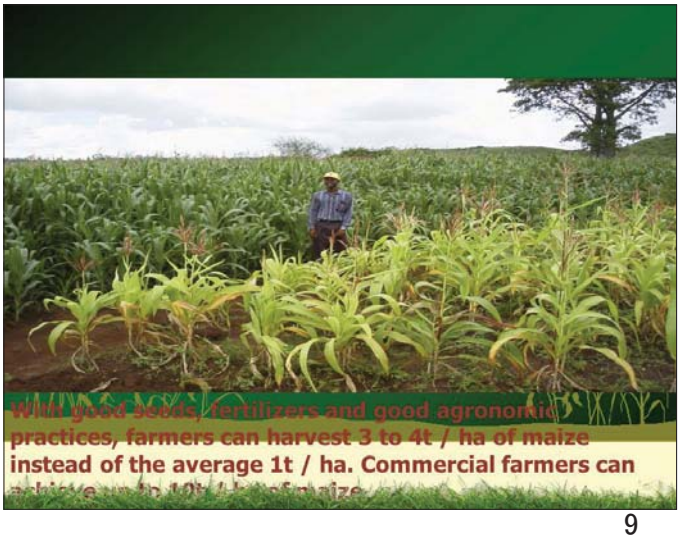

With good seeds, fertilizers and good agronomic practices, farmers can harvest 3 to 4t / ha of maize instead of the average 1t / ha. Commercial farmers can

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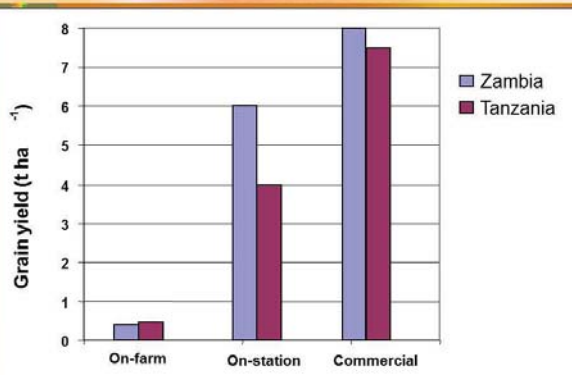
The Yield Gap: Some observations from sub-Saharan Africa



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Low Investment of Banks

- Only 1% of total bank financing goes to agriculture in Africa, yet the sector accounts for 70% of all employment and 25-50% or more of the GDP of African economies.
- These low investments are due to the high risk associated with farming

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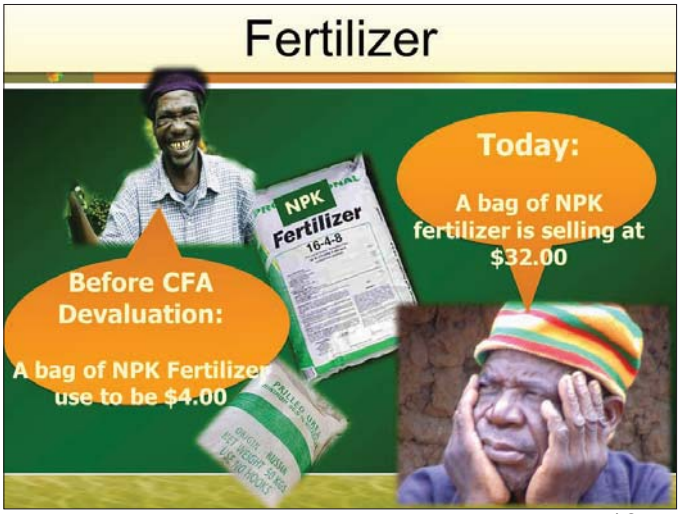
Fertilizer



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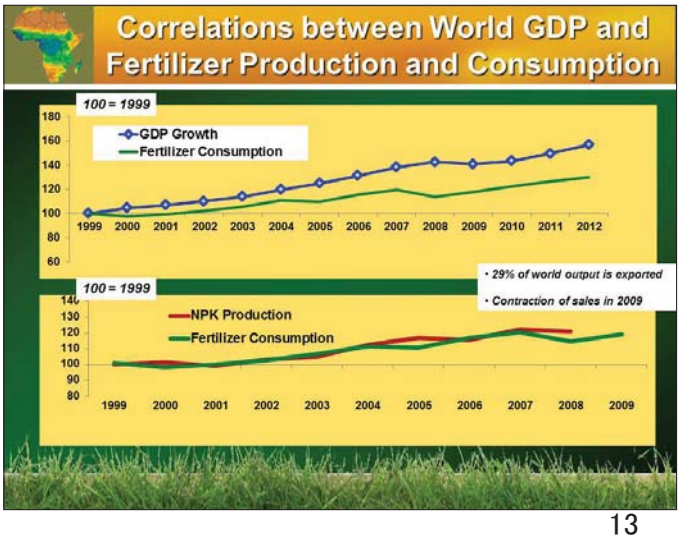

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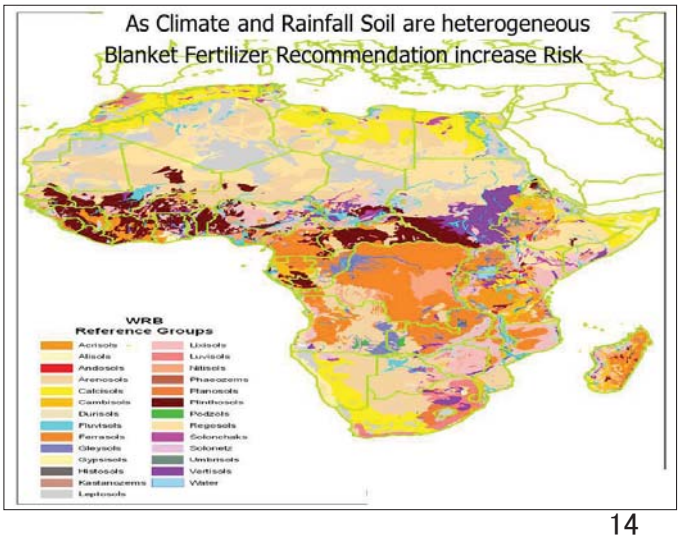

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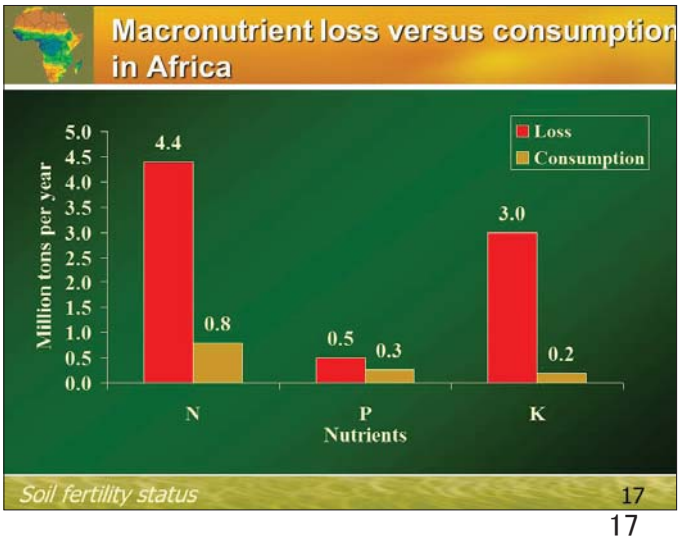

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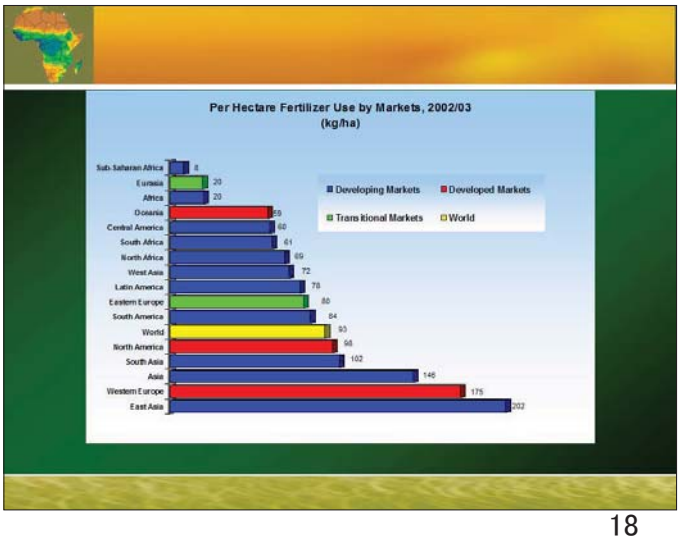

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Evolution Of The Integrated Soil Fertility Management Toward Intensification

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Tropical soil fertility research

70's
- first paradigm (Sanchez, 1994):

Inorg. Org.

'overcome soil constraints to fit plant requirements through purchased inputs'

- large success in Asia/Latin America

- subsidies on fertilizer in a number of African countries

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Tropical soil fertility research

Inorg. Org.

Mid-80's

- Africa should try to avoid the negative impact of increased fertilizer use, experienced in Asia/Latin-America
- Structural Adjustment Programs: lifting of subsidies on fertilizer
- Focus on biological management of tropical soil fertility and development of the term 'low input sustainable agriculture' (LISA) ('alley cropping' is an excellent example of a 'low input' technology)

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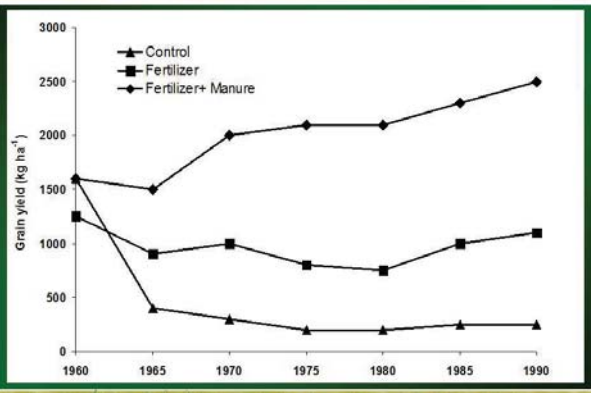
Sorghum grain yield as affected by mineral and organic fertilizer in LTE, Saria Burkina Faso



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Tropical soil fertility research

Mid-90's

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- Second paradigm (Sanchez, 1994):

'overcome soil constraints by relying on biological processes by **adapting germplasm** to adverse soil conditions, enlacing **soil biological activity**, and optimizing nutrient cycling to **minimize external inputs** and **maximize their use efficiency**

- Need for organic matter (maintenance of soil physico-chemical health) and inorganic fertilizer (nutrients)
- LISA is a *contradictio in terminis*; 'adequate input' agriculture

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Africa nutrient balances

Stoorvogel & Smaling 1990, Stoovorgel et al 1993 estimated nutrient balances for 38 countries in SSA

- Average N, P and K balances were -22, -2.5 and -5 kg ha^{-1} yr^{-1}, respectively
- Three nutrient depletion classes identified:
- Moderate/Low rate- less than negative 30 kg NPK ha^{-1} yr^{-1}
- Medium- btw negative 30 and 60 kg NPK ha^{-1} yr^{-1}
- High- greater than negative 60 kg NPK ha^{-1} yr^{-1}

Soil fertility status 24

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Countries grouped by average level of NPK balances (kg NPK/ha/yr) in 1993-95

High Worse than -60 kg		Medium (between -30 and -60 kg	Moderate/Low Better than -30 kg
Burkina Faso	Mali	Benin	Angola
Burundi	Mozambique	Cape Verde	Botswana
Cameroon	Nigeria	Central Republic of Africa	North Africa Countries
Cote d'Ivoire	Rwanda	Chad	South Africa
DR Congo	Senegal	Congo	Zambia
Ethiopia	Somalia	Equatorial Guinea	
Gambia	Swaziland	Gabon	
Ghana	Tanzania	Lesotho	
Guinea	Uganda	Mauritania	
Guinea Bissau		Niger	
Kenya		Sierra Leone	
Liberia		Sudan	
Madagascar		Togo	
Malawi		Zimbabwe	

Soil fertility status 25

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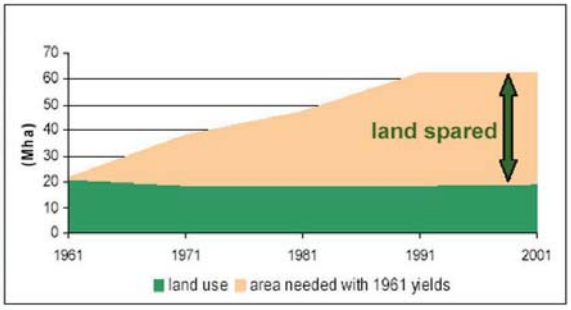
France: Cultivated Land



| Introduction | **West Europe** | India | Africa | Conclusion |

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Percentage increase in crop production

Crops	Area (%)/year	Productivity (%)/year	Production (%)/Year
Cassava	2.6	0.7	3.3
Maize	0.8	0.2	1.0
Yam	7.2	0.4	7.6
Cowpea	7.6	-1.1	6.5
Soybean	-0.1	4.8	4.7
Plantain	1.9	0.0	2.0

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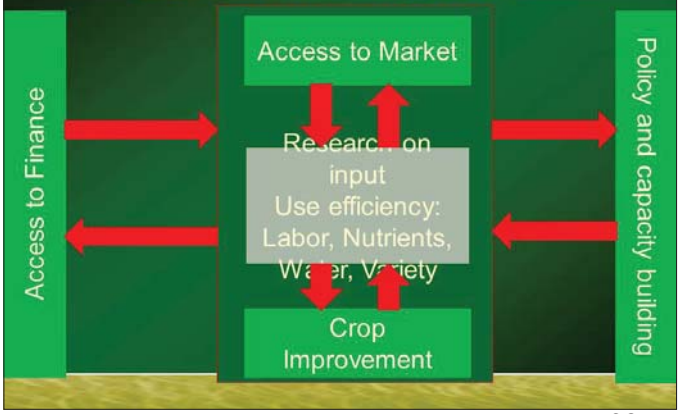
Sustainable Intensification Model For Impact



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Grain yield (GY) and water use efficiency (WUE) for millet in Niger

Treatments	SADORE		DOSSO	
	GY	WUE	GY	WUE
- Fertilizers	460	1.25	780	2.04
+Fertilizers	1570	4.14	1700	4.25

Improved soil fertility enhances the water use efficiency of crops in the Sahel

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P fertilizer use:

- SSA: 1.6 kg P/ha
- Latin America: 7.9 kg P/ha
- Asia: 14.9 kg P/ha

About 80% of SSA soils are short in P

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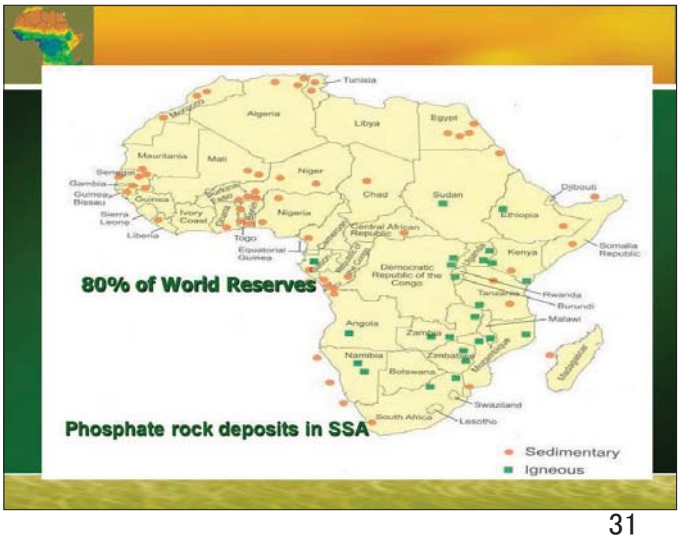

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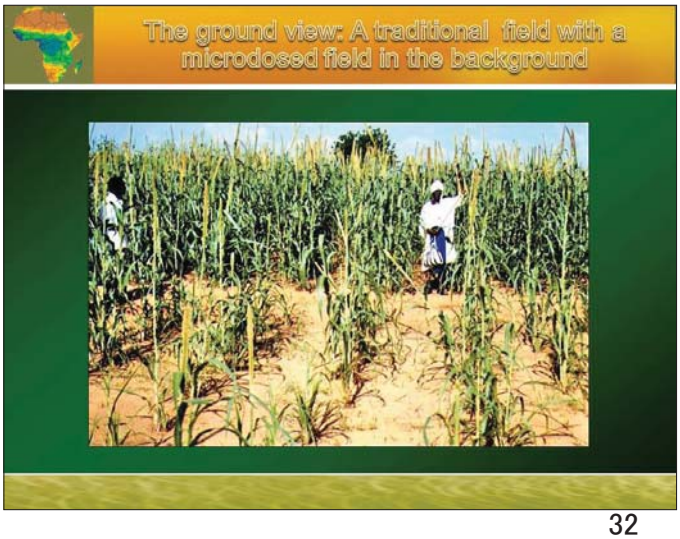

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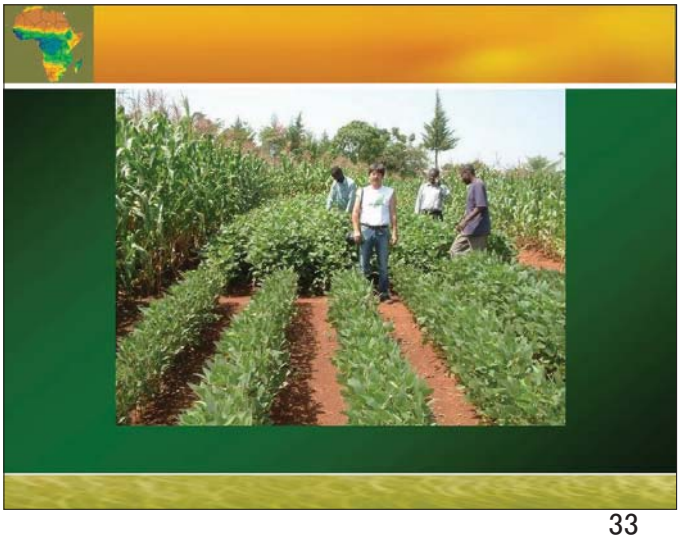

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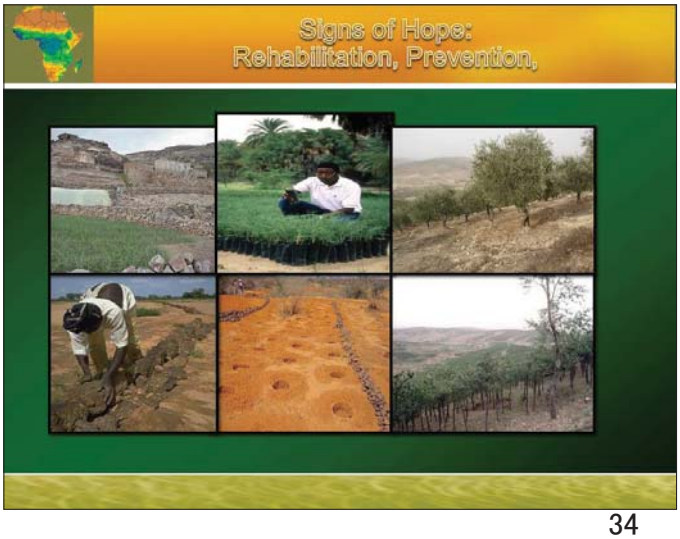

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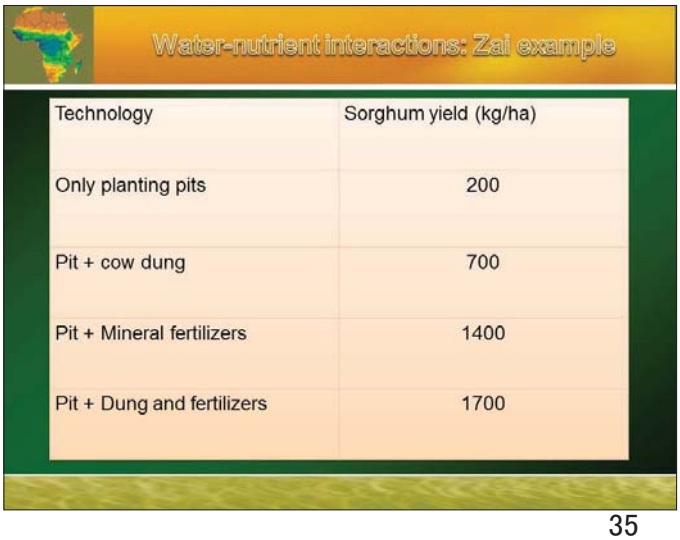

Technology	Sorghum yield (kg/ha)
Only planting pits	200
Pit + cow dung	700
Pit + Mineral fertilizers	1400
Pit + Dung and fertilizers	1700

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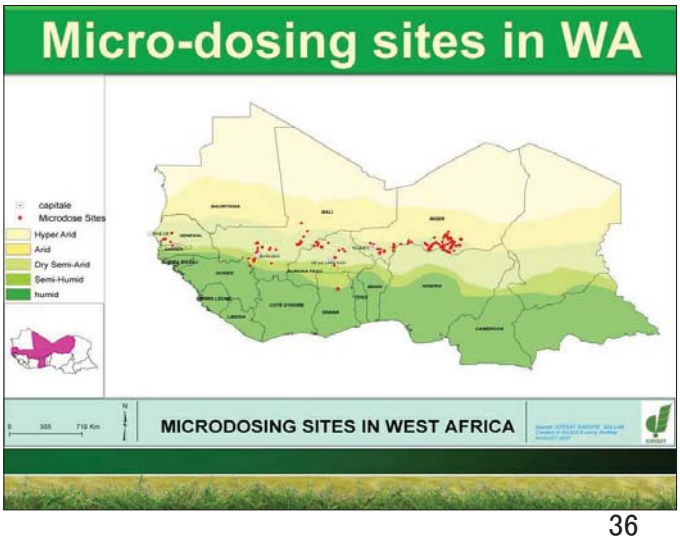

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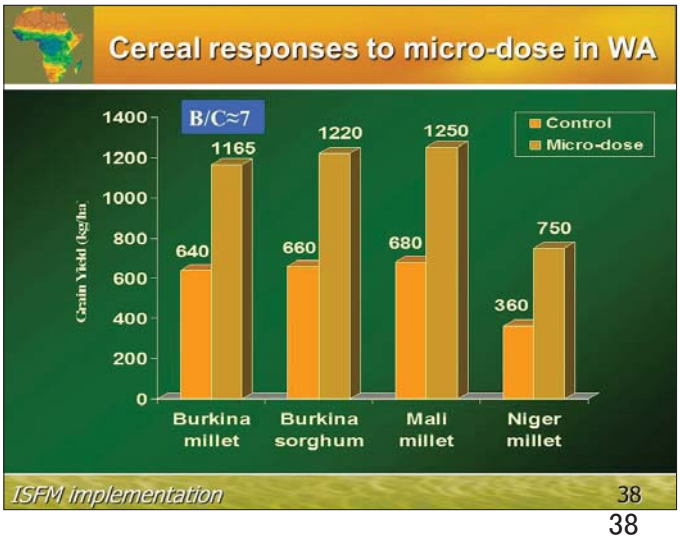

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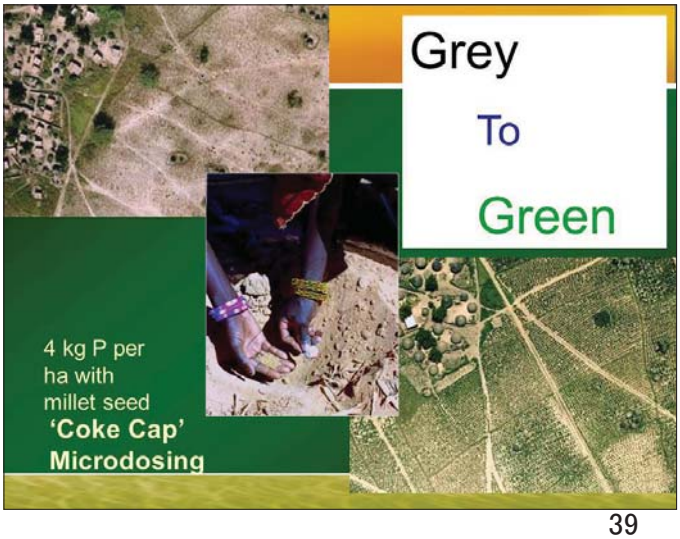

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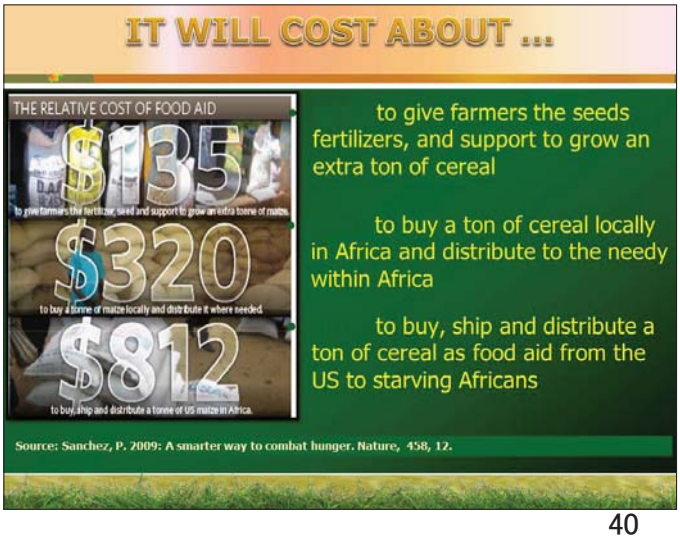

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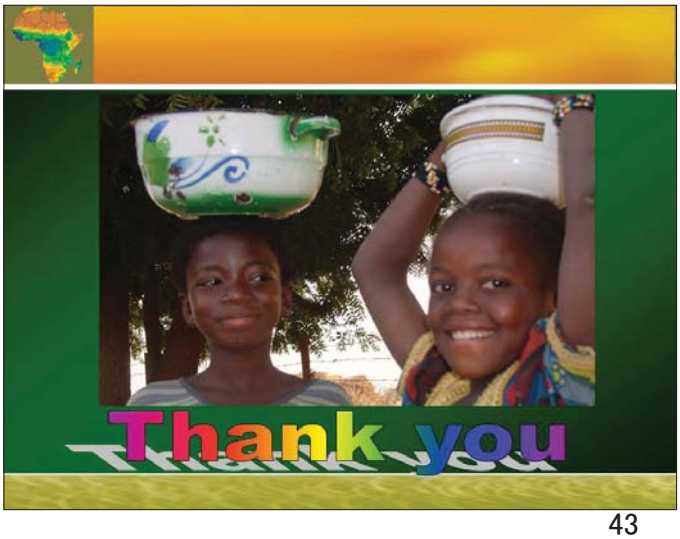

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Chair Tobita: Ladies and gentlemen, welcome to the Session 1: Improvement of Crop Productivity in Infertile Soils. My name is Tobita, Director of Crop, Livestock and Environment Division. This session has a total of seven presentations. Before lunch, we have four presentations; and after lunch, we have three presentations. The first session starts from the presentation by Dr. Andre Bationo to overview the soil fertility in Sub-Saharan Africa and followed by the presentations associated with the technologies for the nitrogen nutrients; and after lunch, the presentations are focused on the technologies associated with the phosphorous nutrition.

All speakers are provided 15 minutes for their presentations and plus 5 minutes discussion with the participants. We'd like to request you kind cooperation to keep the time. So, I'd like to introduce the first speaker Dr. Andre Bationo. For me, it's my very big honor to introduce Dr. Bationo.

Dr. Bationo is a citizen of Burkina Faso and holds a Ph.D. degree in Soil Chemistry from Laval University in Canada. He is now the President of a newly created NGO, the name is Action for Integrated Rural Development. He served as Director for the AGRA, Alliance for a Green Revolution in Africa, for long time and in charge of the Soil Health Program. Before his position at AGRA, he was Coordinator of the African Network for Soil Biology and Fertility, AfNet, of the TSBF, CIAT in Nairobi, Kenya. Now he also serves as Principal Soil Scientist seconded to the International Crops Research Institute for Semi-Arid Tropics, ICRISAT, by the IFDC, International Fertilizer Development Center.

His presentation title is "Overview on Soil Fertility and Crop Production in Sub-Saharan Africa." Dr. Andre Bationo, please. The floor is yours.

Dr. Andre Bationo: Thank you very much, Chairman. I would like first to take opportunity to thank the organizers of this symposium. It's really a big pleasure for me to be here today. I am interacting with JIRCAS scientists for the past 25 years and it's really an opportunity here again to thank them. It was I learned a lot by interacting and collaborating with different scientists from JIRCAS. Thank you very much.

This is the title of my presentation. They asked me to give just an overview of soil fertility and crop productivity associated to soil fertility in Sub-Saharan Africa.

I will first quickly discuss about some biophysical and socio-economic constraints. Before presenting the different paradigm, we went through in Sub-Saharan Africa. As far as integrated soil fertility management is concerned, discuss a little bit of extent of nutrient mining and present some example of integrated soil fertility management.

Unfortunately, Africa is known as a problem continent. When you talk about Africa, it means you talk about poverty, is crop failure, is drought, is poor governance. Africa bypassed the green revolution. We have many diseases, malnutrition, HIV, and more recently Ebola came in. So, Africa is really known more as a problem continent.

By today with a population of about 1 billion, Africa is spending $50 billion annually to import food and we know by the 2050 we will be about 3 billion people in Africa. So, the situation will be much worse.

We know that today we have about 200 million people, what is 23% of population of Sub-Sahara Africa are hungry. And if on the present trend continues, by 2050 Africa will have producing only 13% of food we are consuming.

When you look at again data in terms of productivity, you see by end of 60s Africa was producing 160 kilos of cereal grain per capita. But today, Africa is producing about 140 kilograms of cereal per capita. So, we have a downward situation.

This again shows where Africa is standing. As you can see, for example, in the US where the yield increased from 1 ton today to about 10 to 14 tons of cereal per hectare; in China or Latin America, you can see what average is. For China, it's about 5 tons per hectare. You can see what Sub-Saharan Africa is flat. In most of the countries, we are producing the yield of cereal is less than 1 ton per hectare.

But it was the same thing in China. You can see that in the 60s China was also producing about 1 ton per hectare, but you can see with increased use of fertilizer in China make what today is really yield increased from 1 ton to today to 5 tons of cereal per hectare.

What we can see in the landscape in Africa? The yellow crop, where we produce less than 1 ton when we know on the same piece of land commercial farmers can produce up to 10 tons of maize per hectare.

This just illustrate for taking the case of Zambia and Tanzania where you can see that on-farm yield is about half a ton of maize in the two countries, but on station scientists were able to produce up to 3 tons maize per hectare and some commercial farmers can even produce better up to 8 tons. So, we have a large yield gap.

When we look at investment, we know that agriculture accounts for 70% of employment in Africa and agriculture accounts for up to 50% of GDP, but yet only 1% of total bank financing goes to agriculture. This mainly is due to high risk associated with farming.

When I started my career after I graduated, I remember we used to buy a bag of 5 kilos or 50 kilos of fertilizer for $4, but today the same bag costs $30 to the farmers. But yet we know we don't have choice, Africa need to use more input.

If you look at this graph as you can see, it's a graph developed by IFA, International Fertilizer Industry Association, you can see a strong correlation between GDP and fertilizer consumption, meaning that if Africa is to increase to have a GDP growth, we have no choice and also increasing the use of input as soil fertility input.

When you come to the top of soil, the soils are very diverse. It is not like in Asia where you have a more uniformity, but unfortunately we have what we call Blanket Fertilizer Recommendation cannot be profitable because the recommendation need to be really site specific.

It was pointed out by the last presentation a lot of African soil is leading a lot of degradation due to water erosion.

A lot of degradation due to wind erosion, as you can easily see in the Sahel.

When we talk about nutrient mining, you see every year in Africa you take nitrogen, we are removing from the soil 4.4 million tons of nitrogen is what the crop is taking from the soil. But what farmers are putting back is only 0.8 million tons of nitrogen, so we are just mining the soil every year. You can see the large gap between what is we are adding to the soil compared to what we are taking from the soil.

Again world statistics show you, you can see that in terms of fertilizer use, world average is 100 kilos of NPK per hectare. But the average for Africa is only 8 kilos, Sub-Saharan Africa using 8 kilos of fertilizer per hectare compared to world average of 100 kilos of NPK per hectare.

Let me discuss briefly about a model we try to propose as a really way for intensification.

Before, as you know, the integrated soil fertility management went through different paradigm.

In the 70s, it was believed that what Africa need is just inorganic fertilizer. So, the first paradigm is everybody thinks that with inorganic fertilizer we can make it through. As you can see, it worked well in Asia, in Latin America, but it didn't work in Africa.

In the 80s, a new paradigm came, but African farmers can only use. We cannot buy mineral fertilizer. We can use only organic fertilizer. And again we know that it didn't work out for many reasons. And we believe that the new paradigm really is to use both organic and inorganic. If you look at the data of this long-time trial, you can see that using just mineral fertilizer cannot sustain for production in Africa.

But when you combine mineral fertilizer with manure, you can see that sorghum yield in that long-time trial that starts with 1960s can be up to more than 2.5 tons, where just use of mineral fertilizer will not produce more than 1 ton.

So we believe it need for intensification. If you see this slide, you see that in France we were using 20 hectares in the 60s to produce food they need, but today we are using less than 20 million hectares. If France were to produce the same quantity of food we are producing today with the same technology in the 60s without intensification, France will need to use 60 million hectares instead of 20 million hectares. That means by intensification we have land spared up to 40 million hectares. You can leave for carbon segregation. You can leave under forest.

And Africa we know everything was based in past off intensification. You take the example of maize, for example, where total production predicted to increase, but it was not due to productivity but it was due to expansion to clearing more land.

Now let me quickly maybe go back about what we would like to propose as a model for intensification is ready to use with the use of nutrient soil fertility being as frequent. But, we know to really make it through we don't want to fail. We have to make sure we use improved germplasm from the crop improvement. We need to make sure farmers have access to market. And more and more importantly we know if farmers don't have access to finance – it's very important to buy the input. And we are where we are because lack of linking farmers to market. Also, making sure we are linked, we have access to finance. Of course, your policy and capacity building aspect is very important.

Let me now move maybe to and I will not talk much about the rock phosphate because there is a presentation, but our work in the past we – Africa, 80% of the world reserves of phosphate are in Africa, yet Africa, as I told you, we need to really develop those rock phosphate.

This just gives you an example where we apply rock phosphate and a small quantity of fertilizer. And you can see with some of the rock how we can improve the yield. We associate with a microdose.

Many trials have been developed all over Africa, but I think I would not have much time.

A lot of work has been done where we do soil water harvesting associated with improvement of soil fertility.

Technology we really developed recently, and Africa has a high potential, is what we call the microdose technology.

You can see here a plot without the microdose where we just apply a small quantity of fertilizer, 4 kilograms of P per hectare mixed with the seed, compared to a plot where we with farmer's practice.

All over West Africa, we have very high increase in yield, we've very significant increase in yield and we've benefit cost ratio of 7.

We know that with technology alone it's really enough to end hunger in Sahel, where we can transform the Sahel from grey to green.

Let me now conclude by telling that many, many technologies have been developed. Of course, I cannot go through all of them. I just took the microdose to illustrate. We believe that Africa needs to really to produce the food we need through the use of integrated soil fertility management. If you have to produce 1 ton of maize in Africa, it will take you $135. But if you wait and you have to buy it from the neighboring country, the same ton of maize will cost you $320. But if you have to wait and get it to come all the way from Europe or from France like it happens most of the times, it's going to cost you $812.

To tell you now, farmers are telling us everywhere you go in Africa, you will find a bottle of Coca, you will find beer, but you cannot find seeds, you cannot find fertilizer. Farmers are telling us enough is enough, what we need is not only Coke or beer; we are looking for seeds and fertilizers.

We think that really what we see here we need to give a green revolution through the adoption of integrated soil fertility management technologies.

Thank you very much.

Chair Tobita: Thank you very much, Dr. Bationo, for your excellent speech with a lot of statistics with importance. Time is not so many, but I'd like to have some questions to Dr. Bationo for this presentation from the audience. If somebody wants to ask him? Saito-san, please.

Dr. Andre Bationo: Please go ahead.

Dr. Kazuki Saito: Thank you very much. The slide showing the commercial farmer produce higher yield than the researcher's field; then I realized that if we have the market access and access to the input, access to the finance, probably farmer can produce more. So if it is true, what can scientist do to create such an environment?

Dr. Andre Bationo: Yeah. I think first a lot of things we really need enabling policy environment and I have realized most of the times scientists we don't discuss much with policy makers. We need to really take them to the field and show them the potential of all the things we are doing what potential that can have on. Like I was telling if I look at my few years of experience, right now I believe more and more we need to make sure that farmers have access to credit. Because when I started my career, we were using 10 kilograms of NPK per hectare in Africa. Today, instead of 10, it's even 8. It means it's towards no progress. I think that the main constraint is lack of access to credit.

Chair Tobita: Is it okay, Dr. Saito-san? So one more question, if possible. Yes, Asanuma-san, please.

Dr. Shuichi Asanuma: Thank you very much, Bationo. My name is Shuichi Asanuma. I am from Nagoya University. You showed some data of the increase and decrease of the cropping area of some agriculture commodities and my finding is compared with other crops but soybean is now increasing in terms of cropping area and also some data. So compared with other like cowpea or the cassava or yam which is very common in West Africa, what is the reason why the people prefer to increase the soybean cultivation in Africa, if you have some reason?

Dr. Andre Bationo: I really don't know if it's not a little bit, but it's mainly due to the work of our IITA. I think you were associated with this work, soybean work in IITA in West Africa where it was really a success. I think there were many reasons. There is a lot of intensification. And when you go to some part of Nigeria, you can see that it's one of the crops where farmers are really using input. So, we have increase in productivity for soybean is more due to intensification instead of other crop is more due to expansion to new land. I think you were a part of the team at IITA when the work on soybean started.

Chair Tobita: Yeah, thank you very much, Dr. Bationo. Give a big hand to him.