# Improving rice productivity in nitrogen-deficient and saline environments of Sub-Saharan Africa

## Proceedings of a Consultative Meeting

**27 March 2006**

**Cotonou, Republic of Benin**

Arcadia BIOSCIENCES

AATF
AFRICAN AGRICULTURAL TECHNOLOGY FOUNDATION
FONDATION AFRICAINE POUR LES TECHNOLOGIES AGRICOLES

WARDA™ ADRAO

# Improving rice productivity in nitrogen-deficient and saline environments of Sub-Saharan Africa

## Proceedings of a Consultative Meeting

27 March 2006
Cotonou, Republic of Benin

AFRICAN AGRICULTURAL TECHNOLOGY FOUNDATION
FONDATION AFRICAINE POUR LES TECHNOLOGIES AGRICOLES

*Correct citation*

Gospel Omanya, Francis Nang'ayo, Nancy Muchiri, Monity Odera and Peter Werehire (eds). Improving rice productivity in nitrogen-deficient and saline environments of Sub-Saharan Africa: Proceedings of a Consultative Meeting, 27 March 2006, Cotonou, Benin. Nairobi, Kenya: The African Agricultural Technology Foundation



Printing: Regal Press, Nairobi, Kenya

*Logistics team*

Zainab Ali, Mildred Achieng, Samuel Kariuki, Safiatou Yabre and Patricia Hounvou

*Acknowledgements*

The editors gratefully acknowledge the assistance of Africa Rice Center (WARDA), Arcadia Biosciences Inc., AATF staff and all the workshop participants for making the event possible and provided assistance with information necessary for compiling this report.

## List of acronyms

| | |
|---|---|
| AATF | African Agricultural Technology Foundation |
| ECOWAS | Economic Community of West African States |
| FAO | Food and Agriculture Organization of the United Nations |
| FARA | Forum for Agricultural Research in Africa |
| FTO | Freedom to operate |
| GM | Genetically modified |
| IP | Intellectual property |
| IRRI | International Rice Research Institute |
| MAS | Marker assisted selection |
| MOU | Memorandum of understanding |
| MTA | Material transfer agreements |
| N | Nitrogen |
| NARS | National agricultural research systems |
| NDA | Non Disclosure Agreement |
| NERICA | New Rice for Africa |
| NGO | Non-governmental organisation |
| NUE | Nitrogen use efficiency |
| NUE | Nitrogen use efficiency |
| R&D | Research and development |
| ROCARIZ | Reséau Ouest et Centre Africain du riz |
| RSA | Republic of South Africa |
| RSA | Republic of South Africa |
| SSA | Sub-Saharan Africa |
| ST | Salinity tolerance |
| ST | Salt tolerance |
| SWOT | Strengths, Weaknesses, Opportunities, and Threats |
| WARDA | Africa Rice Center |

## Contents


| | |
|---|---|
| List of acronyms | iii |
| Executive summary | v |
| Background | 1 |
| Summary of plenary presentations | 2 |
| Plenary discussions on project activities | 4 |
| Project initiation formulation | 4 |
| Product development and testing | 7 |
| Rice transformation and regeneration | 7 |
| Salt tolerance | 8 |
| Introgression of NUE and ST into selected rice varieties | 8 |
| Regulatory compliance | 8 |
| Communication strategy | 10 |
| Product deployment | 12 |
| Project management | 13 |
| Way forward | 15 |
| Annex 1: Meeting programme | 16 |
| Annex 2: Issues for discussion | 17 |
| Annex 3: List of participants | 19 |

# Executive summary

These proceedings summarise the tripartite consultative meeting of The African Agricultural Technology Foundation (AATF), Africa Rice Center (WARDA) and Arcadia Biosciences Inc, held at the WARDA headquarters in Cotonou, Benin on 27 March 2006. The partners:

> *Recognising* the importance of rice as a food crop in Sub-Saharan Africa whose demand outstrips current local production and supply
>
> *Signifying* the declining soil fertility trends as a major rice production constraint in the major rice producing areas of Africa in general and west Africa in particular
>
> *Aware* that nitrogen deficiency is a leading constraint to rice productivity in over 80% of west Africa's rice lands
>
> *Understanding* the challenge posed by soil salinity to rice production in lowland flooded and mangrove environments of Africa, and
>
> *Recognising* previous and current R&D efforts targeting rice productivity in Africa by various national and international institutions,

jointly committed themselves to this initiative for adding value to rice productivity in Africa by undertaking to work towards improving rice varieties with traits for nitrogen use efficiency (NUE) and salinity tolerance (ST).

To jump start this initiative, it was proposed that license agreements necessary to access needed technologies inferring NUE and ST be drafted. This would then pave the way for formulating the project, including conducting baseline and feasibility studies from this year.

## Background

Rice is a staple food crop in most parts of Africa whose demand has been growing rapidly since the mid-1970s. The average growth of rice consumption is now more than 6% per annum and amounts to over 10 million tonnes of milled rice per year, of which 3.3 million tonnes are imported annually. The increase in consumption is due to population growth and the increased proportion of rice in the African diet, attributable mainly to rapid urbanisation.

Many abiotic and biotic factors curtail rice productivity under both irrigated and non-irrigated ecosystems. Efforts are under way by the Africa Rice Center (WARDA) to develop improved rice varieties that have better genetic potential, stress tolerance and nutritive value. As part of this effort, AATF is exploring collaborative linkages to promote technological interventions that will improve rice productivity in Africa. Towards this end, a consultative meeting was held at WARDA, in Cotonou, Benin jointly with Arcadia Biosciences Inc. to set in motion the process of access, adaptation and delivery of technologies to raise the productivity of rice under smallholder farming systems characterised by low soil nitrogen and saline environments.

Pursuant to this goal, the partners met to:

- explore the prospects of improving productivity of rice in nitrogen-deficient and saline environments of Sub-Saharan Africa
- discuss modalities of accessing and using technologies from Arcadia Biosciences for nitrogen use efficiency and salt tolerance
- determine intellectual property (IP) and regulatory issues involved in the acquisition and deployment of these technologies
- foster partnerships and formulate research and development activities for nitrogen use efficient and salt tolerant rice varieties
- clarify institutional roles in project implementation and sign a memorandum of understanding (MOU) between WARDA, Arcadia Biosciences and AATF
- formulate a project document outlining activities to be conducted by the partnership.

## Summary of plenary presentations

Underscoring this commitment, Dr K Nwanze, the Director General of WARDA, in his address to the meeting stated that WARDA welcomed the opportunity to work in partnership with AATF and Arcadia Biosciences for the benefit of rice farmers in Africa. He emphasised that forging partnerships with the private sector entities engaged in agriculture, NGOs, farmer organisations and advanced research institutions is the hallmark of WARDA's success in generating and disseminating technologies for resource-poor farmers on the continent. He noted that such partnerships involving WARDA and other institutions had already borne fruit going by the success of NERICA rice. WARDA received the World Food Prize for this (this what? Partnerships or success of Nerica) in 2004. More recently another scientific breakthrough is expected to gain rapid use in SSA: the development of 'lowland NERICAs' by WARDA and NARS scientists working within the ROCARIZ (spell out) network. This outstanding achievement at WARDA has been rightly acclaimed by the world scientific community with the award of the 2006 Fukui International Koshihikari Rice Prize of Japan to Dr Moussa Sié, WARDA's senior lowland rice breeder. However, there are still many challenges in the path of rice improvement. These he summarised as:

- low-yielding and poorly adapted varieties
- nutrient deficiency, mainly due to nitrogen, 4.4 million tonnes of nitrogen are lost annually in Africa's cultivated soils
- 2.5 tonnes of salt are deposited per ha in one crop season from irrigation water
- low use of fertiliser: SSA fertiliser use is estimated at 9kg/ha compared to more than 200kg/ha in east Asia
- the cost of fertiliser in SSA is prohibitively expensive. It costs $90 to ship one tonne of fertiliser from Iowa to Mombasa (a distance of 7000km) compared to $240 transport costs from Mombasa to Kampala (a distance of only 900km)
- Iron toxicity.

The questions that were uppermost in the minds of participants at the meeting were: *Is there hope for Africa? Are there options for addressing some of the challenges raised above?*

By the end of the meeting, it was agreed that Africa had a chance. This would be done by incorporating the NUE gene into popular rice varieties such as NERICA, which would significantly reduce the need for costly N fertiliser. Even more promising, greater use efficiency of N fertiliser should reduce N loss through runoff and erosion, thus protecting ground water from pollution. Incorporating the salt tolerance gene into popular rice varieties would enhance rice productivity in lowland agro-ecologies including mangrove swamps.

The presentation by the President of the Arcadia Biosciences Inc, Mr Eric Rey, raised hopes and expectations that potential exists for tackling low soil N and high salinity in rice growing areas of Africa. Arcadia Biosciences Inc. is based in Davis, California and is emerging as a leader in the development of transgenic, stress-tolerant crops. For example their nitrogen use efficient (NUE) canola, developed and field tested in California, performed well without nitrogen fertiliser addition. However, its benefits grew as nitrogen additions were increased to 125kg N per ha. In addition, Arcadia has demonstrated that the benefits of NUE increase under slower-release fertilisation and that transgenic and non-transgenic canola do not differ in terms of their tissue nitrogen, protein and seed oil concentrations or in seed size, indicating that benefits are derived from higher crop yields resulting from increased nitrogen acquisition. Arcadia Biosciences has also demonstrated the potential returns from transgenic salt tolerance in tomato. When *SAL*+ transformed plants are grown alongside non-transformed plants in 200mM dissolved salt (about 1/3 the salinity of seawater), plants lacking salinity tolerance are severely stunted and unable to bear fruit, while salt tolerant plants appear little different from their freshwater control. The salinity tolerance trait has also been incorporated into cotton, canola, alfalfa and rice, crops that are currently being field tested in the United States.

Faced with the challenges raised above on the one hand and the opportunities pointed out on the other hand, AATF came forward to propose a conceptual framework for harnessing technologies developed by Arcadia Biosciences as a means to adding value to improving rice productivity in Africa. Dr Mignouna of AATF briefed participants on the proposed framework for the initiative, indicating amongst other things the need to address intellectual property matters, product development, testing and deployment including attendant issues such as regulatory compliance, communication and public awareness. AATF also proposed a management structure to facilitate implementation of the project, specifying the roles of the partners.

# Plenary discussions on project activities

Following the introductory presentations by WARDA, Arcadia Biosciences and AATF, discussions were held as guided by the issues related to product development and deployment (Annex 2). A summary of these deliberations follows in the next sections.

## Project initiation formulation

### Intellectual property (IP) matters

Under IP matters, partners discussed inventory of proprietary technologies needed in the project; ownership issues and freedom to operate (FTO) assessment; technology transfer strategy including licensing, sub-licensing, material transfer agreements; and stewardship issues such as liability.

While discussing the above issues, clarification was sought regarding genes of interest and associated promoters and other genetic elements, IP status on these genes, and the rice transformation protocol.

These rights were discussed in regard to the two genes in question as summarised below.

#### The nitrogen use efficiency (NUE) gene

The gene for NUE is the *Alanine aminotransferase* gene from barley driven by a monocot promoter derived from rice and carried by background vectors developed by Arcadia. The gene for salinity tolerance on the other hand is the *Sodium antipolar* gene from *Arabidopsis* regulated by the 35S and NOS promoters. Arcadia has rights of ownership for the genes of interest and some of the promoters.

Regarding the protocol for rice transformation which is *Agrobacterium*-mediated, Arcadia has sub-licensed the right from Japan Tobacco, the patent holder, and assurance was given that this would not raise any obstacles regarding the transfer of this technology for rice improvement by WARDA.

Concerning ownership issues in the end product, Arcadia would continue to own genes or what is called background technology while of course the project consortium including WARDA would own the foreground technologies including the resulting end products. Arcadia, however, expressed sensitivity to genes moving outside of Africa, say to China or India, indicating that they cannot sub-licence the transformation process to other partners, but have no restrictions on the transfer of material from the USA to Africa.

It was concluded that typical licensing arrangements (and there are a range of possibilities arising from issues such as liability protection, indemnification and stewardship arrangements) would apply in this consortium and that the nitty-gritty agreements and negotiations be deferred for further discussions by management teams from the three partners.

### Salt tolerance gene

The functional gene is from the NX1–NX9 family of genes acquired from the University of Toronto. This gene is derived from *Arabidopsis thaliana.*

Arcadia also has the right to the mutated form of the gene from the University of California, Davis and holds a licence for this from the Japanese Ministry of Agriculture.

The 35S and 34S or mass promoters which have been expressed in multiple crops are being used as the promoter. Gene construct and transformation processes are similar to those for NUE.

AATF would own the improvement due to implications of liability and stewardship while Arcadia would continue to own 'background technology', that is the genes themselves. The favoured technology transfer sequence would be for Arcadia to sub-license to AATF, who would in turn arrange sub-licensing to WARDA. Typically, AATF indemnifies the technology provider, with possibility of renegotiations for issues such as commercialisation.

Liability is generally addressed by indemnification and disclaimer of warranties.

Arcadia also raised concerns on use of the technologies in other areas (outside mandated/agreed areas), an issue that needs to be further addressed.

### Feasibility study of proposed project

This will include assessment of the projected demand, expected return on investment and a SWOT analysis. The feasibility study will be coordinated by AATF and specifically will target issues such as projected demand, expected return on investment, SWOT analysis, and environmental impact of NUE and ST genes.

### Baseline study

The partners resolved that WARDA, having a comparative advantage on efforts targeting rice improvement in Africa, should lead in efforts at carrying out the feasibility and baseline studies. The issues raised are important and the studies should be conducted ex-ante so that the information arising from them can be used in the preparation of the project business plan.

### Development of a project business plan

Upon successful completion of the baseline and feasibility studies, there is need for the consortium partners to develop a Project Business Plan. Currently, AATF leads this effort on various projects but has not yet developed full in-house capacity for this. It was thus suggested that Arcadia Biosciences should assist in setting up the Technical Implementation Plan with milestones for the project. It was also suggested that consideration should be given to phasing out implementation of activities into three-year periods with clear budgets. The proposed concept note shared among participants indicates that the initiative will be implemented in three phases from 2006 through 2015.

# Product development and testing

## Rice transformation and regeneration

The meeting deliberated at length on the choice of germplasm for transformation and resolved that careful selection criteria need to be identified taking into account the traits of interest (NUE and ST), ecological diversity and the gains so far made in developing existing NERICA materials available in west Africa. WARDA, with their vast experience, was mandated to lead the selection of materials for transformation but generally it appears that *japonica* and NERICA should be targeted for transformation with NUE genes, while lowland NERICA and *indica* should be targeted for salinity tolerance.

Arcadia has a functional transformation protocol and it was noted that it may be useful to have the transformation at the location where expertise is available. If transformation of NERICA is to be done, then representative lines could be sent to USA as soon as possible, using the MTA unit to be facilitated by WARDA. The estimated period for the transformation exercise is estimated at 1–2 years. There is therefore need for speedy action considering the lengthy and stringent quarantine requirements that have to be complied with.

There has never been an attempt to combine the two genes (ST and NUE) in one plant. However, Arcadia Biosciences are willing to try and this would require that very technical issues are addressed. Thus Arcadia will provide feedback as soon as possible for the partners to forge ahead in this project.

There is risk of loss of adaptation traits through classical backcross techniques. However, transformation may maintain the traits of interest because only the required NUE and ST genes would be inserted into a favourable genetic background. There is also a possibility of using marker-assisted selection (MAS) to clean the genetic background, thereby retaining only the genes of choice into the introgressed germplasm.

### Clean events

Existing transformants are not clean events, thus end products have selectable markers. In the case of the transformed rice, the selectable markers are herbicide tolerance – *PAT* or *Bar* genes.

It was noted that there may be public sensitivity due to perceived impact of selectable markers on health, for example development of resistance among people. Notably, it is only in Republic of South Africa where antibiotic markers are authorised.

### Timelines for transformation

Transformation of the genes could take about one year. These would then be taken to the greenhouse and selected or screened for two generations to identify suitable lines. Thus in total about two years would be needed.

Research is still under way for new transformation events for NUE and Arcadia would provide an update on the available events.

There is about 84% of *japonica* in upland NERICA rice, and both upland and lowland NERICAs could be used for the introgression processes. The newly developed lowland NERICA is an *indica* type.

## Salt tolerance

In the case of imparting the salt tolerance trait, it was agreed that WARDA was in the best position to select the relevant germplasm which could be used in the crossing programme.

## Introgression of NUE and ST into selected rice varieties

Participants discussed issues related to trait evaluation, sites, target varieties and MAS.

It was agreed that WARDA should take a lead in identifying candidate rice lines for a backcrossing programme assisted by MAS. The required primers can be accessed from Arcadia. About 1½–2 years would be sufficient to transform popular varieties using MAS. The transformed lines will be handled according the WARDA policy on biotechnology.

### Sites for product testing

Pilot testing should be done in a country where transgenic (GM) crops have good acceptance, a favourable regulatory environment, and there is likelihood to have an impact. Burkina Faso stood out as a possible entry point for testing before the technology is taken to other countries. Criteria such as importance of stress, representation of agro-ecologies and regulatory climate will be used while selecting the countries.

## Regulatory compliance

Pilot target countries will be chosen based on capability and capacity for regulatory enforcement. Subsequently, a multi-criteria approach may be used to select countries for technology deployment.

Regarding biosafety, partners agreed that Arcadia, AATF and WARDA jointly work together to ensure that:

- a preliminary risk assessment based on information available be compiled upfront
- a comprehensive transformation event-specific risk assessment be carried out, though at a later stage.

The three partners will also learn from other projects elsewhere such as Golden Rice (IRRI) in Asia, the ECOWAS Biosafety Initiative, and FAO and CODEX Alimentarius Commission guidelines.

The following persons were identified to lead the Bioafety and Regulatory compliance issues: Francis Nang'ayo (AATF), Danielle Fasiotti (Arcadia Biosciences Inc.), Marie-Noelle Ndjiondjop (WARDA) and Yacouba Sere (WARDA).

## Communication strategy

It will be important to ensure that the product developed actually benefits the public. Therefore, planned communications that will support product knowledge, acceptance and uptake is important. A communication strategy should therefore be formulated and implemented. The strategy would deal with:

**Product definition**

This would describe the product components, including details on expected availability, benefits it would bring, possible risks if any and their management, current product image and positioning, projected image and positioning, distribution and pricing, and a general SWOT analysis.

**Current perceptions of the NERICA**

What do people think of NERICA and what would be their inclination towards a transgenic NERICA?

**Defining the target**

This would include answering questions such as: Who and why? What are the regulatory constraints? What are the sensitive issues to address? What is the targets' level of literacy/understanding of the main issues? What are the knowledge and information gaps? What geographic coverage should be considered?

**Identifying partners in information dissemination**

The issues here will include channels, tactics and a copy release process. Whereas announcements of 'fact' can be made by the partners; statements of 'promise' should be issued with caution. One factual statement that partners can communicate is the commitment by all to the achievement of the project goals. Parties should be aware of different institutional sensitivities. It is also important for partners to commit to transparency and integrity.

Link persons with reference to communications were identified as Eric Ray (Arcadia Biosciences), Savitiri Mohapatra (WARDA) and Nancy Muchiri (AATF).

The copy release process will be handled by the link persons above who will take it through the different organisations' internal approval processes.

**Developing the communication strategy**

The strategy will seek to align its communication activities with the benefit/value addition of the product rather than with the technology. It will support product development activities and deployment and its intention will be to achieve acceptance of the product among its targets and encourage knowledge and information sharing that will support informed decision making. It will be based on solid data generated by the project to support public awareness.

**Monitoring and evaluation.**

The issues above will also be addressed in the feasibility and baseline studies, and the risk management strategy.

## Product deployment

Discussions on delivery of the transformed rice varieties to farmers in Africa were based on rice seed systems, which included product dissemination models, on-farm demonstrations, seed production and commercialisation, impact assessment and stewardship activities.

There is heterogeneity in seed systems across Africa meaning that there will not be one system that suits deployment, since NUE and ST rice is a new product altogether. For example, currently NERICA has been disseminated through participatory variety selection using community-based organisations in west Africa, while in Uganda seed companies have assisted.

In delivering the transgenic rice, an approach agreed upon was to use an existing seed system in a pilot country and evaluate how it works. Later on this could be scaled-up based on a particular country or region. This may involve both private and public institutions. Initial dissemination of transgenic rice seeds could be in a package approach, incorporating fertiliser and user instructions.

It is important to incorporate fertiliser delivery strategies since, besides nitrogen, other elements such as phosphorus, potassium and organic matter are also as important. This begs for integrated product delivery package mechanisms.

Production and marketing ventures should also be looked into as they promote seed commercialisation efforts. Farmers can be contacted through their associations, and rice marketing systems to sell surplus can be initiated.

## Project management

To coordinate the proposed project activities, the following issues were discussed: the organogram, human resource needs, resource mobilisation (that is funding sources), budget, partner review/planning meetings and institutional roles.

The proposed organogram for coordinating the project is presented in Figure 1.

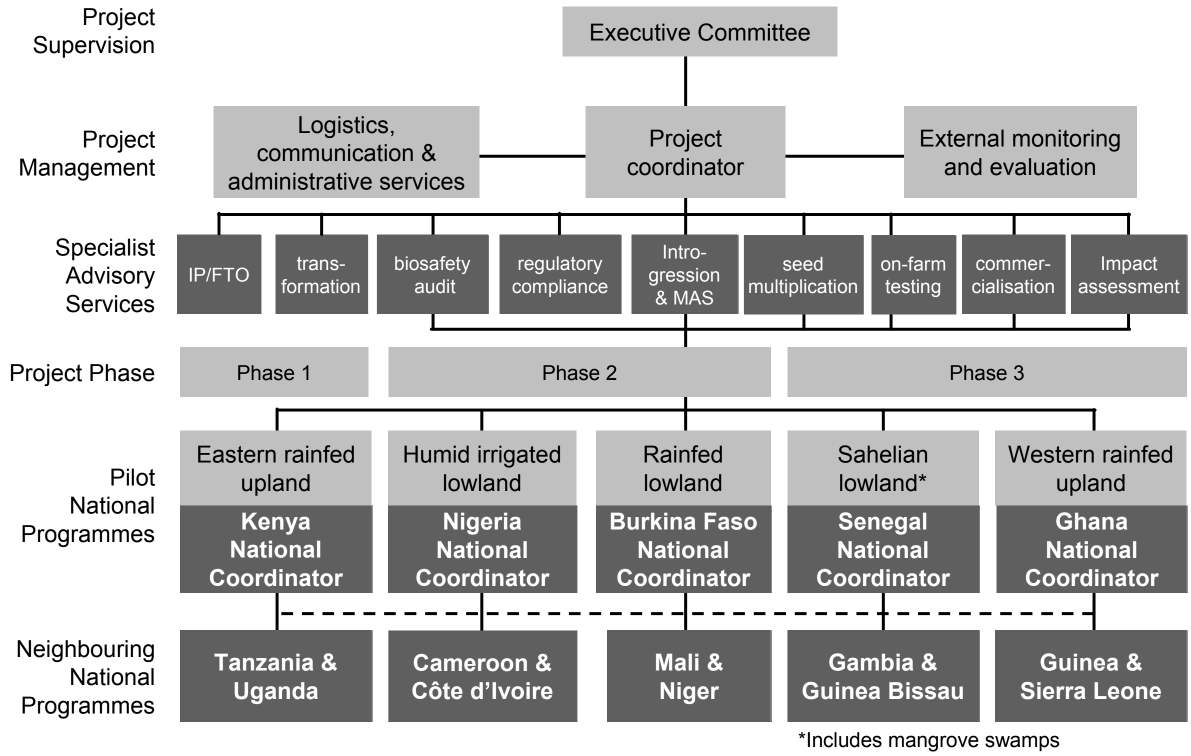


*Figure 1. Proposed project management structure*

The overall project implementation will be coordinated by AATF through its Project Management Unit.

For the specific management of this project, a Steering Committee was set up and charged with the responsibility of strategic guidance and advice. The Steering Committee comprises representatives of AATF, WARDA, Arcadia Biosciences, and representatives from the Forum for Agricultural Research in Africa (FARA), the five pilot country NARS (Figure 1) and selected NGOs and seed companies.

A full time Project Coordinator will be recruited by AATF and WARDA and will be hosted by WARDA. He/she will be responsible for the day-to-day implementation of all project activities, and will report to the Steering Committee through AATF for programmatic issues and through WARDA for administrative issues. He/she will also receive additional services and technical advice from various project partners as required through various specialist advisory units. The Project Coordinator will act as the secretary to the Steering Committee.

Project activities will be divided into three phases:

1. IP access and business plan development
2. Product development
3. Product deployment.

Phases 1 and 3 will be supervised by AATF, while WARDA will take responsibility for Phase 2.

**Milestones**

It was noted that milestones can be extracted from the organogram and put explicitly in the project proposal document and phased in, for example, over three years. The project milestones will be carefully synthesised into the final project document with a logframe showing deliverables.

**Project meetings**

Virtual meetings could be held during the course of the project via teleconferences. In this regard, use of Skype software was proposed as efficient and economical. In addition, occasional 'physical' meetings would be held. Subsequently, the partners would determine how frequently the executive committee is to meet.

## Way forward

To ensure successful implementation of the project, the following timeframes and resolutions were established.

1. Project collaborative agreements including the License Agreement and MOU should be drafted and made available by 14 April 2006.
2. Proceedings of the consultative meeting be compiled by AATF within 4–6 weeks.
3. Baseline and feasibility studies by WARDA should be worked out and possibly be commissioned within 4–6 weeks.
4. The project business plan led by Arcadia Biosciences be initiated by the end of 2006.
5. WARDA should lead the process of material transfer and this should be treated with a sense of urgency.
6. WARDA to nominate a scientist who will proceed to Arcadia to help with the rice transformation.
7. Sharing of regulatory issues such as MTAs and IP policy should be done in a framework of 1–2 weeks.
8. Project updates/reports should be done consistently.
9. It was also proposed that an internal advisory board should be established.
10. WARDA to specify when the material will be sent to the US once the technical people decide. This should be done as a matter of urgency.

# Annex 1: Meeting programme

| Time | Session one – Chair: DG, WARDA | Facilitator/Presenter |
|---|---|---|
| **09.00–09.30** | • Welcome remarks and introduction of participants<br>• Challenges and opportunities for raising rice productivity in SSA | **WARDA** |
| **09.30–10.00** | • Introductory remarks<br>• Potential technological interventions for improving rice productivity: The case of salinity tolerance and nitrogen use efficiency | **Arcadia Biosciences** |
| **10.00–10.30** | • Introductory remarks<br>• Proposed conceptual framework for improving productivity of rice in nitrogen-deficient and saline environments of Sub-Saharan Africa | **AATF** |
| **10.30–11.00** | *Coffee/Tea break and photo session* | |
| | **Session two – Chair: ED, AATF** | |
| **11.00–12.30** | • Plenary discussion on the conceptual framework of the proposed project on rice improvement<br>➢ Project formulation<br>➢ Product development and testing<br>➢ Product deployment | |
| **12.30–13.30** | *Lunch hosted by WARDA* | |
| **13.30–15.00** | Continuation of plenary discussion | |
| **15.00–15.30** | *Coffee/Tea break* | |
| **15.30–16.00** | **Wrap-up session** | |
| **16.30–17.00** | Tour of WARDA facilities | **WARDA** |
| **19.00** | *Dinner hosted by AATF* | **AATF** |

# Annex 2: Issues for discussion

## Project formulation

### Intellectual property (IP) matters

- Inventory of proprietary technologies needed in the project
- Ownership issues and freedom to operate (FTO) assessment
- Technology transfer strategy: Licensing, sub-licensing, material transfer agreements
- Stewardship issues, for example liability issues

### Feasibility study of proposed project

- Projected demand
- Expected return on investment
- SWOT analysis
- Environmental impact of NUE and salt tolerance

### Baseline study

- Current production systems, constraints and opportunities
- Consumer acceptance/preferences
- Perception of GM technology

### Development of a project business plan

- Product development work plan
- Product deployment strategy
- Budget requirement
- Institutional roles

## Product development and testing

### Rice transformation and regeneration

- Choice of material, for example *japonica, indica* or NERICA
- Transformation protocol
- Facilities for transformation work – Africa, USA, its implications

### Gene introgression

- Trait evaluation
- Site, target varieties
- Marker assisted selection

**Product testing**

- Target countries (see regulatory compliance)
- Locations – laboratory, screenhouse, greenhouse, confined and open field trials

**Regulatory compliance**

- Identification of target countries – policy and regulatory environment
- Generating biosafety dossier
- Risk management strategy
- Infrastructures – regulatory laws, human resources/capacity for risk assessments, screenhouses, greenhouses (containment facilities)

**Communication strategy**

- Communication plan
- NDA, policy for press release

**Product deployment**

- Rice seed systems – product dissemination models
- On-farm demonstrations
- Seed production and commercialisation
- Impact assessment
- Stewardship activities

**Project management**

- Organogram for the proposed project
- Human resource needs for the proposed project, resource mobilisation – funding sources, budget, partner review/planning meetings, institutional roles

# Annex 3: List of participants

**Akintayo, Inoussa**
ARI Coordinator, Africa Rice Center (WARDA)
01 BP 2031
Cotonou, Benin
Tel: +229 35 01 88; Cell phone: +229 97 12 1069
Fax: +229 21 35 05 56
Email: i.akintayo@cgiar.org
Website: www.warda.org

**Ali, Zainab**
Special Assistant to the Executive Director, The African Agricultural Technology Foundation
PO Box 30709–00100 GPO
Nairobi, Kenya
Tel: +254 020 4223700; Cell phone: +254 0733 750040
Fax: +254 0200 422 3701
Email: z.ali@aatf-africa.org
Website: www.aatf-africa.org

**Boadi, Richard**
Legal Counsel, The African Agricultural Technology Foundation
P.O. Box 30709–00100 GPO
Nairobi, Kenya
Tel: +254 020 4223700; Cell phone: +254 0735 992205
Fax: +254 020 422 3701
Email: r.boadi@aatf-africa.org
Website: www.aatf-africa.org

**Bokanga, Mpoko**
Executive Director, The African Agricultural Technology Foundation
P.O. Box 30709–00100 GPO
Nairobi, Kenya
Tel: +254 020 4223700; Cell phone: +254 0735 99 22 00
Fax: +254 020 422 3701
Email: m.bokanga@aatf-africa.org
Website: www.aatf-africa.org

**Katuli, Nurdin**
Head of Operation and Administration Services, WARDA
01 BP 2031
Cotonou, Benin
Tel: +229 21 350 188; Cell phone: +229 95 429 629
Fax: +229 21 350 556
Email: n.katuli@cgiar.org
Website: www.warda.org

**Keya, Shellemiah**
Assistant Director General – Research and Development, Africa Rice Center (WARDA)
01 BP 2031
Cotonou, Benin
Tel: +229 35 01 88; Cell phone: +229 95429617
Fax: +229 36 05 56
Email: s.keya@cgiar.org
Website: www.warda.org

**Kormawa, Patrick**
Assistant Director of Research and Leader Rice Policy & Development Program
01 BP 2031
Cotonou, Benin
Cell phone: +229 95 84 6808
Fax: +229 21 35 05 56
Email: p.kormawa@cgiar.org
Website: www.warda.org

**Muchiri, Nancy**
Communication and Partnerships Manager, The African Agricultural Technology Foundation
PO Box 30709–00100 GPO
Nairobi, Kenya
Tel: +254 020 4223700; Cell phone: +254 0735 992206
Fax: +254 020 422 3701
Email: n.muchiri@aatf-africa.org
Website: www.aatf-africa.org

**Nang'ayo, Francis**
Regulatory Matters Specialist, The African Agricultural Technology Foundation
PO Box 30709–00100 GPO
Nairobi, Kenya
Tel: +254 020 4223740; Cell phone: +254 0735 992203
Fax: +254 020 422 3701
Email: f.nangayo@aatf-africa.org
Website: www.aatf-africa.org

**Ndjiondjop, Marie-Noëlle**
Molecular Biologist, Africa Rice Center (WARDA)
01 BP 2031
Cotonou, Benin
Tel: +229 21 35 01 88; Cell phone: +229 95 42 94 82
Fax: +229 21 35 05 56
Email: m.ndjiondjop@cgiar.org
Website: www.warda.org

**Nwanze, Kanayo F.**
Director General, Africa Rice Center (WARDA)
01 BP 2031
Cotonou, Benin
Tel: +229 21 35 0188; Cell phone: +229 95 42 93 95
Fax: +229 21 35 0556
Email: k.nwanze@cgiar.org
Website: www.warda.org

**Oikeh, Sylvester**
Soil Fertility Agronomist, Africa Rice Center (WARDA)
01 BP 2031
Cotonou, Benin
Tel: +229 21 35 0188; Cell phone: +229 9323 6677
Fax: +229 21 35 0556
Email: s.oikeh@cgiar.org
Website: www.warda.org

**Omanya, Gospel**
Project Manager, The African Agricultural Technology Foundation
P.O. Box 30709–00100 GPO
Nairobi, Kenya
Tel: +254 020 4223700; Cell phone: +254 0735 992204
Fax: +254 020 422 3701
Email: g.omanya@aatf-africa.org
Website: www.aatf-africa.org

**Ousmane, Youm**
Assistant Director of Research (Integrated Rice Production Systems), Africa Rice Center (WARDA)
01 BP 2031
Cotonou, Benin
Tel: +229 21350188; Cell phone: +229 95429408
Fax: +229 21 35 0556
Email: o.youm@cgiar.org
Website: www.warda.org

**Rey, Eric**
President, CEO, Arcadia Biosciences Inc.
202 Cousteau Place
Suite 200
Davis, CA 95616, USA
Tel: +1 530 750 7173; Cell phone: +1 510 526 1969
Fax: +1 530 756 7027
Email: eric.rey@arcadiabio.com
Website: www.aracadiabio.com

**Salameh, Roger**
Business Development Manager, Arcadia Biosciences Inc.
202 Cousteau Place
Suite 200
Davis, CA 95616, USA
Tel: +1 530 750 7164; Cell phone: +1 949 637 1295
Fax: +1 949 203 6277
Email: roger.salameh@arcadiabio.com
Website: www.aracadiabio.com

**Sie, Moussa**
Lowland Rice Breeder, Africa Rice Center (WARDA)
01 BP 2031
Cotonou, Benin
Tel: +229 21 35 0188; Cell phone: +229 97 22 0367
Email: m.sie@cgiar.org
Website: www.warda.org

**Woomer, Paul**
Consultant, FORMAT
P.O. Box 79, The Village Market
Nairobi, Kenya
Tel: +254 020 7122337; Cell phone: +254 0733 972 722
Email: plwoomer@africaonline.co.ke
Website: formatkenya.org

AFRICAN AGRICULTURAL TECHNOLOGY FOUNDATION
FONDATION AFRICAINE POUR LES TECHNOLOGIES AGRICOLES

PO Box 30709-00100, Nairobi, Kenya
Tel: +254 20 422 3700, Fax: +254 20 422 3701
Via USA – Tel: 1 650 833 6660, Fax: 1 650 833 6661
Email: aatf@aatf-africa.org
Website: www.aatf-africa.org