1. Cover Page

Title of Research Proposal: Optimization of the seed ball technology for pearl millet, and agronomic and socio-economic evaluation in the context of smallholder farmers in Senegal and Niger

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Authorized Organizational Representative

[signature] – 7. Feb. 2014

Signature **Date**

2. Executive Summary

Pearl millet [Pennisetum glaucum (L.) R. Brown] productivity in the Sahel is severely constrained by the combination of scattered rainfall, low soil fertility and resource scarcity. Especially the beginning of the rainy season is variable and unpredictable, forcing farmers to take high risks at planting, and, in case of poor seedling survival, to replant fields several times. Labour availability at the beginning of the rainy season is another challenge that some farmers try to overcome by the technique of dry planting. But dry planting also bears a risk of crop failure, because of insufficient first rains, and untreated seeds in the dry soil being prone to insects, bird and rodent damage. Technologies that could help to enhance seedling survival in the Sahel, both in case of dry planting and in case of planting with the first good rain, could be an important contribution to reduce the overall cropping risks in the Sahel, and thereby to enhance pearl millet productivity and yield stability.

Crop management techniques exist that are able to counteract these constraints, but not all of them are accessible to smallholder farmers. More techniques are required that are simple to understand and that are compatible with the socio-economic background of smallholder farmers. In this proposal, we present the seed ball technology as a valid option to reduce cropping risks and improve farmers' yields, especially that of women farmers, by using low-cost resources that are readily available. The seed ball technology has been in development since 2012 at the University of Hohenheim (Germany) and the Senegalese Institute for Agricultural Research (ISRA). It represents a special form of seed pelleting with natural loam and additives (e.g. wood ash from cooking places and chemical fertilizers in micro-dosages) to enhance early plant establishment and plant development of pearl millet.

With this project, we would like to extend our research on the seed ball technology in cooperation with ISRA and the National Agricultural Research Institute of Niger (INRAN) and to further develop this technology for the benefit of Sahelian subsistence farmers. In a highly interdisciplinary and participatory approach we suggest to (1) further optimize the seed ball technology for pearl millet, to (2) validate the seed ball technology under Sahelian field conditions and determine the agronomic and socio-economic benefits for farmers and to (3) strengthen local capacity for seed ball research and application in Senegal and Niger. We intend to achieve these objectives in a collaborative effort, by including smallholder farmers, farmer organizations, local and international research institutions and multimedia in a continued process of seed ball development, refinement, validation and adaptation to local conditions. At least four local Master students will be trained. Results will be communicated widely, via a project-specific web page, a wiki site, peer-reviewed publications, a training manual, communitarian radio spots, farmer-to-farmer video and farmer exchange visits. We will consider our objectives achieved once Sahelian subsistence farmers (individually or as a community) are able to create seed balls independently and, when applied in the field, can benefit from a reduced likelihood of cropping failures, improved early plant establishment and grain yield formation.

3. Introduction and Objectives:

The challenge of early pearl millet establishment and why it is important

Pearl millet [Pennisetum glaucum (L.) R. Brown] productivity in the Sahel is severely constrained by the combination of scattered rainfall, low soil fertility and resource scarcity of smallholder farmers. Especially the beginning of the rainy season is highly variable and largely unpredictable (Haussmann et al., 2012), forcing farmers to take high risks at planting, and, in case of poor seedling survival, to replant fields several times. This results in heterogeneous, low-yielding plant stands, and sometimes in seed shortages. Labour availability at the beginning of the rainy season is another challenge that farmers, especially in Senegal but also in many parts of Niger, tend to overcome by the technique of dry planting. While dry planting of often untreated seed reduces the work load after the first good rain, it also bears a high risk of crop failure, because the very first rains are rarely sufficient to ensure seedling survival, and untreated seeds in dry soil are prone to insects, bird and rodent damage. Technologies that could help to enhance seedling survival in the Sahel, both in case of dry planting and in case of planting with the first good rain, could be an important contribution to reduce the overall cropping risks in the Sahel, and thereby to enhance pearl millet productivity and yield stability.

Several techniques already exist to tackle the above-mentioned production constraints. Seed coating and seed priming have been studied intensively during the last decades and were found to significantly improve early plant establishment, yield formation and pest control (Niranjan et al, 2004; Karanam and Vadez, 2010; Aune and Ousman, 2011). In the early 90's Rebafka et al. (1993) studied the effect of phosphorus (P) coating on pearl millet development in acidic, P-deficient soils in Niger. Seed treatment with ammonium di-hydrogen phosphate increased early dry matter production in 3-weeks old seedlings by 280%, dry matter production at maturity by 30%, and grain yield by 45% compared to the untreated control. Next to coating and priming to enhance seedling nutritional status, methods of seed pelleting additionally focus on homogenizing seed sizes to ease sowing for plant species with varying seed size. With the pelleting technique, using coaters (e.g. mono-amonic phosphate) and binders (e.g. bentonite), pellets are formed that are dried and then applied in the field (Yehia, 2008; Becker Peske and Novembre, 2010).

However, seed coating and pelleting are often expensive, demand a high degree of education, and most importantly, are dependent on access to the required materials. Therefore, it can be assumed, that the attempt to transfer these technologies to Sahelian smallholder agriculture will most likely fail.

When aiming to serve smallholder farmers, there is need to develop simple-to-understand techniques that enhance resource use efficiency, reduce cropping risks, and that are compatible with the socio-economic level of the target people (Schlecht et al., 2006; Fowler and Rockstrom, 2008; Ayuke et al.,2011; Twomlow et al., 2011; Vanlauwe et al., 2010). The seed ball technology represents a valid option to contribute to enhanced Sahelian pearl millet production by (1) using low-cost, locally available, often underutilized resources to improve early plant establishment, plant nutrition and final yields and (2) relaxing labour bottlenecks at the beginning of the rainy season.

The seed ball technology is a novel approach to lower cropping risks and improve farmers' yields in pearl millet production at Sahelian subsistence levels. It comprises the use of low-cost resources such as loam, charcoal, wood ash, manure and residual fertilizers to specifically target water scarcity and the inherent low soil fertility present in most Sahelian soils (Graef and Haigis, 2001). To create a pearl millet seed ball, loam, sand and other additives are air dried and sieved to maximally two mm particle size. Thereafter the materials are mixed together with the seeds in a defined gravimetric ratio. Latest results indicated 50 parts quartz sand and 80 parts loess loam in the prototype seed ball to be recommendable (Butzer, in progress). By adding water, the materials start to bind and create a moist dough from which seed balls are formed by hand (diameter 1 to 2 cm). The balls have to be immediately dried before the seeds inside can germinate (as happened in figure 1, left).

Figure 1: Germinated seed ball prototype after insufficent drying (left); germination of pearl millet seed balls placed on soil surface (right).

Initial research on pearl millet seed balls, performed in 2012 in a collaborative project between ISRA (Senegal) and the Institute of Soil Science and Land Evaluation (310), University of Hohenheim (Germany), showed that seed balls can significantly contribute to improved early pearl millet growth (Mühlena, 2013). Increased nutrient availability next to the emerging rooting system resulted in greater biomass formation and improved nutritive constitution of the plants. Thus, the seed ball technology proved that it had the potential to reduce cropping risks in Sahelian pearl millet production.

Biegert (2013) evaluated the potential of the technology in the social environment of Senegalese subsistence farming using an ex-ante approach. No significant obstacles were identified. Since October 2013, the technology has been further refined at the University of Hohenheim (Butzer, in progress).

The present proposal is in alignment with the submitted concept note; no major changes have been made regarding goal and research hypotheses. Only an additional objective (Objective 3) has been added which more explicitly includes capacity strengthening and communication aspects of our work.

Goal and objectives

The overall goal of the present project is to bring the seed ball technology to a level where it can be integrated in Senegalese and Nigerien farming systems and significantly contribute to improved and less risky subsistence-oriented pearl millet production. Specific objectives are:

1. To optimize the seed ball technology for pearl millet in the Sahel using locally available resources;
2. To validate the seed ball performance under Sahelian field conditions and to determine the agronomic and socio-economic benefits for smallholder farmers in different contexts;
3. To strengthen capacity for seed ball research and application in Senegal and Niger.

4. Testable Hypotheses:

The following hypotheses will be investigated, relating to objective 1 (H1) and objective 2 (H2 & H3):

H1: Locally available resources can be used within the seed ball technology to support early plant development of pearl millet at pilot sites in Niger and Senegal. The local resources of interest are materials that mainly target P deficiency in low fertility soils of the Sahel (e.g. wood ash as source of P, K and $CaCO_3$) but also N during early development stages (manure, modest levels of mineral fertilizer, etc.). In the context of further technology refinement, the focus will lie on resources with low or no monetary input that are readily available to subsistence farmers. In the case of wood ash, this refers to the wood ash quantities that are usually readily available in the smallholder farmer's households; especially to women.

H2: Sahelian subsistence farmers benefit from the seed ball technology with regard to seed and labour requirements, and labour bottlenecks. Seed balls could be made in the dry season when labour for farming activities is less constrained compared to the labour-intensive time of field preparation and planting at the beginning of the rainy season. Seed balls are placed on the soil surface (figure 1, right). Dry planting, a common practice in certain regions of the Sahel, also is possible with seed balls. During planting, the use of seed balls reduces labour requirements as it combines the successive steps of (1) creating planting pockets, (2) inserting seeds and basal fertilizer (in case of fertilizer micro-dosing) and (3) closing the pockets, into one step. In-situ, seed balls could further contribute to reduced seed losses caused by insects, birds and rodents (Overdyck et al., 2013). Overall, seed balls are expected to economize the amount of seed required for planting. Whether seed balls can also economize the required time for thinning will be equally investigated.

H3: Seed balls lower cropping risks and improve farmers' yields in Sahelian pearl millet production systems. As integrative component in Sahelian pearl millet production systems, seed balls could help to maintain grain yields on acceptable levels in times when water is limited and even reduce the risk of total crop failure in the event of a dry spell after planting. As shown in pot experiments by Mühlena (2013), seed balls were able to extent plant growth and seedling survival during a simulated dry spell of up to two days in a sandy soil. Under more favorable moisture conditions, seed balls could contribute to increased grain yields as they provide plant available nutrients next to the emerging rooting system. For the farmers, the costs to produce seed balls are low due to the use of locally available resources, and may even allow the use of very low quantities of mineral fertilizer. The planned economic benefit analysis based on large-scale on-farm data will shed light on these assumptions.

5. Research Strategy:

General research approach and linkages across disciplines

The research in this interdisciplinary, three-year project consists of (1) basic research to optimize the seed ball technology, and (2) applied, farmer-participatory research to assess the agronomic and socio-economic technology performance under "real" target conditions, and to enable and assess related farmer innovations. In addition, capacity development of both scientists and farmers is included as explicit objective in the project. The activities cover the disciplines of agronomy, soil science and socio-economics. Senegalese and Nigerien scientists, students and farmers will cooperate with scientists from University of Hohenheim (Germany) in the process of participatory technology development and implementation, and local capacity building. Our research approach is structured around the three principal objectives, the anticipated results (Outputs) under each, and the respective activities (Act.) to achieve these outputs (see also Appendix, Operational Plan).

Anticipated outputs per objective

Objective 1: To optimize the seed ball technology for pearl millet using locally available resources

Output 1.1. Seed balls mechanically and chemically optimized

Output 1.2. Interactions of seed balls with surrounding soil environment and nutrient flows described

Output 1.3. Knowledge about seed ball performance under different water regimes and under dry versus wet sowing created

Output 1.4. Option for mechanized seed ball manufacturing developed

Output 1.5. Seed ball technology discussed with farmers and adapted to local conditions

Objective 2: To validate the seed ball performance under Sahelian field conditions and to determine the agronomic and socio-economic benefits for smallholder farmers in different contexts

Output 2.1. Seed ball performance and effect on pearl millet productivity validated under large-scale on-farm field conditions

Output 2.2. Economical benefits and risk reduction potential of seed ball technology determined for different contexts and scenarios

Objective 3: To strengthen capacity for seed ball research and application in Senegal and Niger

Output 3.1. Manual for seed ball manufacturing available in French and three local languages

Output 3.2. NARS researchers in Niger and Senegal trained in participatory seed ball research

Output 3.3. Capacity of smallholder women and men to apply seed ball technology strengthened

Output 3.4. International public awareness about seed ball potential increased

Detailed description of activities and methods to be used to reach the anticipated outputs

Objective 1: To optimize the seed ball technology for pearl millet using locally available resources

Output 1.1. Seed balls mechanically and chemically optimized

Act. 1.1.1. Greenhouse pot experiments

Based on previous research (Mühlena, 2013; Biegert, 2013; Butzer, in progress) the seed ball technology will be further optimized by Hohenheim scientists with regard to additives and plant nutrient sources that are available to Nigerien and Senegalese subsistence farmers. Additives as well as different nitrogen sources can severely change the chemical and/or physical properties that in turn have the potential to enhance or inhibit germination and early plant development. To this point, wood ash from cooking places (source of P and K), manure and compound fertilizer (allround nutrient source), charcoal (as porosity enhancer) and different sources of nitrogen have been chosen for further investigation. Specific attention is on the role of nitrogen components on germination. Therefore, a pot experiment series will be conducted in Hohenheim greenhouse facilities to investigate the effects with increasing concentration levels. In particular, CO_2, NH_3 and NO_2^- formation will be measured. The results will provide information for optimal seed ball composition and will enable recommendations regarding maximum dosages of applied additives.

In the frame of this basic research we plan to integrate a Master thesis study conducted by a Hohenheim AgriTropics student , if possible, from one of the target countries.

Output 1.2. Interactions of seed balls with surrounding soil environment and nutrient flows described

Act. 1.2.1. Rhizotron experiments to assess interactions between seed balls and soil matrix

The optimal seed ball does behave like an integral part of the soil matrix and does not present any obstacle to convective or diffusive transport. In order to investigate this, it is planned to adapt methods from rhizosphere research by the Hohenheim team (J. Mühlena, L. Herrmann (PI) and G. Neumann). In particular, the use of rhizotrons is envisaged to investigate water and nutrient (nitrate, ammonium, phosphate and potassium) transport around seed balls. Rhizotron allow the installation of micro-tensiometers or micro-TDR probes to measure water flow. Thus the influence of seed balls on water flow with mimicked rainfall can be determined. According to Neumann (2006) and Neumann et al. (2009) small filter paper chips introduced into the soil can be used to trap defined amounts of soil solution for the analysis of a substance of interest. By arranging filter papers in a 3D grid across the rhizotron, it should be possible to determine the influence of seed balls on the distribution of relevant soil chemical variables (pH, plant nutrients). If successful, this adapted method will help to quickly assess seed ball effects on early plant development. Of superior interest is to determine the interaction with the adjacent rhizosphere in particular with respect to pH, and available phosphate and nitrogen compounds. In this research we would like to integrate a MSc student, favoring candidates from the target countries.

Output 1.3. Knowledge about seed ball performance under different water regimes and under dry versus wet sowing created

Act. 1.3.1. Soil column experiments

This experiment aims at clarifying the feasibility of the seed ball technology under dry and wet sowing conditions. Therefore, 3D soil columns (diameter 0.1m, depth 0.3m) with Arenosol (very sandy soil) material will be applied. Real world rainfall scenarios will be taken from the CODE-WA project (2008-10) collected at the intervention site in Niger. These scenarios cover the whole range of potential events from an extremely dry, over an average to an excessive rainfall year. Dry sowing (before any rainfall) as well as farmer practice (sowing after rainfall that humidifies the top 0.1m) will be explored. In addition, seed ball application on top of the soil as well as covered by the soil are considered. Special attention is on the pearl millet performance during the first four weeks (establishment phase). After four weeks the rainfall simulation will be stopped in order to determine against an absolute control which treatment will lead to the longest survival during an intra-seasonal drought. The experiment will be conducted by J. Mühlena and L. Herrmann (PI, University of Hohenheim).

Act. 1 3.2. Journal paper communication (Plant Nutrition and Soil Science)

From the basic research conducted under Outputs 1.1 – 1.3, the project team will prepare a first, open-access, peer-reviewed journal paper about the seed ball technology. It is planned to use the data from the greenhouse soil column and rhizotron experiments. The paper will be the first publication that deals with Hohenheim seed ball technology research. It will present the technology basics and serve as methodological reference for successive publications during the 3 years project.

Output 1.4. Option for mechanized seed ball manufacturing developed

Act. 1.4.1 Construction of a handicraft mechanical seed ball device

So far, seed balls are made by hand with an approximate output of 800 seed balls per person and day. Under Sahelian conditions approximately 10,000 seed balls are required per hectar. Consequently, mechanization is required. A handicraft mechanical seed ball manufacturing device will be constructed at University of Hohenheim and tested with respect to feasibility and output. First construction efforts have already begun in January 2014 and comprise the use of a wooden plate and a wooden frame which holds a set of parallel arranged cutting threads. However, easier solutions are currently evolving. In contrast to already existing seed ball machines (fuel operated) with an output of 10,000 seed balls per person and day (YouTube documentary: Bones, 1998), it is planned to set the output to 5,000 seed balls per person and day (presuming a working day of 8 hours). Its technical design primarily aims at intuitive handling, ease of repair and low cost construction materials. These criteria are expected to encourage male and female farmers to operate such a device and to provide input on further improvements. This device will allow subsistence farmers and farmer organizations to act as seed ball manufacturer, to potentially commercialize seed balls and thereby become part of the pearl millet value chain.

Output 1.5. Seed ball technology discussed with farmers and adapted to local conditions

Act 1.5.1. Surveys - Understanding local production constraints

During the dry season in 2014/2015 surveys will be conducted at the household level with a stratified random sample of subsistence farmers (gender, age, wealth) in Niger and Senegal. The surveys will specifically target access issues for seed ball materials (involving costs and availability), local production constraints and the viability of seed ball application in the context of subsistence farming (i.e. what are key characteristics that favor technology adoption). The farmers will then be invited for on-station field visits and subsequent introductory seed ball presentation and discussion which will supplement the survey data. In this context it is planned to involve two Master students (socio-economy), one in Niger and one in Senegal (see also Act 2.1.1).

Act. 1.5.2. Field trials in Niger and Senegal and adaptation to local conditions

With the start of the rainy season 2014, on-station field trials with optimized seed balls will be established at ISRA (Bambey station, Senegal). The trials will serve as demonstration site and will provide first agronomic data on seed ball performance as a north-to-south transfer. We shall use a simple two-factorial experimental design (seed ball type and planting depth). Seed ball performance with regard to early plant establishment and final grain yield will be assessed by applying local crop management practices (e.g. thinning and weeding). Site selection will be based on prior soil sample analysis in order to avoid overfertilized fields. Arenosols, the most dominant soil type (belonging to the chemically most infertile ones) in Sahelian West-Africa. The plots will only be established where nutrient contents equal those in subsistence farmer fields.

Act. 1.5.3. Adaptation of the technology with different local materials

Potential seed ball materials differ from source to source (e.g. wood ash) having variable chemical and physical properties (Mühlena, 2013). Differing material properties can therefore change seed ball performance by affecting germination and early plant growth. Therefore, the performance of seed balls based on local materials shall be tested in a repeated field trials and material composition adapted accordingly.

Objective 2: To validate the seed ball performance under Sahelian field conditions and to determine the agronomic and socio-economic benefits for smallholder farmers in different contexts.

Subsistence farmers, especially women, have to cope with various and often complex constraints that might lead to rejection of new technologies (Doss, 2001; Sidibé, 2004; Shiferaw et al., 2008). The development and implementation of the seed ball technology therefore requires careful consideration of both the agronomic and the socio-economic implications. In a transdisciplinary and highly farmer-participatory approach, the seed ball technique will be validated during on-station trials and large-scale on-farm trials that will also stimulate farmer-driven technology refinement by applying methods from participatory rural appraisal (PRA) and participatory learning and action (PLA). Capacity building will focus on four local master students.

Output 2.1. Seed ball performance and effect on pearl millet productivity validated under large-scale on-farm and on-station field conditions

Act. 2.1.1. Identification of MSc students

In each country, two local MSc students will be identified and associated to this work, one agronomy and one socio-economy student each. The students will be trained and mentored by the NARS scientists as well as by the German scientists associated to the project.

Act. 2.1.2. Pre-season workshops, focus group interviews and subsequent farmer-sided technology application

Focus group interviews and participatory workshops will be held together with farmers belonging to the partner farmer organizations, local and international agronomists, and facilitators (the students) during the dry season 2015 (preferably in April/May). The gatherings are planned to be gender-disaggregated to avoid any gender-related bias. Workshops and focus group interviews will be conducted with the aid of the participatory rural appraisal tool (PRA) (Narayanasamy, 2009) and methods from participatory learning and action (PLA) (Neef et al. 2013). The participatory approach encourages farmers to actively involve themselves in the process of technology innovation, get in physical touch with the technology, and so enables them to articulate constructive refinement ideas and critical concerns. The workshops will start with a social gathering, where the technology itself, a pre-version of the seed ball manufacturing guide (see Act. 3.1.1.) and the handicraft seed ball making device (Act. 1.4.1.) will be introduced to the audience. In a second step the farmers will be asked to create seed balls themselves (according to the guide and by using the device or their hands, as they prefer) with a provision of seed ball materials they can freely choose from. By doing so, it will be possible to evaluate their preferences towards certain materials and methods. The workshops will continue with focus group interviews and the farmers' perception, refinement ideas and critics of this technology will be recorded and evaluated (as a prospective). The farmers will then be instructed in important principal application rules that will aid scientist and farmers during the field visits (such as marking planting pockets) and thereafter to take home their self-made seed balls and compare them with their local planting practice ("handing over the stick"). At least 30 farmers per location (hopefully > 50) shall participate in testing the seed ball technology on their farms.

Act. 2.1.3. On-farm field visits to assess seed ball performance

Field visits to on-farm tests will provide agronomic data about performance of the farmer-made seed balls. They will also serve to conduct interviews that capture socio-economic aspects and farmers' experiences with the technology. These findings will be used to further refine the technology, making farmers to innovators and scientists to attendants. If there will be any application issues, all participants, but explicitly women, will be advised throughout the trial period. In fact, the seed ball technique is expected to give a comparative advantage especially on women fields which are often less fertile than men’s fields. Finally, yield data will be collected and farmers' preferences evaluated.

Act. 2.1.4. Retrospective workshop

After harvest, all participating farmers are invited to retrospective workshops (gender-disaggregated) where seed ball performance of all applied seed ball types on grain and stover yield will be compared. This “contest game experience” aims at increasing farmers’ awareness of the possibilities within this technology and a graspable result that is detached from abstract terms and explanations. The workshop closes with a last round of focus group interviews that may confirm or revise previous perceptions of the technology (as discussed under Act. 2.1.2), and stimulate independent innovation ideas, exchange of experiences and future options for seed ball application (e.g. application to sorghum, seed ball commercialization).

Act. 2.1.5. Complementary on-station field trials in Senegal and Niger

Complementary on-station field trials will be conducted in multi-factorial designs which are aligned to farmers’ seed ball applications (as discovered during the participatory workshops). The possible factors are: seed ball type (various material mixtures), mean of seed ball application (at-surface, sub-surface), seed ball size, seed density per ball, way of seed ball manufacturing (mechanically or by hand), and amount of additive dosages. Economic and agronomic data will be collected on all key variables.

Output 2.2. Economic benefits and risk reduction potential of seed ball technology determined for different contexts and scenarios

Both on-farm and complementary on-station field trial data gained under Output 2.1. will be thoroughly analyzed and result into four MSc. theses and two peer-reviewed journal articles that will summarize the agronomic and economical benefits and risk reduction potential of the seed ball technology in different contexts and scenarios.

Act 2.2.1. Master theses on agronomic and risk-reducing effects of the seed balls

The agronomy master theses (one per country) will benefit from the large number of on-farm trials comparing the seed ball technology with local farmers’ practice, and aim to understand and analyze the expected heterogeneity of results. Questions to answer include where and when which type of seed ball provides a comparative advantage and reduces the cropping risk? Throughout their work the students will be aided by their local advisors, and in addition receive support from the Hohenheim scientists J. Mühlena and L. Herrmann.

Act 2.2.2. Master theses write-up on economical benefits

The socio-economic master theses (one per country) will cover the village surveys, the participatory workshops and focus group interviews. Farmer typology, gender issues, and socio-economic constraints will receive particular attention in these studies. Throughout their work they will be aided by their local advisors, and in addition receive support from the Hohenheim scientists J. Mühlena and Prof. R. Birner (Institute of Agricultural Economics and Social Sciences in the Tropics and Subtropics, University of Hohenheim), who has agreed to support the socio-economic part of this project.

Act 2.2.3. Journal paper communications

In a joint effort, the project team and students will jointly elaborate two open-access, peer-reviewed journal papers that deal with the agronomic seed ball performance and the socio-economic aspects under Sahelian field conditions.

Objective 3: To strengthen capacity for seed ball research and application in Senegal and Niger

Output 3.1. Manual for seed ball manufacturing available in French and three local languages

Act. 3.1.1. Release of a seed ball manufacturing guide

On the basis of continued seed ball research and farmer participation, a seed ball manufacturing guide will be released to the public using iconic figures, symbols and pictures and an intuitive user interface. The guide will be translated in French and three local languages, however, it will try to avoid written language to avoid comprehension hurdles for illiterate people. The guide will include information about (1) how to make seed balls by hand or by using the seed ball machine, (2) where to find specific resources, (3) the quality of the resource regarding its benefits and potential risks if applied in the wrong way. It will further cover (4) hints on how to enhance its quality (e.g. how to enrich wood ash from cooking places with P) and (5) a recipe table for making the seed ball dough with possible material combinations and their maximum dosages. The guide will be multiplied as take-home hand manual and poster to equally serve extension purposes.

Output 3.2. NARS researchers in Niger and Senegal trained in participatory seed ball research

Act. 3.2.1. Final project workshop

Through the whole process of the project, and especially during the activities conducted by the project team under Output 2, NARS scientists and students will become increasingly familiar with the seed ball technology and associated participatory research. A final project workshop conducted at the end of the project will synthesize the hands-on experience, identify highlights and shortcomings, constraints and opportunities, and will thus maximize learning for the whole project team.

Act. 3.2.2. Presentation of results at the “Tropentag” conference

For the year 2016 it is planned to invite selected students and project scientists from Niger and Senegal to the “Tropentag” conference http://www.tropentag.de/conference/general.php?menu=2), which is an International Conference on Research on Food Security, Natural Resource Management and Rural Development. During this conference, they will have the chance to present the project results either during poster sessions and/or in panel discussions in front of an international scientific community. The Tropentag conference offers excellent conditions for networking and to receive inputs and experience about development-oriented scientific activities around the globe.

Output 3.3. Capacity of smallholder women and men to apply seed ball technology strengthened

Once the seed ball technology validation will have been complete and will have proven significant advantages for smallholder farmers, local Nigerien and Senegalese public media will be used to communicate the seed ball technology to farmers, farmer organisations, NGOs and other institutions. The campaign will include a wide range of locally available media:

Act. 3.3.1. Elaboration of at least one communitarian/rural radio spot in each country that will be emitted several times at different locations.

Act. 3.3.2. Development of one farmer-to farmer training video. The video will be published on YouTube and distributed on demand to any interested party.

Act. 3.3.3. Design of one poster / brochure that can be suitable also for illiterate farmers, to advertise the seed ball technology, to share experiences and facts about the technology, to self-educate about seed ball application and to engage into further technology innovation. Copies of the brochure and a sample of seed ball for taking home will be distributed to local farmer organizations across Senegal and Niger.

Act. 3.3.4. Organization of at least one farmer-to-farmer exchange visit in each country, to promote farmer knowledge exchange and joint learning.

Farmer organizations play a key role in farmer-driven technology transfer and local adaptation. The partner farmer organizations in each country will be entrusted to act as central meeting point for participating farmers and researchers, and also to sustain communication with the public audience. The goal is to bind future technology extension and farmer-driven innovation to the farmer organization's capacity and by doing so strengthening their importance and influence. In Senegal, the farmer organization FAPAL (Fédération des Associations Paysannes de Louga) will play this role, while in Niger the farmer federation Fuma Gaskiya will be responsible. Fuma Gaskiya represents a strong farmer federation with a sophisticated infrastructure, including rural radio stations in some of the unions. Similarly, in Senegal, rural radios will be used to disseminate knowledge about the seed ball technology to farmers. This will create excellent incentives for farmers to continue their engagement in the innovation process, using this opportunity to start enterprises (e.g. a seed ball manufacturing) and develop self-confidence in their individual agricultural activities, especially for women farmers.

Output 3.4. International public awareness about seed ball potential increased

Communication activities to reach a larger international audience will include:

Act. 3.4.1. Continuous elaboration of a project web site, hosted at University of Hohenheim;

Act. 3.4.2. Creation of a wiki (in French) which will represent a highly dynamic and participatory platform of information exchange. Next to the contributions by external seed ball innovators, it will, at the beginning, provide information about applicable seed ball materials, seed ball making, seed ball application and links to all open access internet sources regarding the project activities;

- At least three publications in international peer-reviewed journals as outlined under Act. 1.3.2. and Act. 2.2.3.

Capacity to conduct this research in Niger and Senegal

The project team is highly qualified to do this work. The PI L. Herrmann draws on more than 20 years field research in West-African. He served as project coordinator of the ICRISAT CODE-WA project (2008-2011) which was funded by the German Federal Ministry of Economic Cooperation and Development (BMZ). The CODE-WA project included studies on West-African climate variability, agro-phytodiversity, multi-location integrated genetic and natural resource management, crop diversity and natural resource management options and additional participatory research activities to assess and strengthen adaptive capacity to changing climates of local stakeholders. BMZ evaluated the project as outstandingly successful. During the CODE-WA project, very good relationships were formed with INRAN and the farmer organization Fuma Gaskiya (next to other institutions across the target countries).

In Senegal the project will benefit from the well established relationships between ISRA and University of Hohenheim within the frame of the BMZ-funded "Abiotic Stress Project". In 2012, first seed ball research was conducted jointly by L. Herrmann, O. Sy and J. Mühlena at the ISRA station, Bambey. Mr. Mühlena spent three months at ISRA, to conduct basic research on the development of a seed ball prototype from a broad range of possible materials. The results of his master thesis encouraged him to continue with seed ball research together with his supervisor L. Herrmann. Since then, two more BSc. Students have been trained at ISRA and University of Hohenheim in seed ball research (Biegert, 2013 and Butzer, in progress). Mr. Mühlena's experiences and strong motivation to bring the seed ball technology to farmers' fields, combined with the good relationships to Ousmane Sy (ISRA), provides excellent preconditions to successfully implement the project.

The long-standing collaboration between University of Hohenheim, INRAN and the partner farmer organization in Niger, Fuma Gaskiya, and between ISRA and the partner farmer organization in Senegal, FAPAL (Fédération des Associations Paysannes de Louga), represent the third pillar of the project that will contribute to successful completion. The project partners know and trust each other, which is an important asset for the planned work.

Likelihood of success in a time frame of three years

Given the outstanding qualification and long-standing cooperation of the project team, team members' strong experience in the target countries, and previous successful cooperation, the probability of success within the three project years is very high. Only the uncertain security situation in the West African region, especially in Niger, might present a slight risk, e.g., hindering site visits of the German experts. But in this case, meetings would be held in Niamey and should not impede project implementation.

Summary of time sequence

The timeline of the project will be three years. The basic research will be completed in the first 2 project years. The applied research will start with preliminary trials in the first year, and the main validation of the optimized technique will take place in years two and three (figure 2).

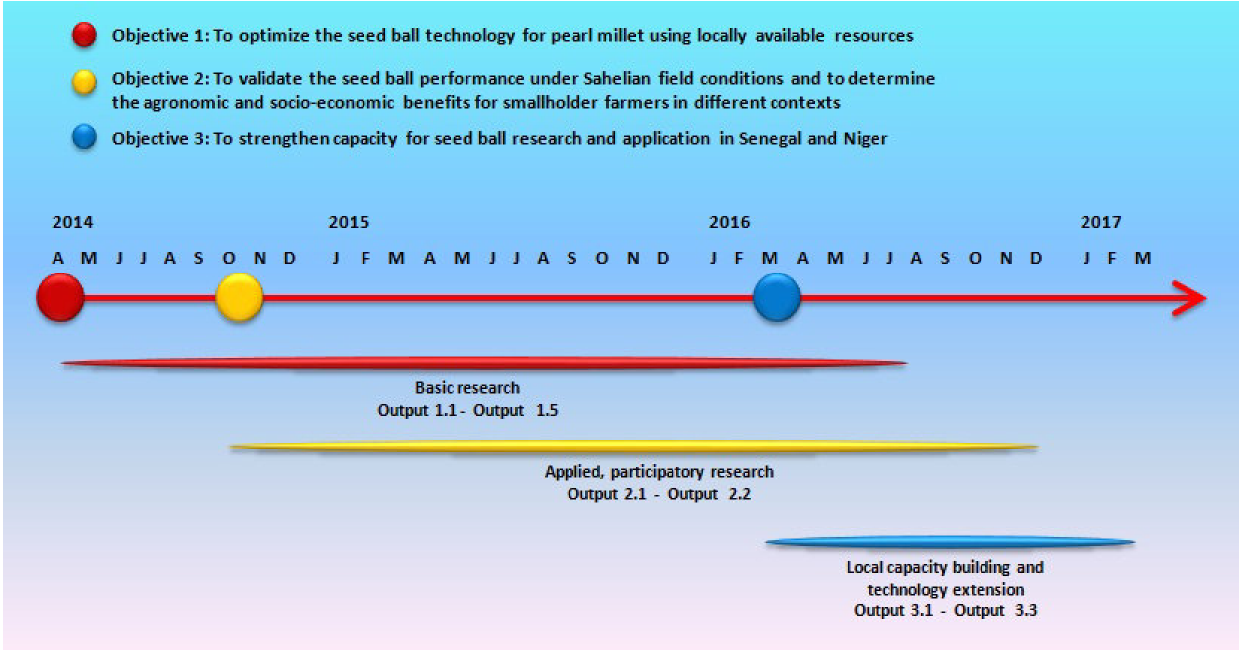

Figure 1: Timeline and project activities.

6. Theory of Change Statement

The projected theory of change for this project is presented in figure 3 below. The diagram is separated into four sections: (1) the current situation subsistence farmers face in the context of Sahelian crop production ("Is-State"), (2) the theoretic background of the participatory seed ball research, (3) the objectives and working activities (as described in more detail under "research strategy") during the three project years and (4), the "New-State" of agronomic and socio-economic conditions for Sahelian subsistence farmers after completion of the project.

The Is-State (e.g. a low plant establishment rate under erratic precipitation scenarios) invokes the motivation for change that is tackled by both, subsistence farmers and scientists. Farmers strive to improve early plant development by means of dry planting. At the same time, scientists provide plant nutrition knowledge, boosting early plant growth by providing nutrients that are readily available right after germination. Seed ball research facilitates and stimulates the innovation processes by mutual action of scientists and subsistence farmers (activities and outputs from Objective 1), trying to include farmers' views in advance, and then further refine the technology and its transfer by actively including subsistence farmers in the innovation process (activities and outputs from Objective 2 and 3).

The theory of change is a working document that will be reconsidered each year and, if need be, revised, based on the learnings of the previous project year.

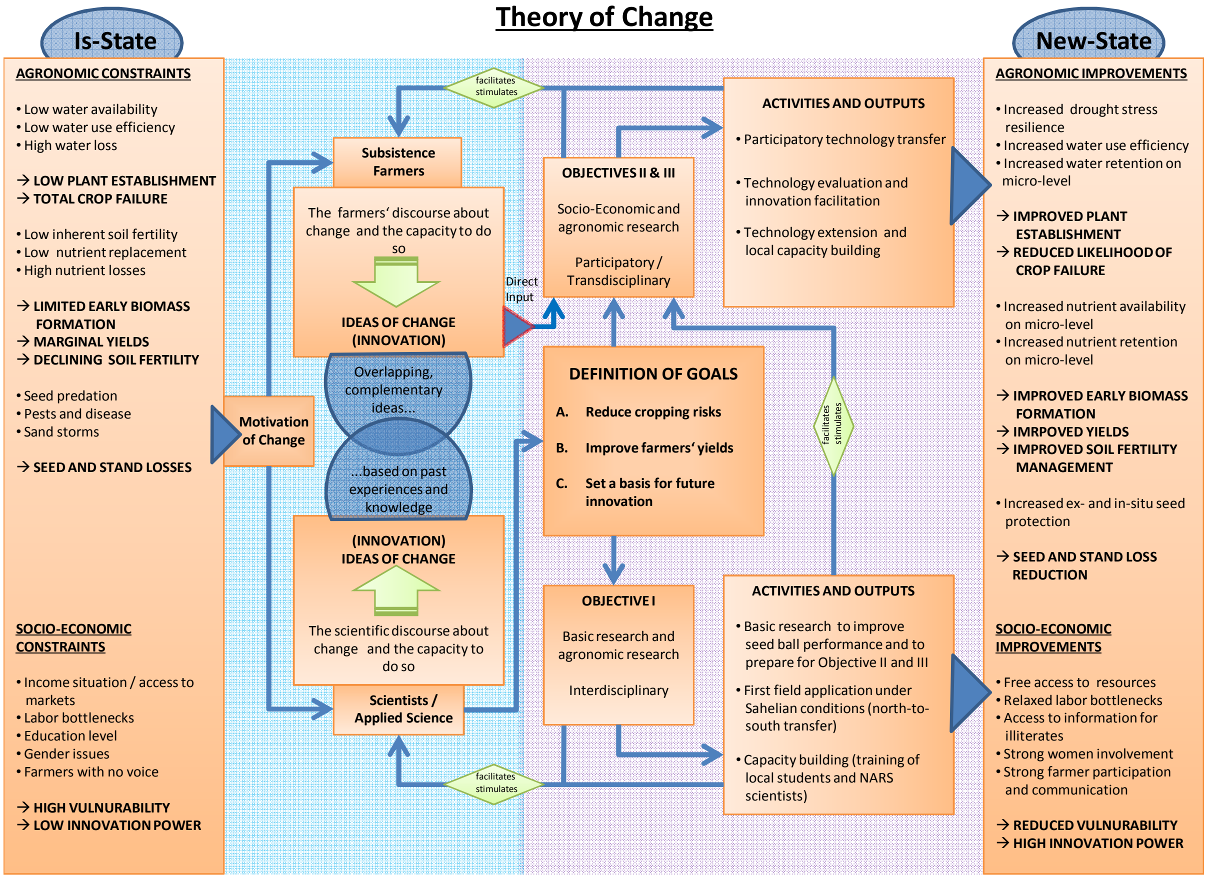

Figure 2: Theory of change flow diagram.

7. Gender Issue Planning

Women will be explicitly involved in the field evaluations, and gender-disaggregated data will be collected whenever possible. In fact the seed ball technique is expected to give a comparative advantage especially on women. This is due to the fact that women fields are often less fertile and farther away from the villages. On the other hand women have easy access to wood ash as one potentially important ingredient as P and K source in seed balls.

Gender issues related to pearl millet cultivation and how they will be approached by the project

Especially in Senegal, planting machines are widely used for pearl millet planting at the beginning of the rainy season. Women often face access restrictions to this technology (expensive lending fees, no draught power, etc.) and may get access to the technology, if at all, at much later dates than men. In Niger, studies have shown that women fields are often less fertile compared to men fields, resulting in lower crop yields. In fact, farming activities with a high monetary, time and labour requirements lead to technology rejection most of the time since such activities are incongruous with women's day-by-day responsibilities. On the other hand, as soon as women get access to easy-to-apply technologies such as wood ash for improved P availability, women would most likely adopt.

With the seed ball technology, women farmers will be offered an alternative planting option to reduce labour requirements at the beginning of the rainy season, gain a time advantage and to profit from a quick and improved plant establishment. By applying chemical fertilizers in micro-dosages and nutrients from alternative sources such as wood ash (P and K), women farmers could enhance early plant development which is determinant to grain yield formation. During the participatory research, women will explicitly be involved in the innovation process, trained in seed ball making and application. By using multimedia for technology transfer, the project will provide the opportunity for women farmers to act as successful pearl millet growers and, potentially, as seed ball manufacturers provided with all tools required to produce sufficient quantities and consistent quality. It is expected that female farmers will play a major role in applying the seed ball technology. In this regard, the project is expected to facilitate a process that makes women farmers leading in seed ball application, manufacturing and marketing.

8. Human and Institutional Capacity Development Strategy:

Objectives in human capacity building

In total four master students will be recruited in Senegal and Niger. They will conduct their master theses in 2015/2016. For each country, there will be one agronomy student and one with a socio-economic background (preferably female). They will be supervised by Ousmane Sy (ISRA), Maman Nouri (INRAN) and the German project scientists and provided with full support to conduct their work on- and off-station. The master students will be involved in all the working steps under Objective 2 to acquire skills and knowledge in a “learning-as-you-do” process. This includes working together with project members to implement household-level surveys and field trials, development of experimental designs, applying these designs during their agronomic and socio-economic data generation and to gain experiences of working in a multi-cultural, interdisciplinary context. As part of the research team, they will take part in the publication process of journal papers and selected students (English language skills mandatory) will be invited to the “Tropentag” (International Conference on Research on Food Security, Natural Resource Management and Rural Development) 2016 in Europe, to present their results to an international audience. This will also enhance their professional networks.

Furthermore, the option of bringing the students from Niger and Senegal to the University of Hohenheim to participate in a summer school or in specific modules of the AgriTropics programme will be investigated.

Objectives in institutional capacity building

Institutional capacity building starts with individual people. The present project, being rather small, can only indirectly contribute to institutional capacity building, by training individual scientists that may take over leading positions in the future.

Time plan for human resource development (short term and long term) and key institutional capacity building

The main human resource development activity will take place during the years 2015 and 2016, when the large scale on-farm trials and participatory evaluation of the seed ball technology will take place. The process of data analysis and writing up the results and especially the publications will be a joint effort, involving constant peer-reviewing and mentoring among the project team members (student-student, scientist-student). The final workshop at project end is expected to bring the gained knowledge and learnings to the point. Further capacity strengthening will be provided by enabling the NARS partners and selected students to present results at the “Tropentag” Conference.

9. Communication Planning

Communication of project progress, learnings, ultimate results and recommendations will be an integral part of the project and is made explicit under Objective 3. Communication and knowledge sharing will be achieved through the following means:

- A project-specific web-site (hosted at University of Hohenheim)
- Annual workshops with all project partners, including farmer representatives;
- Annual planning and review/feedback sessions with the participating farmers;
- At least three communitarian radio spots at the Niger site;
- At least three open-access publications;
- At least two conference papers / posters;
- One farmer-to-farmer training video (once the seed ball technology has been sufficiently validated);
- At least one brochure for farmers;
- At least one farmer-to-farmer exchange visit in each country.

10. Conflict of interest statement

This research proposal has not been submitted to any other donor, and we do not see any conflict of interest. Our suggested research would build on previous collaboration of University of Hohenheim with ISRA and Fuma Gaskiya that took place within two completed ICRISAT research projects funded by the German Ministry for Economic Cooperation and Development (BMZ), namely the projects "Community management of crop diversity to enhance resilience, yield stability and income generation in changing West African climates (CODE-WA)" (2008-2012; http://codewa-icrisat.uni-hohenheim.de/Website/Welcome_to_the_CODE-WA_homepage.html) and "Tackling abiotic production constraints in pearl millet and sorghum-based agricultural systems of the West African Sahel" (2010-2014). The present project will seek synergies with the Fuma Gaskiya-led project entitled "Improving family welfare through diversifying production on womens' fields in Niger" funded by the McKnight Foundation Collaborative Crop Research Program. This will facilitate the explicit inclusion of women in the present project.

11. Detailed Budget, Budget Justification and Contingency Planning:

The total requested funds for this project amount to US $ 195,000.-. Budget repartition among partners is as follows: ISRA: US $ 37,730, FAPAL: 18,040.-; INRAN: US $ 43,670.- ; Fuma Gaskiya: US $ 24,664.-, University of Hohenheim: US $ 70,896.-. For details, please see the separate template.

Personnel Cost/Salaries

For Hohenheim the costs concern the salary of the co-investigator (Ph.D. level) when working in West Africa (Activities 1.4, 1.5).

The farmer organisations (FAPAL, Fuma Gaskiya) receive support for animators, continuously working with farmers in cooperating villages and in case of Fuma Gaskiya a salary topping up for the director who is a key person for the success of the project and, in previous projects, has shown to be highly engaged for the interest of the farmers.

The national research institutions (ISRA, INRAN) get one full salary for one technician each who is responsible for the on-station trials as well as for the support of on-farm trials with the farmer organizations. The line item includes also a topping up of the national researcher in charge. In the case of INRAN we intend to also support the re-integration of Hannatou Moussa into the national research of her home country. Hannatou Moussa is a Ph.D. candidate of the University of Hohenheim (defense in March 2014) and the majority of her salary will be covered by a CIM stipend. Hannatou Moussa is intended to be the major research partner at INRAN. Dr. Nouri is intended to be in charge of supervising the master students only.

Travel

The farmer organisations (FAPAL and Fuma Gaskiya) receive a budget for all on-farm related travel activities (2.1, 2.2) and for two farmer exchange visits each (self-organised 2015/16).
The NARS (ISRA, INRAN) also contribute to on-farm activities (1.5, 2.1, 2.2) and need therefore, an in-country travel budget.
International travel costs of Hohenheim concern five travels in 2014-16 to West Africa in the context of activities 1.4, 1.5 and 2.1 (research stays, workshops).

Supplies

The supplies attributed to Hohenheim concern the basic research experiments conducted under activities 1.1-1.4 in Hohenheim (e.g. soil column, rhizotron) during the first two years.
The NARS receive supplies for the on-station trials (ISRA 2014/15, INRAN 2015, activity 1.5) and the farmer organisations for on-farm trials (activities 2.1, 2.2)

Training

The greatest share of the budget for Hohenheim is dedicated to the final workshop (20,000 USD), inviting all major project participants (probably to Niger, depending on security situation). In addition two master and one bachelor study are funded under activities 1.1-1.3.
The NARS supervise 4 master studies in the field of agronomy (2, one per site) and economics (2, one per site). Costs are calculated as 200 USD per month for one year per study.
Farmer training on seed balls happens during at least three workshops organized by ISRA, FAPAL and Fuma Gaskiya (one each).

Other direct costs

Hohenheim is responsible for seed ball mechanization, seed ball manual production including translation into 4 languages, and at least three international journals.
ISRA and INRAN scientists as well as the Fuma Gaskiya director will receive funding for the Tropentag conference in order to present their results.
In addition the farmer organisation FAPAL receives funding for the production and emission of radio spots and the on-farm trial planning and summarizing meetings (2015/16, 4 meetings in total per farmer organization).

Indirect costs

For the indirect costs the following scenario is applied. University of Hohenheim serves as major partner. The overheads charged are 12%. Overheads for the other institutions are calculated with 10%.

Contingency planning

In the case of a 10% lower contingency than requested, we would reduce the line item international travel, since the related activities can partly be replaced by skype or video conferences. In the case of a higher budget attribution we would invest in further communication of results (e.g. radio emissions) and capacity strengthening of local farmer organisations, since they represent the most efficient multipliers of innovations.

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13. Curriculum Vitae

1. CV of Main Investigator Ludger Herrmann

Profile

Name:	Dr. Ludger Herrmann
Country of Citizenship:	Germany
Date and Place of Birth:	April 9th 1963 (Recklinghausen, Germany)
Profession:	Senior Researcher (Akademischer Oberrat)
Contact Address:	University of Hohenheim Institute of Soil Science and Land Evaluation (310) 70593 Stuttgart, Germany Phone. +49 711 459 2324 Fax. 49 711 459 3117 email: herrmann@uni-hohenheim.de Internet: www.uni-hohenheim.de/~herrmann

Professional Experience

Since summer 2010	Senior researcher and head of laboratory at the Institute of Soil Science and Land Evaluation, University of Hohenheim, Stuttgart, Germany. Presently finalizing the habilitation (venia legendi in general and tropical soil science).
2008 - 2010	Scientific employee of University of Hohenheim, coordinating the BMZ-funded CODE-WA project in collaboration with ICRISAT – Niger, based in Niger (West Africa).
2005 – 2008	Parental time and freelance, based in Niger (West Africa). During this period volunteer staff in the SFB 564 and in the BMZ project CODE-WA. Activity as highschool teacher (Université Abadou Moumouni Niamey) and extension agent (Eirene, ICRISAT). Freelancing as book author and movie director (educational and documentary movies).
1999 – 2004	Leader of the mineralogy lab at the Institute of Soil Science and Land Evaluation, University of Hohenheim.
1996 – 1999	Assistant professor, laboratory head and coordinator of the interdisciplinary project "Atlas of natural and economic resources of Niger and Benin“ at the Institute of Soil Science and Land Evaluation, University of Hohenheim.
1991 – 1996	Researcher in the "Special Research Programme 308 Adapted Farming in West Africa“ at the University of Hohenheim in collaboration with ICRISAT, IITA, INRAN and CENAP.

Focus on soil fertility, terrestrial element cycles, spatial soil resource distribution.

Publications relevant for the research project

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2. CV of Co-Investigator Ousmane Sy (ISRA, Senegal)

Profile

Name:	Ousmane Sy
Country of Citizenship:	Senegal
Date of Birth:	January 2nd 1957
Profession:	Millet breeder
Contact Address :	ISRA/CNRA Sélectionneur mil BP 53, ISRA/CNRA, Bambey, Senegal Phone (int) +221 33 973 63 48 Fax. +221 33 973 63 48 Mobile. +221 77 652 80 19 email: oussousyso@yahoo.fr

Education

2006	Master of Science (biology), University of Bermingham (England)
2004	Bachelor of Science (biology), University of Bermingham (England)
1986	Certificat d'Aptitude professionnelle en sélection des plantes (CAP), Faculté des régions Chaudes, Gembloux (Belgium)
1980	Diplôme universitaire de Technologie (DUT), University Cheikh Anta Diop de Dakar (Senegal)
1978	Baccalauréat Technique en Biologie (Bac F), Lycée technique André Peytavin, Saint-Louis (Senegal)

Professional Development

2009	Training in techniques of millet breeding and multi-spatial analysis with GENSAT (ICRISAT, Niamey, Niger)
2009	Advanced training in millet breeding techniques and multi-spatial analysis with GENSAT (ICRISAT, Niamey, Niger)
2008	Training on preventive measures to respect when using genetically modified organisms (GMOs). (BIOSECURITE), University of Bamako (Mali).
2008	Training on advanced statistical methods in agronomic research. (ICRISAT / Bamako / MALI).
2008	Training on marker assited breeding methods (Université Legon de Accra / Ghana).

2007	Training on participative plant breeding (NARI/Barentu/ERYTREA).
2007	Training on concepts and techniques of pearl millet and sorghum hybrid breeding. (ICRISAT / Bamako / MALI).
1999 – 2000	Training on plant protection in oleiferous crops in West Africa (Centre AGHRYMET / Niamey / NIGER).
1989 – 1990	Training on techniques of seed protection and conservation in West Africa (ICRISAT / Niamey / NIGER).
1983	Training on medium to long-term seed conservation (IITA, Ibadan, NIGERIA).

Professional Experience

2006 – 2014	Pearl millet breeder and responsible for genetic resources at Centre National de Recherches Agronomiques (CNRA) de Bambey.
1981 – 2004	Plant breeding research assistant at Centre National de Recherches Agronomiques (CNRA) de Bambey.

Languages Skills French (first language), English (advanced).

3. CV of Co-Investigator Jan Mühlena

Profile

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Education

2010 - 2013	Master of Agricultural Sciences in the Tropics & Subtropics, University of Hohenheim (AgriTropics Master Programme) with emphasis on natural resource management and tropical plant production systems.
2005 - 2010	Bachelor of Agricultural Sciences, University of Hohenheim, with emphasis on soil and plant science.
2001 - 2004	Common Academic Degree, Agrarian-Scientific Gymnasium (Richard-von-Weizsäcker-School), Öhringen, Germany.

Professional development

From December 2013 onwards	Scientific employee (Ph.D student) at University of Hohenheim.

Scientific Experience and Trainings

2013	Invitation to the Science Day 2013 at the Stuttgart Media University and presentation of up-to-date seed ball technology research.
2012	Stay in Senegal at the Senegalese Agricultural Research Institute (ISRA) for the development of the seed ball technology for subsistence-oriented pearl millet production systems.
2009	Stay in Ethiopia in collaboration with the Institute of Sustainable Development (ISD, Addis Ababa) for research on the impact of long-term compost application on soil Properties in subsistence-oriented farming systems.

2007 - 2008	Stay in Australia for a practical training on fruit production and crop management (mango, pineapple and strawberry). Company: Pinata Marketing PTY LTD, Wamuran, Queensland.

Publications relevant for the research project

Mühlena J. 2013.”Seed Ball Technology Development for Application in Pearl Millet Production Systems in Semi-Arid Senegal.” Master thesis. University of Hohenheim. Advisors: Stahr K., Asch F., Herrmann L.

Languages Skills	German (first language), English (advanced), French (elementary).

4. CV of Co-Investigator Ali Maman Aminou (Fuma Gaskiya)

Profile

Name:	Ali Maman Aminou
Country of Citizenship:	Niger
Date of Birth:	June 28th 1972
Profession:	Director of farmer organisation Fuma Gaskiya, Maradi, Niger.
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Education

1998 – 2002	Bachelor of Science (agronomy), University of Agriculture Abeokuta. Federal Republic of Nigeria
1997 – 1998	English study, Alvan Ikoku College of Education Oweri (Nigeria)
1992 – 1996	Senior secondary school (Tagama), Agadez, Niger
1986 – 1991	General College of Education, Madaoua, Niger
1979 – 1986	Primary school Agadestaoua, Madaoua, Niger

Professional Experience

2004 onwards	Director of FUMA Gaskiya, Maradi, Niger.
2004	Regional officer of agricultural inputs at the regional agricultural service in Maradi.
2004	Deputy officer of agricultural inputs at the regional agricultural service in Maradi.
2003- 2005	National civil servant.
2001	Student at Teaching Farm Management Committee, University of Agriculture Abeokuta, Federal Republic of Nigeria.

Language Skills French (first language), English (advanced).