Alliance of CGIAR Centers
Best Bets to Boost Crop Yields
in Sub-Saharan Africa

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▪ Preface ▪

The following data entry sheets are to be included in an e-database that may be built by the CGIAR Secretariat or the World Bank for further use. Each Center of the Alliance of CGIAR Centers was asked to fill out the proforma, which evolved after the first teleconference of April 2008 between the World Bank, CGIAR Centers and Sasakawa Africa Association, which was facilitated by the CGIAR Secretariat. There was feedback given thereafter by Karen Brooks and other World Bank staff to David Watson during a NEPAD/AU workshop held in Johannesburg in May 2008, and further exchanges on a 2nd teleconference in June 2008 facilitated by the CGIAR Secretariat. Under the guidance of the Alliance of Deputy Executive Mark D. Winslow and Rodomiro Ortiz exchanged views to simplify the information of best bet through data entry sheets. Each proforma was for up to ten of the respective Center's or system-wide program most promising best bets for boosting crop yields in sub-Saharan Africa. The information captured has helped the Alliance of CGIAR Centers to compile inputs across Centers efficiently into a database format that can be organized into different useful views (by country, region, center or time-frame).
The filled Best Bet proformas are given sequentially by Center as submitted by 12th June 2008. They almost adhere to the format and word limits as given below:

1. Acronym of lead Center for this Best Bet;
2. Best Bet keyword description (1-3 words ONLY);
3. Best Bet short description (5-10 words ONLY);
4. Best Bet full description (Do not exceed 300 words. Use simple non-formatted text in concise factual abstract style);
5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet;
6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone; please give a single number, not a range; please be realistic based on farmer-managed on-farm testing results;
7. Location-specificity: 1 = low (the Best Bet can scale-out widely with minimum local adaptation), 2 = requires a moderate degree of local testing and/or adaptation, 3 = high (requires significant local testing and/or adaptation;
8. Most promising countries for this intervention. Name up to ten (not more; less is OK) countries that you would prioritize for this intervention. List them in priority order (highest priority first) based on your judgment of highest potential impact/benefit;
9. Time frame required to effectively deploy (including needed research, testing, capacity-building, local customization etc.) the Best Bet in a typical target country if sufficient resources are provided. Choose one of the following: Short (1-2 years), Medium (3-5 years), Long (6 or more years);
10. Most effective modes of delivery (100 words or less), mentioning partnership types (public, private, market-chain, policy, etc., not naming specific institutions but just types of institutions) and modes (e.g. participatory selection, commercial-led, community-based, farmer co-ops, extension service-led, farmer field schools required etc.);
11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries (100 words or less);
12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet (surveys, diagnostics, monitoring, impact and risk assessments, backstopping, key bottleneck or knowledge-gap research, key research opportunities to enhance this Best Bet, etc.) Describe the research budget needed in approximate terms (e.g. a team of four scientists from which disciplines needed for 3 years for a region, @US $250,000/year-scientist; pro-rate according to part or full time); (100 words or less);

13. Any special information you feel is important concerning this Best Bet that is not covered in the above, e.g. special cautions, enabling pre-conditions required, special risks, synergies, spillovers, opportunities, value-addition, timeliness, circumstances, country-specific issues etc. (100 words or less);
14. Key contact person for more info (one or at most two names only, first + last name, plus email address only).

The data sheets were compiled by Rodomiro Ortiz (Alliance Deputy Executive chair, r.ortiz@cgiar.org) with inputs from:

Africa Rice Center;

Bioversity International;

Centro Internacional de Agricultura Tropical;

Centro Internacional de Mejoramiento de Maíz y Trigo;

Centro Internacional de la Papa;

International Center for Agricultural Research in Dry Areas;

International Crops Research Institute for the Semi-Arid Tropics;

International Institute of Tropical Agriculture;

System-wide Program on Integrated Pest Management;

International Rice Research Institute;

International Water Management Institute.

Data entry sheet: 2.1

1. **Acronym of lead Center:** Bioversity International

2. **Best Bet keyword description:** Diversity field fora

3. Best Bet short description: Modified farmer field schools with focus on crop diversity assets

4. Best Bet full description: Marginal environments are often very heterogeneous, creating a multitude of side-effects that combine to make it difficult for breeding programmes to select appropriate cultivars. The challenges that they create for farmer selection of cultivars and the development of reliable seed systems (formal or informal) are less well recognized. These factors include:

- Strong genotype by cultivar interactions, so that evaluations of cultivars only apply within a limited environment
- Low heritability of yield, meaning that cultivars need to be tested with more replicates over more years before reliable results are obtained
- Low yield stability, complicated by the fact that in subsistence situations farmers tend to be very risk averse
- Rate of adoption of improved seed is generally very low due to institutional, agronomical and socio-economic constraints

All of these constraints are exacerbated by the difficulty farmers face in obtaining information on the appropriateness of cultivars. While some superior cultivars exist within the diversity of local cultivars present in a region, their superior qualities may go unrecognized or untapped because of a dearth of information. The diversity field forum was developed as a means to bring together farmers' groups (men and women) to exchange information that will allow the identification of "elite" local materials or improved cultivars. Using their own criteria, farmers evaluate and select from collections of local and introduced materials suitable cultivars. With assistance from researchers and extension services, they produce quality seed of the selected cultivars. Through the diversity field fora, seed distribution is organized more effectively within and outside participating villages. The system was very successful in boosting production of pearl millet and sorghum, as well as neglected crop species and newly domesticated crops in Sahelian Africa (Burkina Faso, Mali and Niger). In addition, the system resulted in greater social cohesion among participating farmers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna of Sahelian region of West Africa

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: Ten per cent yield increase has been observed in Aguié, Niger and Bomboro, Mali

7. Location-specificity: 1 - Can scale-out widely with minimum local adaptation

8. Most promising countries for this intervention: Mali, Niger, Burkina Faso, Benin, Togo, (northern) Nigeria, Senegal, The Gambia, Mauritania, Guinea Bissau

9. Time frame: Short (1-2 years)

10. Most effective modes of delivery: For effective delivery of diversity field fora, facilitators

(technician or farmers) will be trained. They will communicate with farmers' groups to assess key production constraints. Existing local or introduced solutions will be identified. Partnerships among experienced national and international research and development institutions will be established for scientific and technical supports. A public awareness campaign through meetings, mass media and appropriate publications will be organized to obtain the buy-in of decision makers. To scale up or scale out the approach at national and regional levels, local and national governments support in the form of incorporation of the initiative in development agendas is needed

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: In Mali, financial resources are needed to cover:

- Training of facilitators:
- Number:120 facilitators for Mali on millet, cowpea and bambara groundnut
- Duration of the course: three sessions for 40 participants based on agro-ecological zones. Each course will last 5 days
- Cost: Each course including travels and trainers will cost US$ 25,000
- Setting up of diversity field fora:
- Basic field equipment (plow, spray machine, cleaners etc.): US$ 10,000
- Fertilizers and chemicals, bags and other supplies: US$ 10,000

Total budget (one year): US$ 120,000

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research efforts are needed in backstopping. A team of three scientists (agronomist, seed specialist and socio-economist) will visit the farmers at starting, implementation and harvest stages to assist in technical aspects of research or seed production/distribution

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Local governments' and national research and extension services' buy in is essential to the success of the diversity field fora

14. Key contact person for more info: Raymond S. Vodouhe, **r.vodouhe@cgiar.org**

Data entry sheet: 2.2

1. **Acronym of lead Center:** Bioversity

2. **Best Bet keyword description:** BBTV-free bananas

3. **Best Bet short description:** Vitroplants and macro-propagated banana plants free of BBTV

4. **Best Bet full description:** No resistant cultivars or source of resistance are known for banana bunchy top virus (BBTV) and re-infection can occur readily. The best bet technology is to develop a reliable testing system and clean seed multiplication strategy. Initially suckers of superior mother plants of preferred marketable cultivars must be collected, tested for BBTV and then cleaned of the virus if present. Clean shoot tips can then be multiplied in tissue culture laboratories. Once clean planting material is multiplied, a screen house can be established to maintain a source of new suckers for tissue culture readily available for on-going multiplication. In the infected zones farmers must learn the diagnostic of BBTV symptoms, virus and vector ecology and the need for eradication of infected plants. Virus-free vitroplants can be grown out in hardening nurseries locally in shade houses near farmers' fields. Farmers need to learn to manage tissue culture plants which are more demanding in soil moisture and weed management than suckers, monitor the re-infection rate, eradicate infected plants and develop decision criteria about when to completely replant. In regions where infection rate is low, macro-propagation can be used to multiply additional clean planting material locally at a lower cost. However, when re-infection rates are high, a continual supply of planting material is needed for annual or biennial replanting. This technology is easily applied in dessert type bananas (AAA) and cooking bananas (ABB). In plantain (AAB) the presence of banana streak viruses (BSVs) integrated into the cell DNA complicates the use of routine tissue culture for commercial multiplication of vitroplants. Strategies to macro-propagate BBTV-free local plantain cultivars in protected screen houses can be used to minimize the expression of BSVs. However, virus testing and tissue culture are still needed to maintain a regular supply of BBTV-free vitroplants

5. **Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet:** Non-irrigated zones where bananas are grown with BBTV present, including humid forest, dry forest, moist savanna and highland

6. **Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone:** 80% on-farm yield gain in the first crop cycle when BBTV free planting material is used to replant in zones heavily infested with BBTD. Ratoon crop yields depend on re-infection rate. If re-infection rate is high, frequent replanting is needed

7. **Location-specificity:** 1 = Low location-specificity. Only condition is that BBTV be widespread among local cultivars of banana and plantain

8. **Most promising countries for this intervention:** Democratic Republic of Congo, Malawi, Angola, Burundi, Republic of Congo, Central African Republic, Rwanda, Mozambique, Zambia

9. **Time frame:** Medium (3-5 years) for dessert banana type AAA and cooking banana type ABB
Long (6-10 years) for plantain type AAB

10. **Most effective modes of delivery:** Public research and extension organizations to identify preferred

market cultivars and collect suckers, develop understanding of BBTV and vector ecology and train extension and farmer promoters; advanced research laboratories to test for and clean BBTV and other viruses; private tissue culture laboratories to multiply rooted vitroplants; farmer organizations, NGOs or private nurseries to grow out plants; NGOs, extension agencies or farmers' organizations to run farmer field schools; plant quarantine offices locally and nationally to run public awareness campaigns, control importation of virus-free planting material and to restrict movement of planting material from infected areas to uninfected areas

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: To reach 4000 farm households (small country or region in large country), a team of project management, extension agents and young promoters works with farmer organizations through farmer field schools for three to five years. They need the support of local office and transportation set-up, tissue culture labs, technical assistance from advanced scientists in BBTV, national agricultural scientists for field research and training, plant quarantine offices and national social scientists for baseline surveys, monitoring and evaluation. Key activities are extension agent training, farmer field schools, local nurseries and feedback to local and national decision-makers. The budget would be about US$ 2,000,000

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: A team of part-time international advisors and regional scientists could cover three countries described in 11. Scientists need to have knowledge of BBTV in the laboratory and in the field, of BSV in tissue culture multiplication, diagnostic surveys of diseases, baseline surveys, monitoring and evaluation, training and policy analysis. Research is particularly needed for simple virus detection methods for use in national seed systems, improved procedures for tissue culture multiplication of plantains to reduce BSVs expression and hybridization and simple monitoring strategies in the field. Budget - US$ 450,000 for two months/year - 3 advanced scientists; US$ 1,350,000 - 3 full time regional scientists

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: The development of clean seed strategies depends on factors which are not uniform in BBTV-infected countries. The first factor is the extent of local or unique banana or plantain crop diversity. Where diversity is high, more efforts are needed to conserve clean seed of diverse cultivars on farm and in the market. The second factor is the importance of plantain types AAB. Finally, countries vary in terms of existing infrastructure for setting up and maintaining clean seed supplies. The implementation of this best bet needs to take into account these factors for initial success and on-going development

14. Key contact person for more info: Charles Staver, **c.staver@cgiar.org**; Gus Molina, **a.molina@cgiar.org**

Data entry sheet: 2.3

1. Acronym of lead Center: Bioversity International

2. Best Bet keyword description: Managing *Xanthomonas* wilt

3. Best Bet short description: Adopting budless cultivars and de-budding to manage banana *Xanthomonas* wilt

4. Best Bet full description: Banana bacterial (=*Xanthomonas*) wilt is spreading aggressively in East and Central Africa causing serious losses in dessert and staple food bananas that are a mainstay of the local economy. Transmission of the disease can be interrupted immediately if farmers are trained, using participatory methods, to understand the disease and especially to remove the male flower buds from their bananas (interrupting insect transmission) and to disinfect contaminated tools. Longer term improvement depends on encouraging farmers to rigorously destroy infected plants and enabling them to replant with clean material. The robustness of the strategy can be enhanced with the introduction and adoption by farmers of mutant cultivars that genetically lack a male flower bud and can be substituted for traditional cultivars. Wider spread can be contained by education and quarantine measures to reduce the spread of contaminated material by human agency

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highland, moist savanna, humid forest

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 40%

7. Location-specificity: 1 = low

8. Most promising countries for this intervention: Democratic Republic of Congo, Tanzania, Kenya, Uganda, Rwanda, Burundi, Ethiopia

9. Time frame: Medium

10. Most effective modes of delivery: Simple farmer field schools and farmer education needed for dissemination and adoption of on-farm disease management and for evaluation of adoptability of new (budless) cultivars; international public sector actions for introduction (from Asia) of budless cultivars; collaboration between public research and private sector for dissemination of clean planting material; policy action for quarantine measures; training of quarantine and extension staff to reduce spread of infected material

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Training of trainers for farmer field schools in each district @ US$ 30,000 per District for two years, plus central (national) unit to prepare/adapt training materials and develop/monitor national strategy: US$ 100,000/year, consultancy to evaluate capacity of national clean seed system and recommend upgrades: US$ 30,000, interventions to strengthen national seed system at US$ 300,000, consultancy to facilitate policy changes (quarantine measures, byelaws): US$ 20,000, training course for national quarantine officers: US$ 50,000, and training course for extension officers: US$ 25,000 per Province

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best: Surveys, initially to evaluate current disease status, as well as farmer knowledge/attitudes, later to monitor impacts of interventions and evaluate need for further actions: one biophysical researcher, one socio-economic researcher, plus enumerators, in year 1, year 3 and year 5 – total US$ 300,000 for each of these years. Knowledge gap research to confirm user acceptability and adaptability of one element (budless mutants from Asia to replace similar local cultivars): Two years, one researcher 50% FTE at US$ 100,000/year. Backstopping research, to ensure that clean planting material remains clean (risk of re-infection from non-crop hosts): Two years, one researcher 50% FTE at US$ 100,000/year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Considerable effort and resources have already been invested by various donors in 'solving' this problem but such efforts have been piecemeal and not properly coordinated – and not supported by proper monitoring and evaluation. It will be important in a new effort to have a flexible approach with sufficient resources for planning and coordination, in order to tailor generic approach to needs of each country and achieve gains by sharing experiences and resources among countries at different stages of implementation

14. Key contact person for more info: Eldad Karamura, **e.karamura@cgiar.org**; Guy Blomme, **g.blomme@cgiar.org**

Data entry sheet: 3.1

1. Acronym of lead Center: CIAT

2. Best Bet keyword description: Climbing bean, high yield, adaptation

3. Best Bet short description: Recent innovation, high yield potential bean in populated, food deficit highlands

4. Best Bet full description: Climbing bean has 3:1 yield potential compared with traditional bush bean cultivars. It is ideally suited to densely populated, moist regions above about 500masl, with chronic food deficits and severe land pressure. Improved cultivars with multiple resistance to the crop's main diseases and in a broad range of marketable grain types and edible leaves, are popular with farmers in the Great Lakes region, where they were first introduced. High adoption rates (>50%) were reported in Rwanda soon after introduction. More than 14 NARS in East, Central, Southern and West Africa have identified or released cultivars within record times due to their popularity. For example, new high yielding cultivars were released recently in Democratic Republic of Congo, Burundi, Uganda, Kenya, Tanzania and Rwanda. Their vertical exploitation of space encourages cultivation in small plots even in urban areas. They can be harvested over 30 to 60 day period because pod maturity starts from the bottom, either as quick-cooking green shelled seeds, as mature dry grain, or as edible leaves, further broadening and complementing dietary options. Two types of cultivars have been developed: high altitude climbers (> 1500 m.a.s.l.) suited to relatively fertile soils and high rainfall, disease-prone areas, which are the traditional production environments; and medium altitude climbers for the warmer, humid to sub-humid regions (500-1500 m.a.s.l.) with heat stress and moderately low soil fertility. Main limitation to broad dissemination is seed availability, partly because there are not large scale seed production programs, and secondly because farmer and consumer preferred grain types were not previously available in many countries. Staking is needed, and distribution of a quick-growing agro-forestry species is advisable for extensive cultivation or use of alternative staking options. Inoculation with well tested and locally available rhizobia strains (singly or in multi-strain inoculants) with a small dose of phosphate (e.g. triple super phosphate) strongly enhances the realization of yield potential

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highland

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 200% (compared to bush bean - current local practice)

7. Location-specificity: 2 = requires a moderate degree of local testing and adaptation

8. Most promising countries for this intervention: Burundi, Democratic Republic of Congo, Uganda, Kenya, Tanzania, Rwanda, Malawi and Ethiopia

9. Time frame: Short (1-2 years)

10. Most effective modes of delivery: The following delivery mode, know as 'The Wider Impact Program (WIP) is based on past experiences in a highly successful collaboration among PABRA partners:
1. Adaptive participatory testing in specific agro-ecologies where agronomic performance is not yet confirmed, by PABRA-CIAT, NARS, farmers, with input from traders, grain dealers.

2. Production of nucleus seed by CIAT and NARS scientists
3. Production of breeder seed by NARS and certification agencies for delivery to formal and informal seed producers, under contract
4. Production of foundation seed by private sector, farmer groups, communities, CBOs, or NGOs in partnership with NARS and CIAT
5. Large scale production and dissemination of certified, quality declared and other types of seed with private sector, communities, farmer groups. Decentralized producers, in particular, often have intensive coverage even in marginal and hard-to-reach zones
6. Production (i.e. development, adaptation and/or translation of new and existing manuals), distribution and use of training and promotion materials
7. Cultivar promotion with partners through diverse channels and partners: including demonstrations, brochures, posters, radio and occasionally TV. Cultivars have to be promoted with information, so farmers can make informed decisions about potential use

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Key resources needed:
a) Facilities for seed production – both in-season and off-season including land, land preparation equipment, irrigation facilities (where needed), driers, seed cleaning and dressing, packaging and labeling and storage
b) Product packaging funds, including for promotional and small packet sale
c) Distribution networks: including input dealers and transport, and marketing
d) Development of wide and complementary national partnerships: including NARS, extensionists, seed producers, certification agencies, farmer representatives, transporters and traders, seed production specialists
e) Input dealers: provide inputs for seed production including fertilizers, inoculants, packaging materials, and seed cleaners. - Quantity of above depends on target production
f) Backstopping of national teams
g) Financial resources to NARS partners: US$ 1.5 million per year

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Successful and sustained climbing bean production requires: additional options for staking; and training farmers, extension workers and seed producers in production techniques. Introgression of resistance genes for bean viruses and other diseases in combination with market preferred grain types is critical for sustainable production of climbing beans. Development of snap (French) climbing beans (not currently produced in this region), will lead to higher yield, extended harvest and hence reliable supply systems, better incomes, dietary diversification and land productivity from this bean type. Enhanced biological nitrogen fixation will reduce reliance on expensive external inputs and stabilize production. Staff time for 4 scientists (breeder/pathologist and on-farm agronomist/seed specialist) @ US$ 250,000/ year-scientist including operational funds for national partners = US$ 250,000 per year for 2 yrs.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Many countries throughout Africa have requested improved climbing bean germplasm and training for this new, promising technology. Demand for beans is rising, and many countries such as Kenya cannot meet their domestic requirements. Incorporation of iron and zinc accumulation genes in climbing beans will contribute to human health. Combining agro-forestry species specific to each agro-ecology with climbing bean production will provide new synergies in sustainability and resilience of production systems. Enhanced production will provide key raw materials to a rapidly growing bean processing industry and create employment opportunities. Further, adoption studies in Rwanda have shown climbing beans to be wealth and gender-neutral, meaning that there is good adoption even among poor, female-headed households

14. Key contact person for more info: Robin Buruchara, **r.buruchara@cgiar.org**

Data entry sheet: 3.2

1. Acronym of lead Center for this Best Bet: CIAT

2. Best Bet keyword description: High yielding bush beans

3. Best Bet short description: New high yielding, consumer preferred, bush bean with multiple disease resistance

4. Best Bet full description: Development of high yielding, consumer preferred bush bean cultivars, resistant to major diseases, and targeting major production environments and systems is considered an appropriate strategy in increasing bean production for resource-poor farmers. The member NARS of the Pan African Bean Research Alliance (PABRA) have been implementing a breeding strategy since 2003 focusing on a number of major consumer preferred grain classes. The objective of the program was to develop and disseminate well adapted high yielding bean cultivars with resistance to two or more biotic constraints and with consumer preferred characteristics (seed and culinary traits, cooking time, marketability). Major biotic constraints in Africa include fungal diseases, especially angular leaf spot, anthracnose, root rots; viral diseases, especially bean common mosaic and necrotic viruses; and bacterial diseases especially common bacterial blight and halo blight. In Sub-Saharan Africa, annual losses to these diseases vary from more than 384,200 t for angular leaf spot to more than 220,000 t for common bacterial blight (Wortmann et al., 1998). By December 2007, more than 98 new bean cultivars with combined resistance to angular leaf spot, anthracnose, root rots, and/or common bacterial blight, and with farmer and consumer preferred traits were released or pre-released in Angola (4), Burundi (6), Democratic Republic of Congo (11), Ethiopia (6), Kenya (15), Lesotho (1), Madagascar (10), Malawi (6), Mozambique (3), Tanzania (9), Sudan (7), Rwanda (12), Uganda (4), Swaziland (2), South Africa (2), Zambia (2) and Zimbabwe (3) after five years of intensive participatory testing across agro-ecological zones with farmers, traders, processors, exporters and consumers. Large-scale dissemination of these cultivars can make considerable positive impact on food security, incomes and poverty reduction for the majority of resource- and food-insecure, marginalized rural and urban communities currently threatened by escalating food prices within a relatively short term

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highland

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 30%

7. Location-specificity: 1= low

8. Most promising countries for this intervention: Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, Uganda, Zambia and Zimbabwe

9. Time frame: Short (1-2 years),

10. Most effective modes of delivery: The following delivery mode, known as 'The Wider Impact Program (WIP) is based on experiences in a previously developed and highly successful collaboration among PABRA partners: (Rubyogo et al., forthcoming)
a. Adaptive testing: participatory testing of best bet cultivars for target zones by PABRA-CIAT,

NARS, farmers, with inputs from traders, grain dealers.
b. Production of nucleus seed through partnership (CIAT and NARS).
c. Production of breeder seed by NARS and certification agencies for formal and informal seed producers. Formal seed producers (NARS and private sector companies) may have multiple outlets and select national coverage.
d. Contract production of foundation and certified seed by private sector, farmer groups, communities, CBOs, NGOs in partnership with NARS and CIAT.
e. Large scale production and dissemination of certified, quality declared and other types of acceptable seed through partnerships with private sector, communities, farmer associations, NGOs and other locally-based groups. Decentralized producers, in particular, often have intensive coverage in even marginal and hard-to reach zones.
f. Training, production and distribution of training and promotion materials
g. Cultivar promotion with partners through diverse channels (demonstrations, brochures, posters, radio and occasionally TV). Cultivars have to be promoted *with* information, so farmers can make informed decisions about potential use.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries:
a) Facilities for seed production – both in-season and off-season including land, land preparation equipment, irrigation facilities (where needed), driers, seed cleaning and dressing, packaging and labeling and storage.
b) Product packaging funds, including for promotional and small packet sale
c) Support for distribution networks: including input dealers and transport, and marketing
d) Development of wide and complementary national partnerships: including NARS, extension, seed producers, certification agencies, farmer representatives, transporters and traders, seed production and marketing specialists,
e) Input dealers: provide inputs for seed production including fertilizers, inoculants, packaging materials, seed cleaners, driers Quantity of above depends on target production
f) Backstopping of national teams
g) Financial resources: US$ 1.5 million per year for 2 yrs

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet:
a) Several materials for target environments in pipeline and with unique and better resistance genes and need to be advanced
b) Combine multiple resistance with nutritional traits (e.g. Fe and Zn); resistance to drought; efficient soil nutrient use; and tolerance to soil acidity (especially Al and Mn toxicity) and salinity
c) Will require services of a breeder, systems agronomist seed specialist, crop protection specialist and a social-economist for three years, and at least 2 full time research assistant/cum extensionists in each target country
d) Financial Resources: = US $ 350,000 per year for 2 yrs.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above:
a) Strong linkages with national extension systems, seed companies or other seed producers
b) Production of promotional materials
c) Promotional campaigns when seeds are available

14. Key contact person for more info: Robin Buruchara, **r.buruchara@cgiar.org**

Data entry sheet: 3.3

1. Acronym of lead Center for this Best Bet: CIAT

2. Best Bet keyword description: Drought tolerant beans

3. Best Bet short description: Intensifying common bean productivity for drought prone environments in Africa

4. Best Bet full description: The short growth cycle of bean (70 days) permits production when rainfall is erratic, thus bean has a niche in production areas where drought is a problem. Drought causes production losses of 300,000 t per annum in Africa. Improved productivity under drought conditions would stabilize yields and increase food availability. Drought resistance offer a unique opportunity for stabilizing productivity and is hinged an inherent capacity for accelerated growth completing a growth cycle before severe soil moisture deficits impact negatively on its reproductive capacity and /or coupled with inherent plant traits for reducing water loss under stress conditions. In Latin America CIAT has produced improved drought tolerant germplasm in the small-seeded red and cream-striped bean types that are popular in Africa. In the last few years PABRA has also embarked on developing drought resistant cultivars. More than ten new drought resistant cultivars have been released or pre-released by June 2008 following development under severe drought conditions in Kenya (8), northern Tanzania (2) and Ethiopia (1). They included early maturing cultivars such as Kat B1, Kat B9, Kat X56 and Miezi Mbili (E2), Kenya Early (E4), Kenya Sugar (E7) and New Rosecoco (E8) released in June 2008. There is significant effort in drought prone areas in Kenya and Ethiopia through the Bill & Melinda Gates Foundation-funded Tropical Legumes II project (TLII) to diffuse cultivars that are relatively drought tolerant. Additionally, at least 300 promising lines are in the pipeline for regional testing. We seek to replicate this effort in several countries in Africa where active research partnerships exist. However, in these marginal areas limited amounts of seed are produced and distributed locally to those farmers who might immediately benefit. An immediate response will be to intensely multiply seed of available drought tolerant bean cultivars in countries where these have been identified, to increase the supply of seed to farmers. In the medium term, new drought prone areas will be targeted for scaling out, and in these areas a low-to-moderate level of local testing will be needed to validate performance of cultivars.

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Semi-arid

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 20% yield increase

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Rwanda, Burundi, Malawi, Tanzania, Zambia, (southern) Democratic Republic of Congo

9. Time frame:
- Short term intervention (1-2 years) for adaptive testing, capacity building (human and infrastructural), participatory variety selection, to multiply seed stocks in areas where limited seed exists
- Medium term (3-5 years) to expand to similar agro-ecoregions where minimal adaptation of cultivars will be required and evaluation of materials in pipe to meet a wide range of production

environments and end user needs

10. Most effective <u>modes of delivery</u>:
1. Adaptive participatory testing in specific agro-ecologies where agronomic performance is not yet confirmed, by PABRA-CIAT, NARS, farmers, with input from traders, grain dealers.
2. Production of nucleus seed by CIAT and NARS scientists
3. Production of breeder seed by NARS and certification agencies for delivery to formal/informal seed producers, under contract.
4. Production of foundation seed by private sector, farmer groups, communities, CBOs, or NGOs in partnership with NARS and CIAT.
5. Large scale production and dissemination of certified, quality declared and other types of seed with private sector, communities, farmer groups. Decentralized producers, in particular, often have intensive coverage even in marginal and hard-to-reach zones.
6. Production (i.e. development, adaptation and/or translation of new and existing manuals), distribution and use of training and promotion materials
7. Cultivar promotion with partners through diverse channels and partners: including demonstrations, brochures, posters, radio and occasionally TV. Cultivars have to be promoted *with* information, so farmers can make informed decisions about potential use

11. Key <u>development and financial resources</u> needed to deploy this Best Bet within a typical country among the target set of countries:
a) Training workshops in drought selection
b) Local testing of promising materials
c) Ramping up of seed production of elite lines
d) Validation of methods from TL-II project
e) Coordination and equipment
f) Promotional materials
g) Financial resources to NARS partners: US$ 1.6 million in 3 yrs

12. <u>Research efforts</u> that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet:
a) Participatory selection and confirmation of regional nurseries (in the pipeline) for drought resistance.
b) Combining drought resistance with other desirable traits such as resistance to major diseases of drought regions, enhanced nutrition quality and grain characteristics
c) Marginal areas present special challenges in seed production. Lessons learned in the TL-II project will need to be validated in other countries and environments
d) Consumption patterns of marginal communities may be impacted by generally higher prices of staple commodities such as beans: Will households sell off staples to take advantage of improved prices?
Staff time for three specialists in agronomy; multiplication & delivery of seed; economics, field assistant diagnostic studies: @ US$ 200,000 per year for 3 yrs

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Knowledge gaps exist in this best bet and are related to other CIAT bean best bets. In particular, the expression of drought tolerance can be limited if soil fertility is critically low, thus drought tolerance needs to be viewed in the context of local edaphic constraints. Introducing risk management for small scale farmers in the production and marketing of staple commodities- implications for managing shocks
14. Key contact person for more info: Robin Buruchara, **r.buruchara@cgiar.org**

Data entry sheet: 3.4

1. <u>Acronym of lead Center</u> for this Best Bet: CIAT

2. <u>Best Bet keyword description</u>: Low fertility beans

3. <u>Best Bet short description</u>: Integrating bean cultivars adapted to low soil fertility with agronomic management

4. <u>Best Bet full description</u>: Most bean production areas in Africa are in humid and sub-humid areas with highly weathered soils with edaphic constraints (low nitrogen, low phosphorus and low pH accompanied by aluminum and/or manganese toxicity). Edaphic constraints are estimated to reduce bean production in Africa by more than a million MT per year, and also aggravate losses due to soil borne pests and diseases and drought. Genetic variability exists for tolerance to these edaphic constraints, and relatively tolerant cultivars have been identified in several countries through a regional nursery, the Bean International Low Fertility Adaptation nursery (BILFA). More than 50 bean lines tolerant to low soil nitrogen and phosphorus, and Al/Mn toxicity were validated with farmers at test sites in Uganda, Tanzania, Kenya, Madagascar, Democratic Republic of Congo and Rwanda. On the other hand, a "micro-dosing" or targeting small amount of fertilizer to crops has shown to be extremely efficient and cost effective way to supply nutrients. Addressing edaphic constraints should combine the best of genetic and agronomic solutions. The technology consists of targeted bean cultivars identified to perform better under such soil conditions, combined with small quantities of phosphate fertilizer (e.g. 20 of P_2O_5 kg ha^{-1}) application at planting. Modest inputs of P drastically improve nitrogen fixation, and thus fertilization will be coupled to seed dressing with rhizobium inoculation. Best practices also include weed management and post-harvest handling to reduce yield losses.

5. Main intended target <u>agro-ecozone</u> for optimal, sustainable performance of this Best Bet:
Highland and moist savannas

6. Estimated <u>average (not potential) on-farm yield gain</u> in percent, compared to average local current practice in the most appropriate agro-ecozone: This can raise yield on-farm from 500 to 1000 kg ha^{-1}, which is 100% increase

7. <u>Location-specificity</u>: 1 (=low) in most countries, but in others 2 (= requires a moderate degree of local testing and/or adaptation)

8. Most promising <u>countries</u> for this intervention: Ethiopia, (southern) Democratic Republic of Congo*, Kenya, Rwanda, Uganda, (southern) Tanzania*, Malawi*, Zambia*, Mozambique*, Zimbabwe*
* = countries with released BILFA cultivars in SABRN and in ECABREN countries
9. <u>Time frame</u>: Short (1-2 years)

10. Most effective <u>modes of delivery</u>: Millions have benefited from seed based technologies diffused by the bean network through a strategy of linking production of: breeder seed by researchers; foundation seed by parastatals; and certified or quality declared seed by a range of partners (private sector; CBO's; NGO's; etc). These strategies are being fine-tuned, for example, through the sale of small seed packets combined with fertilizer. National capacity must be enhanced in rhizobium production and delivery combined with modest phosphorus application. There is need to improve fertilizer distribution mechanism. The technology is not knowledge-intensive so simple demonstrations by researchers and

extensionists partnering with governmental and non-governmental development partners, including the private sector and farmer organizations will work.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries:

a. Seed and inoculums production
b. Training of partners, CBOs
c. Local testing of promising materials
d. Participatory evaluation
e. Coordination and equipment
f. f) Promotional materials
g. g) Financial resources to NARS partners: US$ 1.2 million per year

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research would sharpen the incipient efforts that contribute to the efficient production and delivery of seed of new cultivars and rhizobium inoculums to farmers. Here, we seek to answer the following questions: i) what are the most effective and efficient ways of producing bean seed? – formal versus non-formal seed systems, and ii) which are the most efficient bean seed and inoculum delivery systems? – small packs versus large package sizes; using formal (inputs shops) versus non-traditional outlets (e.g. clinics). Staff time for a team of 3 CIAT/PABRA scientists (breeder/coordinator -50%, soil scientist – 50% and seed specialist – 50%. Total = US $200,000/year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: There is need to have the right strain of rhizobium

14. Key contact person for more info: Robin Buruchara, **r.buruchara@cgiar.org**

Data entry sheet: 3.5

1. Acronym of lead Center for this Best Bet: CIAT

2. Best Bet keyword description: Bean pest management

3. Best Bet short description: Scaling out integrated pest management (IPM) strategies for bean producers

4. Best Bet full description: Three insect pests (bean stem maggots, foliage beetles and bruchids) and a soilborne disease, bean root rots, restrict bean productivity in Africa. Root rots cause yield losses of 221,000 t per annum. Bean stem maggot alone may cause losses of 500,000t annually. Resistance levels against these pests are low with a limited number of tolerant cultivars. Effective management therefore requires integration with cultural or biological approaches. CIAT and partners have developed integrated management technologies using farmer participatory approaches, pre-tested and piloted dissemination in selected target locations. More than 30,000 farmers were reached with IPM technology in a previous project. Bruchid management strategies are based on: (a) genetic resistance (arcelin seed protein), which is effective against only one bruchid species but the range of resistant germplasm is very limited, (b) cultural methods involving timely harvest to avoid field infestation, good post-harvest handling practices to disinfest grains, and good storage hygiene. Bean stem maggot management is also based on genetic materials with moderate levels of resistance (e.g. G22501 and G 22258 released in Democratic Republic of Congo, and Beshbesh released in Ethiopia) and cultural practices such as seed dressing with small doses of commercial pesticides, timely planting, and agronomic practices of soil fertility improvement with manures, mulching and earthing up. Foliage beetle management is based on cultural practices such as timely planting, crop rotation with cereals, and the application of bio-rational pesticides. Extension promotional materials on these strategies have been prepared (and translated into local languages) and pre-tested through participatory approaches with farming communities and extensionists in pilot areas of Kenya, Tanzania, Uganda and Malawi with good adoption rates. A few cultivars (RWR 719, MLB-49-89A, RWR 1946 and RWR2075) are tolerant to bean root rots. Their use combined with agronomic practices such as organic amendments and timely planting has increased bean yields in south-west Uganda and western Kenya. Accelerated and wider use of integrated management practices can improve bean crop health and ultimately bean productivity in part of highlands areas of Africa.

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highlands of Eastern, Central, West and Southern Africa

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 20%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Kenya, Tanzania, Uganda, Ethiopia, Malawi, Rwanda, Democratic Republic of Congo, Madagascar, Mozambique, Zambia

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: The management approaches for these pests are knowledge

intensive. CIAT has found community led participatory approaches to technology dissemination with multiple service providers and policy support from local governments very effective in reaching end user and enhancing adoption. It will be important to involve all stakeholders within the community and the target market centers (including farmer co-ops, extension service providers, seed and grain merchants, local leaders and local governments and micro-credit institutions) in the development and execution of the technology delivery process. The delivery process will involve an initial planning with key stakeholders; development of training and dissemination materials and training of trainers in service provider institutions and farmer groups.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries:

Item	Details	Annual costs US$ x 1,000	# of years	Total US$ x 1,000
Stakeholder meetings	Local group planning and progress monitoring 2 per country @$2000 each	4	4	16
Partners	5 service providers with ag. focus and skills @ US$ 15,000	75	4	300
Training	6 courses including training materials for training of trainers and others @ US$ 8,000 each	48	4	192
On-farm activities	Operations at 100 sites @ US$ 1,000 each	100	4	400
Publications	Two extension manuals per year in local languages @ US$ 1,500	3	4	12
Village information Centers	200 centers @ US $80/yr	16	4	64
Total		**246**		**984**

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Though some the technologies are already available, pre-tested and partially disseminated at pilot sites, there would be need gap research to adapt and improve to fit local resources and production circumstances in other areas. The gap research would also offer opportunities for the discovery of new products and adaptation of local traditions technologies. Financial resources required are to support staff time (partial) of two technology promotion specialists with experience in integrated pest and disease management to backstop NARS partners in Eastern and Southern Africa; facilities, travel and accommodation. Financial resources US$ 160,000 per annum for 3 years

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: PABRA operates in some 20 countries and developments in any one country is disseminated through its information sharing mechanisms and training activities. The Best Bet has a high potential for spill over across all PABRA countries, where the problem and opportunities exist.

14. Key contact person for more info: Robin Buruchara, **r.buruchara@cgiar.org**

Data entry sheet: 3.6

1. Acronym of lead Center for this Best Bet: CIAT

2. Best Bet keyword description: Fertilizer micro-dosing

3. Best Bet short description: Targeting fertilizer in combination with water harvesting for millet and sorghum-based systems in the semi-arid savannas

4. Best Bet full description: The technology consist of target placing small quantities of fertilizer (e.g. 5 kg/ha) in the planting hole of cereals with low planting density as sorghum and millet and accompany this with water harvesting techniques such as zai or tied ridges. Best practices also include rotating the cereal with grain legumes since rotational effects can be quite important.

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Semi-arid savannas

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 100%

7. Location-specificity: 1 = low (the Best Bet can scale-out widely with minimum local adaptation)

8. Most promising countries for this intervention: Burkina Faso, Mali, Niger, Senegal

9. Time frame: Short (1-2 years)

10. Most effective modes of delivery: The provision of fertilizer, access to legume and cereal seeds, and linkages to output markets are essential components of the delivery of this technology. The technology is not very knowledge-intensive so simple extension messages through partnerships with governmental and non-governmental development partners will work. At the output marketing level, systems for grading and temporary storage of crop produce could require collective produce marketing activities. Linking these with the provision of fertilizer would be ideal.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Estimated costs for one target country for 5 years, excluding inputs are indicated below.

Item	Details	Annual costs US$ x 1,000	# of years	Total US$ x 1,000
Staff	Coordinator and 2 ISFM specialists	90	5	450
Partners	20 partners with farm liaison skills	60	5	300
Facilities	Office, lab, field and training facilities	50	5	250
Local travel	Including vehicles in first year	48	5	240
Communication	Including computer and telecom	50	5	250
Local training	4 courses @ US$ 15,000 each	60	5	300
Field activities	200 sites @ US$ 80 each	16	5	80
Publication	Two extension booklets per year	30	5	150
Total		**404**		**2,020**

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Although at an aggregated level, this technology can be disseminated in the short term, proper monitoring of crop response as a function of initial soil fertility status and rainfall patterns will supply the required information to fine-tune the technology and achieve greater use efficiencies of the fertilizer applied.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Severe drought or climatic variability can impact on the actual yield figures.

14. Key contact person for more info: Andre Bationo, **a.bationo@cgiar.org**; Nteranya Sanginga, n.sanginga@cgiar.org

Data entry sheet: 3.7

1. Acronym of lead Center for this Best Bet: CIAT

2. Best Bet keyword description: Legume-maize rotations

3. Best Bet short description: Dual purpose legume-maize rotations with targeted inputs of fertilizer

4. Best Bet full description: The technology consists of rotating dual purpose grain legumes (e.g. soybean, groundnut) with improved maize (e.g. resistant to *Striga*, maize streak virus, N-use efficient cultivars) and applying appropriate amounts of P (and K) to the legumes and N to the maize. The right amount and composition of the fertilizer will depend on the soil type of the targeted areas. Dual purpose grain legumes improve the soil fertility status through promiscuous nodulation and leaving a positive N balance after harvest and give some immediate returns to farmers in terms of income (access to markets) or improved nutrition.

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savannas with either one or two growing seasons that are sufficiently long to allow a maize crop

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 50% for the legume, 100% for the maize

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Nigeria, Kenya, Uganda, Zimbabwe, Malawi, Ghana, Tanzania, Mozambique, Benin Republic, Togo

9. Time frame: Short (1-2 years)

10. Most effective modes of delivery: Access to fertilizer and maize and legume seeds is crucial to ensure successful delivery. This access to inputs needs to be accompanied by access to output markets, especially for a crop like soybean. The technology is not very knowledge-intensive so simple extension messages through partnerships with governmental and non-governmental development partners will work. At the output marketing level, systems for grading and temporary storage of crop produce could require collective produce marketing activities. Linking these with the provision of fertilizer would be ideal. Efforts to train households and communities on how to add value to the grain legumes through grading and/or processing are also needed.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Estimated costs for one target country for 5 years, excluding inputs are indicated below.

Item	Details	Annual costs	# of years	Total
		US$ x 1,000		US$ x 1,000
Staff	Coordinator and 2 ISFM specialists	90	5	450
Partners	20 partners w/ farm liaison skills	60	5	300
Facilities	Office, lab, field and training facilities	50	5	250
Local travel	Including vehicles in first year	48	5	240
Communication	Including computer and telecom	50	5	250
Local training	4 courses @ US$ 15,000 each	60	5	300
Field activities	200 sites @ US$ 80 each	16	5	80
Publication	Two extension booklets per year	30	5	150
Total		**404**		**2,020**

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Although at an aggregated level, this technology can be disseminated in the short term, proper monitoring of crop response as a function of initial soil fertility status and rainfall patterns will supply the required information to fine-tune the technology and achieve greater use efficiencies of the fertilizer applied. Other research efforts are related to the proper nodulation requirements of the dual purpose legumes, depending on the soil inoculum and the provision of external inoculants.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: This technology has most potential in areas where agricultural intensification is a requirement and where fallows are virtually absent.

14. Key contact person for more info: Bernard Vanlauwe, **b.vanlauwe@cgiar.org**; Nteranya Sanginga, **n.sanginga@cgiar.org**

Data entry sheet: 3.8

1. Acronym of lead Center for this Best Bet: CIAT

2. Best Bet keyword description: Tropical Forages

3. Best Bet short description: Forage grasses and legumes for livestock production and natural resources management in the humid and sub-humid tropics

4. Best Bet full description: Improved tropical forage grasses and legumes contribute to sustainable agricultural productivity in the sub-humid and humid tropics through their effects on milk and meat production, soil fertility, restoring degraded lands, reducing deforestation and mitigating the effects of climate change. High yielding and high quality forages, particularly at the crop-livestock interface, enable smallholders to be more competitive, with positive effects on income generation and improving food security. Improved forages also contribute to nutrient cycling via animal manure, resource conservation and reversing land degradation, with further potential for adaptation to climate change through the provision of ecosystem services (e.g., carbon sequestration, inhibition of biological nitrification, improved soil and water quality). Tropical forage (grasses and legumes) options suitable for sub-humid and humid tropical environments (> 800 mm rainfall, including low fertility (acid) soils) will be evaluated with farmer participation. These options can be utilized for feeding of ruminants and monogastrics; grazing or cut and carry; forage conservation; forage-based concentrates, plantation cover crops, and natural resource management (initially: *Brachiaria* hybrid, *Brachiaria brizantha*, *Canavalia brasiliensis*, *Cratylia argentea*, *Desmodium heterocarpon*, *Lablab purpureus*, *Vigna unguiculata* (some overlap with other CGIAR centers))

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savanna, dry savanna (but going partly beyond it)

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: There is a range in the current practice. In systems without current use of improved forages livestock productivity can be doubled, in addition to positive benefits on environmental services.

7. Location-specificity: Grasses mostly 1 (=low; the Best Bet can scale-out widely with minimum local adaptation), legumes mostly 2 (= requires a moderate degree of local testing and/or adaptation)

8. Most promising countries for this intervention: We would focus initially on Eastern Africa (Kenya, Democratic Republic of Congo, Rwanda, Uganda, Tanzania), possibly to extend to similar environments in Southern Africa

9. Time frame: Short to medium for available best bet; medium to long term based on options identified according to specific demands from clients in the region

10. Most effective modes of delivery: Several of the above cited partnership types (public, private, market-chain, policy) will be employed, specific partnerships to be developed according to the concrete local context. Participatory selection and technology innovation will be employed to deliver options suitable to clienteles' constraints and opportunities. Collaboration with research institutions including other CGIAR centers will be sought for complementary expertise

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: In line with the above statement on partnership types the deployment of options will be defined by local context. Suitable partners such as extension and development institutions, seed companies, farmer organizations and required resources depend on expected impact, number of clients to be reached

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: The research efforts need to achieve the targeted impact again depends on extent of the expected impact, the status of technologies, the specific production systems to be targeted. To refine targets we would commence with surveys, diagnostics, monitoring, impact and risk assessments. A rapid diagnostic can be done in 2 weeks/country, using larger groups of reviewers (cost estimate US$ 5.000-10.000/country). Need for in depth surveys will be defined according to the results from the rapid diagnosis, this can be done in a year. Based on these needs for backstopping, key bottleneck or knowledge-gap research will be identified. It is anticipated that research efforts needed are a minimum of 3 to 5 years, with 1 to 3 scientists (forage agronomy, animal nutrition, socio-economics) in the region, plus technical support depending on number of countries and locations

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Good partnerships to be established, training program, seed production. Intensive livestock production based on improved forage grasses and legumes will have many positive environmental effects, on C accumulation and soil quality enhancement in particular

14. Key contact person for more info: Michael Peters, **m.peters-ciat@cgiar.org**

Data entry sheet: 4.1

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: Drought tolerant maize

3. Best Bet short description: Stabilize and increase maize production under drought

4. Best Bet full description: Drought affects about 50% of the eastern and southern Africa maize area, or close to 8 million hectares. CIMMYT is working with the public and private sector to develop and disseminate more drought tolerant maize cultivars to farmers in Africa. Investment is proposed to accelerate introgression of drought tolerance from CIMMYT into best maize germplasm used by NARS and the private sector in Africa, release those cultivars and support sufficient breeder seed production for the cultivar to be known and to become adopted by farmers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Significant maize yield reductions due to drought are experienced in dry savanna, dry forest, moist savanna. Drought is erratic and large yield losses are experienced in areas that are consider "moist" in an average year

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 20%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Zimbabwe, Malawi, Ethiopia, Kenya, Tanzania, Zambia, Mozambique, Angola, Uganda, Sudan

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery:
CIMMYT: germplasm provision and support to local breeding and seed production projects by NARS and seed companies
NARS and seed companies: local adaptation
Seed services: cultivar release
Seed companies: seed production
Seed companies and NGOs: scale up of information and farmer feed-back

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Financial resources per country: US $ 0.5 to 1 million per year depending on size and scope of activities/country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: 80% of the total budget is for research to adapt and release drought tolerant cultivars, 20% to support breeder seed production and information dissemination. Given that drought tolerant germplasm needs to be evaluated under managed drought conditions, in-country capital investment in screening sites is needed. Also given that seed sector in drought affected areas is less developed, more significant effort is needed for seed dissemination

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: CIMMYT has a significant amount of drought tolerant maize germplasm available. Support is needed to public and private breeders to build drought tolerance into their own cultivars, release these cultivars and scale them up

14. Key contact person for more info: Marianne Bänziger, **m.banziger@cgiar.org**

Data entry sheet: 4.2

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: Highland maize

3. Best Bet short description: Enable and increase maize production in highly populated highland areas

4. Best Bet full description: Poverty is widespread, and population density and pressure for land high in highland areas of Eastern Africa. Large numbers of people and governments depend upon the produce and exports originating in the intensively cultivated highlands of Eastern and Central Africa. They constitute about 23% of the total landmass in the region, yet house over 50% of the population. High population densities have resulted in critically small, often fragmented farms averaging 0.25 to 1 ha for a family of six. In Ethiopia for example, farmers no longer have sufficient area to plant tef, the traditional staple, to meet household food consumption and therefore these farmers change to grow maize which is more productive. Countries with significant maize area in the highlands have few maize cultivars released and the majority originates from the 1960-1980s. There is need to accelerate the adaptation and widen the number of recently bred, high yielding highland maize cultivars. Investment is proposed to support NARS and the private sector in target countries to adapt and release highland cultivars and support sufficient breeder seed production for the new highland cultivars to be known and become adopted by farmers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highland

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 15%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Ethiopia, Kenya, Tanzania, Rwanda, Uganda, Burundi, Lesotho

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery:
CIMMYT: germplasm provision and support to local breeding and seed production projects by NARS and seed companies
NARS and seed companies: local adaptive breeding projects
Seed services: cultivar release
Seed companies: seed production
Seed companies and NGOs: scale up of information and farmers feed-back

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Financial resources per country: USD 0.25 to 0.4 million per year and country depending on size and scope of activities/country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of

this Best Bet: 75% of the total budget is for research to adapt and release highland cultivars in various countries, 25% to support breeder seed production and information dissemination

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: In collaboration with ASARECA and the Government of Ethiopia, CIMMYT has developed a range of highland inbred lines and synthetics. Support is needed to public and private breeders to test or combine these lines with their own cultivars, release a larger number and scale up seed production

14. Key contact person for more info: Twumasi Afriyie, **t.afriyie@cgiar.org**

Data entry sheet: 4.3

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: Maize seed production

3. Best Bet short description: Maize seed for areas insufficiently supplied by the seed industry

4. Best Bet full description: In Eastern and Southern Africa, only 35% of all farmers have access to improved maize seed and this severely constrains maize production increases. Even though the number of maize seed companies has grown five times over the past decade (1996 – 2006), the amount of maize seed production has not similarly increased (from 25% to 35%). A 2007 survey indicates that new seed companies urgently need know-how in all aspects of seed production and marketing to develop and implement solid business plans and access production credits. They also need experience in adapting and preparing cultivar release dossiers for their own maize cultivars. Investment is proposed to empower the large number of newly emerging local maize seed companies to more effectively access publicly bred maize germplasm, acquire technical and business related training, and access capital and production credits. This intervention builds up on highly successful experiences made with maize seed business training conducted in 2008 and back-stopping of new seed companies in the scale up of new hybrids and open-pollinated cultivars (OPVs) over the past 5 years. Investment in maize seed sector training has a positive spill-over to other crops as maize seed companies tend to take on other crops as their seed business evolves

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Not ecology specific

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 20%

7. Location-specificity: 1 - Low

8. Most promising countries for this intervention: Ethiopia, Tanzania, Angola, Malawi, Mozambique, Uganda, Kenya, Rwanda, Burundi, Democratic Republic of Congo

9. Time frame: Short (1-2 years)

10. Most effective modes of delivery:
CIMMYT: organization of maize seed business training
Resource persons: Personnel from CIMMYT and established seed companies in Africa and world-wide (i.e., emerging seed companies learn from those who have succeeded in Africa and world-wide)
Capital and production credits: Commercial bank and donor support

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Financial resources: US$ 12,000 per private sector participant; US$ 360,000 for a fully funded regional course of 30 participants coming from all target countries

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: This project is 100% capacity building and includes no research

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Market liberalization has led to a large number of new seed companies. If they are empowered to deliver quality seed to areas so far undersupplied with improved seed, they will become the engine for transferring breeding gains and new technologies to farming communities

14. Key contact person for more info: John MacRobert, **j.macrobert@cgiar.org**

Data entry sheet: 4.4

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: Productive maize cultivars

3. Best Bet short description: More productive maize cultivars to replace outdated poorer performing cultivars

4. Best Bet full description: Recent household surveys indicate that lack of farmer-relevant information greatly hinders the adoption of new maize technologies in Africa. As a result African farmers grow seed of outdated maize cultivars and hence they do not benefit from research gains made in the last 20 years. Also farmers are not aware of appropriate crop management practices that are cost-effective given the rapidly changing input and output prices. Investment is proposed to (1) use farmer feed-back to large-scale farmer-managed demonstrations to develop updated recommendations on recently released maize cultivars and complementary cost-effective maize crop management practices, (2) make this information widely available to farmers across the country, (3) link with suppliers for faster scale-up of required inputs, and (4) link with output markets for more effective use of surplus production. Given that recommendations are ecology-specific rather than country-specific and these ecologies typically go across country limits, regional synergies will be used to more rapidly develop the information and use common effective tools for scale-up. Project execution is in collaboration with Ministries of Agriculture, the private seed sector and NGOs. Use of data from farmer-participatory country-wide maize cultivar demonstrations have proven to be extremely powerful tools in more advanced economies to stimulate cultivar adoption, provide feed-back to cultivar developers, support in-country maize production predictions and inform traders, importers/exporters and policy makers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Not ecology specific

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 20%

7. Location-specificity: Low – the information collected will be analyzed and used by ecology

8. Most promising countries for this intervention: Tanzania, Ethiopia, Kenya, Malawi, Zimbabwe, Mozambique, Angola, Uganda, Zambia, Rwanda

9. Time frame:
First benefits arising: Short (1-2 years)
Sustainable implementation: Medium (3-5 years)

10. Most effective modes of delivery:
Consortium of partners (CIMMYT, Ministries of Agriculture, the private seed sector, NGOs): to decide on hybrids and OPVs and complementary best-bet crop management practices to be included in demonstrations
Seed companies, Ministry of Agriculture and NGOs: execute demonstrations under farmer-managed conditions
Farming communities: provide feed-back to demonstrated cultivars and best-bet crop management practices

With advice from CIMMYT, staff from the Ministry of Agriculture: analyze farmer feed-back, technology performance by ecology and develop information for wider dissemination.
Private sector: scale up seed production and disseminations of farmer-selected cultivars
With advice from CIMMYT and using input from on-farm cultivar demonstrations, staff from the Ministry of Agriculture: develop improved maize yield predictions for the country and make such information available to output markets for more effective trading of surpluses

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Financial resources per country: US$ 1 to 2 million per year depending on size and scope of activities/country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research is in-built in this intervention. Farmer-participatory demonstrations provide seasonally insights into best farmer-adapted and farmer-accepted cultivars and complementary technologies and this information is scaled-up to inform all farmers in the country and output markets

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Use of data from farmer-participatory country-wide maize cultivar demonstrations have proven to be extremely powerful tools in more advanced economies including in South Africa, Australia, Europe, USA and Latin America. Different to current practices in sub-Saharan African countries, they are conducted at large-scale, under farmer-relevant conditions and the results systematically analyzed and disseminated to stimulate cultivar adoption, provide feed-back to cultivar developers, support in-country maize production predictions and inform traders, importers/exporters and policy makers

14. Key contact person for more info: Marianne Bänziger, m.banziger@cgiar.org

Data entry sheet: 4.5

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: *Striga* resistant maize

3. Best Bet short description: Restore maize production in *Striga*-affected areas using IR-maize

4. Best Bet full description: IR-maize is a maize seed based technology that combats *Striga*, a parasitic weed affecting maize production in large parts of Africa, with Kenya, Malawi, Tanzania and Uganda among the most strongly affected countries. Independent evaluations by farmers and socio-economists have ascribed a high poverty focus and good economic rates of return to the IR-maize technology. In essence, maize production on *Striga* affected soils can be restored to normal yield levels and the technology also depletes the *Striga* seed bank in the soil. Though lot of efforts has been made to develop and test the technology, funding is required to scale-out the IR-maize technology to significant numbers of affected farmers. At this stage, local seed companies and their ability to absorb the risk have become the rate-limiting factor for scaling out the IR-maize technology, given that a new technology is being deployed and new markets are being explored. Investment is proposed to bring the technology to a level of acceptance by suppliers and farmers where the further growth of the technology is self-sustaining. Project activities include capacity building of NARS, seed companies, retailers and national seed agencies in all aspects of this technology, cultivar registration, seed production, and awareness creation among farmers, NGOs, extension, and other farmer support groups

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: *Striga* occurs most prominently in dry savanna, moist savanna, dry forest

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 30%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Kenya, Tanzania, Uganda, Malawi

9. Time frame: First benefits: (1-2 years); Significant impact: Medium (3-5 years)

10. Most effective modes of delivery:

CIMMYT: germplasm provision and capacity building
Seed services: cultivar release
Seed companies: seed production
NGOs and seed companies: scale up of information, on-farm demonstrations and collection of farmer feed-back
BASF (private company): support to seed treatment and stewardship

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Financial resources per country: US$ 0.5 million per year and country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: 30% of the total budget is for research to adapt and release IR-maize cultivars, 70% to support capacity building, scale-up seed production and disseminate information

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: A wide range of IR-maize inbred lines are available adapted to various ecologies. To deploy this technology, seed companies need to apply a new type of seed treatment which requires capital investment and training, and farmers need to be made aware that IR-maize seed can be grown in *Striga* affected soils where maize production has been abandoned

14. Key contact person for more info: Fred Kanampiu, **f.kanampiu@cgiar.org**

Data entry sheet: 4.6

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: Maize technology shopping

3. Best Bet short description: Accelerated deployment of improved maize technologies in countries affected by recent civil conflicts

4. Best Bet full description: Countries that have recently experienced civil conflicts typically lack research capacity, infrastructure and in-country suppliers to effectively access and disseminate new technologies. Investment is proposed to more effectively support researchers, NGOs and maize farmers in affected countries (Angola, Democratic Republic of Congo, Rwanda, Burundi, Sudan, Somalia) to (1) identify best-bet maize technologies based on research results from similar ecologies in neighboring countries, (2) execute simple farmer-participatory evaluations with best-bet technologies, (3) Plan for effective supply delivery from neighboring countries while (4) building up in-country capacity for maize seed production

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Not ecology specific

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 20%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Angola, Democratic Republic of Congo, Rwanda, Burundi, Sudan, Somalia

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery:
CIMMYT and NGOs: provision of know-how to personnel from NARS and NGOs
NARS: identification of most promising best-bet maize technologies from adaptive research conducted in similar ecologies in neighboring countries
Min. Agriculture and NGOs: execution of simple farmer-participatory evaluation of best-bet technologies, and sourcing of seed of farmer-selected maize cultivars from seed companies in neighboring countries
CIMMYT and NGOs: training of Min. Agriculture and NGOs in maize cultivar maintenance and sustainable scale-up of community-based maize seed production (focused on OPVs)
CIMMYT: training of emerging maize seed entrepreneurs

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Financial resources per country: US$ 0.5 to in excess of US$ 2 million per year and country depending on size and scope of activities/country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: 25% of the total budget is for capacity building, 60% to support farmer-participatory evaluation of best-bet technologies and initiate seed production, 15% to disseminate information among

farmers and development agencies engaged in the provision of agricultural inputs

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Technology shopping allows countries emerging from civil conflicts to more rapidly identify promising technologies, initiate seed production of best performing cultivars, and provide farmer-relevant information without having an elaborate research and seed system in place

14. Key contact person for more info: Peter Setimela, **p.setimela@cgiar.org**

Data entry sheet: 4.7

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: Rust resistant wheat

3. Best Bet short description: Replacement of current wheat with improved cultivars resistant to devastating diseases

4. Best Bet full description: Wheat rusts (*Puccinia* spp.) have been a scourge on humankind since the beginning of historical time. Many epidemics have been recorded over the past 150 years, in the Near and Far East, Africa, Europe, and the American continent. Several devastating rust epidemics have resulted in famines in Asia, Africa and North America. For several decades the historically enormous problem of wheat stem rust had been "solved" through the use of genetic resistance. In Uganda in 1999, that resistance was overcome by a new, devastating race of the disease designated as "Ug99" that has proven to be highly virulent to most wheat cultivars grown today by small-holder farmers in sub-Saharan Africa. Plant breeders and pathologists have made progress since then in developing new cultivars that are resistant to this pathogen. Now is the opportunity to supply seed of these new cultivars to farmers and seed producers, enabling farmer-participatory selection of cultivars that meet their own local demand and custom, while providing wheat cultivars that are more input-use efficient, harbor more diverse and durable resistances to diseases and climatic extremes, and are more market oriented to enable smaller-holder farmers to sell excess grain beyond their family needs, more profitably to their local communities and beyond. This project will enable rapid multiplication and distribution of seed to farmers of wheat cultivars that meet all of these criteria

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highlands

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: At least a two hundred (200) kg/ha grain yield gain is anticipated

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Ethiopia, Kenya, Sudan, Eritrea, Tanzania, Mali, Nigeria, Zambia, Mozambique and Madagascar

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: Testing and release of a cultivar takes 3-5 years and its adoption by farmers is often slower. Problems associated with seed multiplication and distribution are the most important reason for slow adoption. CIMMYT together with Kenyan and Ethiopian NARS have developed candidate cultivars suitable for most sub-Saharan wheat agro-ecologies

11. Key development and financial resources needed to deploy this Best Bet within a typical country: Seed multiplication of newly developed stem rust resistant cultivars will require (1) farmers and other stakeholders play a leading role, (2) breeding programs be supported in the maintenance and

multiplication of Breeder's and Foundation Seed, (3) commercial seed should be readily available to farmers, and (4) on-farm demonstrations of elite cultivars be conducted. To achieve this, US$ 75,000 per year, per country will be required

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: No research effort is sought for this Best Bet intervention, given that at-hand improved cultivar technology products will be delivered by the currently active Borlaug Global Rust Initiative

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: None

14) Key contact person for more info: Hans-Joachim Braun, **h.j.braun@cgiar.org**

Data entry sheet: 4.8

1. Acronym of lead Center for this Best Bet: CIMMYT

2. Best Bet keyword description: Animal traction conservation agriculture

3. Best Bet short description: Conservation agriculture systems based on ripper tines and direct seeders

4. Best Bet full description: Animal traction conservation agriculture in Southern Africa involves both ripper tines and animal traction direct seeders as seeding implements. Ripper tines are attachments, fitted to the plough frame. They were developed to open furrows for moisture capture or to break superficial compacted layers, but in conservation agriculture they work well to open planting furrows. The animal-drawn Magoye ripper works at shallow depth (10-15cm) and, after making the rip line, seed and fertilizer are placed manually in the furrow and covered. Other ripper tines such as the knife rippers can be found in the region but they are not as common. In the first year of conservation agriculture, if there is a plough pan, then a sub-soiler can be used to break the pan. The furrow may be suitable for seeding or may need to be reformed. The Palabana sub-soiler is an efficient implement that can work up to 25 cm. Direct seeders are designed to seed into surface mulch in untilled soil. The implement has separate seed and fertilizer bins and a cutting disk (coulter). The coulter cuts through the residues, a ripper tine opens a furrow, and the seed and fertilizer are placed in the furrow- all in a single operation. Seeder units are available for both oxen and donkeys.

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna to moist savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: Labor savings (not yield increase) are the major benefits at the beginning but in the longer term yield increases of 30 % or more can be expected

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation):

8. Most promising countries for this intervention: Zambia, Zimbabwe, Mozambique

9. Time frame: Medium to Long

10. Most effective modes of delivery: In Southern Africa, the community-based innovation network (innovation platform) approach seem to work well involving farmers, IARCs, governmental extension services, NGOs, machinery manufacturers, input suppliers, or Universities, among others. Other players have to be more and more included such as credit providers, politicians, seed systems.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: The ideal size to start in one community of 100 to 200 households should be six paired plot demonstrations and one on-farm trial. Each community is led by an extension officer from the governmental system or an NGO with monitoring from the District or IARCs scientists. In each community an intensive process of awareness building, in season monitoring, participatory diagnosis, or machinery evaluation led by the extension people and scientists develop and support the ownership of farmers of the best bet.

12. **Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet:** Several research items have been identified:

- How to maintain and or increase residues in drier areas to make the conservation agriculture system functional?
- How to deal with weed pressure in an effective and productive way when the soil is not ploughed any more?
- What are the best fertilization strategies under conservation agriculture?
- What other sources of manures (i.e., green manure cover crops) can be effectively incorporated into the system?
- What machinery is required and has to be adjusted to local conditions?
- What are the mechanisms of adoption (why do people adopt the technology)?
- What processes have to be supported to improve adoption?
- What works where, with what and how?

In summary, there is need of significant agronomic on-farm research and perhaps complementary on-station research supported by socio-economic surveys and research. A team of 3 full-time scientists (an agronomist, a soil scientists and a socio-economist) are needed for 3 to 5 years

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: For animal traction systems, enough animals have to be available. In the past this was identified as one of the limitations to adoption in southern Zambia (corridor disease). Machinery is often limiting and more efforts have to flow into machinery development, production and distribution

14. Key contact person for more info: Patrick Wall, **p.wall@cgiar.org**; Christian Thierfelder, **c.thierfelder@cgiar.org**

Data entry sheet: 5.1

1. Acronym of lead Center for this Best Bet: CIP

2. Best Bet keyword description: Sweetpotato vine multiplication

3. Best Bet short description: Accelerated disease free sweetpotato vine multiplication

4. Best Bet full description: Sweetpotatoes are propagated by planting the vine tips. In sub-Saharan African conditions, most sweetpotatoes carry a high burden of disease which reduces yields. A 'flush through' system of screen house vine production with farmer-managed field production can produce significant amounts of planting material. Depending on the ecosystem and virus pressure, farmers yield levels from sweetpotato production fall rapidly due to disease buildup. A steady supply of clean planting material is a key factor for improved on-farm productivity. Yields can increase by 50% or more with clean planting material. Sweetpotato has relatively high counts of vine tips per square meter and so multiplication facilities can provide clean planting material to cover large areas

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 50%

7. Location-specificity: 1 = low (the Best Bet can scale-out widely with minimum local adaptation)

8. Most promising countries for this intervention: Uganda, Tanzania, Rwanda, Kenya, Mozambique, Ethiopia, Burundi, Democratic Republic of Congo, Nigeria, Cameroon

9. Time frame: Short

10. Most effective modes of delivery: NARI, private sector, or farmer organizations for screen house production, technical support from NARI agricultural technicians; farmer organizations for field multiplication; and marketing agents for planting material distribution

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Tissue culture capable private sector or NARI labs capable of maintaining an in vitro source of clean planting material for periodic renewal of starter material for screen house multiplication. Construction of screen houses and supplies of production inputs. Disease testing kits and technicians capable of using them. Extension agents for training of farmer multipliers. Marketing specialists for the sale and distribution of the planting material

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Minimal additional research efforts are needed. Backstopping from a seed technologist or agronomist for screen house production. An engineer for screen house construction. A pathologist for training in disease detection. Adaptive research by a M. Sc.-level agronomist for fine tuning management of local cultivars for maximum vine production

13. Any special information you feel is important concerning this Best Bet that is not covered in the above:

14. Key contact person for more info: Jan Low, **j.low@cgiar.org**; Oscar Ortiz, **o.ortiz@cgiar.org**

Data entry sheet: 5.2

1. Acronym of lead Center for this Best Bet: CIP

2. Best Bet keyword description: Seed potato production

3. Best Bet short description: Accelerated seed potato production through positive selection and aeroponics

4. Best Bet full description: Poor quality seed is the major constraint to improving the productivity of potato farming. A combination of rapid multiplication using aeroponics to provide a source of clean basic seed and a program of on-farm positive selection can provide many thousands of tons of seed tubers after two years. Aeroponics is used as a low cost technique for producing disease-free basic seed that is multiplied twice in the field by contract farmer multipliers. As a rapid multiplication technique, production per square meter reaches a 1000 minitubers, greatly exceeding the 200 to 300 per m^2 from traditional rapid multiplication. The high rate of multiplication eliminates the need for one additional round of field multiplication, accelerating the delivery of large quantities of high quality seed by a cropping cycle. The volume of basic seed production is proportional to the investment in aeroponics production facilities. In most sub-Saharan African conditions quality seed can double yields. An investment in 1,200 m^2 of aeroponics multiplication tables can result in 48,000 t of seed in 24 months, enough to plant 24,000 ha. Aeroponics screen houses, low cost disease testing, technician training, farmer-multiplier contracting, diffused light storage are the main investments. These are simple, robust technologies that are easily mastered and managed. The revenues earned make the system self financing. Over 90% of all potato seed used is saved by the farmer from the previous harvest. Farmers typically save 10% of their production for seed the next season. On-farm seed management through positive selection can increase yields by 25%. Positive selection is the practice of marking healthy plants and saving their tubers as seed. This combined with farmer training for disease identification and modern low cost disease detection for extension agents is a technology package readily transferable to existing extension infrastructure. The volume of improved seed produced is proportional to the number of farmers reached

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highland

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 30%

7. Location-specificity: 1 = low (the Best Bet can scale-out widely with minimum local adaptation)

8. Most promising countries for this intervention: Ethiopia, Rwanda, Kenya, Uganda, Malawi, Tanzania, Democratic Republic of Congo, Nigeria, Angola, Cameroon

9. Time frame: Short

10. Most effective modes of delivery: Install rapid multiplication facilities preferably with private sector actors, if none, then with the NARI. Collaborate with existing governmental or NGO extension networks or farmer organizations for contacting farmer multipliers. Install diffused light seed stores with the locally appropriate marketing agency, either the farmer organization (stimulated to be a seed growers cooperative) or the relevant government agency. Extension agent led participatory farmer

training is the preferred delivery mode for positive selection, The visual impact of healthy potato plants is obvious and adoption rates are high. Training in disease detection requires collaboration with the local NARI

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: NARI or private sector skills capable of maintaining tissue culture based initial planting material and managing production in quarantine screen houses. District extension teams or farmers organizations to manage contracts with farmer multipliers. Initial capital investments in the construction of aeroponics facilities, on-going supplies purchases of disease testing kits, training of technicians and extension teams

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Adaptive research by an M. Sc.-level agronomist to optimize aeroponics production for the multiplication characteristics of locally preferred cultivars (planting density, fertilization rates, harvest schedules …). An engineer is needed for aeroponics production facilities construction (most materials can be locally sourced). A seed technologist is needed to train local technicians in facilities management and disease testing. A participatory training specialist is needed to conduct training of trainers courses for seed management for the farmer-multipliers and positive selection for the commercial farmers. Three teams with this expertise for Eastern, Southern and West Africa would be sufficient

13. Any special information you feel is important concerning this Best Bet that is not covered in the above:

14. Key contact person for more info: Ian Barker, **i.barker@cgiar.org**; Oscar Ortiz, **o.ortiz@cgiar.org**

Data entry sheet: 6.1

1. Acronym of lead Center for this Best Bet: ICARDA

2. Best Bet keyword description: High-yield, drought-tolerant, chickpea

3. Best Bet short description: High yielding Kabuli -chickpea tolerant to drought, *Fusarium* wilt and *Ascochyta* blight

4. Best Bet full description: The germplasm and advanced breeding lines within the region and outside will be assembled in targeted countries and evaluated, either in the hot spots or artificially created environments, for biotic and abiotic stresses and adaptation. For drought and heat tolerance, the germplasm will be evaluated under late spring planting at ICARDA. The resultant tolerant genotypes will be evaluated in the targeted environments in sub-Saharan Africa. Similarly for biotic stresses like *Ascochyta* blight and *Fusarium*, the disease nursery will be developed at ICARDA and distributed to the target countries for testing for resistance under their environments and monitoring the variability (using differentials) in the pathogen population, in order to select best bets for the target environments. The crosses will be made among adapted cultivars from the region and drought and heat tolerant, *Fusarium* and *Ascochyta* blight resistant, high yielding and agronomically desirable germplasm to develop elite lines for testing in the target environments in different sub-Saharan countries, both at the research station and in farmers' fields. These elite advanced lines can be fast-tracked and immediately tested in on-farm trials throughout the chickpea growing regions in the targeted countries, and recommended for release by national programs. Large scale multiplication of seed of existing and newly released adapted cultivars will result in the up-scaling/out-scaling of Kabuli chickpea production, which not only will contribute to improving farm incomes but will also contribute to the improvement of soil health through biological nitrogen fixation and improving humus content

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Rainfed conditions in chickpea growing areas

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 35%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Ethiopia, Eritrea, Sudan

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: The partnerships that would bring this fast-tracking of pre-tested chickpea lines to farmers prior to release decisions include: participatory variety selection and on-farm research with farmers, national researchers, government extension services, NGOs, farmer associations, and through farmer field schools. For seed delivery systems the following are key institutions at different stages of seed multiplication from breeder seed to certified seed production and marketing: public seed sector, private seed sector, farmer-based seed production including community or village-based seed enterprises, cooperatives or NGOs

11. Key development and financial resources needed to deploy this Best Bet within a typical country

among the target set of countries: Donor/investor support will be needed for training, demonstration, and farmer field days/schools, seed multiplication, and appropriate production technology as needed. In particular, availability of, access to and use of improved seed is critical in the deployment of adapted crop cultivars. Generally, there is a time lag between identifying a new cultivar and seed availability because of several constraints. Therefore, substantial resources will be needed to support seed delivery, whether through formal/informal approaches. This includes pre-release/early generation multiplication of breeder, pre-basic and basic (foundation) seed, and the large-scale seed multiplication and distribution of promising cultivars. The basic (foundation) seed is made available to the public or private seed sector for further multiplication to produce certified seed; community or village-based seed enterprises for further multiplication to produce quality seed; or through informal small pack seed distribution for on-farm seed production with individual farmers to accelerate informal seed diffusion. Preliminary estimates of the financial cost of deployment are US$ 1 million per country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research will be needed in monitoring the variability in pathogen populations in target locations, evaluating germplasm for specific target countries, crossing germplasm to develop elite lines, and the optimal selection of sites for on-farm trials using GIS-based site-similarity studies. VBSE technologies are in place and in some of the targeted countries these are already up and running (e.g. Ethiopia). Socio-economic impact studies including market-chain analysis are also needed. The research budget would include partial time (15-20%) of breeder, pathologist, socio-economist and seed specialist at ICARDA (@US $ 140,000 per year per scientist), plus support staff and operational costs estimated at a total of US$ 300,000 per year. A further US$80,000 100,000 per year is needed for operational costs in each country, with an estimated total research budget over three years of US$ 1.75 million

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: The present conventional breeding methodologies, which require a relatively longer period for the development of improved cultivars, can be shortened using advanced biotechnological tools such as molecular marker assisted selection. The chickpea cultivars currently grown by farmers are less remunerative because of their small seed size, which can be improved to increase the income of poor farmer in the target countries. The project would collaborate closely with other crop improvement research to take account of cultivar and agronomic practices interactions. Synergies are to be sought to position the best overall cultivar plus agronomy package with the farmers

14. Key contact person for more info: Imtiaz Mohammed, **m.imtiaz@cgiar.org**

Data entry sheet: 6.2

1. Acronym of lead Center for this Best Bet: ICARDA

2. Best Bet keyword description: Drought tolerant lentil

3. Best Bet short description: High yielding lentil cultivars with tolerance to drought

4. Best Bet full description: Using adapted cultivars from the region plus other more widely adapted cultivars, crosses have been made to develop drought tolerant germplasm. Advanced lentil lines have been developed that show high yields in several of the target countries and in similar environments experiencing rainfed conditions, in research station trials. These advanced lines can be fast-tracked and immediately tested in on-farm trials throughout the lentil growing regions in the targeted countries. This will result in high yielding lentil cultivars with tolerance to drought, heat, frost/cold and resistance to foliar and soil-borne diseases. The upscaling/outscaling of recently released high yielding and stress tolerant cultivars will be promoted in a participatory approach while advanced breeding lines will be tested at several locations for immediate release

5. Main intended target agro-eco zone for optimal, sustainable performance of this Best Bet: Rainfed conditions in non-tropical lentil growing areas.

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 30%

7. Location-specificity: 1 = the Best Bet can scale-out widely with minimum local adaptation

8. Most promising countries for this intervention: Ethiopia, Eritrea and Sudan

9. Time frame: Short/Medium (3 years)

10. Most effective modes of delivery: The partnerships that would bring this fast-tracking of pre-tested lentil lines to farmers prior to release decisions include: participatory variety selection and on-farm research with farmers, national researchers, government extension services, NGOs, farmer associations, and through farmer field schools. For seed delivery systems the following are key institutions at different stages of seed multiplication from breeder seed to certified seed production and marketing: public seed sector, private seed sector, farmer-based seed production including community or village-based seed enterprises, cooperatives, or NGOs

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Donor/investor support will be needed for training, demonstration, and farmer field days/schools, seed multiplication, and appropriate production technology as needed. In particular, availability of, access to and use of improved seed is critical in the deployment of adapted crop cultivars. Generally, there is a time lag between identifying a new cultivar and seed availability because of several constraints. Therefore, substantial resources will be needed to support seed delivery, whether through formal/informal approaches. This includes pre-release/early generation multiplication of breeder, pre-basic and basic (foundation) seed, and the large-scale seed multiplication and distribution of promising cultivars. The basic (foundation) seed is made available to the public or private seed sector for further multiplication to produce certified seed; community or village-based seed enterprises for further multiplication to produce quality seed; or through informal small pack seed distribution for on-farm seed production with individual farmers to accelerate informal seed diffusion. Preliminary estimates of the financial cost of deployment are US$ 1 million per country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research will be needed in monitoring the variability in pathogen populations in target locations, evaluating germplasm for specific target countries, crossing germplasm to develop elite lines, and the optimal selection of sites for on-farm trials using GIS-based site-similarity studies. VBSE technologies are in place and in some of the targeted countries these are already up and running (e.g. Ethiopia). Socio-economic impact studies including market-chain analysis are also needed. The research budget would include partial time (15-20%) of breeder, socio-economist and seed specialist at ICARDA (@ US$ 140,000 per year per scientist), plus support staff and operational costs estimated at total of US$ 300,000 per year. A further US$ 80,000 to 100,000 per year is needed for operational costs in each country, with an estimated total research budget over three years of US$ 1.7 million

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: This effort is to collaborate closely with other cropping management research and development efforts, as for example vertisols management practices. Synergies are to be sought to position the best overall cultivar + agronomy package with the farmers. Short duration and drought tolerant breeding lines developed at ICARDA will be tested to fit into small rainy season of February to May (Belg) in Ethiopia and Eritrea. The spillover from this project can be used in the non- tropical dry land areas of Kenya and Malawi

14. Key contact person for more info: Geletu Bejiga, g.beijiga@cgiar.org

Data entry sheet: 6.3

1. Acronym of lead Center for this Best Bet: ICARDA

2. Best Bet keyword description: Stress-tolerant barley

3. Best Bet short description: More productive barley cultivars with better end-user quality (food) to replace outdated poorer performing cultivars

4. Best Bet full description: Using locally adapted cultivars and introduced breeding lines, advanced lines have been developed that show high yields in several of the target countries and in similar environments experiencing rainfed conditions, in research station trials. These advanced lines can be fast-tracked and immediately tested in on-farm trials throughout the barley growing regions in the targeted countries. This will result in high yielding barley cultivars and lines adapted to the targeted areas, with tolerance to drought (Northern Ethiopia and Eritrea), water logging (Central Highlands of Ethiopia), acid soils (Ethiopia), resistance to net blotch, scald, and rusts (Ethiopia and Eritrea) and shootfly (Ethiopia), and improved end-user quality (food). High yielding fodder barley cultivars and lines adapted to the oasis conditions in Mauritania with tolerance to foliar diseases

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Highlands (Ethiopia and Eritrea); Irrigated, oasis condition (Mauritania)

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 25%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Ethiopia, Eritrea, and Mauritania

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: The partnerships that would bring this fast-tracking of pre-tested barley lines on-farm prior to release decisions include: participatory selection and on-farm research with farmers, national researchers, government extension services, NGOs, farmer associations, and through farmer field schools. For seed delivery systems the following are key institutions at different stages of seed multiplication from breeder seed to certified seed production and marketing: public seed sector, private seed sector, farmer-based seed production including community or village-based seed enterprises, cooperatives or NGOs.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Donor/investor support will be needed for training, demonstration, and farmer field days/schools, seed multiplication, and appropriate production technology as needed. In particular, availability of, access to and use of improved seed is critical in the deployment of adapted crop cultivars. Generally, there is a time lag between identifying a new cultivar and seed availability because of several constraints. Therefore, substantial resources will be needed to support seed delivery, whether through formal/informal approaches. This includes pre-release/early generation multiplication of breeder, pre-basic and basic (foundation) seed, and the large-scale seed multiplication and distribution of promising cultivars. The basic (foundation) seed is made available to the public or

private seed sector for further multiplication to produce certified seed; community or village-based seed enterprises for further multiplication to produce quality seed; or through informal small pack seed distribution for on-farm seed production with individual farmers to accelerate informal seed diffusion. Preliminary estimates of the financial cost of deployment are US$ 1 million per country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research will be needed in evaluating germplasm for specific target countries, in the optimal selection of sites for on-farm trials using GIS-based site-similarity studies, and on the users' acceptability of the new technology. VBSE technologies are in place and in some of the targeted countries these are already up and running (e.g. Ethiopia and Eritrea). Socio-economic impact studies including market-chain analysis are also needed. The research budget would include partial time (15-20%) of breeder, socio-economist and seed specialist at ICARDA (@US $ 140,000 per year per scientist), plus support staff and operational costs estimated at total of US$ 300,000 per year. A further US$ 80,000 to 100,000 per year is needed for operational costs in each country, with an estimated total research budget over three years of US$ 1.7 million

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: This effort is to collaborate closely with any other research for development going on or being started up on natural resource management, as for example cultivar by agronomic practices interactions do occur. Synergies are to be sought to position the best overall cultivar + agronomy package with the farmers

14. Key contact person for more info: Stefania Grando, s.grando@cgiar.org

Data entry sheet: 6.4

1. Acronym of lead Center for this Best Bet: ICARDA

2. Best Bet keyword description: Stress tolerant faba bean

3. Best Bet short description: High yielding faba bean with tolerance to biotic and abiotic stresses

4. Best Bet full description: Using adapted cultivars from the region plus other more widely adapted cultivars crosses have been made for resistance to different biotic and abiotic stresses, and advanced faba bean lines have been developed that show high yields in several of the target countries and in similar environments experiencing rainfed conditions, in research station trials. These advanced lines can be fast-tracked and tested in on-farm trials throughout the faba bean growing regions in the targeted countries. This will result in more productive stress tolerant faba bean that include high yield potential with desirable quality (cooking time, protein content, micronutrient, low anti-nutritional factors), heat, drought tolerance foliar disease resistance (chocolate spot, *Ascochyta*, rust) and parasitic weed tolerance (*Orobanche*)

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Rainfed and irrigated conditions in non-tropical faba bean growing areas

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 20%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Ethiopia, Sudan, Eritrea

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: The partnerships that would bring this fast-tracking of pre-tested faba bean lines on-farm prior to release decisions include: participatory variety selection and on-farm research with farmers, national researchers, government extension services, NGOs, farmer associations, and through farmer field schools. For seed delivery systems the following are key institutions at different stages of seed multiplication from breeder seed to certified seed production and marketing: public seed sector, private seed sector, farmer-based seed production including community or village-based seed enterprises, cooperatives or NGOs

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Donor/investor support will be needed for training, demonstration, and farmer field days/schools, seed multiplication, and appropriate production technology as needed. In particular, availability of, access to and use of improved seed is critical in the deployment of adapted crop cultivars. Generally, there is a time lag between identifying a new cultivar and seed availability because of several constraints. Therefore, substantial resources will be needed to support seed delivery, whether through formal/informal approaches. This includes pre-release/early generation multiplication of breeder, pre-basic and basic (foundation) seed, and the large-scale seed multiplication and distribution of promising cultivars. The basic (foundation) seed is made available to the public or private seed sector for further multiplication to produce certified seed; community or village-based

seed enterprises for further multiplication to produce quality seed; or through informal small pack seed distribution for on-farm seed production with individual farmers to accelerate informal seed diffusion. Preliminary estimates of the financial cost of deployment are $1 million per country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research will be needed in monitoring the variability in biotic and abiotic stresses in target locations, evaluating germplasm for specific target countries, crossing germplasm to develop elite lines, and the optimal selection of sites for on-farm trials using GIS-based site-similarity studies. VBSE technologies are in place and in some of the targeted countries these are already up and running (e.g. Ethiopia). Socio-economic impact studies including market-chain analysis are also needed. The research budget would include partial time (15-20%) of breeder, pathologist, socio-economist and seed specialist at ICARDA (@ US$ 140,000 per year per scientist), plus research support staff and operational costs estimated at a total of US$ 300,000 per year. A further US$ 80,000 to 100,000 per year is needed for operational costs in each country, with an estimated total research budget over three years of US$ 1.75 million

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: The project would collaborate closely with other crop improvement research and development efforts to take account of cultivar and agronomic practices interactions. Synergies are to be sought to position the best overall cultivar plus agronomy package with the farmers

14. Key contact person for more info: Fouad Maalouf, f.maalouf@cgiar.org

Data entry sheet: 6.5

1. Acronym of lead Center for this Best Bet: ICARDA

2. Best Bet keyword description: High-yield, drought-tolerant wheat

3. Best Bet short description: Productive, drought-tolerant, disease-resistant wheat cultivars to replace outdated poor-performing cultivars

4. Best Bet full description: Both bread and durum wheat are important food crops in sub-Saharan Africa. Recent increases in frequency and intensity of drought spells have led to crop failures and catastrophic food security problems in East Africa countries of Ethiopia and Eritrea. In traditionally irrigated areas (e.g Sudan and Mauritania) the water available for agriculture faces competition for reallocation to urban areas and industry due to increased population growth. Thus, water is a scarce resource and water-use efficiency and water productivity are becoming increasingly important in irrigated agriculture. In addition to drought stress, diseases such as Septoria and out-breaks of rust epidemics cause great losses in wheat production; the emergence in East Africa of the new virulent stem rust race Ug99 constitutes a serious threat to food security. Development of high-yielding, disease-resistant wheat cultivars with better capabilities to utilize water and withstand environmental stresses is a key component in enhancing productivity. Such cultivars are developed through a breeding methodology involving a targeted crossing program that emphasizes selective use of landraces, locally adapted cultivars, widely-adapted regional cultivars, high-yielding advanced lines and synthetic wheats, followed by selection of segregating populations under both severe and moderate drought stress conditions and disease screening under artificial inoculation and at disease hot spots, coupled with multilocation testing of elite advanced lines combining high yield potential, drought-tolerance and host plant resistance to diseases (rusts and Septoria). These elite advanced lines can be fast-tracked and immediately tested in on-farm trials throughout the wheat growing regions in the targeted countries leading to the release of best bets for general cultivation in farmers' fields. Large scale multiplication of seed of existing and newly released adapted cultivars will result in the up-scaling/out-scaling of wheat production leading to enhanced incomes of resource poor farmers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Rainfed conditions in non-tropical wheat growing areas

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 25%

7. Location-specificity: 1 = the Best Bet can scale-out widely with minimum local adaptation

8. Most promising countries for this intervention: Ethiopia, Eritrea, Sudan, other East African countries and Mauritania

9. Time frame: Short/Medium (3 years)

10. Most effective modes of delivery: The partnerships that would bring this fast-tracking of pre-tested wheat lines on-farm prior to release decisions include: participatory variety selection and on-farm research with farmers, national researchers, government extension services, NGOs, farmer associations, and through farmer field schools. For seed delivery systems the following are key institutions at different

stages of seed multiplication from breeder seed to certified seed production and marketing: public seed sector, private seed sector, farmer-based seed production including community or village-based seed enterprises, cooperatives or NGOs

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Donor/investor support will be needed for training, demonstration, and farmer field days/schools, seed multiplication, and appropriate production technology as needed. In particular, availability of, access to and use of improved seed is critical in the deployment of adapted crop cultivars. Generally, there is a time lag between identifying a new cultivar and seed availability because of several constraints. Therefore, substantial resources will be needed to support seed delivery, whether through formal/informal approaches. This includes pre-release/early generation multiplication of breeder, pre-basic and basic (foundation) seed, and the large-scale seed multiplication and distribution of promising cultivars. The basic (foundation) seed is made available to the public or private seed sector for further multiplication to produce certified seed; community or village-based seed enterprises for further multiplication to produce quality seed; or through informal small pack seed distribution for on-farm seed production with individual farmers to accelerate informal seed diffusion. Preliminary estimates of the financial cost of deployment are US$ 1 million per country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research will be needed in monitoring the variability in pathogen populations in target locations, evaluating germplasm for specific target countries, crossing germplasm to develop elite lines, and the optimal selection of sites for on-farm trials using GIS-based site-similarity studies. VBSE technologies are in place and in some of the targeted countries these are already up and running (e.g. Ethiopia). Socio-economic impact studies including market-chain analysis are also needed. The research budget would include partial time (20% +) of breeders, pathologist, socio-economist and seed specialist at ICARDA (@ US$ 140,000 per year per scientist), plus support staff and operational costs estimated at total of US$ 600,000 per year. A further US$ 250,000 per year is needed for operational costs in the target countries, with an estimated total research budget over three years of $ 2.375 million

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: This effort is to collaborate closely with other cropping management research and development efforts. Synergies are to be sought to position the best overall cultivar+agronomy package with the farmers

14. Key contact person for more info: Osman Abdalla, o.abdalla@cgiar.org

Data entry sheet: 6.6

1. Acronym of lead Center for this Best Bet: ICARDA.

2. Best Bet keyword description: Water harvesting for supplemental irrigation

3. Best Bet short description: Integrated water harvesting/supplemental irrigation package for small farms to improve agricultural productivity

4. Best Bet full description: The problem in rainfed production systems is not the total amount of rainfall in the season but rather its distribution throughout the season and the soil water holding capacity. Dry spells cause severe stress to crops and can drastically reduce yields and water productivity. Soils generally have low water holding capacity; as a result most of the rainwater is lost from the plant root zone through deep percolation. In addition, rain often falls in intense showers and water is lost to run-off. Such water losses can be harvested and stored at the field or farm level to be used later during dry spells as supplemental irrigation to alleviate moisture stress, thereby increasing yields and supporting the more intensive use of other inputs. The proposed package to be tested and deployed includes options for an optimal water harvesting system encompassing farm water storage facilities and best supplemental irrigation techniques. Other necessary cultural practices such as improved soil fertility and cropping systems management will also be part of the package within a fully integrated system. Issues to be resolved through research and testing include technical and socioeconomic issues involved in local adaptation of the technologies. Suitable parameters associated with reservoir size and irrigation networks are some of the technical aspects to be resolved. Cost of the system and associated returns in addition to upstream-downstream consequences are also important issues

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Rainfed areas with frequent dry spells during the growing season

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 75%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Ethiopia, Eritrea, and Mauritania

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: The adaptive research work would be conducted with farmers' communities in farmers' fields using participatory approaches. NARS will lead the work with ICARDA providing technical support in planning, training, implementing, analyzing and delivering the outputs. Community organizations and civil society organizations will be involved to facilitate the sustainability of the development and the transfer of the technologies

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Financial support will be needed to set up and implement appropriate water harvesting/supplemental irrigation packages in pilot farmers' fields in major regions of the countries. As the extent of adoption will depend on community participation, resources will be needed to organize meetings with the communities and other relevant stakeholders. Financial and

human support will also be needed to develop a strategy and plan for the technology transfer to farmers and communities outside the pilot areas. The total financial resources needed to usefully deploy the water harvesting/supplemental irrigation package is estimated at $ 2.5 million per country

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research is needed to optimize and test the proposed package under local conditions. This will include fine-tuning of water harvesting and supplemental irrigation parameters to local climatic, soil and socioeconomic conditions. The package will be tested in target sites to develop appropriate recommendations. Baseline and characterization studies will be conducted to help monitor the system and develop appropriate impact indicators. Socioeconomic studies are necessary to provide information for optimization of the system. Training of NARS, local civil society organizations, community leaders and participating farmers in planning, implementation and managing the system is crucial for its success. This research and training support will require a full time water resources engineer, agronomist and economist for three years (@ US$ 140,000/year-scientist). It will also require testing and training materials and equipment for the first year of about $500,000 and annual operational costs of about US$ 100,000 for four years. Total annual testing, research and training cost for each country is estimated at US$ 800,000 per country

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: None

14. Key contact person for more info: Theib Oweis (t.oweis@cgiar.org)

Data entry sheet: 6.7

1. **Acronym of lead Center for this Best Bet**: ICARDA

2. Best Bet keyword description: Productive feed legumes

3. Best Bet short description: Productive feed legumes and best practices for boosting fodder and livestock production

4. Best Bet full description: A package consisting of high-yielding feed legumes and improved cultural practices will be introduced into existing cereal (barley, wheat and teff) cropping and fallow systems to increase grain and quality fodder production and improve soil health in smallholder crop-livestock systems in the non-tropical dry areas of eastern and southern Africa. High-yielding lines of vetch and grasspea selected by ICARDA, ILRI and partners will be the target legumes. The best practices will include land preparation methods, seeding rate and seeding time, types and amount of fertilizer applied, and control of weeds and pests. The package will ensure optimal and sustainable production of quality fodder supply per unit area of land in smallholder crop-livestock systems.

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Rain-fed, drought-prone, non-tropical grasspea and vetch growing areas in Eastern and Southern Africa

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 40%

7. Location-specificity: 1 = low (the Best Bet can scale-out widely with minimum local adaptation)

8. Most promising countries for this intervention: Ethiopia, Eritea, Sudan.

9. Time frame: Medium (3-5 years).

10. Most effective modes of delivery: A multi-stakeholder partnership consisting of farmers, local communities, public and private enterprises, and policy/decision makers will be established to facilitate delivery. Participatory approaches involving community-based organizations, farmers' interest groups, farmer field schools, travel workshops, and round-table discussions with policy makers will ensure highest potential impact/benefit. Linkages with other development projects will also enhance delivery

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Resources will be needed to establish and sustain multi-stakeholder partnerships for scaling-out/up. Monitoring, socio-economic surveys, seed multiplication and distribution, on-farm demonstrations, technical backstopping, capacity building, farmer field schools, and development of knowledge sharing materials will also require resources for deployment

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research efforts will include surveys combined with GIS to select sites, define recommendation domains, and monitor and assess impacts of the best-bet options. Strategic research is needed to screen feed legumes for high water productivity, and grasspea lines for low grain neurotoxin-toxin content. Applied and on-farm adaptive research will be needed to identify best-bet agronomic and feeding practices under local environments. A multi-disciplinary team of four research scientists consisting of forage and livestock systems specialist, cropping systems agronomist, socio-economist, and

ruminant nutritionist will be needed over a 3 year period @ US$ 140,000 per scientist/year, plus research support staff, operational costs and international travel. Research costs are estimated at US$ 1 million per year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Local landraces of grasspea contain high levels of a neurotoxin that causes paralysis in humans and livestock. This project will promote low-toxin grasspea lines, thereby contributing to improved human health. Increasing the supply of feed legumes will improve the nutrition of livestock, resulting in more meat and milk for household use and sale of excess products to generate income. Promoting a package of high-yielding lines and better agronomic practices adds value to the improved lines

14. Key contact person for more info: Asamoah Larbi (a.larbi@cgiar.org), Jean Hanson (j.hanson@cgiar.org).

Data entry sheet: 6.8

1. Acronym of lead Center for this Best Bet: ICARDA

2. Best Bet keyword description: Seed Policies and Institutions

3. Best Bet short description: Institutional arrangements and policies for effective seed multiplication and delivery

4. Best Bet full description: To safeguard food security and incomes, and improve the livelihoods of millions of poor households in Africa, substantial research and development efforts need to be directed toward reducing the huge yield gap of major crops produced by small farmers. Plant breeders have developed promising new cultivars with significant advantages in yield and adaptation to various stresses. However, the adoption of these improved cultivars is still very low due to the limited availability of improved seeds to farmers, as indicated by several technology adoption studies. This is mainly attributed to the lack or failure of seed delivery systems, which in turn is attributed to the lack of effective institutional arrangements and absence of enabling policies. Studies have shown that informal seed systems are the main source of seed for smallholders even in situations where formal seed systems have a large number of seed outlets, and that the diffusion of new crop cultivars is done primarily through informal seed systems. To facilitate the widespread adoption and use of improved cultivars, the seed must be easily and widely available to farmers. This requires the development of institutional options and conducive policies to expedite formal and informal seed multiplication and delivery systems

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet:
Dry areas and rainfed production systems for staple food crops such as wheat, barley, chickpea, faba bean, maize, sorghum and millet

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 50- 100%

7. Location-specificity: 1 = the Best Bet can scale-out widely with minimum local adaptation

8. Most promising countries for this intervention: Ethiopia, Eritrea, Sudan, and Democratic Republic of Congo (among others in Eastern and Southern Africa)

9. Time frame: Short (1-2 years)

10. Most effective modes of delivery: Lack of functioning institutions and enabling economic and policy environments lead to unavailability and inaccessibility of the improved cultivars where they are actually needed to enhance food security and improve the livelihoods of poor households. To overcome this deficiency, decision support tools will be used by farmers and policy makers to determine and facilitate effective and fast production and deployment of improved seed cultivars. This includes the development of enabling institutional arrangements and policy options and incentives to facilitate the uptake of improved cultivars and the development of village-based seed enterprises

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Development and financial resources to support capacity building of national seed production programs and the institutionalization of seed delivery (formal and informal)

systems and policies

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research efforts will include farm household surveys to establish baseline information and define vulnerability profiles and risk coping strategies; collection of market data to establish information on seed production, supplies, trade and prices; studies of crop seed sectors, stakeholders and institutions; reviews of policies regarding certified seed multiplication and distribution, involvement of the private sector, and regulations regarding the informal seed sector; and building policy decision support tools to enhance the uptake of the improved seeds and project their production, food security, nutrition and budgetary implications. The total estimated costs (for the four countries) are US$ 1 million per year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: This effort would collaborate closely with other research and development efforts related to cultivar development of staple food crops in the targeted countries

14. Key contact person for more info: Kamil Shideed, k.shideed@cgiar.org and Koffi Amegbeto, k.amegbeto@cgiar.org.

Data entry sheet: 7.1

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Micro-dosing – Planting Basins

3. Best Bet short description: Micro-dosing in planting basins to increase crop nutrient response

4. Best Bet full description: Much research shows that improved seed alone generates little benefit. Soil fertility must first be enhanced. "Planting basins" are a form of conservation agriculture appropriate for the poor (based on manual labor) that generates powerful synergies in the use of rainfall, nutrients (including micro-doses of chemical fertilizer) and improved cultivars to boost yields of a range of crops across rainfed dryland Africa (e.g. sorghum, millet, maize, cowpea, sunflower, soybean, cotton). It boosts returns to labor, profitability and sustainability. Planting basins double or triple yields of staple crops, depending on conditions and practices employed. Yield gains are substantial in dry as well as in wet years. Planting basins are shallow (15cm^3) depressions scooped out of the soil during the off-season, concentrating rainfall and nutrients around the base of the plant, improving early plant stand establishment while minimizing erosion and runoff losses. The technique encompasses a suite of synergistic options that farmers choose from depending on their circumstances: manure, micro-dosing, winter weeding, legume rotation, and 30% ground cover with crop residues. Micro-dosing has also been widely tested as a sole practice in both West and Southern Africa, generating yield increases of 50-100%. Adoption of planting basins is strongest so far in Zambia and Zimbabwe due to strong donor support, NGO and national extension participation and research contributions. It appears to have wide potential applicability across dryland Africa. Tried by an estimated 50,000 farmers so far, the planting basin method increases labor requirement by about 40% but a detailed survey showed that this has not constrained adoption, even in this region highly afflicted by HIV/AIDS; returns to labor tripled, from US$1.70 to $5.25 per day. Micro-dosing alone increases profits from millet farming fourfold in West Africa. Such nutrient efficiency gains are increasingly crucial because fertilizer costs have risen much faster than food prices

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 150%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Zambia, Zimbabwe, Niger, Burkina Faso, Kenya, Mali, Tanzania, Senegal, Chad, Nigeria

9. Time frame: Medium

10. Most effective modes of delivery: Planting basins and micro-dosing require training and skilled implementation but are well within the capabilities of poor dryland farmers. Trained NGO and government extension services catalyze these practices at the farm level, with flexibility for local customization based on conditions. Farmer field schools and farmer "champions" help spread the practice. Development agencies engage the private sector as well, so that they can sustain input supplies and output markets

after NGOs withdraw

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Farmers need donor and development agency assistance to obtain training, fertilizer, seed and technical backstopping. Inputs are obtained through bulk purchases (e.g. fertilizer in bulk from YARA, seeds from seed multiplication programs like AGRA, SCOSA, ESASA or others). Research and development agencies catalyze the intervention but over time linkages to village agricultural supply shops or farmer cooperatives take over for the long term (e.g. inventory-credit or warrantage associations in parts of West Africa). Technical backstopping and research linkages are required among NARS, NGOs and centers such as ICRISAT with development agencies and NGOs such as CARE, CRS, World Vision or FAO

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research is needed on ways to further increase nutrient use efficiency, helping farmers cope with rising fertilizer costs; fertilizer is the crucial driver of increased productivity and thus food security and poverty alleviation. Seed treatment research can boost seedling vigor and early establishment, raising yields. Research is needed to understand the interactions between planting basin management practices and crop traits to help plant breeders optimize cultivar adaptation and productivity in this system. Impact assessment research including market-chain analysis will accelerate the adoption and out-scaling of the system

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Sensitivity analysis has shown that crop yield advantages under planting basin cultivation are relatively robust across different rainfall levels and crops. Close linkages with seed supply initiatives are critical since the intended yield gains from improved cultivars are dependent on a precondition of improved soil fertility. The feed usage of crop residues competes with its use for soil protection. Inadequate supplies of improved legume seed have been a constraint to crop rotation so far. Provision must be made for absorbing surplus produce to avoid price collapses that could hurt farmers

14. Key contact person for more info: Steve Twomlow, s.twomlow@cgiar.org.

Data entry sheet: 7.2

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Improved sorghum, millet

3. Best Bet short description: Sorghum and millet bred for higher productivity under improved cultivation

4. Best Bet full description: Sorghum and millet are the staple cereals that sustain life for Africa's poorest peoples, who live in dryland areas along the Sahel, Kalahari and other inland regions. Since the 1970s ICRISAT has been breeding cultivars of sorghum and millet for dryland Africa that are higher yielding under improved management. This long-term investment is yielding a continuing stream of improved cultivars which, when grown in conjunction with improved soil fertility, double or triple yields on-farm. In addition to ready-to-go cultivars, current research on hybrid cultivars will add another 20-30% yield advantage when the necessary additional seed production skills are put into place in Africa – creating another yield jump in the longer term. Non-hybrid sorghum cultivars such as Macia in Eastern and Southern Africa and S35 in Chad, and millets such as Okashana 1 in Namibia are being widely adopted. However on an Africa-wide basis, improved sorghum and millet cultivars only occupy about 2% of the total crop area so far, so the opportunity for major productivity gains still awaits. Seed systems must be improved while integrating them with input supplies and output markets (see mode-of-delivery discussion) so that the fertilizer-cultivar synergy is captured. Besides high yield, additional traits appreciated by farmers are early maturity (where end-of-season drought is a risk), photoperiod sensitivity (synchronizes plant development with rainfall), resistance to diseases and insects, and grain qualities preferred by markets. Sorghum cultivars exhibit two sub-types: the guinea types (loose panicles) that predominate in West and Central Africa, and the caudatum types (compact panicles) in Eastern and Southern Africa. Caudatums tend to be higher-yielding but are more susceptible to grain mold, a greater risk in West and Central Africa due to climate. Millets include pearl millet (most common) and finger millet (Lake Victoria region). Downy mildew resistance is an important trait for pearl millet, and resistant cultivars have been bred

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 50%

7. Location-specificity: 2= requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Nigeria, Ghana, Kenya, Mali, Burkina Faso, Tanzania, Niger, Uganda, Zimbabwe

9. Time frame: Short

10. Most effective modes of delivery: Improved cultivars should be delivered to farmers together with fertilizer and other soil fertility enhancement practices to get the most benefit (see "planting basins and microdosing" best bet). The West Africa Seed Alliance (WASA) and the developing Eastern and Southern Africa Seed Alliance (ESASA) are vigorous mechanisms fostering the growth of African seed industry.

They disseminate products (seeds, etc) and knowledge through agro-dealers who in turn are linked to commercial input suppliers and financial institutions. These input supply channels are also being used for output marketing, creating the demand that is needed to incentivize the system

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Plant breeders in public and private organizations must team up with government seed bodies and regional seed networks to create the momentum, policy support, standards and practices needed for improved seed to be bred, multiplied, and made accessible to farmers. Regional agreements that help seed move across borders expand the scope of benefits to farmers while reducing transaction costs. Innovative partnerships with rural agro-input supply retailers and their wholesale suppliers ensure the flow of seed along with fertilizer, technical advice and other synergistic components

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Regional research teams of at least four scientists (breeder, agronomist, crop protection scientist, outreach scientist) are needed in each of West/Central, Eastern, and Southern Africa, full time for each crop (sorghum and millet); i.e., 24 scientist-years. In addition, seed networks require three staff (one for each region) for a total of 27 scientist-years, at a cost of approximately US$ 7 million per year. This cost does not include seed distribution or input supply personnel from the private sector

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Reiterate the need for simultaneous provision to farmers of soil fertility enhancement technology (e.g. fertilizer + manure) to create large synergistic yield gains with improved cultivars

14. Key contact person for more info: Bettina Haussman, b.ig.haussmann@cgiar.org; Richard Jones, r.jones@cgiar.org.

Data entry sheet: 7.3

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Improved dryland legumes

3. Best Bet short description: More disease and stress-resistant, higher-yielding groundnut, chickpea, pigeonpea

4. Best Bet full description: Groundnut, pigeonpea and chickpea are major leguminous crops of the drylands, vital to the diets of many poor who cannot afford enough meat to obtain required dietary protein. They are also important for maintaining agro-ecosystem health, acquiring their own nitrogen from the atmosphere which improves soil fertility, and breaking pest and disease cycles when grown in rotation with cereals. Legume stems and leaves (haulms) are also preferred fodder for animals. Improved cultivars supplemented with fertilizers such as phosphorus (where needed) increase yields by 30%. Fungal wilt and leaf spot diseases, and pod-borer insects damage these crops on a wide scale, creating a major risk for farmers. Integrated pest and disease management including resistant cultivars are essential for reliable productivity. Drought and heat resistance are also important, enabling these crops to be grown in shorter seasons or to fit as second crops that mature after the rains cease. High-value grain-type cultivars of these crops are much in demand in urban areas and in export markets, creating strong income-earning potential for poor farmers. Market connections to input supply systems provide access for the poor to improved seed, fertilizer and management advice, raising increased productivity over time. Improved cultivars of groundnut for foliar spot diseases; wilt-resistant and short-duration pigeonpeas; and drought and heat-resistant, high-value kabuli type chickpeas are having significant impact in different parts of Africa. Pigeonpea exports from East Africa to India and South Asian populations worldwide are an important opportunity enabled by improved cultivars. Seed systems for legumes are especially constraining because of the low multiplication rate in groundnut, and the rapid deterioration of seed viability in storage

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet:
Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 30%

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation)

8. Most promising countries for this intervention: Kenya, Burkina Faso, Tanzania, Malawi, Mali, Ghana, Ethiopia, Uganda, Benin, Guinea-Conakry

9. Time frame: Medium

10. Most effective modes of delivery: Research institutions breed new legume cultivars and develop improved soil fertility and integrated pest management systems to accompany them. Seeds are tested nationally. Farmer organizations assist in the testing and evaluation, including during the breeding process jointly with researchers. Regional seed networks WASA and ESASA help harmonize regional seed policies and connect farmers to input suppliers and output markets so that commercialization can

sustain and intensify production systems. When approved, new cultivars are multiplied by the public and private sectors (depending on national seed policies) and demonstrated to farmers together with the management practices

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Large-scale multiplication, storage (protecting viability) and dissemination of legume seed requires skilled personnel and infrastructure. Seed companies are effective sources for this task, but in Africa they must connect to small-scale village agro-supply shops to disseminate the seed in concert with fertilizer and insecticides for legumes. Such agro-dealers need training in order to adhere to standards and to transmit the best advice to farmers. Hybrid cultivars require additional skill. Groundnuts face a particular challenge because of their low seed-to-seed multiplication rate; village farmers can be engaged to increase the scope of multiplication

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Integrated crop improvement, management and pest/disease management is essential to underpin a steady output of improved cultivars. Disease races shift over time and a constant stream of new plant resistances flowing from the breeding program is required. Regional research teams of at least four scientists (breeder, agronomist, crop protection scientist, outreach scientist) are needed in each of West/Central and East/Southern Africa, full time for each crop (groundnut, pigeonpea, chickpea); i.e., 24 scientist-years. In addition, seed networks require three staff (one for each region) for a total of 27 scientist-years, at a cost of approximately US$ 7 million per year. This cost does not include seed distribution or input supply personnel from the private sector

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Legumes seed systems and supporting research were recently strengthened substantially by the launch of the Tropical Legumes II project supported by the Bill and Melinda Gates Foundation, IFAD, and the Kellogg Foundation

14. Key contact person for more info: Farid Waliyar, f.waliyar@cgiar.org; Richard Jones, r.jones@cgiar.org.

Data entry sheet: 7.4

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: African Market Garden

3. Best Bet short description: Drip-irrigated high-value trees, fruits and vegetables in drylands

4. Best Bet full description: Many dryland areas in Africa have access to sustainable groundwater supplies that could revolutionize agriculture for poor farmers. Drip irrigation is the most water-efficient method of application and it also reduces energy and infrastructure costs, and environmental risks compared to conventional surface flood irrigation. The judicious use of drip irrigation on high-value fruit and vegetable crops can multiply net incomes ten-fold or more compared to rainfed farming while insulating farmers from drought risk. Household food security and nutrition are also increased (vitamins supplied through vegetables). ICRISAT has developed an affordable gravity-powered drip irrigation system for small plots managed individually or collectively (e.g by village women's groups) called the African Market Garden (AMG). When water supply is thus assured, the tropical drylands become climatically suitable for a wide range of crops, such as tomato, onion, date palm, citrus, mango, lettuce, grapes, peppers and many others. Farmers located in proximity to growing urban areas can readily market these crops and even develop export markets e.g. for fruit juices, dried fruits, fresh-frozen vegetables, herbs and ornamentals. The system is readily up-scalable; farmers typically begin with plot sizes of just 1/20th of one hectare and add capacity in subsequent seasons by re-investing the increased profits. The investment required per farmer for the initial small plot is only about US$ 200 (often partially sponsored by donors) which is more than compensated by increased net incomes in a single growing season. About 2,000 AMGs have been sponsored and disseminated with training in West African dryland countries in recent years. A USAID project, for example in 2007, catalyzed 500 AMGs in Burkina Faso and Ghana, in the latter case increasing the utility and profitability of an irrigated rice development. The AMG is now spreading in Mali, Niger, Mauritania, Senegal, The Gambia, Guinea Bissau, Chad, and Cape Verde

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 500%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Mali, Burkina Faso, Senegal, Ghana, Niger, Nigeria, Mauritania, Chad, The Gambia, Guinea Bissau

9. Time frame: Medium

10. Most effective modes of delivery: Delivery is usually through shared costs by a donor and farmer, deployed through NGOs via training, research and technical backstopping partnerships with appropriate agencies. The replicability of the AMG through unit expansion is a major advantage for development, as is its resolution of the drought risk problem which opens many options for reliable productivity and income gains. Womens' community groups adopting AMG become empowered with a significant new income-

earning activity; they are most likely to share the nutritional and income benefits with children

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Tripartite partnerships between donors, development agencies, and research agencies are needed. Donors can sponsor community developments on a shared cost basis to ensure farmer commitment while easing the startup capital bottleneck, e.g. 50/50 sharing of the approximate US$ 200 setup cost per small AMG plot. NGOs need resources for training, and research institutions for technical backstopping, the breeding of adapted fruit and vegetable cultivars along with integrated pest management, and continued adaptive problem-solving

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Research and development should be closely integrated. Per African region (West/Central, Eastern, or Southern) a dedicated research/development team of about 5 full time scientists is needed to drive the system (irrigation specialist, horticulturalist, agronomist, and two outreach scientists), costing US$ 1 million per year. This core team will form partnerships with NGOs, national development agencies, donors and others to enable the needed funding, training and research for rapid expansion of the AMG area and continued improvements

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Women often lack tenure rights for land ownership. A special opportunity of the AMG is its effectiveness in recovering degraded lands that village leaders are often willing to provide to women. The AMG profits provide enough income to pay for fertilizer, tillage and planting requirements needed to rehabilitate these lands (e.g. hardened lateritic soils in West Africa). Women's groups cooperatively organize their input procurement, transport and marketing to ensure that most of the profits accrue to them

14. Key contact person for more info: Dov Pasternak, d.pasternak@cgiar.org.

Data entry sheet: 7.5

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Dryland Ecofarming
3. Best Bet short description: Dryland Ecofarm, an integrated high-value tree-crop system with rainwater harvesting

4. Best Bet full description: Africa's poorest farmers struggle to survive on subsistence cropping of low-productivity dryland cereals. Grain yields are typically less than one ton per hectare, and one year out of five crops fail almost completely due to drought. The vicious cycle of dryland risk and subsistence cultivation is driven mainly by three biophysical constraints: low soil fertility, drought, and soil erosion. An integrated approach to alleviate these problems devised by ICRISAT is called the Dryland Ecofarm (DEF). The DEF integrates leguminous trees and water harvesting to enrich soils, ease droughts and protect against water and wind erosion, while increasing incomes through higher-value tree fruits and other specialty crops. Leguminous, hardy *Acacia* tree species have been identified that grow vigorously in drylands, fixing atmospheric N that helps farmers who are unable to purchase sufficient fertilizer. The trees are pruned when the cereals are sown so their nitrogen-rich leaves form a protective soil mulch, and the branches supply firewood, the main energy source of the poor, reducing the drudgery of firewood collection that currently falls on women, also alleviating deforestation. Tree rows are widely-spaced (10 meters) across the slope of the field, and enclosed in bunds that interrupt sheet erosion and increase the infiltration of rainwater into the soil. The *Acacia* tree rows are interspersed with rows of high-value drought-tolerant fruit trees such as Pomme du Sahel (*Ziziphus mauritania*). Between the tree rows, vital subsistence food and feed crops such as millet, sorghum, and cowpea are grown, along with higher-value drought resistant crops such as roselle (*Hibiscus sabdariffa*), senna (*Senna obtusifolia*), and numerous well-adapted indigenous leafy vegetables that are locally-preferred. These leafy vegetables improve family nutrition, supplying vitamins A and C, iron, and other minerals and other nutrients that tend to be deficient in cereal-based diets of the poor, severely affecting human capacities

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 300%

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation)

8. Most promising countries for this intervention: Niger, Mali, Burkina Faso, Nigeria, Senegal, Chad, Ethiopia, Kenya, Tanzania, Malawi

9. Time frame: Long

10. Most effective modes of delivery: Dryland ecofarming increases profits which will sustain the needed components of the system if assisted through public development policies to first catalyze and up-scale the system (infrastructure, research, market facilitation or land tenure issues among others)

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: The Dryland Ecofarm is an integrated system and therefore requires

the simultaneous introduction of several synergistic components. A team approach between donors, research and development institutions is therefore required. Supplies of seeds of the range of crops and tree propagules is needed, e.g. including the establishment of tree nurseries. Connections to markets must be established for remunerative and reliable sales of the higher-value produce to reward and sustain farmer's intensification efforts

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Experts in rainfed tree culture, high-value and indigenous crop horticulture, agronomy (including water harvesting) and outreach are needed. Since rainfed agriculture adapts to land variability, teams must be decentralized at least to the regional level. Thus, one such team each (three persons) in each of three regions (West/Central, Eastern, and Southern Africa) is required, or 3 x 4 = 12 scientists, at a total cost of US$ 3 million per year. These teams will catalyze partnerships with national agencies, NGOs and the private sector (input supply and output markets) needed to implement DEF on a large scale

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: In some social cultures the planting of trees is problematic; it is considered an indication of land ownership. Development practitioners and institutions must work closely with communities to find ways to overcome this inhibition where it exists. Once communities realize the benefits from the system and community leaders support it, they are likely to adjust traditional tenure systems to accommodate it

14. Key contact person for more info: Dov Pasternak, d.pasternak@cgiar.org.

Data entry sheet: 7.6

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Sweet sorghum ethanol

3. Best Bet short description: Sweet sorghum – smart ethanol crop generates food, feed, and fuel

4. Best Bet full description: "Sweet" cultivars of sorghum produce grain for humans and stalk for livestock, but add a third valuable product: ethanol, derived by crushing the stalks and fermenting the sugar-rich juice. This third additional use of an old but valued crop enables nations to re-invest some of their currency outflows that are now going foreign oil purchases, back into the development of their own poorest areas: their drylands. At the same time energy security is increased (less vulnerability to skyrocketing oil prices) and global warming is alleviated. Instead of a food-fuel tradeoff, connecting sorghum farmers to a commercial processing facility creates technology flows that stimulate a green revolution in sorghum farming, doubling or tripling grain and stalk yields, e.g. by stimulating increased fertilizer use, better crop management and the emergence of an African hybrid seed industry. Sorghum is a C4 crop, highly efficient in converting renewable solar energy into biomass while removing carbon from the atmosphere. Under good management it can produce up to 80 tons (fresh weight) of stalks per hectare in just four months of growth, but a reasonable first target for African farmers may be 20 to 30 t. Twenty tons of stalk yields 1,000 liters of pure ethanol, enough for 200 automobile gas tank refills (compact car, 10% blend of ethanol to gasoline). In sorghum-dependent African countries, growing sweet sorghum on just a small fraction of the existing sorghum crop area would meet national ethanol production needs. A medium-sized processing facility can produce 40,000 liters of ethanol per day, employing 9,000 people including 5,000 farmers. After crushing and juice extraction the residual stalk material ("bagasse") can be pressed into nutritious feed blocks for cattle and sheep. Dryland peoples depend heavily on sorghum stalks to feed livestock, particularly in the dry season

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 200%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Kenya, Nigeria, Mozambique, Mali, Ghana, Uganda, Tanzania, Madagascar

9. Time frame: Medium

10. Most effective modes of delivery: Government policy support mandating the use of ethanol in commercial fuel supplies stimulates the entry of commercial processors into a country, creating a demand pull. Alliances between ethanol processors, research institutions such as ICRISAT, input suppliers (e.g. seed companies, fertilizer dealers) and farmer associations form to meet the need. Successful processing requires reliable large-volume sources of feedstock (sorghum stalks) which motivates the processors to ensure farmer access through the technology partners to the most effective crop management practices and inputs such as seed and fertilizer

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: A medium-sized ethanol processing plant (40,000 kiloliters ethanol output per day) costs about US$ 10 million. This processes about forty hectares of harvested stalk per day. This private sector investment provides the catalyst for the feedstock production system and its required partners to join (research, technology extension, farmer groups). Contracts guaranteeing purchase of their stalk at a defined price are reached with the farmers. Given the financial constraints of small-scale farmers in Africa, the processing plant will need to issue credit to farmers to buy inputs and deduct that expense from the value of the harvested stalks. This motivates farmers to obtain the highest outputs possible from the inputs through careful management

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: A systems perspective must be taken by the research team, including production, processing, marketing, farmer welfare and environmental impact issues. A multidisciplinary team including one each of: plant breeder, agronomist, economist, and systems engineer is required per region, which represents a cost of US$ 1 million per region per year, or US$3 million annually for Africa's three regions

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Costly processing facilities plus the investments required to plant and manage the crop cannot be subject to crop failure risk. Therefore sweet sorghum should be grown in the higher-rainfall end of the dryland spectrum, e.g. 400 mm of well-distributed rainfall over 4 to 5 months. Also, a key bottleneck is the harvest time, because the sugar in stalks is soon consumed by bacteria if not fermented to ethanol. Decentralized crushing and fermentation facilities are advised to avoid transportation bottlenecks. Once fermented, the ethanol is stable in storage. Boiling the juice down into syrup also preserves it for later processing, but consumes energy

14. Key contact person for more info: Bekele Shiferaw, b.shiferaw@cgiar.org.

Data entry sheet: 7.7

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Food safety, nutrition

3. Best Bet short description: Improving food safety and nutrition of the dryland poor

4) Best Bet full description: The World Health Organization and other bodies estimate that anemia caused by iron deficiency affects over two billion people worldwide, including most poor women; that zinc deficiency, which causes stunting and morbidity affects three-quarters or more of those in Asia and Africa; and vitamin A deficiency, which can cause blindness, growth retardation and disease susceptibility damages one-third of the developing world population. Breeding cereal cultivars higher in iron and zinc content can help; lines in ICRISAT's gene bank have concentrations of these minerals up to four times higher than in widely-grown cultivars. Complementing this improvement in the staple foods of the poor, efforts are needed to diversify their diets to include vitamin-rich vegetables. The revival of overlooked indigenous species is one promising avenue. Leaves from the Moringa "miracle tree" for example contain 50 times more pro-vitamin A per unit weight than millet grain. Other species often picked wild and consumed include *Corchorus* spp., *Senna obtusifolia*, *Hibiscus sabdariffa* and *Adansonia digitata*. These forgotten crops also earn farmers a high income, helping combat the poverty that is also a cause of poor diets. In addition to nutritional deficiencies, 'aflatoxins' produced by certain fungi growing on food products impair the functioning of the human immune system and causing stunting, liver cirrhosis and cancer. The aflatoxin-producing fungi *Aspergillus flavus* and *A. parasiticus* must be controlled both by crop management practices (they are often triggered by drought) and also in storage (where moisture can trigger them). In addition to controlling moisture levels, important research targets include: biological control agents; fungicides; resistant crop cultivars; timely harvesting and sorting to remove infected grains; quick drying and dry storage of grains; and monitoring food supplies to remove and dispose of contaminated lots. Assured control of aflatoxin could also open up lucrative foreign export markets to African farmers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: Human health benefit

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation)

8. Most promising countries for this intervention: Malawi, Mozambique, Tanzania, Kenya, Ethiopia, Niger, Mali, Burkina Faso, Senegal, Nigeria

9. Time frame: Long

10. Most effective modes of delivery: Nutritionally-enriched crop cultivars can be delivered through the same systems used for other types of improved seed (see "best bet" for improved dryland cereals). Controlling plant toxins requires extension services/NGOs providing training to farmers, methods for monitoring food quality, and connections to commercial markets. For example, ICRISAT developed a low-cost, highly accurate aflatoxin testing kit based on ELISA immunoabsorbent technology that is being

used by the National Smallholder Farmers' Association of Malawi (NASFAM) to meet quality assurance standards required for export groundnuts to the European Union — an approach that is now expanding into Mozambique, Tanzania, and Kenya

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Strengthened seed systems (see accompanying improved cereals best bets) will also pay off in the delivery of nutritionally-enhanced cultivars. To enhance the cultivation and consumption of local nutrient-rich vegetables, capacities and infrastructure need to be strengthened through interventions and farmer training by extension agencies and NGOs. For the integrated control of aflatoxin, capacity-building and the establishment of market chains is required according to the needs and circumstances of major production areas of particular susceptible crops. Multidisciplinary teamwork is required involving agriculturalists, medical experts and marketers. An estimated US$ 10 million annually could make major progress on this initiative

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Breeding for higher nutritional content in dryland cereals is recognized as an enormous opportunity as reflected the multi-donor HarvestPlus CGIAR Challenge Program, and in the Bill and Melinda Gates Foundation-supported Africa Biofortified Sorghum project. Much more support though is needed for research into the collection, domestication, cultivation and marketing of African dryland indigenous vegetables to diversify and nutritionally-enrich diets of the poor. A regional multidisciplinary team approach is needed involving a crop diversity scientist, a horticulturalist/agronomist, an economist and a marketing expert, for a total of 4 scientists x 3 Africa regions, costing about US$ 3 million per year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Mineral content of grain will also be influenced by available mineral levels in the soil, and cultivation practices. Controlled drip irrigation of vegetables as described in an accompanying best-bet would give farmers better control over the moisture conditions that influence aflatoxin likelihood

14. Key contact person for more info: Farid Waliyar (food toxins), f.waliyar@cgiar.org; Tom Hash (breeding nutrient content), c.hash@cgiar.org .

Data entry sheet: 7.8

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Climate change adaptation
3. Best Bet short description: Adapting dryland farming systems to impending climate change

4. Best Bet full description: The Intergovernmental Panel on Climate Change (IPCC) recently concluded (Fourth Assessment) that the drylands of Africa are one of the global agro-ecosystems at highest risk from climate change. The poorest peoples who live there are highly vulnerable because they are dependent on agriculture and have few fallback options if climates cause crops to fail. ICRISAT research estimates that climate-change induced increases in temperature will cause significant (8% to 30%) reductions in grain yields of dryland crops. To magnify capacities and increase momentum on the crucial topic of climate variability, ICRISAT is building a coalition with the Soil-Water Management Network of the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA) and 15 national, regional and international organizations. This consortium is endorsed by the New Partnership for Africa's Development (NEPAD) and its Comprehensive African Agricultural Development Plan (CAADP). Seasonal climate forecasting enables farmers and governments to receive early warnings and take appropriate actions. Decision-support frameworks identify options (e.g. cultivars and management techniques) best suited to expected conditions (drought, heat, etc.) Crop growth simulation models tested against past rainfall data infer how the different options are likely to perform. Past weather data is being rescued from hundreds of African locations before it is lost; spatial weather generators and satellite imagery are used to in-fill missing data. Researchers are also learning from farmer insights, since dryland farmers have been coping with variable weather in the past. Village-level socioeconomic studies, land-use surveys, and farmer field schools are some methods used to gain and share knowledge

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: Yield stabilization, risk reduction

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation)

8. Most promising countries for this intervention: Madagascar, Malawi, Mozambique, Sudan, Tanzania, Uganda, Zambia and Zimbabwe

9. Time frame: Long

10. Most effective modes of delivery: Climate forecasting and early-warning systems will be implemented by strengthening existing African agro-climatology institutions and interlinking them amongst each other and with international and regional research institutions, development agencies and farmers. These associations will develop additional response options, facilitate rapid and timely flow of climate forecasts, advisories, recommend preventive and coping practices, new technologies, capacity-building and further mutual learning

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Sustained institutional frameworks that allow research

and development partners to work together are crucial. Partnerships between the agro-meteorological, agricultural and development communities focused on adapting to climate change will be forged in order to collect past climatic data, develop forecasting and response models, and conduct field validation, testing and extension of those models. The development of additional technical options such as heat-resistant crop cultivars and more robust, resilient farming systems is also essential, expanding the toolbox of available options. Approximately US$ 10 million per year is needed to bring these parties together and efforts to fruition

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Much more needs to be learned from studies of dryland crops and cropping systems developed by farmers in the face of past climate change. By combining local knowledge with new scientific possibilities, the number of preparatory and coping options will increase (early-warning, buffering, adaptation, resilience, diversification, insurance etc.) A multidisciplinary team approach is needed involving at least one agro-climatologist, agronomist, breeder, socio-economist, modeler, and outreach specialist in each of three African sub-regions, or 18 scientist-years total for sub-Saharan Africa (US$ 4.5 million per annum)

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Climate change patterns are likely to differ across Africa's different regions since the driving forces (sea/land temperature differentials, in turn driven by different ocean current and atmosphere-land surface interactions and patterns) require that sub-regional approaches and capacities are needed

14/ Key contact person for more info: Peter Cooper, p.cooper@cgiar.org.

Data entry sheet: 7.9

1. Acronym of lead Center for this Best Bet: ICRISAT

2. Best Bet keyword description: Dryland biotechnology breakthroughs

3. Best Bet short description: Podborer-resistant pigeonpea and marker-assisted backcrossing in sorghum and millet

4. Best Bet full description: Biotechnology can break through longstanding constraints to continue the momentum of an African green revolution long into the future, if current initial efforts are expanded and sustained. Two key dryland crop opportunities are: 1) resistance to highly-damaging legume pod borer insects by transforming pigeonpea with the *Cry1Ab Bt* gene; and 2) the application of marker-assisted backcrossing (MABC) to sorghum and millet for resistance to the enormously important crop improvement targets of resistance to drought, *Striga* (a parasitic weed) and downy mildew (a fungal disease of millet). Past major efforts through conventional breeding approaches have not been able to conquer these challenges. ICRISAT has already developed and an efficient genetic transformation protocol for pigeonpea, setting the stage for the *Bt* gene transfer to locally-adapted pigeonpea cultivars. A number of different promoters will be evaluated to find out which works most efficiently. ICRISAT and others have also developed effective MABC methodologies (which do not involve genetic transformation) for quantitative traits and including mapped markers for sorghum and pearl millet. In conjunction with participatory farmer selection, these tools will be used to develop regionally-adapted sorghum and pearl millet cultivars that are much more robust in the face of these major yield-threatening stresses

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 50% in affected years/locations, e.g. yield stability

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Mozambique, Tanzania, Kenya, Uganda, Eritrea, Ethiopia, Nigeria, Malawi , Mali, Sudan

9. Time frame: Long

10. Most effective modes of delivery: Transgenic pigeonpea will be developed and deployed only in countries where the appropriate regulatory frameworks are in place. MABC sorghum and millet cultivars are not transgenic and therefore will be delivered through regular improved seed testing and dissemination channels.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Transgenic research requires advanced research facilities and trained personnel (BL2 laboratories, BL2 greenhouse, confined field trial sites) reviewed and approved by government regulatory authorities. Transformation activities include laboratory work, evaluation of plants in controlled greenhouses and confined-field trials, impact and risk assessment, and technical backstopping to farmers. Once transgenic products are approved, district extension teams, seed

companies, farmer organizations and input suppliers contribute to their dissemination and use by farmers. MABC requires good genotyping facilities and relevant breeding skills

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Pigeonpea transformation requires a full-time biotechnologist, plus expenses for extensive biosafety testing and external review/approval. MABC research requires one scientist each for sorghum and for millet. The total requirement is approximately US$ 750,000 per year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Key bottleneck/knowledge gap is the negative perception of GMOs in Africa, lack of proper regulatory frameworks in some/all of the target countries and the slow adoption of the technology in Africa

14. Key contact person for more info: Santie de Villiers (genetic engineering), S.devilliers@cgiar.org; Dan Kiambi (MABC), d.kiambi@cgiar.org.

Data entry sheet: 8.1

1. Acronym of lead Center for this Best Bet: IITA

2. Best Bet keyword description: Availability cassava cultivars

3. Best Bet short description: Provision of new improved cassava cultivars to replace current farmers stock

4. Best Bet full description: Cassava is well recognized for its capacity to address food needs of vulnerable communities in unstable environments especially as a result of drought, in Africa. In collaboration with NARS, IITA has released an estimated 206 cultivars between 1970 and 1998 suitable for different agro-ecologies. Today, more than 50% of the cassava area in Nigeria is planted to improved cultivars and, across Africa, the average is 30%. It has been estimated that between 40%-50% of cultivars grown in Nigeria and Ghana are unimproved local cultivars, in the rest of Africa the numbers are between 60% and 80%. Improved cultivars have the ability to double farmer's current yields with minimal additional input. Due to the nature of cassava planting material improved cultivars cannot be easily diffused to farmers without an active multiplication and distribution strategy. Rapid multiplication techniques to be used will include using farmers and out growers to practice the 2- and 4- node techniques of stem multiplication. After primary multiplication of available best bet cultivars, groups of selected cultivars will be deployed to different farms for on-farm selection, further multiplication and distribution. The improved cultivars are resistant to major cassava diseases and pests and have optimal on farm yields of about 22 t/ha under natural soil fertility. Weed management and competitive farming using middle level machines will also be introduced to encourage return of youths to agriculture, reduce labor costs, and improve incomes. Product diversification will also be emphasized along with the new cultivars to prevent glut, and storage root rot. Farm gate processing that will add value to cassava will also need to be taught and appropriate machinery be introduced. Research in Nigeria have shown that technology will go nowhere without markets, hence additional effort will be put to link extra production to appropriate markets

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 80%

7. Location-specificity: 2 = Requires a moderate degree of local testing and or adaptation

8. Most promising countries for this intervention: Nigeria, Ghana, Democratic Republic of Congo, Tanzania, Mozambique, Cameroon, Malawi, Sierra Leone, Liberia, Guinea

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: The delivery will involve fast track participatory testing (simultaneous on-farm, demonstration, and multi-location trials), field days, and training events with NARS, the extension service (government and NGOs), individual farmers, farmer associations, out growers, and NGOs interested in helping local communities. Stems will be distributed in bundles and sachets. Other stakeholders that will be involved are national phytosanitary units, and input suppliers

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: The involvement of the following development agencies is necessary:
1. Farmer organizations
2. District extension teams from the Ministry of Agriculture and, in some countries, extension departments of local universities
3. Ministry of Commerce, Ministry of Information, and Agricultural Banks
4. Private sector agencies interested in helping local communities (e.g. NGOs, CBOs)
5. Agro-input dealers (e.g. sellers of relevant agrochemicals)

Financial resources:
1. Input supplies: fertilizer, herbicides, insecticides
2. Trucks, tractors
3. Personnel for research, training and coordination; travel; labor, vehicles
4. Training guides (publications, audio visuals)
5. Publicity (Radio, TV, print)
6. Field days
7. Demonstrations

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet:
Activities:
Participatory rural appraisals for baseline data on cassava production, yield, pests, available technologies, needs, indigenous knowledge
Description of socioeconomic characteristics of target groups
Ex-ante and *ex-post* adoption studies on cultivars deployed
Monitoring and evaluation of sustainability of farm enterprises (on-farm evaluation, and field days)
Training and dissemination of agronomic and post-harvest techniques for cassava
Profitability analysis of sustainability of farm enterprises

Budget:
Personnel: total time equivalent to six FTE scientists @ US$ 150,000/year-scientist for 4 years for project management, agronomy, physiology, economics, pathology, nematology, entomology, virology, breeding, agro-enterprise management, technology transfer.
Materials/supplies: US$ 300,000/year
Travel: US$ 300,000/year
Labor: US$ 200,000/year
Trucks/tractors/Vehicles/maintenance: US$ 800,000/4 years
Publicity awareness and training guides: US$ 150,000/year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Countries in Eastern and Central Africa (ECA) have reported Cassava Brown Streak Disease (CBSD). There is urgent need along side this current best bet to evaluate and select for more and better cultivars resistant CBSD for secondary re-supply in Eastern and Central Africa and mitigation activity in West and Central Africa.

14. Key contact person for more info: Alfred Dixon, a.dixon@cgiar.org; Richardson Okechukwu, r.okechukwu@cgiar.org.

Data entry sheet: 8.2

1. Acronym of lead Center: IITA

2. Best Bet keyword description: Healthy seed yams

3. Best Bet short description: Mass production of healthy planting materials of recommended yam cultivars

4. Best Bet full description: Improving the availability of healthy, affordable yam planting material (up to 60% of total production cost) is necessary to raise productivity of yam based production systems. The multiplication ratio of yams in the field is very low (less than 1:10) compared to some cereals (1:300). Pests and diseases are major constraints to seed material and yam production with good-quality, clean planting material expensive and scarce. Planting material in general is insufficient to meet demand, while healthy material much less so. Rapid production of healthy seed yams consists of first selecting the healthiest tubers of recommended cultivars as mother seed yams. Depending on cultivar, agro-ecology and target market 50 to 100 g pieces were found as most effective with farmers. The pieces are treated with a simple, effective low dosage mixture of fungicide and insecticide and then planted at 25 to 30 cm spacing along ridges set 1 m apart (33,000 – 40,000 stands/ha). Better yields are obtained if the plants are staked, but there is better suppression of weeds if the plants are allowed to form a dense mat over the ground. Ideally the starting material should be selected in the field the previous season to avoid propagating virus infected plants (virus infection can usually be readily recognized in the leaves of growing plants). Application of the pesticide mix to cut seed setts in on farm studies resulted in higher yields (more seed yams) of healthier yams, which stored better and longer, leading to substantially (up to 700%) higher ware yam production. Tuber-borne pests result in heavy losses during storage in quantity and quality. This project will work with yam farmers through local partner organizations' and national programs for the promotion of cost-effective, sustainable and environmentally sound production of healthy planting material including the development of dedicated seed yam producers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 100%

7. Location-specificity: 2 = requires a moderate degree of local testing and or adaptation

8. Most promising countries for this intervention: Nigeria, Ghana, Benin, Togo, Côte d'Ivoire, Cameroon, Ethiopia, Sierra Leone, Liberia, Guinea

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: The delivery will involve participatory testing, demonstrations, and training events with NARS, the extension service (government and NGOs), individual farmers, farmer associations, seed producers, and private sector agencies interested in helping local communities. Community based production of healthy seeds would be used in several areas but interested individuals would be trained as specialist seed producers. It will also involve government institutions relevant to the development of inspection and certification procedures. The involvement of seed yam sellers

and chemical companies in stakeholder meetings and demonstrations would facilitate links with seed producers for input supply and efficient marketing strategies.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: The involvement of the following development agencies is necessary:
1. Farmer organizations
2. District extension teams from the Ministry of Agriculture and, in some countries, extension departments of local universities
3. Local government authorities and area councils
4. Private sector agencies interested in helping local communities
5. Agro-input dealers (e.g. sellers of relevant agrochemicals)
6. Transport and marketing agencies

Financial resources:
1. Input supplies: Baskets and net bags for distribution; fungicides, insecticides
2. Facilities (barns) for temporary storage
3. Personnel for research, training and coordination; travel; labor

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet:
Activities:
Participatory rural appraisals for baseline data on seed yam production, pests, available technologies, needs, indigenous knowledge
Description of socioeconomic characteristics of target groups
Ex-ante and *ex-post* adoption studies on propagation and pest management techniques
Evaluation of propagation and pest management techniques with farmer participation
Training and dissemination of agronomic and crop protection techniques for seed yam production, storage and marketing
Profitability analysis of seed yam production and marketing
Budget:
Personnel: total time equivalent to five FTE scientists @ US$ 150,000/year-scientist for 4 years for project management, agronomy, physiology, economics, pathology, nematology, entomology, virology, breeding, agro-enterprise management.
Materials/supplies: US$ 300,000/year
Travel: US$ 300,000/year
Labor: US$ 200,000/year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: The countries proposed for this project produce about 95% of the world's yams. For traditional major yam producer countries where IITA has had relatively more exposure to seed yam work (e.g. Nigeria and Ghana), we can readily deploy within 1 or 2 years with the Location-specificity rank of 1 = low (the Best Bet can scale-out widely with minimum local adaptation) and the Time frame required to effectively deploy would be lower than less traditional countries. Poor quality seed yams carry pests from storage barns to the field the next season resulting in low tuber yields followed by heavy storage losses

14. Key contact person for more info: Daniel Coyne, d.coyne@cgiar.org and Robert Asiedu, r.asiedu@cgiar.org.

Data entry sheet: 8.3

1. Acronym of lead Center: IITA

2. Best Bet keyword description: Drought-tolerant maize cultivars

3. Best Bet short description: Drought tolerant maize cultivars and productivity increasing crop management

4. Best Bet full description: The importance of maize in human diets, livestock feed and as an industrial raw material increased rapidly in West and Central Africa (WCA) since the 1980s. Maize has the greatest production potential in the savannas due to increased solar radiation and reduced incidence of pests and diseases. Maize production in the savannas is constrained by recurrent droughts. IITA, in collaboration with the NARS in WCA has developed early and extra-early cultivars adapted to the short rainy season on the fringes of the northern Guinea and Sudan savannas. Some cultivars are also tolerant to drought stress common in the savannas and parts of the forest zone. They are used for filling the hunger gap in the savanna zones and for planting in the hydromorphic soils of the forest zones to provide rainy season green maize. Appropriate plant population density, planting dates, and soil fertility management practices have been developed for these maturity groups. The cultivars and the appropriate crop management practices have been tested in on farm trials to a limited extent in Benin Republic, Nigeria, Ghana, Togo, Mali, Burkina Faso, Cameroon, Senegal and Guinea. Results of the on farm trials have shown that the improved early and extra-early cultivars in combination with the improved cultural practices out yield the local cultivars by at least 100%. More extensive testing of the technologies on farm and vigorous promotion will be needed for widespread adoption. Moreover, there is need to establish effective seed systems to make good quality seeds of the early and extra-early maize cultivars available to farmers in those countries that do not have well established seed industries. In countries where the private seed sector exists, efforts will be made to link with this sector to promote the production and marketing of seeds of the maize cultivars

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist and dry savannas

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 100%

7. Location-specificity: 2 = requires a moderate degree of local testing and or adaptation

8. Most promising countries for this intervention: Nigeria, Benin, Togo, Ghana, Côte d'Ivoire, Mali, Burkina Faso

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: National maize scientists in collaboration with extension staff, NGOs and the private seed companies of the pilot countries will conduct a large number of participatory on farm trials while technical backstopping would be provided by IITA. The project staff would be responsible for the training of the farmers in on farm experimentation. Community based seed production schemes would be initiated to provide good quality seed wherever there is no seed company. Seed producers will be trained in the techniques of seed production. Also, NARS scientists will organize the

seed producers into cooperatives and link them to markets, sources of credit and inputs

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: An annual budget of US$ 1 million would be required to support the on-farm testing, demonstrations and promotion of the adoption of the combination of the early and extra-early cultivars and the improved cultural practices, community based seed production schemes, capacity building of seed producers, farmers and project staff and stakeholder meetings. This budget will be sufficient to support project activities in one country for one year

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: There will be a need for an *ex-ante* impact assessment study and targeting to establish a benchmark for measuring the impact of the technologies to be deployed. Also, adoption studies will be conducted to monitor the level and pathways of adoption of the technologies to be promoted. Furthermore, monitoring tours will be organized to assess progress in the implementation of the project activities. It is estimated that an amount of US$ 400 000 would be needed for these activities

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: None

14) Key contact person for more info: Baffour Badu-Apraku, b.badu-apraku@cgiar.org; Abebe Menkir, a.menkir@cgiar.org.

Data entry sheet: 8.4

1. Acronym of lead Center for this Best Bet: IITA

2. Best Bet keyword description: Stress tolerant maize

3. Best Bet short description: Deployment of low-N and drought tolerant maize in West Africa

4. Best Bet full description: Soils in the savanna of West and Central Africa are inherently low in nitrogen and also prone to drought, yet are the region best suited to maize production. The application of nitrogenous fertilizers can improve production but the availability and use of them is a serious limitation. Average fertilizer use on maize in Nigeria is about 12 kg NPK/ha. Fertilizer use in other countries of the region is much lower. Therefore, improving productivity of maize in the savanna will rely on improving soil fertility, ensuring efficient use of inputs and using low-N tolerant maize cultivars. Several reports have highlighted a direct relationship between low-N and drought tolerance in maize. Results from selection experiments conducted with the developed cultivars revealed that grain yield of 2.5 t/ha is achievable with moderate (60 kg N/ha) nitrogen application. This yield gain under low-N is attained without compromising the yield potential of the cultivars under normal N application. Average grain yield of these cultivars in on farm trials conducted in the savanna of Nigeria and Ghana has demonstrated their superiority over the best local check at suboptimal (60 kg N/ha) and recommended fertilizer (120 kg N/ha) applications. Therefore, the low-N, drought tolerant cultivars will have immediate utility in the stressed environments of West and Central Africa. The cultivars will fit well and benefit from the synergistic effect of the maize and legume rotation system advocated for improved productivity of the savannas of the region

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 50%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Nigeria, Ghana, Benin, Cameroon, Togo, Côte d'Ivoire, Mali

9. Time frame: Short for Nigeria and Ghana; medium for Benin Republic, Cameroon, Togo, Côte d'Ivoire and Mali

10. Most effective modes of delivery: Public private partnership is envisaged. Mode will change depending on country and institutional arrangement on the ground. In Nigeria and Ghana, a commercial mode will work due to existence of private seed companies that can multiply and market the seeds. In Benin and Togo, farmers' cooperatives will aid initial deployment of the cultivars, but there is need to aid the transformation of well managed cooperatives into micro seed enterprises for wider dissemination. Effort in Cameroon, Côte d'Ivoire and Mali will initially be community based but eventually linked entrepreneurial seed vendors for wider deployment.

11. Key development and financial resources needed to deploy this Best Bet within a typical country

among the target set of countries: Using Nigeria as a typical country, there exist several seed companies that can partner IITA to produce and market the cultivars in the medium to high maize production areas of the country. States Agricultural Development Projects will ensure that farmers are mobilized and empowered in the deployment program. Quantities of inputs required for standard demonstration plot of a 0.25 ha are 5 kg of improved seed, 1 L each of pre- and post emergence herbicide and 2x 50kg bags of NPK fertilizer. An average of 200 trials in each of 20 States of the country will give a total of 4,000 trials per year @ US$ 150/trial = US$ 600,000/year for Nigeria

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Extensive backstopping is needed. A team of three scientists (breeder, agronomist, socio-economist) at US$ 150,000/scientist year (= US$ 450,000/year), travel @ US$ 25,000/scientist (= US$ 75,000/year), in country team of similar discipline and an extensionist @ US$ 20,000/scientists year (=US$ 80,000 x 7countries = US$ 560,000/year). Total for three years ~ US$ 3.3 million

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Development of multiple stress tolerant genotypes will enhance stability of maize performance on farm. There is a positive relationship between drought and low-N tolerance in maize because similar selection criteria are applied in breeding for both tolerances. However, *Striga* and stem borer also thrive best on poor soils, therefore, there is need to confirm the synergy and possible spillover effects of the various technologies on farm

14) Key contact person for more info: Sam Ajala, s.ajala@cgiar.org; Abebe Menkir, a.menkir@cgiar.org.

Data entry sheet: 8.5

1. Acronym of lead Center for this Best Bet: IITA

2. Best Bet keyword description: Integrated *Striga* control

3. Best Bet short description: Use resistant maize cultivars with legumes occasioning suicidal *Striga* germination

4. Best Bet full description: *Striga* is an endemic root parasite in the savannas of West and Central Africa that causes significant yield losses in maize and other cereals. The diversity of the farming systems and that of the parasite have rendered the use of a single control method against *Striga* ineffective. A combination of control options would be more effective in controlling *Striga* . An ideal integrated control strategy should minimize the impact of crop losses, deplete the *Striga* seed bank in the soil, reduce further *Striga* seed production, and improve soil fertility to achieve enhanced, sustainable, maize production. Use of *Striga* resistant or tolerant maize cultivars in rotation with legumes capable of causing suicidal germination of *Striga* seeds will attain these goals. Several *Striga* resistant or tolerant extra-early, early- and late-maturing maize cultivars, soybean and cowpea lines capable of eliciting high suicidal germination of *Striga* seeds have been developed at IITA. Extensive on farm trials involving the two component technologies conducted in Benin Republic, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Mali and Nigeria demonstrated significant increases in productivity of maize under *Striga* infestation and the reduction of *Striga* seed density in the soil. However, the promotion of this integrated approach has been restricted to a few farming communities in each country. Furthermore, adoption of these component technologies by farming communities is limited because of lack of effective seed production and distribution systems. There is, thus, a need to conduct more on farm trials and demonstrations of these technologies with active participation of NARS, extension system, non government and community based organisations. Engagement of the private seed sector and establishment of community based seed production schemes can also make good quality seeds of *Striga* resistant maize cultivars as well as cowpea and soybean lines capable of causing high suicidal germination of *Striga* seeds, available to farmers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist and dry savannas

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: Average of 40% yield advantage over farmers' practice in the savannas

7. Location-specificity: 2 = requires a moderate degree of local testing and or adaptation

8. Most promising countries for this intervention: Nigeria, Benin Republic, Ghana, Burkina Faso, Cameroon, Côte d'Ivoire, Mali

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: NARS in each country will multiply seeds of the *Striga* resistant or tolerant maize cultivars, soybean and cowpea lines capable of stimulating suicidal germination of *Striga* seeds and supply them for on farm testing. The national extension institutes in partnership with the

NARS, private seed companies and NGOs will conduct extensive on farm trials to promote rotation of the resistant cultivars with legumes in communities residing in *Striga* endemic areas. In countries with a less developed private seed sector, progressive farmers selected by the communities will produce and market seeds of the resistant maize cultivars, soybeans and cowpea lines to their respective communities

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: To conduct a total of 40,000 on farm trials to promote the rotation of resistant maize cultivars with legumes in 200 communities selected in five major maize producing states in Nigeria where *Striga* is a serious problem US$ 400,000 are needed. Likewise, US$ 450 000 are needed to support the production of seeds of resistant maize cultivars, soybean and cowpea lines by seven lead farmers selected in each community. An additional amount of US$ 400 000 will be needed for coordination, breeders' seed production, organizing stakeholder meetings and training of seed producers. This budget will be sufficient for project activities in Nigeria for one year.

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: A baseline study should be conducted to establish a benchmark for measuring the impact of deploying the combined technologies. Socio-economic studies of on farm trials and community based seed production will be useful for assessing the profitability of the combined technologies and the risk arising from outputs and prices of the community based seed production with that of the production of grain. Specific adoption studies will also be needed to monitor the changes in on farm productivity. Some modeling work for scaling up integrated *Striga* control options to other areas and yield gap analysis would require the services of an agronomist and GIS experts. These studies will require a total of US$ 1.5 million for three years

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Market information should be provided to seed producers and farmers to ensure purchase of inputs at reasonable prices while marketing seeds at competitive prices. Successful community based seed producers identified in each country need to be transformed into micro-enterprises by providing loans for purchasing small shelling, sorting, and seed packaging equipment and for opening more seed outlets. Such successful seed production schemes should also be linked to credit and input sources

14. Key contact person for more info: Abebe Menkir, a.menkir@cgiar.org; Baffour Badu-Apraku, b.badu-apraku@cgiar.org.

Data entry sheet: 8.6

1. Acronym of lead Center for this Best Bet: IITA

2. Best Bet keyword description: Improved banana systems

3. Best Bet short description: A. Biofortified tissue cultured bananas; B. Integrated multiplication and dissemination pathways for improved banana "seed" (propagules); C. Banana and coffee intercropping is much more (>50%) profitable than mono-cropping

4. Best Bet full description: A. Biofortified bananas consist of sterile tissue cultured bananas in which beneficial endophytes are reincorporated. This technology will reduce the impact of biotic and abiotic production constraints, thus reduce yield losses and increase crop sustainability. B. Banana production is often limited by planting suckers already infested with nematodes or diseases. Together with NARO (Uganda), IITA has bred high yielding highland selections resistant to black Sigatoka and burrowing nematodes. High quality "seed" of both traditional and high yielding cultivars will increase productivity in both market and subsistence economies. Although pathogen tested tissue cultured plants are the global standard for commercial bananas, integration of tissue cultured plants and macro-propagation from clean mother gardens may be a seed delivery system capable of reaching even remote subsistence farmers with limited cash income. Additional multiplication will be required to produce even a fraction of the 5 billion (5×10^9) banana plants in Eastern and Southern Africa. Efficient market pathways are created to supply, cultivate and market high quality banana planting material, based on tissue culture, to small scale farmers through the promotion of novel and sustainable partnerships between farmers and private enterprises, which are supported by improved institutional policies. The following activities include: facilitate establishment of regional standards, policies and networks for production; link producers with the rural population through farmer managed community nurseries and mother gardens; provide farmers with training on plant health, management and multiplication; stimulate formation of farmer cooperatives; link farmer communities to markets using a novel process of engaging the supplier and user in a dedicated relationship in the supply and demand market chain. C. Bananas are a major cash and food crop for some 30 million farmers in rural households in the East African Highlands (eastern Democratic Republic of Congo, Rwanda, Burundi, western Tanzania, Uganda), providing a major staple food to nearly 100 million people. Coffee is a major cash crop and is the major foreign exchange earner for this region. Most farmers practice mono-cropping for both banana and coffee. However, a recent study in Uganda showed that banana-coffee intercropping systems are much more profitable (>50%) than banana and coffee mono-cropping systems. Arabica coffee intercropped with bananas did not suffer yield loss, while yield losses for intercropped Robusta coffee were minimal (13%). IITA activities on banana-coffee systems would focus on (i) extrapolating the results to other major banana and coffee growing areas in the East African Highlands, (ii) validating the results in existing and new intercropped fields on-farm, while (iii) engaging with policy, extension, and trade partners on disseminating improved intercropping technologies

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: A. Highland or irrigated lowlands, wherever tissue cultured plants are available from private sector; B: Highland or irrigated lowlands, wherever TC plants are available; C. East African highlands with bimodal rainfall pattern, with rainfall varying between 800 to 2000 mm/annum, and with the altitude varying between 800 to 2000m. The countries would be Rwanda, Burundi, Democratic Republic of Congo (east), Tanzania (west and around Kilimanjaro and Mt. Meru), Uganda, Kenya (western highlands and around Mt Kenya).

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: A. 15%; B. 15-30%, C. 30%

7. Location-specificity: 2 = all (A, B and C) require a moderate degree of local testing and or adaptation

8. Most promising countries for each intervention: All in Uganda, Kenya, Burundi, Rwanda, Tanzania, where ever tissue culture plants available from private suppliers. In addition, option C could be deployed in Democratic Republic of Congo

9. Time frame: Long for A; medium for B and C

10. Most effective modes of delivery: A. agro-business; public-private partnership; commercial led; B. agro-business; public-private partnership; community based; farmer cooperatives; market led; C. The coffee sector is highly organized in the region, with strong involvement from private partners (traders) and government bodies, alongside NGO and extension partners. The banana sector is much less organized. Dissemination and promotion of banana-coffee systems would require a dialogue with policy and extension officers to make recommendations 'official'. Dissemination of the recommendations can be done through the private sector (i.e., coffee sector), especially when combined with fertilizer use, which will boost coffee and banana production, while improving sustainability. Local adoption has to be encouraged through linking extension partners to farmer co-ops and farmer field schools

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: A. (1) Registration of bio-pesticide: US$ 40,000, (2) equipment tissue culture: US$ 30,000, (3) variable costs: US $ 0.1/plant; B (1) market studies: US$ 50,000, (2) training: US$ 50,000, (3) variable costs: US$ 2,000/nursery; C. Activities (1) regional workshops on extension and policy bottlenecks – 3 types of partners x 6 countries x US$ 800 per participant + IITA staff = US$ 20,000. Repeat in years 3 and 5, (2) extension materials (e.g. 5,000 leaflets per country) in four languages = US$ 120,000, (3) Local production distribution US$ 2000 x 6 countries = US$ 12,000, (4) staff costs – 1 coordinator per country (MSc holder) x 6 countries x US$ 12,000 per year = US $ 72,000 per year, (5) training of trainers workshops twice per country with 20 participants each = US$ 500 per participant x 2 workshops x 6 countries + US$ 20,000 = US$ 140,000, (6) total extension costs for 5 years estimated at US$ 692,000

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: A. Two scientists with input from other scientists and private industry at US$ 500,000 for 2 years; B. Two lead scientists with input from other scientists and private industry at US$ 1.5 million for 3 years; C. (1) Surveys to confirm suitability and profitability of banana and coffee intercropping outside the original Ugandan research, (2) on-farm and on-station trials to validate the results and suitability of banana-coffee intercropping 2 trials per country x 6 countries) for 5 years = US$ 240,000, (3) international scientist, 1 admin assistant, 1 driver = US$ 180,000 per year, (4) working costs – travel, equipment – US$ 60,000 per year, which adds to US 1.4 million for a 5-year project

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: None for A and B, but for C Rwanda and Burundi have official agricultural policies and recommendations that encourage or impose farmers to do coffee mono-cropping. Hence, a discussion with policy makers and the coffee traders would be needed before pushing ahead new recommendations

14. Key contact person for more info: A and B. Thomas Dubois, t.dubois@cgiar.org; B. Jim Lorenzen, j.lorenzen@cgiar.org; C. Piet van Asten, p.vanasten@cgiar.org

Data entry sheet: 8.7

1. Acronym of lead Center for this Best Bet: IITA

2. Best Bet keyword description: Drought/*Striga* resistant cowpea

3. Best Bet short description: Deployment of drought and *Striga* resistant cowpea cultivars

4. Best Bet full description: Cowpea is an important food legume grown in most of the drier areas of the tropics, particularly in the dry savannas of sub-Saharan Africa. It constitutes a cheap source of protein in the diet of rural and urban populations. Although the crop is known to be more drought tolerant than other crops, it experiences considerable damage due to frequent drought stress in these regions where rainfall is scanty and irregular. With the increased evidence of climate change, the occurrence of low rainfall and high temperature becomes more frequent and compromises cowpea production in these regions. Besides drought, the parasitic flowering species, *Striga gesnerioides,* causes considerable yield losses in the dry savanna regions. The combined action of drought and *Striga* can cause complete crop failure. Considerable efforts have been made by IITA and partners to develop cowpea cultivars resistant to *Striga* with good levels of tolerance to drought that meet consumer preferred traits. The deployment of these cultivars in the dry regions of sub Saharan Africa will increase cowpea production by 60-80% and improve food security and farmer incomes. In addition, increased cultivation of cowpeas improves soil fertility, and human and animal nutrition. To popularize the cultivars and increase the adoption, farmer participatory demonstrations and efforts to make available improved seeds will be required. The proposed project will evaluate and demonstrate improved cultivars in targeted countries, train farmers and seed organizations to produce and market quality cowpea seeds, and link the farmers to markets. The success of the increase of cowpea productivity will largely depend on the partnership between IITA, NARS, extension service, seed companies and farmers

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: Yield advantage of 60% over local *Striga* and drought susceptible cultivars

7. Location-specificity: 2 = requires a moderate degree of local testing and or adaptation

8. Most promising countries for this intervention: Nigeria, Niger, Burkina Faso, Benin Republic, Cameroon, Mali, Tanzania, Senegal

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: Using a value chain approach within an innovation platform, improved cultivars will be evaluated in large scale farmer demonstration plots to enhance rapid adoption of the improved cultivars. The platform will comprise IITA, national agricultural research and extension institutions, input and output dealers, policy makers, CBOs and NGOs. Promising cultivars will be multiplied using community seed growers identified and trained in seed production in order to ensure availability of seeds for wider dissemination. The community seed growers will also be linked to community stockists and private seed companies in order to create effective demand and sustain the seed production.

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: To conduct a total of 20,000 on farm trials and demonstrations to promote drought and *Striga* resistant cowpea cultivars in different systems in 600 communities in six States in the dry savanna agro-ecological zone of Nigeria will require US$ 600,000 annually to support provision of labor, inputs and extension services. About US$ 200,000 per year is required to support the production of breeder, foundation and certified seed of improved cultivars at various levels. Additional US$ 250,000 per year would be needed for capacity building, traveling, support staff and stakeholder meetings

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: *Ex-ante* and *ex-post* analysis will be carried out to determine impact of cultivars deployed. New sources of resistance to different strains of *Striga* will be identified and used to develop new cultivars for specific regions *via* farmer-PVS. Using different modeling tools, yield gap analysis will be done to determine and predict performance of different cultivars and to scale up to other regions. A team of four scientists, breeder, agronomist, economist, and physiologist is required at US$ 50,000/year-scientist at 0.3 FTE plus US$ 20,000/annum for consultants. Research cost will be US$ 110,000/annum. Total cost will be US$ 290,000/annum.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Selection of countries and collaborating partners will largely depend on the capacity of institutions in those countries and potential to create impact, and also on political stability. The projects will work with existing relevant projects and other stakeholders in the countries to increase impact. The success of the project largely depends on continuous funding for minimum of five years

14. Key contact person for more info: Ousmane Boukar, o.boukar@cgiar.org; Alpha Kamara, a.kamara@cgiar.org

Data entry sheet: 8.8

1. Acronym of lead Center for this Best Bet: IITA

2. Best Bet keyword description: Improved soybean cultivars

3. Best Bet short description: Introduction of improved high yielding promiscuously nodulating soybean cultivars

4. Best Bet full description: In order to promote and advance soybean production in sub- Saharan Africa, 17 IITA bred-cultivars have been released. Most of these cultivars were released in Nigeria, but some were released by the NARS of Ghana, Benin, Togo, Democratic Republic of Congo and Uganda. Among these cultivars, five were early maturing (<100 days), six medium maturing (100-120 days) and another six late maturing (>120 days). These cultivars are capable of giving 1500 to 2300 kg/ha grain and 2000 to 3000 kg/ha fodder without the use of *Bradyrhizobium* inoculants. However, they need 100 kg/ha NPK (15:15:15) as a starter fertilizer and an additional 50 kg/ha TSP in phosphorus deficient soils. The average yield of soybeans in many African countries is below 1 t/ha and on-farm yield could easily be doubled by using these improved cultivars. Other traits of these improved cultivars are enhanced seed longevity, promiscuous nodulation, resistance to shattering, lodging, and important diseases such as bacterial pustule and frogeye leaf spot. Some of the cultivars have high potential for reducing *Striga hermonthica* seed through suicidal germination. Moreover, some cultivars were bred for dual-purpose use and have good stover quality in addition to high grain yield. Besides, these promiscuous cultivars have a great contribution in promoting the sustainable agricultural system of the savanna by way of improving soil fertility and having a favorable effect on subsequent crops like maize and sorghum in the rotation. IITA has also developed a large number of superior promiscuous soybean lines ready to be utilized by national programs. In the early, medium and late maturity groups there are 35, 30 and 21 lines available, respectively. These lines were selected because they showed 10 to 100% grain yield advantage over their respective standard checks in different years of trials in addition to other desirable traits

5. **Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet:** Moist savanna and mid-altitude zones

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 100%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Nigeria, Malawi, Mozambique, Zambia, Ghana, Tanzania, Uganda, Rwanda, Democratic Republic of Congo, Ethiopia

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: Participatory approach will be followed to deploy cultivars using on-farm testing, demonstration and field days that involves a number of stakeholders. Collaboration and partnerships need to be established with national research and extension institutions, farmer organizations, private seed growers, processors, marketing agents, exporters and NGOs. Since breeder seeds will be produced by IITA and NARS, a mechanism should be developed to produce foundation and certified seeds using, farmer organizations and private institutions. To drive production in soybean,

small scale processing and market linkages with large scale processors and traders are essential

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: On-farm trials and demonstration will cost US$ $200,000. The seed system in cooperation with farmer organizations and private entities will cost US$ 65,000. Approximate cost for input supplies like fertilizers, herbicides and pesticides is US$1 million. Personnel for on-farm testing, training and coordination (labor, travel) are estimated to be US$ $250,000. At least two 4WD vehicles (US$ 60,000) and ten motorbikes (US$ $50,000) are required for the work. Platform meetings, training guides, publicity may cost US$ $100,000. Seed shipment and communication will cost about US$ $10,000

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Backup breeding and multi-location testing of the already available lines are necessary to sustain the yield levels achieved. As leaf rust disease is becoming important in Africa, deploying resistance to this disease and others is essential. Processing and utilization of this crop should also be promoted by using existing and new recipes. Moreover, optimization of agronomic practices, *ex-ante* and *ex-post* adoption studies on cultivars introduced are necessary. The backstopping research work will require four FTE scientists @ US$ 150,000/year for project management, breeding, agronomy and pathology for three years. It will also require socio-economist and food scientist (50% FTE) @ US$ 150,000/year

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: As soybean is not readily consumed by households like other legumes, it is necessary to address the whole value chain to create demand for seed and drive production. Processing and utilization should be demonstrated to small-scale farmers to improve human nutrition as the crop has the highest protein content (40%) among legumes. Creation of strong market linkages with commercial processors and exporters is necessary to increase incomes of farmers. A number of processors that produce corn-soya blend, cooking oil and feeds for livestock are emerging in Africa and the linkage will help to sustainably supply soybean grain to these entities

14. Key contact person for more info: Hailu Tefera, H.Tefera@cgiar.org or HTefera@iitamw.org

Data entry sheet: 8.9

1. Acronym of lead Center for this Best Bet: IITA

2. Best Bet keyword description: Improved cereal and legume systems

3. Best Bet short description: Improved cereal and legume cropping system for integrated natural resource management

4. Best Bet full description: The bulk of agriculture in the savannas of sub-Saharan Africa is still based on traditional intercropping systems, with low plant density and little or no purchased inputs. Yields are low due to biotic and abiotic factors. Such practices lead to decreasing soil organic matter content, increasing populations of chronic parasitic weeds, reduced soil biological diversity, and enhanced erosion risk. This, in turn, leads to a negative balance of nutrients in the soil and continuous declines in crop yields. Grain and fodder yields as well as the quality and quantity of crop residues must be improved to ensure food security and enhanced livestock integration in the farming system. Without inputs crop yields cannot increase significantly. At the same time large quantities of fertilizers and chemicals are not physically or economically available in the region, nor desirable. IITA have shown that overall farm yields could increase in a sustainable manner through the adoption of improved cultivars and cropping systems, and a general increase in intensification of crop and livestock integration. Participatory evaluations and demonstrations of the improved cereal and legume cropping systems and cultivars, involving relevant stakeholders (farmers' groups, NARS, NGOs, agro-input companies or processors, among others) in the dry savannas of sub-Saharan Africa will increase productivity of the system by over 150%, improve food security, raise farmer incomes income, and improve natural resource management and sustainability. Information would also be generated to help scientists to focus research activities on higher relevant outputs and better outcomes. The project will help update, consolidate and disseminate improved integrated cropping systems and cultivars in the region

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Dry savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: Yield advantage of 150% over current local practices

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Nigeria, Niger, Burkina Faso, Benin Republic, Cameroon, Tanzania, Senegal, Mali

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery: A consortium will be developed between IITA, and research and development institutions in the target countries to ensure proper selection of farmers and implementation of participatory evaluation, mass demonstration and dissemination of improved crop cultivars and cropping systems. Special efforts would be made to encourage and assist women farmers to participate in the seed production and on farm demonstration programme in order to ensure equal opportunity for income generation and greatest contributions to household food security. The project will also link with existing relevant projects in target areas for synergies

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: The involvement of the following agencies is necessary: farmers' organizations, NARS, local government authorities, agric. development projects, private sector (agro-input dealers, seed companies and processors). To conduct 10,000 on farm trials and demonstrations to promote relevant improved cropping systems in 500 communities in five states in the dry savanna agro-ecological zone of Nigeria will require US$ 500,000 annually for labor, inputs and extension services. About US$ 100,000 per year is required to source/support the production of seed of improved cultivars of relevant crop. Additional US$ 210,000 per year would be needed for coordination and staff costs

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: *Ex-ante* and *ex-post* analysis will be carried out to determine impact of the project. Using farmers' participatory evaluations improved agronomic practices would be identified and developed which would include different cereal and legume systems as well as agronomic and the use of niche crops. Using different modeling tools analysis will be done to determine and predict performance in other regions for scaling up. A team of three scientists, agronomist and breeder, is required at average of US$ 50,000/year-scientist at 0.3 FTE plus US$ 30,000/annum for consultant fees. Research cost will be US$ 110,000/annum. Total cost will be US$ 300,000/annum

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Selection of countries and collaborating partners will largely depend on the capacity of institutions in those countries and potential to create impact and also on political stability. The projects will work with relevant projects and other stakeholders in the countries to increase impact. The project will also lead to increased awareness and information exchange on important technological, social, economic and environmental issues among target groups. The success of the project largely depends on continuous funding for minimum of five years

14. Key contact person for more info: Hakeem Ajeigbe, h.ajeigbe@cgiar.org; Alpha Kamara, a.kamara@cgiar.org

Data entry sheet: 8.10

1. Acronym of lead Center for this Best Bet: IITA (with ICRISAT and CIMMYT)

2. Best Bet keyword description: Safe healthy food

3. Best Bet short description: Management of aflatoxin contamination in maize and groundnut

4. Best Bet full description: During times of food shortage, the poor are most vulnerable because they can only afford low quality cheap food. Low quality maize is often contaminated with aflatoxins that leads to health hazards and mortality as experienced in Kenya during 2004-2006. Aflatoxins are carcinogens, immuno-suppressive and stunt growth and development of children. Products contaminated with aflatoxins cannot be sold due to regulatory restrictions. The dissemination of maize and groundnut cultivars that combine resistance to aflatoxin production with tolerance to drought for drier areas of Africa is an important aspect of achieving greater productivity in response to climate change. Furthermore, new innovations in improved aflatoxin management methods (such as biological control) together with known good management and storage practices can significantly reduce health hazards and increase productivity across maize and groundnut growing systems. The objective of this undertaking will be to disseminate and institutionalize aflatoxin best management practices along the primary production to consumption chain to reduce losses. Aflatoxin management practices in farmers' fields and stores have been developed and are being implemented through small-scale efforts. The management practices include: awareness campaigns, use of resistant cultivars, biological control through competitive exclusion, timely harvest, rapid grain drying to safe moisture content, insect control in field and stores, storage of products in good storage structures to keep them dry and insect free, and food processing. This undertaking will upscale these proven technologies along with low-cost aflatoxin analytical tools (ELISA) to monitor and eliminate aflatoxin contaminated grain lots. Significant reduction of aflatoxins in maize and groundnuts in sub-Saharan Africa is an eminently achievable goal associated with a high probability of success for increasing value of products in markets. Significant reductions in morbidity and mortality of children, reduced incidence of cancer and infectious disease and an overall improvement in public health will be bonuses

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist and dry savannas

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 10% increase in product value

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Nigeria, Kenya, Mali, Senegal, Malawi, Mozambique, Ghana, Benin Republic

9. Time frame: Medium

10. Most effective modes of delivery: Participatory evaluation (Farmer Field Fora) of aflatoxin management (technical and social) will be carried out for fine tuning and adaptation for local needs. Participatory diagnosis and action research will help identify promising adaptive strategies for promotion after building local capacities to facilitate adoption by wider population. Public-private partnerships,

particularly enhancing linkages between growers associations and commercial food and feed manufacturers would be pursued for increasing cash incomes of farmers. Such a process and continuous interaction with communities as well as policy makers and other stakeholders will identify a range of coping strategies and create a forum for improved food safety

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Extension workers, seed companies, farmer organizations (e.g. national commodity associations such as maize association), community based organizations, food and feed manufacturers, market officials (e.g. buyers, traders), food procurement agencies, food safety officials (e.g. food monitoring and testing labs), public health officials. Links between different institutions (e.g. farmers, markets or regulatory agencies, among others) needed. A commercial plant (owned and operated by commodity association?) is also required to produce non-toxigenic strains of *Aspergillus* for aflatoxin biocontrol. About US$ 1 million per year for five years are needed for each country (Nigeria, Kenya and Mozambique). Also US$ 2.5 million onetime investment is required for setting up a biocontrol product plant

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Baseline information on aflatoxin content in target crops and exposure in humans in target areas for impact evaluation of interventions. Develop and adapt aflatoxin risk prediction and management tools. Identify country-specific aflatoxin biocontrol strains. Fine tune market and institutional innovation system for production to market linkages and up-scaling technology dissemination. Policy advocacy for production and marketing of aflatoxin safe products. Need four person years (pathologist or post harvest specialist, breeder, economist and technology exchange specialist) with US$1 million annual budget for two countries in West Africa. Similar resources required for two countries in Eastern Africa.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Currently, a high proportion of Africans are exposed to unsafe levels of aflatoxins during most parts of their lives. This Best Bet undertaking will not only increase productivity but also will improve safety of maize and groundnut. This will make more people healthier and more productive. Children and women, who are most vulnerable to aflatoxin exposure, would be significant beneficiaries. Sensitization of policymakers is a prerequisite.

14) Key contact person for more info: Ranajit Bandyopadhyay, r.bandyopadhay@cgiar.org; Kerstin Hell, k.hell@cgiar.org

Data entry sheet: 9.1

1. Acronym of lead Center for this Best Bet: System-wide Program on Integrated Pest Management

2. Best Bet keyword description: Locally made bio-pesticides

3. Best Bet short description: Produce low cost, eco-friendly bio-pesticides locally, better pest management

4. Best Bet full description: IITA has tested eight isolates of the entomopathogenic fungi *B. bassiana* and *M. anisopliae* for their virulence and field efficacy against leaf feeding caterpillars of vegetables. Biopesticides based on *B. bassiana* isolates that are indigenous to Benin are in various stages of development by IITA and its private sector partner in Senegal as alternatives to chemical pesticides to control larvae of the diamond back moth (DBM) *Plutella xylostella* on cabbage, the leaf caterpillar *Psara basalis* on amaranth, and the cotton bollworm *Helicoverpa armigera* on tomato. The *B. bassiana* isolates tested against DBM were Bba14, Bba5644, Bba5645, Bba5653, Bba5654, and Bba5655, and *M. anisopliae* isolates were Ma178 and Ma182. The isolate Bba5653 caused 94% mortality of DBM larvae, which mortality was significantly higher than that caused by any of the other isolates. Cabbage yield was 44.1 t/ha for plots treated with water formulation of Bba5653 at 1 kg conidia powder (CP) per hectare and 41.9 t/ha for plots treated with emulsion formulation of Bba5653 at the same CP dose. Each of the yields was approximately three fold higher than the yield in plots treated with the insecticide bifenthrin or in untreated plots. In water formulations, 1 kg/ha of the conidia powder of Bba5653 reduced DBM populations at about the same rate as did 0.75 kg and 0.5 kg CP/ha, but significantly more than did 0.25 kg CP/ha. The results indicate that indigenous (Benin source) isolates of *B. bassiana* hold great promise as biological agents in integrated pest measures against the diamond back moth, *P. xylostella*, in cabbage. The results encouraged the broadening of applied research to exploit a wide range of the local *B. bassiana* isolates e.g. Bba 5644 against *Psara basalis* on amaranth and Bba 5648 against *Spoladea recurvalis* also on amaranth

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Moist savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 25%

7. Location-specificity: 2 moderate further testing and adaptation

8. Most promising countries for this intervention: Benin Republic, Senegal, Ghana, Togo, Guinea, Nigeria, Liberia, Sierra Leone

9. Time frame: Short 1-2 years

10. Most effective modes of delivery: Private producer, farmer participatory production, extension, phytosanitary organizations

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: US$ 1.5 million to establish production and distribution systems, US$ 0.5 million to attain regulatory approval, US$ 1.3 million per annum for five years to finalize validation

and promote

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Further research on

- Appropriate formulations, dosage, persistence
- Effect on non target organisms and the environment
- Multi-locational field trials to assess the robustness of the formulations
- Market studies to assess the commercial viability of the product(s)
- Upgrade spore production facility so as to avoid cross contamination
- Toxicology tests of the entomopathogen on mammals and birds and ecotoxicological studies
- Consultative dialogue with appropriate government agencies in West Africa
- Sustainable linkage with the only private sector in Senegal that is focused on commercial production of biological pesticides

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Success in specifying and testing the potential of Bba isolates has been achieved in a relatively short time by pursuing a research plan in which a number of national (Benin) postgraduate studies were supervised by IITA scientists on different segments of the problem being investigated. Six students tackled issues of virulence, formulations, field efficacy and effect of Bba isolates on parasitoids that are known pests' natural enemies, and other aspects of vegetable IPM. A second aspect of the innovation was integrating research with participatory field trials at pilot sites

14. Key contact person for more info: Braima James, b.james@cgiar.org

Data entry sheet: 10.1

1. Acronym of lead Center for this Best Bet: IRRI and Africa Rice Center (WARDA)

2. Best Bet keyword description: Rice management and mechanization

3. Best Bet short description: Rice production enhanced through improved crop and post-harvest management, cultivar selection and small-scale mechanization

4. Best Bet full description: There is no one single best bet scenario for increasing rice production but an array of activities that are interdependent and sequential. They include suitable cultivars and good quality seed that have resistance to diseases (especially blight, blast and yellow mottle virus), short duration (100-120 days), yield stability especially for drought,
Likewise, crop and land management, e.g. land leveling and bund maintenance to improve water use efficiency, mechanized land preparation to improve quality and timeliness, early weed management and timely fertilizer application. Post-harvest management considers timely harvest-early cutting and threshing, better drying and monitoring grain moisture, safer storage systems using hermetic storage and other pest protection techniques, and improved milling through increased availability of small mechanical mills. Finally, small-scale mechanization needs 2-wheel walking tractor, small mechanical threshers, and small single pass rice mills

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best: Wetland-Rainfed lowland, Irrigated lowland, highland valley floors

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 30% increase in yield per unit area. Expansion in area is also an attractive and in many areas a viable option

7. Location-specificity: 1 = low (the Best Bet can scale-out widely with minimum local adaptation

8. Most promising countries for this intervention:

- Nigeria, Mali, Senegal, Guinea, Côte d'Ivoire, Liberia, Sierra Leone, Democratic Republic of Congo, Cameroun, Burkina Faso in West and Central Africa
- Mozambique, Tanzania, Uganda, Rwanda, Burundi, Kenya, Madagascar in East and Southern Africa

9. Time frame: Short/medium for management and mechanization, medium/long for cultivar

10. Most effective modes of delivery: Partnerships- public private with supporting government policies. Modes-community based working through groups of farmers or with farmer cooperatives that are supported by local extension officers both public and private

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: Farmer accessible commercial credit institutes, district extension services and reasonable priced transport systems. Estimates on seed and fertilizer requirements and training needs for an Emergency Initiative on Rice in 11 countries in West and Central Africa will be available by the end of June 2008.

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Regional surveys are needed to get a better understanding of key bottlenecks and constraints. Understanding farmer's adversity to risk will also help direct the research and development agenda. From an Institutional viewpoint working at ground level in the region would require a team comprised of plant breeders, production specialists, engineers and post harvest specialist, training specialist and socio economists supported by national staff. (10 scientists for a minimum of 5 years @ US$ 300,000/person/year)

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: There is no single Best Bet. Most of the Best Bets are interrelated and interdependent. Improved management will only come about through better soil, water, crop and post harvest management, which will require better access to knowledge, information and monitoring systems as well as an increase in the amount of energy (human or mechanical) required to improve the timeliness and quality of operations. All of the above are known and available. The greatest limitation to the adoption of most of the best bets is the availability of credit for small land holders at a reasonable interest rate with a small enough minimal loan level suitable for individual farm families. The level of risk is very important both for the farmer and creditors

14. Key contact person for more info: Joe Rickman, j.rickman@cgiar.org; Marco Wopereis, m.wopereis@cgiar.org

Data entry sheet: 11.1

1. Acronym of lead Center for this Best Bet: IWMI

2. Best Bet keyword description: Small-scale Full Irrigation

3. Best Bet short description: Dry-season or year-round small scale and community based full irrigation

4. Best Bet full description: The objective and expected impact of this technology is to boost yields and alleviate poverty through support of smallholder market-oriented farming. The technology depends primarily on water from rivers, lakes and aquifers for full irrigation. Beneficiaries would primarily be smallholder farmers with easy access to local markets. It is estimated that this technology is appropriate for 9.4 million ha of land primarily in dry to sub-humid sub-Saharan Africa, and that they could benefit 18.6 million rural farmers, 4.6 million of whom are poor. The technology requires a suite of component technologies that include water collection, storage and application systems. Potential suites of technologies for full irrigation include: (1) small scale community based irrigation suitable for any crops and dry season cropping: earth dam/diversion weir/river + canal, motorized pump + furrow/flooding + soil fertility management and (2) localized or micro irrigation suitable for higher value crops, e.g. horticulture, double/triple cropping and perennial cropping based on surface water: ponds, tanks, subsurface dams, spate irrigation + bucket, treadle/power pump + channels or furrows + soil fertility management; or based on groundwater: Shallow or deep well+ bucket/hand/treadle/motorized pump + storage drum + drip, furrow, sprinkler + soil fertility management

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet:
Dry to sub-humid savanna

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 170%

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation)

8. Most promising countries for this intervention: Ethiopia, Burkina Faso, Kenya, Mali, Senegal, Tanzania, Sudan, Chad, Mozambique, Nigeria

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery:
Partnership type: Research – extension/NGO - farmer linkages
Partnership modes: Farmer field school introduction; Extension/NGO-led dissemination; Participatory monitoring and evaluation process; Knowledge sharing (Cross visits, Stakeholder Dialogues, Field Visits, On-farm trainings)

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: An estimate of financial resources necessary to deploy small-scale full irrigation can be based on the following: US$ 4,300/ha initial investment, US$ 400/ha/yr for soft components, and US$ 100/ha/yr for recurrent costs, results in a total investment need of US$ 40 billion to achieve implementation and benefits on some 9 million ha of land in sub-Saharan Africa. 'Soft'

components include marketing, extension, training, water users associations, credit and cooperatives. Research-extension linkages reaching district level are required, as well as research-NGO linkages. Successful deployment will require significant investment in people, to achieve the capacity building required at national and local levels

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Before technical investment decisions can be made, the broader biophysical, social, economic and institutional settings must be assessed, requiring research at community and meso scales. Sustaining positive impacts requires adaptation to local conditions as well as larger scale water policy to mitigate potential negative externalities, e.g. over exploitation of surface or groundwater, pollution of fresh water, and upstream-downstream conflicts. Successful deployment will require significant investment in people, to achieve the capacity building required at national and local levels. Adaptation studies considering regional/local adoption drivers and constraints: 3 scientists (water engineer/ agronomist/socio-economist) for three years for a particular area, each @ US$ 250,000/year-scientist

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Best options and sustainable adoption will vary with biophysical and socio-economic site conditions that determine water supplies, equitable access to required inputs and markets, and institutional and governance capacity. To enhance the poverty-reducing benefits, gender-equitable development must be considered. Suites of technologies including water supply, storage and delivery components will necessarily require longer times for local adaptation, while individual technologies may result in instant benefits. Suites of technologies for full irrigation cost more and require more expertise to implement than single technologies, but bring greater returns in terms of yields and resilience of farming systems to climate variability

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Data entry sheet: 11.2

1. Acronym of lead Center for this Best Bet: IWMI

2. Best Bet keyword description: Supplemental Irrigation

3. Best Bet short description: Off-site rainwater harvesting, storage and delivery for supplemental irrigation

4. Best Bet full description: The objective and expected impact of these technologies is to boost yields and alleviate poverty by sustaining production in rainfed areas through better water control, and reducing vulnerability to climate change impacts. This technology depends on both rainfall and irrigation. Target beneficiaries would mainly be smallholder farmers relying primarily on rainfed staple food production, with limited market connection. It is estimated that these technologies are appropriate for 30 million ha of land primarily in semi-arid and sub-humid sub-Saharan Africa, and that they could benefit 18.6 million rural farmers, 7.2 million of whom are poor. The technology suite for rainwater harvesting, storage and delivery includes a combination of the following: Ex-situ rainwater harvesting and delivery: Small dams, ponds, tanks, spate irrigation, subsurface dams + bucket, treadle/power pump + channels or furrows + soil fertility management

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Semi-arid to sub-humid savanna, wetland, highland

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 150%

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation):

8. Most promising countries for this intervention: Burkina Faso, Ethiopia, Kenya, Mali, Senegal, Chad, Sudan, Mozambique, Malawi, Tanzania

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery:
Partnership type: Research – extension/NGO - farmers linkages
Partnership modes: Farmer field school introduction; Extension/NGO-led dissemination; Participatory monitoring and evaluation process; Knowledge sharing (Cross visits, Stakeholder Dialogues, Field Visits, On-farm trainings)

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: An estimate of financial resources necessary to deploy supplemental irrigation is based on the following: US$ 3,800/ha initial investment, US$ 400/ha/yr for soft components, and US$ 100/ha/yr for recurrent costs, results in a total investment need of US$ 58 billion to achieve implementation and benefits of supplemental irrigation options on some 30 million ha of land in sub-Saharan Africa. 'Soft' components include extension training, credit and cooperatives. Research-extension linkages reaching district level are required, as well as research-NGO linkages. Successful deployment will require significant investment in people, to achieve the capacity building required at national and local levels

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Before technical investment decisions can be made, the broader biophysical, social, economic and institutional settings must be assessed, requiring research at community and meso scales. Sustaining positive impacts requires adaptation to local conditions as well as larger scale water policy to mitigate potential negative externalities, e.g. over exploitation water, pollution of fresh water, and upstream-downstream conflicts. Successful deployment will require significant investment in people, to achieve the capacity building required at national and local levels. Adaptation studies considering regional/local adoption drivers and constraints: 3 scientists (water engineer/agronomist/socio-economist) for three years for a particular area, each @ US$ 250,000/year-scientist.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Best options and sustainable adoption will vary with biophysical and socio-economic site conditions that determine water supplies, equitable access to other required inputs, and institutional and governance capacity. To enhance the poverty-reducing benefits, gender-equitable development must be considered. Suites of technologies including water supply, storage and delivery components will require longer times for local adaptation, while individual technologies may result in instant benefits. Technologies for supplemental irrigation cost more and require more expertise to implement than simpler soil water management technologies, but bring also greater returns in terms of yield improvement and resilience of farming systems to climate variability.

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Data entry sheet: 11.3

1. Acronym of lead Center for this Best Bet: IWMI

2. Best Bet keyword description: Safe wastewater irrigation

3. Best Bet short description: Making an asset out of low-quality water

4. Best Bet full description: The objective and expected impact of these technologies is to boost yields and alleviate poverty while safeguarding public health through support of smallholder market-oriented farming especially close to urban markets where clean surface and groundwater resources are rare or often heavily polluted with pathogens. This situation is affecting approximately 20 million hectares worldwide, where about 200 million farmers are engaged in peri-urban market production with polluted irrigation water. The technologies fit two scenarios: a) farmers who have no alternative water sources than polluted water and the investment tries to reduce public health risks or b) safe water is rare and wastewater at any kind of treatment or non-treatment standard is made available to boost agricultural production and reduce poverty. Technology suites target mostly poor urban and peri-urban farmers using e.g. watering cans and buckets and include: (1) safe irrigation practices (drip irrigation, furrow irrigation, improved watering cans or pathogen traps, among others), (2) on-farm water treatment (ponds, sedimentation traps, filter), and (3) Combinations of treatment and non-treatment options along the farm to fork pathway (including post-harvest measures)

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: All

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 150%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Ghana, Nigeria, Burkina Faso, Niger, Mali, Senegal, Mauritania, Chad, Somalia, Kenya

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery:

Partnership type: Research – extension/NGO - farmer linkages
Partnership modes: Farmer field school introduction; Private sector-led, Extension/NGO-led dissemination; knowledge sharing via media

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries:
The technology changes build on existing irrigation practices and require most of all awareness and capacity building as well as some initial changes in labor productivity at farmers' end. An estimate of financial resources necessary to implement safe wastewater irrigation should be based on local costs of extension services, Farmer Field Schools and other training events and materials. Initial investment costs are low except for drip kits (US$ 420-1,500 per farm). Research-extension-farmer linkages reaching district level are required, as well as research-NGO-farmer linkages. Successful deployment will require

significant investment in people, to achieve the capacity building required at national and local levels

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Before investment decisions can be made, it is important to understand common health risk perceptions, current farming practices, returns on labor, water and land inputs as well as biophysical conditions that will determine the effectiveness and adoption potential of improved practices. These adaptation and adoption studies will require 3 scientists (water engineer /agronomist/socio-economist) for two years for a particular area, each @ US$ 120,000 to 250,000/year-scientist depending on national or international level

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: The technologies can serve two groups of objectives: (a) reducing poverty and increasing agricultural production by making an asset out of wastewater, and (b) reducing negative externalities by safeguarding public health where farmers have no safer water source.
Best options will vary in both cases with the local risk awareness levels, risk perceptions as well as biophysical and socio-economic site conditions and have so far been tested at various sites in Ghana by the local IWMI office

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Data entry sheet: 11.4

1. Acronym of lead Center for this Best Bet: IWMI

2. Best Bet keyword description: Soil moisture management

3. Best Bet short description: On-site soil water management and rainwater harvesting

4. Best Bet full description: The objective and expected impact of these technologies is to boost yields and alleviate poverty by sustaining production in rainfed areas through better rainwater control and soil management. The technology depends on rainfall, and therefore is appropriate where there is sufficient rainfall to meet crop water requirements. The potential beneficiaries are smallholder farmers relying primarily on staple food production, with low access to markets. It is estimated that these technologies are appropriate for 63.6 million ha of land primarily in sub-humid to humid sub-Saharan Africa, and that they could benefit 125.8 million rural farmers, 27.9 million of whom are poor. The technology suite includes combinations of the following: Planting pits (zai, ngoro)/infiltration ditches/Fanya Juu, Fanya chini/micro-catchments (meskat)/micro basins (half-moons, negarims)/contour ridges/strip cultivation//terracing and bunds/mulches/soil carbon management/minimum tillage/deep ripping/ gully control + soil fertility management

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: Sub-humid to moist savanna, wetland, highland

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: 30%

7. Location-specificity: 2 = requires a moderate degree of local testing and/or adaptation

8. Most promising countries for this intervention: Kenya, Ethiopia, Mozambique, Malawi, Tanzania, Burkina Faso, Uganda, Zambia, Mali, Sudan

9. Time frame: Medium (3-5 years)

10. Most effective modes of delivery:
Partnership types: Research – extension - farmers
Agencies: NARS, extension agencies, farmers' groups, Water Resources Min., international NGOs, international development donors
Farmer field schools recommended

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: An estimate of financial resources necessary to deploy supplemental irrigation is based on the following: US$ 175/ha initial investment, US$ 18/ha/yr for soft components, and US$ 5/ha/yr for recurrent costs, results in a total investment need of US$ 11 billion to achieve implementation and benefits of supplemental irrigation options on some 64 million ha of land in sub-Saharan Africa. 'Soft' components are primarily extension and training. Research-extension-farmer linkages reaching district level are required, as well as research-NGO-farmer linkages. Successful deployment will require significant investment in people, to achieve the capacity building required at national and local levels

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact of this Best Bet: Before technical investment decisions can be made, it is important to understand biophysical conditions that will determine the effectiveness of these strategies for poverty alleviation. Diagnosing the problem; i.e., dry spells versus droughts, and understanding limitations of the technologies is necessary to understand risks. Sustaining positive impacts requires adaptation to local conditions as well as understanding watershed impacts. Successful deployment will require significant investment in people, to achieve the capacity building required at national and local levels. Adaptation studies considering regional/local adoption drivers and constraints: 3 scientists (water engineer /agronomist/ socio-economist) for three years for a particular area, each @ US$ 250,000/year-scientist.

13. Any special information you feel is important concerning this Best Bet that is not covered in the above: Soil moisture management does not require large investments, but also brings smaller returns than investment in irrigation technologies. The climate risk to farmers is still high. However, it is appropriate for large areas of land where other interventions are not possible. There are also significant off-site benefits of these technologies such as reduced sedimentation, improved water quality and watershed function, which should be considered. To enhance the poverty-reducing benefits, gender-equitable development must be considered. Investments in technical assistance for optimizing use of fertilizer seeds and other key inputs in rainfed settings will enhance benefits.

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Data entry sheet: 11.5

1. Acronym of lead Center for this Best Bet: IWMI

2. Best Bet keyword description: Water System Management

3. Best Bet short description: Irrigation System Management/Watershed Management/Basin Water Management

4. Best Bet full description: The objective and expected impact of these technologies - in combination with other agricultural water management interventions - is to boost yields and alleviate poverty, by fostering sustainable management of land and water resources; enhance proactive participation in resource decision-making and development; and manage (negative) externalities. It is estimated that watershed management technologies, whose target beneficiaries are primarily smallholder farming communities are appropriate for 423 million ha of land in all sub-regions of sub-Saharan Africa, and that they could benefit 241 million rural farmers, 57 million of whom are poor. The technology suite includes combinations of other technologies and including especially 'soft' technologies such as: participatory irrigation and community management, conflict resolution (over management and allocation of costs as well as benefits), training and institutional capacity building.

5. Main intended target agro-ecozone for optimal, sustainable performance of this Best Bet: All

6. Estimated average (not potential) on-farm yield gain in percent, compared to average local current practice in the most appropriate agro-ecozone: >50%

7. Location-specificity: 3 = high (requires significant local testing and/or adaptation):

8. Most promising countries for this intervention: Ethiopia, Burkina Faso, Tanzania, Kenya, Uganda, Mozambique, Zambia, Niger, Nigeria, Mali

9. Time frame: Long (6 or more years)

10. Most effective modes of delivery:
Partnerships: Research – extension – farmers, researchers - Basin Water Authorities – NGO's
Agencies: NARES, Extension agencies, Farmer's groups, Water resources ministries, Basin Water Authorities, International NGO's, International development donors

11. Key development and financial resources needed to deploy this Best Bet within a typical country among the target set of countries: An estimate of financial resources necessary to deploy one type of water system management – watershed management - is: US$ 160/ha initial investment, US$ 16/ha/yr soft components, and US$ 2/ha/yr recurrent costs, for a total investment of US$ 66 billion to achieve implementation of watershed management options on 400 million ha of land in sub-Saharan Africa. 'Soft' components include participatory community management, conflict resolution (over management and allocation of costs as well as benefits), training and institutional capacity building. Research-policy linkages are required. Successful deployment will require significant investment in people, to achieve the capacity building required at all levels

12. Research efforts that are needed or recommended to achieve, sustain or enhance the impact

of this Best Bet: To support decisions in water systems management, the biophysical, social, economic and institutional settings required to support them must be assessed. Adaptation to local conditions as well as larger scale water policy to mitigate negative externalities and mediate amongst various users of water at watershed and basin scales is necessary. Significant knowledge gaps include understanding: watershed function and impacts of interventions; institutions, water rights and pricing vehicles to improve irrigation performance; how to develop equitable benefit sharing and allocation policies at larger scales. Four scientists (water engineer/agronomist/socio-economist/institution specialist) for three years each for a region @ US$ 250,000

13. Any special information you feel is important concerning this Best Bet that is not covered in the above:

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