AFRICAN UNION
SEMI-ARID FOOD GRAIN RESEARCH AND DEVELOPMENT
AU-SAFGRAD

Agricultural technologies in Burkina Faso

August 2010

Imprimerie Altesse Burkina Tél. : 70 24 53 52

AFRICAN UNION
SEMI-ARID FOOD GRAIN RESEARCH
AND DEVELOPMENT
AU-SAFGRAD

Agricultural technologies in Burkina Faso

August 2010

ISBN
ELECTRONIC: 978-92-95104-01-3
PRINT: 978-92-95104-00-6

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

AU/SAFGRAD office thanks the consultant who prepared this document Dr Taonda Sibiri Jean Baptiste and all the participants who attended the validation workshop.

ACRONYMS AND ABBREVIATIONS

WARDA	West Africa Rice DevelopmentAssociation
AGF	Agroforestry
ANVAR	National Agency for the Promotion of Research Findings
APIPAC	Association for the Promotion of Private Irrigation and Related Activities
DRS	Soil Defence and Conservation
DVRD	Directorate for Extension and Research & Development
CEAS	Albert-Schweizer Ecology Centre
WSC	Water and Soil Conservation
CREPA	Regional Centre for Low-Cost Water Supply and Sanitation
IFDC	International Center for Soil Fertility and Agricultural Development
IITA	International Institute of Tropical Agriculture
INERA	Institute for Environment and Agricultural Research
IRD	Development Research Institute
IRSAT	Research Institute of Applied Science and Technology / Department of Mechanization
IRSAT / DM	Research Institute of Applied Science and Technology / Mechanization Department
MAHRH	Ministry of Agriculture, Water and Fishery Resources
NGO	Nongovernmental Organization
PDS	Standing stone by subsoiling
PNDSA II	National Project for Developing Agricultural Services, 2 nd phase
PNRA	National Agricultural Research Program
PRSAP	Project for Strengthening Producer Support Services
SAFGRAD	Semi Arid Food Grain Research and Development Project
SNVACA	National System of Extension and Advisory Support for Agricultural
SP/CPSA	Permanent Secretariat for the Coordination of Sectoral Policies

FOREWORD

AU/SAFGRAD office has many core functions amongst them are dissemination to farmers and other end-users of technologies to facilitate the development of micro-enterprises and the generation of employment and income; development of linkages and partnership between sources of technologies (NARS IARCs and Universities) and users of technologies (Farmers, associations and NGOs) as well as documentation of success stories, lessons learned and experiences. AU/SAFGRAD introduces this study to all relevant institutions to facilitate them for more understanding of the agricultural technologies in Burkina Faso.

The study represents a first try of capitalization of the technologies. It is a collection of more than 200 described technologies matched by analysis of the performances. The field of the study mainly focused on the zone of the central tray (plateau) of Burkina Faso. The producers, Extensionists, NGOS as well as the researchers whose activities join the sector of the rural development will find information on the technologies there which will contribute to the development of the performances of the systems of production in the major part of the farms of Burkina Faso. In addition, all Sudanese north agro-ecological zones confronted to the similar constraints which are value added to this study.

Dr. Ahmed Elmekass

Coordinator,
AU/SAFGRAD

INTRODUCTION

As part of the fulfilment of its mission of contributing to the advancement of agricultural research and technology transfer in Africa, the AU/SAFGRAD initiated a study to capitalize on agricultural technologies and innovations in the Central Plateau of Burkina Faso.

By considering the crop varieties as technologies in their own right, the desk research, interviews with resource persons and analysis work allowed to describe briefly the performance of over 200 existing technologies and innovations and classify them into 4 major groups: the natural resource management technologies; the varieties or/and hybrids of 4 crops targeted by the study; the technological packages of production and their economic performance and the post-harvest technologies.

An analysis of the transfer system resulted in the diagnosis that the transfer of technology is hampered by an entanglement of constraints which are mainly the low producer-supervisor ratio; difficulty of access to factors of production; inadequate linkage between research and development; illiteracy of producers; not very inciting farm credit and funding policies, land security problems; weakness of the processing and marketing.

After the diagnosis, a draft proposal for improving the dissemination and adoption of agricultural technologies and innovations could be developed around the following major areas: build producers' capacities; develop policies to support production; adopt a more participatory process for generating and validating technologies; the use of efficient technology transfer tools.

The book is intended as a repository of the key technologies which can be used for promoting agriculture in the Central Plateau of Burkina Faso, where agriculture accounts for over 86% of the labour force and contributes 40% to the GDP.

The paper includes four parts in accordance with the four main areas to which the identified technologies belong: i) - the management of natural resources; ii) - the exploitation of the varietal potential; iii) - the technology packages; iv) - the post-harvest technologies. It also includes the analysis of the constraints to the dissemination and adoption of technologies and innovations; the proposals for improving the dissemination of technologies and innovations. A conclusion and prospects end the paper.

1

Management of Naturals Resources in Burkina Faso

1. Management of Natural Resources in Burkina Faso

The main natural resources are land and water resources, floristic, wildlife, fishery, pastoral and mineral resources. They constitute the fundamental basis of the economic and social development of the country. These resources are experiencing a rapid degradation under the combined effects of climatic and anthropogenic factors (INERA, 2003). Indeed, increased population pressure in arid zones causes profound changes in methods of managing and using these natural resources and rural space (Roose, 1994). Overcutting trees, poor rangeland management and the practice of bush fires ultimately lead to the gradual disappearance of the vegetative cover which gives way to savannah or arid Sahelian steppes with soils exposed to wind and water erosion.

The effects of human actions are accelerated by climatic factors whose major events include: recurrent droughts and declining rainfall.

Given such situation, significant efforts towards generating technologies and innovations for improved natural resource management and production systems have been developed by various stakeholders in rural development.

1.1 Management of soil fertility

Fertility is defined in agronomic terms as the capability of a soil to ensure plant production. It is a measure related to the soil minerals content which can increase or decrease according to farming methods (Lavigne, 1996). The physical and chemical structure and the biological activity are fundamental elements of soil fertility.

In Burkina Faso, declining soil fertility is a major constraint to the development of agricultural production systems. Indeed, there is an overall decline in crop yields and accelerated degradation of agricultural lands. According to INERA (2003), this degradation affects over 24% of arable lands.

Ferruginous tropical soils are, in Burkina Faso, the most frequent soil type; they are characterized by low structural stability of surface horizons due to their high silt and fine sand content and their low organic matter content (Pieri, 1989). The declining organic matter content, under the influence of the high kinetic energy of rainfall and the reduced vegetative development, leads to the formation of crusts limiting infiltration (Casenaveand Valentin, 1989). The immediate consequence is the exposure of soil to erosion.

Chemical degradation of soils is the result of the depletion of soil nutrients, due to a mine type production system, without addition of fertilizers or organic amendments, awhich provide minerals. This explains the drop in production after a few years of use (Taonda, 1995).

Soil fertility management technologies aim essentially to:

- Minimize as much as possible losses due to water and/or wind erosion;
- Use organic and minerals fertilizers in quantity and quality;
- Maintain or improve soil organic matter through the production and use of various organic materials and farming methods that improve soils (crop rotation, fallow, minimum tillage) and appropriate practices of mechanized ploughing and conservation agriculture;
- Manage farms based on soil properties.

Several initiatives to develop technological packages for effective management of soil fertility have been developed through research and other public and private services, NGOs and also by innovative farmers.

The initiatives can be grouped into:

- water, soil and vegetative cover conservation technique;
- agricultural intensification.

1.1.1- Water and soil conservation technologies and innovations

The technologies can be classified into mechanical, farming, biological and agro-forestry technologies.

a. Mechanical water and soil conservation techniques

a.1. Anti-erosion earth and rock bunds

a.1.1. Earth bunds

These are earth embankments with a base of 80 cm to 1 m and an average height of 30 to 50 cm.

Earth bunds retain all the water and promote its maximum infiltration. They are used mainly if stone works are not easy to implement.

This is an appropriate technology in the Sahelian and North Sudanian zone (300 - 900mm).

a.1.2. Stone bunds

These are permeable obstacles formed by a line of rocks which slow down runoff velocity.

This is also an appropriate technology in the Sahelian and North Sudanian zone (300-900mm).

They allow increased infiltration of runoff water and the sedimentation of particles (sand, fine soil, organic matter) upstream from the bund.

Three varying techniques are used:
- The aligned stones system;
- The FEER system (The Water and Rural Equipment Fund) or three-stone system;
- the PDS system consists in opening furrows to serve as anchors

In the Central Plateau, where the slope hardly exceeds 3%, an economic analysis showed that for a producer who can find stones at a short distance and who uses his own equipment to build the bunds (with no addition of fertilizers), the optimal spacing is between 23 and 45 m. For the most widespread case of a farmer working with the assistance of a project in drawing the contour lines and transporting the rocks, it is between 30 and 47 meters (Zougmoré *et al.,* 2000).

Photo 1 and 2: *Building a rock bund using the PDS system in the northern area of Burkina Faso*

(Photo by the MARP Network, 2008)

According to Zougmoré (2002), the construction of rock bunds in a field has the following impacts:

- The runoff on developed field is reduced by 12% with a spacing of 33 m between the rock bunds, and 23% with a spacing of 25 m between the rock bunds compared to a field which has not been developed.
- The construction of rock bunds results in decreased soil loss, 46% with a spacing of 33 m, and 61% with a spacing of 25 m.
- The average moisture content per plot is all the higher since the spacing between the bunds is lower.
- In a deficit rainfall year, the production grain compared with the control is 110% for a spacing of 33 m , and 343% for a spacing of 25m.
- In a good rainfall year (less frequent dry periods), the production gains become less significant: 73% for a spacing of 33 m, 56% for a spacing of 25 m.
- In an excess rainfall year, the yields become all the lower since the spacing between bunds is lower. The yields are very low upstream of rock bunds due to permanent flooding in these areas, leading to suffocation of plants.

a.2. Zai:

The zai is a technique used for recovering encrusted lands consisting in digging 20 to 40 cm diameter holes and 10 to 15 cm in depth in order to collect runoff water and allow its infiltration. The excavated earth is deposited in a crescent downstream to capture runoff water.

Zaï may be done manually: this is manual zaï. It can also be done using animal traction: this mechanical zaï.

Photo 3:
Manual zaï

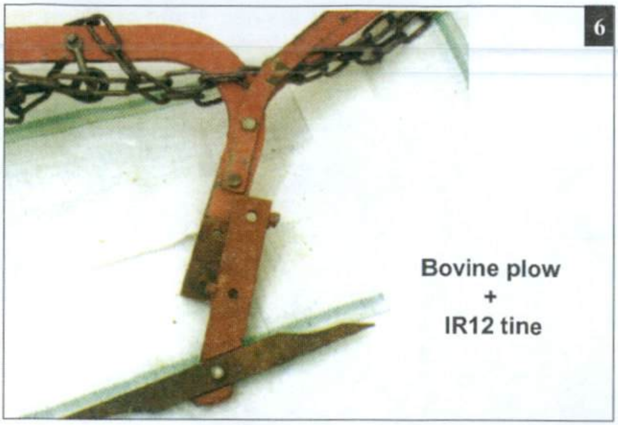
(Photo, The Marp Network Burkina Faso, 2006)

Photo 4 :
Mechanical zai using bovine traction

(Photo INERA, 2006)

Photo 5:
Mechanical zai using donkey traction

(Photo, MARP Network-Burkina Faso, 2006)



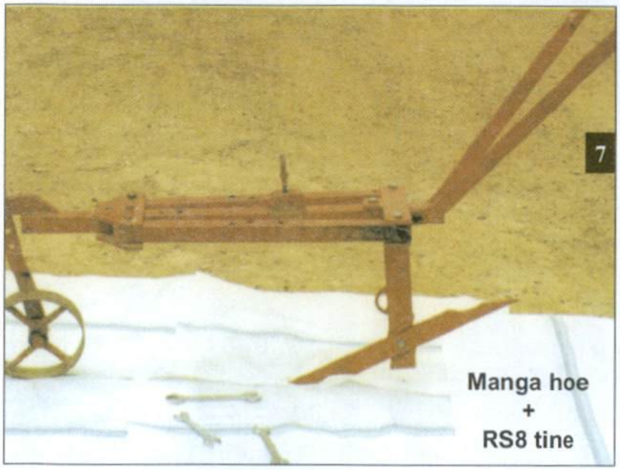


Photo 6 and 7: *Tools used to implement mechanical zai*

(Photo, A. Barro, 1996)

Approximately 300 g of organic matter is applied as manure or compost in the hole before the sowing period. We note, however, that this amount varies according to the farmers (Reij *et al*, 1996). There are two variants of the technique: agricultural zai and forestry zai.

The zai is practiced in the north and central zone.

The benefits of zaï are mainly: the capture of runoff and rain water and the preservation of seed and organic matter. The aim is therefore to achieve a concentration of fertility and available water at the beginning of the rainy season to increase agricultural production.

Photo 8 : Proper development of sorghum plant on zai observed on 23.08.2006 in Lèba of Gourcy

(Photo, Taonda S., 2006)

The zai bowl + 300 g of manure or compost permits to obtain on a zipelle (degraded land) 800 kg/ha of sorghum grain, i.e. 8 times the yield of the control. The addition of 80 kg/h of NPK permits to obtain at least 900 kg of sorghum grain in the sub-sahelian region (Zougmoré *et al.*, 2000) and 1200 kg/ha of grain in the North Sudanian zone (Taonda, 1995).

In cases of surplus rainfall, the yields decrease as a result of the waterlogging conditions of plants.

When implementation conditions are optimal (dry and rather clay to sandy clay soil type), mechanical zai allows to achieve 1200 kg yields against 200 to 300 kg/ha for the control.

In fact, in the same agro-climatic region, the effectiveness of zai depends on the soil type.

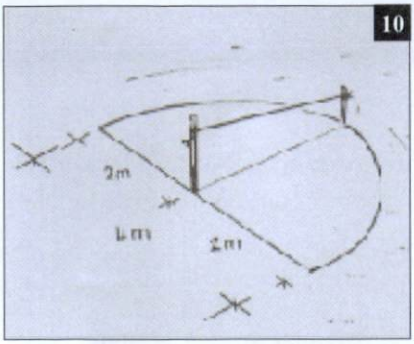
TABLE 1: **Average effect of zai over three years in the North Sudanian zone of Burkina Faso on the production of sorghum grain depending on soil texture (kg/ha)**

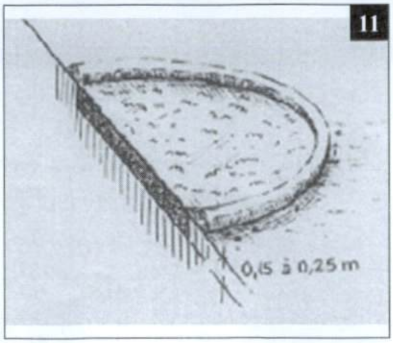
Soil texture	Control	Manual zai	Mechanical zai
Clay soil	685,8	1189,2	1110,6
Gravelly clay soil	491,5	823,5	1002,9
Sandy clay soil	472,8	763,4	786,7
Sandy-loam soil	245,5	432,8	573
Sandy soil	456,9	823,5	1031,9
Gravelly soil	289,3	829,5	851,9

Source : Barro *et al*, 2000

Photo 9. Manual construction of a half-moon on a glacis

(Marp Network-Burkina Faso, 2006)





Photos 10 and 11: sketch and diagram of a half-moon *(Zougmoré et al., 2000)*

a.3. Half-moons

The half-moon is a ditch shaped like a semicircle, dug with a pick. The excavated earth is placed in a semi-circular bund compacted on top like an earth embankment.

The half-moons are arranged according to the contour lines, in a staggered pattern, i.e. the second row of half-moons is arranged in such a way as to be staggered in relation to the first row so that the tips of the half-moons on two successive lines are always at the same level.

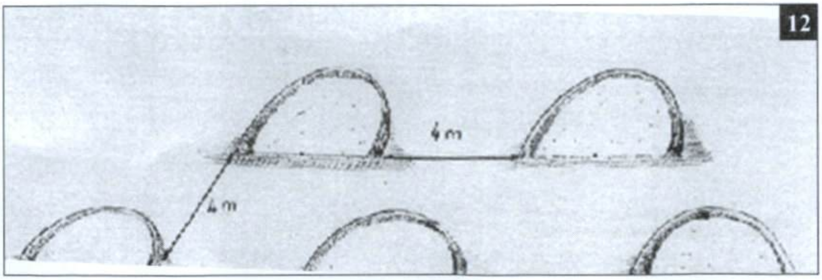


Photo12: half-moons in a staggered pattern *(Zougmoré et al., 2000).*

They are generally constructed on encrusted glacis on which the water just runs off.

The half-moon can be constructed manually or with a tractor with the tool under testing in the North called «Delphino». Indeed, the «Delphino» cart allows digging mechanically semi-circular micro-basins.

The half-moons collect runoff and are adapted to semi-arid and arid zones. The half-moons serve to improve the water reserves of the soil (increase the depth of wetting from 20 to 40 cm or 60 cm depending on the type of soil). The technology of the halfmoon is recommended for the Sahelian Zone with a rainfall being less than or equal to 600 mm. In the other areas flood risk is real.

The half-moons allow increasing agricultural production especially if organic, mineral or organo-mineral fertilization is added. Combining half-moon and manure or compost gives a production range of 1200 to 1600kg/ha of sorghum grain.

Photo 13: The collection of runoff by half-moons in the semi-arid and arid zones

(MARP Network, 2006).

Photo 14 et 15. Sorghum grown in the sub-Sahelian region (Zandoma province) on gravelly slopes using the half-moon technology + rock bunds at the stem elongation and maturing stages

(Photo, Taonda, 2006)

b. Farming techniques for water and soil conservation

Farming techniques include all tillage practices used to loosen the soil or create cracking to increase the overall porosity of the soil surface horizons for infiltration. There are 4 techniques.

b.1. Subsoiling

This involves breaking up the surface layer of a compacted soil to improve its infiltration capacity using a subsoil plow.

It must be followed by preparation of the seedbed with a hoe or an animal drawn tined implement.

b.2. Decompacting with the versatile IR 12 frame decompacting machine

Decompacting means breaking dry soil to capture water from the first rains for early seeding;

The D.IR. 12 tool is composed as follows: A versatile frame; a wheel; a pair of handles; 03 IR12 tines. It should be noted that this tool uses the wheel and the handles of an ordinary plow.

Depending on the work to be done and the animal power available, you can mount 1 tooth, 2 tines, 3 tines with one tine in front, 3 tines with two tines in front.

The tool is designed to be versatile to allow an incremental investment of the user. You can mount on the plow beam a moldboard plow; a ridger; a furrower; weeding tines.

Tillage depth is determined by the height of the wheel from the ground; the plow beam is horizontal. The spacing of the tines depends on animal power available and the soil type. The high position of the handles is adjustable.

The tool can be used on any type of soil in a dry or pre-wet condition. However, maximum grass height should not exceed 15 cm. The tool can be drawn by 1 pair of oxen, a single ox, a horse or a donkey.

Maize yield gain is 8 to 10%; the gain in early seeding is 2 to 3 weeks. Decompacting makes possible the recovery of degraded land and contributes to reducing the use of herbicides.

b.3. Scarification

Scarification means scraping the soil superficially, manually (with the hoe) or with a donkey-drawn tined instrument: the IR 12 tine for sandy soils and the RS 8 for other soil types. On the Central Plateau of Burkina Faso, most often it is a weeding ploughshare like the one commonly called «crow's foot» that is used. Traction can be by donkey or cattle. The aim is to loosen the top 10 cm of soil. It is performed under «dry» or «wet» conditions.

b.4. Plowing

This is a tillage operation which, using a plow body, cuts a more or less broad strip of land and returns it resulting in an undulating surface covered with clods or aggregates whose size depends on the type of soil and soil moisture conditions during tillage. Plowing is done at a depth of 20 to 40 cm with an animal drawn plow or a tractor (plowshare or disc tools).

Plowing can

- break up the soil crust, increase soil porosity, which improves infiltration and reduces runoff;
- bury organic amendments, crop residues, weeds and fertilizers

The benefits of tillage are dependent on soil types: on desaturated sandy ferralitic soils researchers report decreased runoff, but also increased erosion while Nicou and Charreau, 1985 demonstrate the benefits of plowing on sandy tropical ferruginous soils susceptible to surface sealing. On these soil types, without tillage yields are halved. However, it should be noted that tillage can accelerate erosion

b.5. Ridging, earthing up and partitioned ridging

Ridges are made before sowing and ridging is done at the plant shooting stage. The work can be done manually, with a plow or a tractor. To maximize water retention in the plot, the partitioning of the ridges is done one month later. Water is concentrated in the furrows, infiltrates for the benefit of plants. It is recommended to do ridge partitioning one month later. In the North Sudanian and Sahelian zone, ridges can double yields (Taonda *et al.,* 2000).
In the north sudanian zone waterlogging can occur and affect crop development and harvesting as a result.

c. Biological techniques for water and soil conservation

c.1. Mulching

Mulching is done by covering the soil with a layer of about 2 cm of grass, the equivalent of 3 to 6 t/ha or branches or crop residues (maize, millet or sorghum stalks), so as to stimulate macrofauna activity (especially termites) and soil microflora. The superficial soil crust is literally dug with tunnels beneath the mulch, resulting in a loosening of the soil and increase in its macroporosity allowing better infiltration of water (Zombré *et al.,* 1999).

The result on grain yield can reach + 80% compared to the control. Indeed Dickey *et al.* (1994) obtained over 3 years in Donsin of Boulsa in the sub-Sahelian zone an average of 900 kg/ha of sorghum grain against 500 kg/ ha for the control.

c.2. Crop rotation

The rotation is the succession in time, of different crops on the same plot.

Rotation is the distribution of crops on various plots.

The benefits of this practice include:

- improved soil structure and consequently soil fertility: indeed, monoculture uses and exhausts the same nutrients every year in the same topsoil depth;
- reduced weed pressure: planting the same crop each season promotes the development of certain weed species;
- reduced pest pressure: the cycle of insects and crop-specific diseases is broken by planting another crop. A good succession of good crops (cereals/legumes) is more beneficial to soil fertility than a short fallow period (Bado 2002). Results also indicate that a good rotation can break the *Striga cycle* (Traoré, 2005).

Photo 16: *Rotation of groundnut and sorghum in a cereal-based system*

(Photo K. Traoré, 2006)

d. Agroforestry techniques for water and soil conservation

d.1. Reforestation

This is planting in fields, along bunds, reforestation in the form of village groves and hedges around market gardening areas.

This agroforestry practice has many benefits: consolidation of erosion-control structures, production of organic matter through biomass spreading, supply of fuel wood, timber, protection of cropped areas against devastating animals.

The major problem in reforestation is the protection against stray animals.

d. 2. Assisted natural regeneration (ANR)

ANR consists in

- Preserving one shoot per bush and tree seedlings,
- Promoting the growth of the preserved young shoots and/or seedlings by regular pruning,
- Pruning branches in case of excessive shade,
- Removing some individual plants for clearing purposes if the density is considered too high. Wherever an individual plant has been cut down, the producer must preserve as much as possible one stool shoot.

In short, assisted natural regeneration consists in leaving while clearing (in the dry or rainy season) one to three (3) shoots from the stocks of various trees and shrubs (between 80 to150 feet per hectare) for them to continue growing.

ANR is done through the following stages:

- Identification and selection of young shoots to be protected;
- Cutting of unselected shoots;
- Nurturing and pruning selected shoots every year;
- Rational use of the branches from regenerated trees taking into account species and needs (fodder, wood, organic matter, etc.).

The practice of ANR has many benefits especially for Sahel country farmers, including:

- The protection of cropland by controlling wind and water erosion;
- Improved soil fertility;
- Production of fuel wood or service wood;
- Production of animal fodder;
- Reduced evapotranspiration.

This results in:

i. Increased crop yields and improved food security at household level.

ii. Production systems are becoming increasingly complex and productive, translating into reduced rural poverty: the trees produce fodder, enabling farmers to raise more cattle. Animals are better controlled and their droppings are increasingly returned to the soil.

In short, the protection and management of spontaneous natural regeneration enable farmers to better integrate trees, crops and animals in their production systems. These more complex systems make farm operation secure even in years of drought. Under drought conditions, the farmer who has practiced ANR can trim the trees or prune them in order to market the products. This income enable them to buy more grain.

iii. Increased availability of energy wood.

Iv. In some areas, such as Kokologho in the central region of the country, natural regeneration is largely dominated by *Acacia albida*, a species which fixes nitrogen through its roots. It improves soil fertility and increases fodder production.

v. From an economic perspective, it is rational to invest in the protection and management of natural regeneration. An economic study has estimated an internal rate of return of ANR at 31% (Sperling, 2008).

Photo 17: A 9 ha field of 130 baobab plants (Adansonia digitata) per hectare in Yatenga (it produced more than three tons of grain per hectare)

(photo, M. Ouedraogo, 2008).

Photo 18: *ANR over a 14 ha area recovered (in Yatenga) using rock bunds, organic matter and the practice of Assisted Natural Regeneration (ANR), over 140 (Sclerocarya birea trees) per hectare. It earns more than 350,000 CFA Francs per year and produces over 25 tons of grain per year*

(Photo, M. Ouedraogo, 2008).

d.3. Herbaceous cover

The herbaceous cover technology is the recovery of vegetation-free clearings through tillage with tined implements. It is often subsoiling which is practiced followed by the sowing of preferably perennial herbaceous seeds.

The practice allows to quickly restore vast areas of degraded glacis which may be cultivated in the following years.

d. 4. Grassed strips

These are bands of vegetation consisting of herbaceous plants, along the contour lines in the fields, alone or in combination with anti-erosion structures such as rock bunds or earth bunds.

Photo 19: Land plot developed into an herbaceous with a field in the background

(Photo, Hien et al., 2005)

Covering structures with herbaceous species makes them more efficient, more stable and therefore more sustainable. However, grassed strips must be well managed, with the risk of increased competition with the crops as they grow older.

d.5. Exclosure

Exclosure is the protection of an area or land plot against anthropogenic aggressions (grazing, bush fires, wood harvesting) or against predatory animals. This is therefore a fallow land protected against all forms of attack.

When possible, exclosure has a great potential for improving soil chemical and physical properties, especially in areas with high rainfall where natural regeneration occurs quickly. The condition for successul exclosure is the consensus among all the communities of the area.

Photo 20 : View of an exclosure with *Andropogon gayanus*

(photo, Serpantié et al. 2005)

All the technologies identified may be advantageously associated in combination as part of what is commonly called «conservation agriculture» which provides a framework for developing these technologies in a unique context. Conservation agriculture is based on the following three principles:

1) minimum tillage;
2) permanent soil covering;
3) crop rotation and intercropping.

d.6. Conservation Agriculture

For this technique, different species of high-performance and high biomass cover crops, have been identified for the Eastern, Central and Western areas (Segda et*al.*, 1999; Zougmore, 1999). Mucuna and cowpea are a few examples. They have been integrated into the cropping systems (Sedga et *al.*, 1998b, Sedga et *al.*, 1999; Traore et *al.*, 1998; Zougmore; 1999).

Photo 21: Biomass production in Conservation Agriculture plots

(photo, S. Ouedraogo., 2006)

This practice shows real potential for rational soil management especially in areas with relatively high rainfall (over 800 mm) where biomass production is facilitated.

1.1.2 Agricultural Intensification

a. Production and use of organic matter

The organic matter in the soil is a source of nutrients for crops and allows good soil structuring and greater microbial activity. Organic matter plays a crucial role in the cation exchange capacity and the water holding capacity of soils (Ouedraogo *et al.*, 2000). Organic matter is the «pillar» of soil fertility. But the organic matter content of most soils in Burkina is low (less than 1%) (Lompo *et al.*1994). Therefore there is need to produce and increase the use of organic matter.

Some work has been done to characterize the different types of organic matter available and production techniques (stable, pits and deer park) in Burkina Faso. Significant work has been done at INERA which allowed developing techniques for producing organic matter from crop residues (Traoré et al, 2007).

Research activities in the last few years are also focused on the diversification of production techniques in order to make proposals taking into account the variability of the producers' socio-economic conditions.

Several development organizations and NGOs have also developed initiatives for producing organic matter which have capitalized as data sheets.

APIPAC proposes a technique for producing compost using four juxtaposed pits with incorporation of Burkina phosphate. This technique allows avoiding the difficulty of turning in the same pit. This technique can produce compost in 2 months. In 2004, the CEAS proposed a system with two (2) pits for periodic production and the system with four (4) pits for continuous production (CEAS, 2004).

Recognizing the role of organic matter in production systems, the political authorities have initiated measures to ensure large-scale production and use of organic matter.

Photo 22. Windrow composting of crop residues with addition of Burkina phosphate

(photo, K. Traoré, 2006)

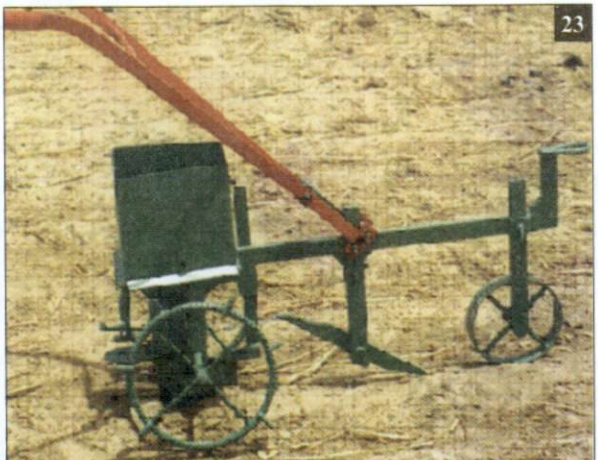


Photo 23: Animal-traction manure and Burkina phosphate spreader

(Photo, IRSAT/DM)

In the Guide to Green Revolution document developed by the Ministries of Rural Development, the production and use of organic matter features prominently. Indeed, the guide is planning to establish the pits using the "compost plus" activator enriched with Burkina phosphate (MAHRH, 2007).

The strategy paper for rural development by 2015 lays emphasis on the production of organic matter in the context of integrated management of soil fertility.

In the last few years, the National Farmers' Day (JNP) has been the appropriate framework for promoting the production and use of organic manure. More than 1.5 million compost pits were implemented during the 2001 to 2006 period. At the 11th JNP edition held in Dori, farmers made the commitment to produce 20 million tons of organic manure.

Through its Mechanization Department, IRSAT has developed an animal-drawn crushed manure spreader (Annex 1). Equipped with the IR 12 tine, it permits to continuously apply manure in the furrow opened by the tine. The spreader is also used for spreading Burkina phosphate in the dry soil so as to obtain results early in the rainy season.

b. Managing soil fertility in Burkina Faso using mineral fertilizers, local agro-mineral resources and human excreta

b.1. Classic fertilization formulas with mineral fertilizers

Soils in Burkina are nitrogen and phosphorus deficient. Indeed, the total nitrogen content is less than 0.06% for 75% of soils and the P2O5 content is below 0.06% for 95% of soils.

This situation is linked to the extensive nature of production systems which explains the observed decline in production after several years of operation (Taonda, 1995). Nitrogen and phosphorus are the two main limiting factors of production in Burkina Faso (Bationo *et al.*, 1998). Lompo (1995) indicates that phosphorus deficiency is the first limiting factor for most soils of Burkina Faso.

The correction of the phosphorus and nitrogen deficiency is a major challenge for agriculture in Burkina Faso. Therefore, fertilization formulas were developed for different crops, particularly profitable fertilizer formulas for cereal crops (sorghum, millet and maize) cheaper than the popularized classic formula. Three areas were considered based on rainfall, soil and farming system.

- Zone A rainfall is less than 600 mm,
- Zone B rainfall is between 600 and 800 mm,
- Zone C rainfall is higher than 800 mm.

The table below gives some information on conventional mineral fertilization per crop and per zone.

TABLE 2: **Mineral fertilization recommended per area and per crop**

Crops	Zone	Formula
Sorghum and millet	A	50 kg NPKSB + 50 kg urea
	B	75 kg NPKSB + 50 kg urea
	C	100 kg NPKSB + 50 kg urea
But*	A	100 kg NPKSB + 100 kg urea
	B	100 kg NPKSB + 100 kg urea
	C	100 kg NPKSB + 100 kg urea

Source : INERA, 2000

For maize, this formula is the minimum formula for good production and for limiting exports.

The mineral fertilizers used are NPKSB dosing 14-23-14-6-1 and urea (46% N).

Mineral fertilization recommended in Burkina for maize per popularized variety (1988-2001) and rainfall is indicated in the table below:

TABLE 3 : Mineral fertilization for maize per type of agriculture

Type of agriculture	Mineral fertilization	Varietal cycle in days after sowing			
		Extra early 70-84 j	Early 85-94 j	Intermédiate 95-110 j	Late + 110 days
SEMI-INTENSIVE AGRICULTURE Varietal potential: 2-3t/ha varietal type: composite	NPK : 100 kg/ha Urea : 100 kg/ha	KEB KEJ JFS	Jaune de Fô	Massayomba IRAT 80	
SEMI-INTENSIVE AGRICULTURE Varietal potential: 3,5-6t/ha varietal type: composite	NPK : 200 kg/ha K_2SO_4 : 50 kg/ha Urea 1:100 kg/ha Urea 2 : 50 kg/ha		Maka*** KPB KPJ FBC 6 ***	IRAT 171 Poza Rica 7822 IRAT 200 *** SR 22 SR 21 FBPC 1 * FBPC 2 * FBMS 1 ** FBMGS 1 ** Obatanpa **** ESPOIR ****	
AGRICULTURE INTENSIVE Varietal potential: 5-7t/ha varietal type: hybrid	NPK : 300 kg/ha K_2SO_4: 50 kg/ha Urea 1 : 100 kg/ha Urea 2 : 50 kg/ha			FBH 1 FBH 33 FBH 33 ST FBH 34 ST FBH 34 SR Oba super 2	IRAT 81
Agro-ecological ones (rainfall)		Rainfall < 600 mm	Rainfall < 900 mm	Rainfall > 900 mm irriguated areas	irriguated areas
Reference site		Saria	Kam-boinsé	Farako Bâ, Niangoloko Kouaré	Kou alley

Legend: ** Popcorn; sweet corn **;*** grilled corn, high-protein corn*****

Source : Sanou J., 1996

b.2. The MicrodoseTechnology on traditional cereals and oil and seed crops

Microdose is the application small mineral fertilizer doses in the seed hole when sowing or next to the seedling after emergence (10 days after sowing).

Mineral fertilization by microdose allows to:

- Locate the fertilizer near the roots, thus obtaining a high concentration area which makes assimilation of nutrients easier;
- Limit phosphorus fixation phenomena by the soil ;
- Reduce loss of potassium (K) and nitrogen (N) through leaching;
- Achieve an early start of plant growth (microdose = « starter » manure) through rapid growth of roots and seedlings, and earlier maturity avoiding droughts at the beginning and end of the rainy season thus ensuring increased crop yields;
- Increase the efficiency of fertilizer use;
- Minimize production costs;
- Improve small producers' income;
- Increase the number of mineral fertilizer users.

b.2.1. Zones and conditions of application

- Sahelian 400-600 mm and Sudanian zone from 1 600 to 900 mm
- Control of measurement for the indicated dose
- Implementation of the required crop maintenance work

b.2.2. The microdose application technique

1. Open a seed hole;
2. take a pinch of NPK fertilizer, place it in the hole and cover with a thin layer of soil to prevent the fertilizer being in direct contact with the seed, which could cause damage to germination, especially in dry years when localization is made too close to seeds at excessive doses;
3. Place the seeds into the hole and close the seed hole.

Microdose fertilization can be applied after emergence (10 days after sowing) next to the seedling and cover the hole.

b.2.3. Doses of microdose

The dose of microdose to apply in the seed hole during sowing or next to the seedling after emergence varies with the crop.

Application of the microdose on sorghum

Seed density: 80 cm x 40 cm

Dose of microdose in the seed hole during sowing or after emergence = 2 g

Application of the microdose on millet

1. Seed density: 80 cm x 60 cm

   Dose of microdose in the seed hole during sowing or after emergence = 3 g

2. Seed density: 80 cm x 40 cm

   Dose of microdose in the seed hole during sowing or after emergence = 2 g

Application of the microdose on maize

Seed density: 80 cm x 40 cm

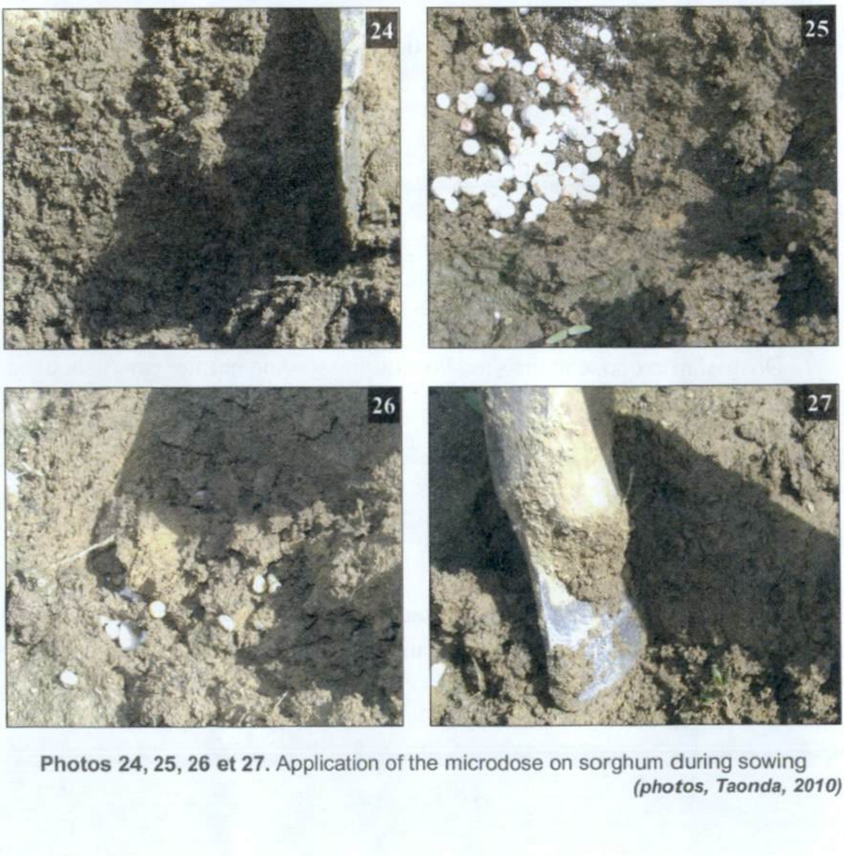
Dose of the microdose in the seed hole during sowing or after emergence = 4 g (dose to perfect) 125 kg NPK/ha against 150 kg NPK + 100 kg Urea at popularized doses per hectare

Application of the microdose on cowpea

Seed density: 80 cm x 40 cm
Dose of microdose in the seed hole during sowing or after emergence = 2 g

Application of the microdose on groundnut

Seed density: 40 cm x 20 cm
Dose of microdose in the seed hole during sowing or after emergence = 0.5 g



Photos 24, 25, 26 et 27. Application of the microdose on sorghum during sowing *(photos, Taonda, 2010)*

Photos 28, 29 ; 30 et 31. Application of the microdose on sorghum after emergence

(photos, Taonda, 2010)

Photos 32 and 33. Application of the microdose on maize after emergence

(photos, Taonda, 2010)

Photos 34 et 35. Application of the microdose on cowpea after emergence

(photos, Taonda, 2010)

b.2.4. Performance of the microdose

Performances on sorghum

The application of the microdose can produce a grain yield exceeding 1.5 tons per hectare (Figure 1). It generates additional grain yield gains of 110% and 20% compared to zero fertilization and at the popularized dose (75 kg of NPK + 50 kg of urea per hectare), respectively.

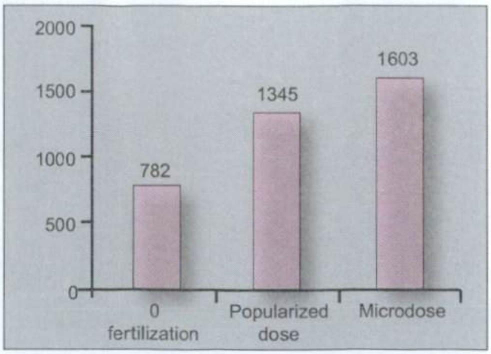


Figure 1: *Effect of the microdose on sorghum grain yield*

Performances on millet

The application of the microdose results in a grain yield exceeding 1 ton per hectare (Figure 2). It generates additional grain yield gains of 100% and 30% compared to zero fertilization and at the popularized dose (75 kg of NPK + 50 kg of urea per hectare), respectively.

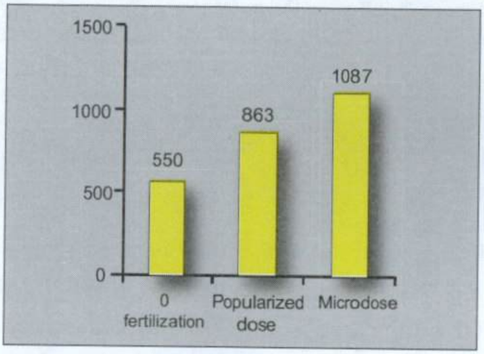


Figure 2: *Effect of the microdose on millet grain yield*

Performance on cowpea

The application of the microdose on cowpea results in a grain yield of about 1 ton per hectare (Figure 3). It generates additional gains in grain yield of 90% and 10% compared to zero fertilization and at the popularized dose (75 kg of NPK + 50 kg of urea per hectare), respectively.

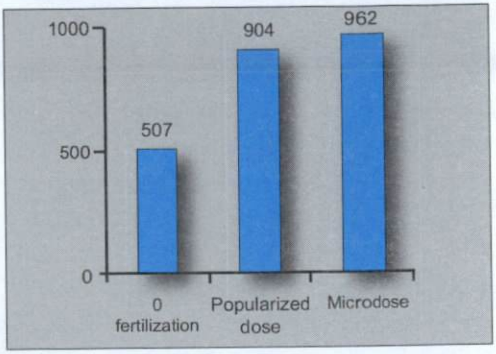


***Figure 3** : Effect of the microdose on cowpea grain yield*

Performance on groundnut

The application of the microdose on groundnut gives a grain yield exceeding 1 ton per hectare (Figure 4). It generates additional grain yield gains of 60% compared to zero fertilization and a yield equivaling the popularized dose (75 kg of NPK + 50 kg of urea per hectare).

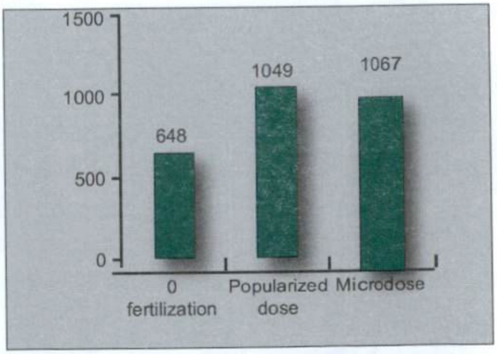


Figure 4: Effect of the microdose on groundnut grain yield

The microdose technology gives interesting economic results through reduced costs of fertilizer use and improved farm income as indicated below.

TABLE 4: **Economic evaluation of the additional agricultural production of fertilization formulas in Nagreongo in the central plateau in 2006, Burkina Faso.**

Crops	Technologies	Technology-specific cost (CFA)	Fertilizer cost relating to the technology (CFA)	Specific expenditure (CFA)	Production additionnelle ($kg.ha^{-1}$)	Selling price of production (CFA/kg)	Value of the additional production (CFA)	Profit (CFA)
Sorghum	microdose	4000	16875	20875	772	150	115800	94925
	vulgarisée	2000	33750	35750	491	150	73650	37900
Millet	microdose	4000	16875	20875	358	200	71600	50725
	vulgarisée	2000	33750	35750	399	200	79800	44050
Cowpea	microdose	4000	16875	20875	378	250	94500	73625
	vulgarisée	2000	20250	22250	249	250	62250	40000
Groundnut	microdose	4000	16875	20875	378	150	56700	35825
	vulgarisée	2000	20250	22250	373	150	55950	33700

Source : Taonda *et al*, 2008

b.3 Fertilization formulas with agro-mineral resources

The natural phosphates occurring in eastern Burkina Faso formed the subject of several studies in the context of research and by the Ministry of Agriculture as part of several development projects (food crop fertilizer project). These studies have established the agronomic effectiveness of Burkina phosphate (BP) on most crops (Bikienga and Sedogo, 1982). The BP has a P_2O_5 content of approximately 25.4% and contains 34.5% of CaO.

The table below shows the effects of the application of crude BP on crop productivity.

TABLE 5: **Surplus production resulting from application of crude BP (kg/ha-¹)**

BP doses kg. ha⁻¹	Rainfed rice (1)	irrigate rice (2)	Sorghum (3)	Millet (3)	Maize (3)	Cotton (3)	Ground-nut (3)	Soy-bean (3)
400 (bottom) + 100 annuel	-	-	600	194	1500	450	121	635
500 (bottom) + 200 (annuel)	-	1162	-	-	-	-	-	-
600 (bottom) + 300 (annuel)	1092	-	-	-	-	-	-	-

1 = one year after application; 2 = 2 years after application; 3 = 3 years after application.

Source : INERA, 2004

The solubility of crude BP in a year is low (about 25%). Studies have shown that it is possible to improve the solubility of BP through composting (Lompo, 1995). Bonzi (1989) suggests 80 kg of BP per ton of crop residue to be composted. Lompo (1995) proposes the following recommendations per crop for crude BP use.

TABLE 6: **Burkina phosphate dose per crop**

Crops	Dose of BP (kg/ha)
sorghum, millet, maize, cotton, groundnut, soybean	400 $kg.ha^{-1}$ as basal dressing and 100 kg $ha^{-1}year^{-1}$the following years;
rainfed rice	500 $kgha^{-1}$ as basal dressing and 200 kg $ha^{-1}year^{-1}$the following years
irrigated rice	600 $kgha^{-1}$ as basal dressing and 300 kg $ha^{-1}year^{-1}$the following years

Source: Lompo, 1995

Under the food crop fertilizer project mentioned above, it was possible to develop partially solubilized BP whose composition is as follows: 4.22 N - 24.55 P_2O_5 - 6.26 S - 25.52 CaO - 0.16 MgO.

The acidulous BP (BPA) is substantially equivalent to TSP (Triple super phosphate) in terms of grain production and better in terms of P $elements_2 0_5$, $K_2 0$ and CaO on the soil and is cost-effective. These inputs of natural phosphates must be completed by nitrogen fertilization of 50kg/ha of urea for sorghum and millet and 100kg/ha of urea for maize.

The effectiveness of BP depends on cropping practices such as tillage, inputs of organic matter and water and soil conservation as well as soil protection and restoration techniques.

b.4 Fertilization using human excreta

INERA in collaboration with CREPA has developed the use of human excreta (urine and faeces) as an agricultural fertilizer due to their high N, P, K, content to improve crop productivity and soil fertility. Due to their composition in N, P, K elements, urine can be compared with urea with the advantage of being liquid and therefore directly available to the plant, while the feces are compared with the NPK fertilizer.

Through sanitation systems (latrines) with a variable cost depending on the model and standing between 75,000 and 180, 000 CFA F (www.faso-presse.net), which were developed by the CREPA ecological sanitation project (Ecosan), urine and faeces are collected separately and then sanitized and processed before reuse as fertilizer on crops at lower costs. The 20-liter can costs 100 CFA francs, and the 50 kg-bag of processed feces costs 2500 CFA F (Ecosan, 2009).

Human excreta can be used alone or combined with mineral fertilizers, and in combination with water and soil conservation techniques.

Results of experiments conducted on maize (extra early variety), indicate that the urine + faeces association produces the highest yield (2.5 t ha^{-1}) compared to the control (0.13 t ha^{-1}) and the NPK + urea association (1.05 t ha^{-1}). In Benin, a yield of 3.6 t $ha^{(-1)}$ was obtained on maize with the NPK + Urine combination against 3.5 t ha^{-1} for NPK + Urea and 2.4 t ha^{-1} for the control (Bonzi, 2008).

TABLE 7: **Periods and urine and feces doses to be applied per crop type**

Period	**Sorghum/Millet**	**Maize**
Sowing/planting out		
15 days after sowing /planting out (2 weeks)	0.5 liter per planting hole at thinning	0.6 liter per seed hole
35 days after sowing /planting out (5 weeks)	0.5 liter per planting hole	0.6 liter per seed hole
Doses of faeces	50 g per zai hole (seed hole) before sowing or 5-7 days after emergence	

Source: Ecosan, 2009

2

Exploiting the varietal potential

2. Exploiting the varietal potential

The technologies consist in making available to users cultivars and varieties according to their characteristics, particularly cycle duration, productivity, quality, marketing opportunities, resistance to various diseases and stress, edaphic and climatic adaptability, and use of inputs especially fertilizers.

The varieties were mainly developed by INERA in collaboration with international institutes including IITA, ICRISAT, SAFGRAD and WARDA.

In the last few years, biotechnology has helped develop several genetically modified (GMO) crop species using very few pesticides (Biotech echo, January 2007).

In Burkina Faso the Bt cotton seeds are in a real farm setting, while the testing of genetically modified organisms (GMOs) of biofortified sorghum and cowpea in Burkina Faso is underway.

On that subject, debate is currently on the dependency of producers upon foreign firms for the supply of seeds. However, numerous consultations are underway to resolve the issue by introducing genes into local varieties and the control of the technology by national scientists.

2.1. Maize varieties

Information on available varieties which may be popularized for various crops is provided in the tables below.

TABLEAU 8 : **Popularized maize varieties and mineral fertilization recommended in Burkina Faso (1988-2008)**

Type of agriculture	**Mineral fertilization**	**Variety cycle in days after sowing**			
		Extra early 70-84 d	Early 85-94 d	Intermediate 95-110d	Late + 110d
SEMI-INTENSIVE AGRICULTURE Varietal potential: 2-3t/ha Variety type: composite	NPK : 100 kg/ha Urea : 100 kg/ha	KEB KEJ JFS	Jaune de Fô	Massayomba IRAT 80	
SEMI-INTENSIVE AGRICULTURE Varietal potential: 3.5-6t/ha Variety type: composite	NPK : 200 kg/ha K_2SO_4 : 50 kg/ha Urea 1:100 kg/ha Urea 2 : 50 kg/ha		Maka*** KPB KPJ FBC 6 *** Wari Barka	IRAT 171 Poza Rica 7822 IRAT 200 *** SR 22 SR 21 FBPC 1 * FBPC 2 * FBMS 1 ** FBMGS 1 ** Obatanpa **** ESPOIR ****	
ASEMI-INTENSIVE AGRICULTURE Varietal potential: 5-7t/ha Variety type: Hybrid	NPK : 300 kg/ha K_2SO_4: 50 kg/ha Urea 1 : 100 kg/ha Urea 2 : 50 kg/ha			FBH 1 FBH 33 FBH 33 ST FBH 34 ST FBH 34 SR Bondofa	IRAT 81
Agro-ecological zones (rainfall)		Rainfall < 600 mm	Rainfall <900 mm	Rainfall > 900 mm irrigate areas	Irrigated areas
Reference site		Saria	Kamboinsé	Farako Bâ, Niangoloko Kouaré	Kou valley

Legend: ** Popcorn; **sweet corn; ***grilled corn; **** high-protein corn*

Source : INERA, 2008

Maize growing technique

TABLE 9: **Technical itinerary of the growing of early maize varieties (BARKA variety)**

TECHNICAL ITINERARY	OPERATIONS
Cultivation area and production cycle	Rainfall: 650 to 900 mm; Irrigation Cycle: 80 days
Production periods	In the rainy season: June to October Dry season, under irrigation: October to May
Field Preparation	End of cycle preparation, preferrably, with burial of crop residues
Sowing	Moisture for sowing: 20 mm water. • Dose: 20kg/ha. • Spacing for intermediate and late varieties: 0.80 m x 0.40 m, 3 grains/ hole • Spacing for early and extra-early varieties: 0.80 m x 0.30 m, 3 grains/ hole
Weeding	on 15th and 25th days
Thinning	2 plants/ hole, between the 8th and 12th day after sowing
Fertilization: Organic manure per year Burkinaphosphate NPK: Urea	2.5 t /ha per year 2.5 kg /ha per year 150 kg/ha 100 kg/ha (50 kgon 25th and 50 kg on 35thday after sowing)
Harvest:	•35th day after general flowering of maize field
Average potential yield:	5 to 6 tons / ha

Source: Sanou J., 2009

2.2. Sorghum varieties

TABLE 10: **Sorghum varieties popularized in Burkina Faso per region**

Climatic Zone	Region	Intensive cropping systems	Semi-intensive cropping systems	Slightly intensified cropping systems
Sub Sahelian	North West		IRAT 204 BF 88-2/31 -3	
	North Central		IRAT 204 BF 88-2/31 -3	
•North sudanian	West centrral	Sariaso 10	ICSV 1049 Sariaso 10 IRAT 9 Framida	Sariaso 09 Nongomsoba
	Center		ICSV 1049 Sariaso 1 0 IRAT 9 Framida	Sariaso 09 Nongomsoba
	Central East and		ICSV 1049 F2-20	Sariaso 09 Nongomsoba
South sudanian	West	ICSH 89002 NG	Sariaso 03 Sariaso 08 Framida	Gnofing Nongomsoba
	South central	IRAI 9	Sariaso 09	
North Guinean	South West	ICSH 89002 NG	Sariaso 03 Sariaso 04 Sariaso 06 Sariaso 07	Sariaso 01 Sariaso 02 Ouedzoure Sariaso 05
Irrigated	Sourou	ICSH 89002 NG	IRAT 204 BF88-2-/31-3	

Source : INERA, 2000

Sorghum growing technique

TABLE 11: **Technical itinerary of sorghum growing, the SARIASSO 14 variety**

TECHNICAL ITINERARY	OPERATIONS
Cultivation area and production cycle	Rainfall: 600-900 Cycle: 110 to 115 days (sowing-maturity)
Preceding crops advised	Groundnut, cowpea or cotton depending on area
Production periods	In the rainy season: June to October Dry season, under irrigation: October to May
Field Preparation	Wet plowing using animal traction or failing that scarification with houe Manga
Sowing	Seed Quantity: 12 kg/ha Date: 10th June to 10th July, on wet ground after a rainfall of at least 20 mm Spacings of 0, 80 mbetween the lines and 0, 40 m between the seed holes Seed treatment: Super-Homai (30 g for 10 kg of seed) or Cal-thio (25 g for 10 kgof seed)
Weeding	1st weeding: just before or during thinning (10 to 15 days after sowing). 2nd: 2 to 3 weeks after the first weeding
Ridging	Advised one and a half month (1 ½) after emergence
Thinning	With three plants per seed hole 10 to 15 days after emergence, under adequate moisture conditions
Insecticide treatment during vegetation	No treatment recommended, except in case of severe attack of poophylus costallum

Striga control	In case of low infestation: regular weeding of weeding of striga plants as they emerge and particularly before their flowering and burn) In case of heavy infestation: Perform a third weeding/ hoeing. Rotation with a legume or fertilization with organic manure are recommended in areas known to be infested.
Fertilization	
Organic manure	2.5 t /ha of organic manure per year
Burkina Phosphate	200 kg/ha
NPK	100 kg/ha at sowing or thinning
Urea	50 kg/ ha at the shooting stage
Harvest:	End of October
Treatment of crops	In granaries: K'othrine or Percal M (stock insects), Guenexo Super (termites) In grains: K'othrine (50 g for 100 kg of grain
Yield (Kg/ha)	1.5 to 2 tons/ha
Grain potential	1, 200 kg/ha
Renewal of seeds (certified seeds)	Every three (3) years

Source : INERA, 2000

2.3. Millet varieties

TABLE 12 : **Popularized millet varieties available in Burkina Faso per region**

Range of maize varieties proposed for extension			
	Region	**Varieties**	**Optimal date of sowing**
Zone 1	Sahel (Soum, Seno,	ICMV IS 89305	1st week of July
(<500 mm)	Oudalan)	IKMV 8201	"
		SOSAT-C-88	"
		ZATIB	"
Zone 2	North, Center North,	ICMV IS 89305	around 15 July
(500 - 700 mm)	Central East	IKMV 8201	"
		SOSAT-C-88	"
		ZATIB	"
		IKMP-2	1st week of July
		IKMP-5	"
Zone 3	Center, Center West,	ICMV IS 89305	After 15 July
(700 - 900 mm)	North-West	IKMV 8201	"
		SOSAT-C-88	"
		ZATIB	"
		IKMP-2	mid July
		IKMP-5	"
		IKMP-3	early July
		IKMP-1	"
		ICMV IS 88102	end June
Zone 4	South, Center South, West	IKMP-3	mid July
(900 - 1100 mm)		IKMP-1	"
		ICMV IS 88102	early July

Source : INERA, 2000

Millet growing technique

TABLE 13: **Technical itinerary of millet growing, variety IKMV 8201**

TECHNICAL ITINERARY	OPERATIONS
Cultivation area and production cycle	Rainfall: 400 to 800 mm Cycle: 70 days
Production periods	In the rainy season, at the onset of rains
Preceding crop	Groundnut, cowpea or cotton depending on area
Field Preparation	Wet plowing using animal traction or failing that scarification with houe Manga
Sowing	0.80 m between the lines and 0.60 m between the seed holes for the 700 to 900 mm zone 1 m between lines and 1 m between seed holes for the 500 mm to 700 mm zone Seed dose: 10 kg/ha
Sowing period	Early July for the 500 to 700 mm zone After 15 July for the 700 to 900 mm zone In wet ground after a rain of at least 20 mm
Weeding	1st Weeding: 15 to 20 days after emergence 2nd weeding: 3 weeks after the first weeding
Thinning	2-3 plants/hole 15 days after emergence in moist soil
Fertilization:	Organic manure: 2.5 t /ha per year Burkina Phosphate: 200 kg/ha NPK: 100kg/ha during plowing or after thinning and the first weeding Urea: 50 kg/ha at the shooting stage (4 to 5 weeks after sowing).

Striga control	In case of low infestation: regular weeding of Striga plants before flowering, and burning In case of severe infestation: frequent weeding and hoeing
Harvest	Towards the end of October
Potential grain yield	1 to 1.5 tons/ha

Source : INERA, 2000

2.4. Improved cowpea varieties resistant to production constraints

Cowpea varieties have been developed to solve the numerous problems facing the cowpea production in Burkina Faso. The table below summarizes most of these varieties

TABLE 14: **Improved cowpea varieties resistant to some production constraints**

Type of resistance					
Weevil	**Aphids**	**Thrips**	**Drought**	**Striga**	**Cowpea mosaic virus**
KVX30G-246-2-5K	KVX 145-27-6	TVX3236	KVX60-PO4-1	KVX30-305-3G	TVV 3236
KVX30G-183-3-5K	KVX165-14-1		KVX250-K-27-18	KVX30G-172-1-6	KKN-1
KVX30G-172-1-6K	KVX146-27-4		KVX268-KO3-3	KVX61-1	KVx 396-4-5-2D
	KVX146-1		KVX326-4	KVX 61 -74	KVx 396-4-4
			KVX396-18	KVX183-1	

Source: INERA, 2000

Cowpea growing technique

TABLE 15: **Technical itinerary of cowpea growing, the KVX 414 – 22-72 variety**

TECHNICAL IITINERARY	OPERATIONS
Cultivation area and production cycle	Rainfall: 400 to 800 mm Cycle: 70 days
Production periods	At the onset of rains
Field Preparation	Wet plowing
Sowing	80 cm between the lines and 40 cm on the line 2 grains per hole
Weeding	2 weeks after sowing
Thinning	2 plants per hole
Fertilization:	NPK: 100/ha
Insecticide treatment during vegetation	1st treatment: Beginning of flower formation, i.e. 35 days after sowing 2nd treatment: early pod formation, i.e. 15 days after first treatment
Treatment dose:	[Decis, Karate (40 cc in a 20-liter sprayer)]
Harvest:	Upon maturity, dry well, treat before conservation
Yield: Average grain yield potential Average yield with menu 1	 1.5 to 2 tons/ha 600 kg /ha

Source: INERA, 2000

3

Technological packages proposed for extension to improve the production of sorghum, millet, maize and cowpea in Burkina Faso

3. Technological packages proposed for extension to improve the production of sorghum, millet, maize and cowpea in Burkina Faso

The technological packages have been defined according to zones with relatively homogeneous production systems:

Zone 1: Sahel region, North Central Region, North Region where production systems are characterized by the presence of millet, cowpea and transhumance. **Zone 2** : Central zone: Central Region, West Central Region, South Central Region, East Central Region, East Region, Region of Boucle du Mouhoun where production systems are characterized by the presence of millet, sorghum, cowpea and small-scale breeding. **Zone 3**: Hauts-Bassin Region, South West Region, Cascades region, where production systems are characterized by the presence of sorghum, maize, cowpea, tubers and small-scale breeding.

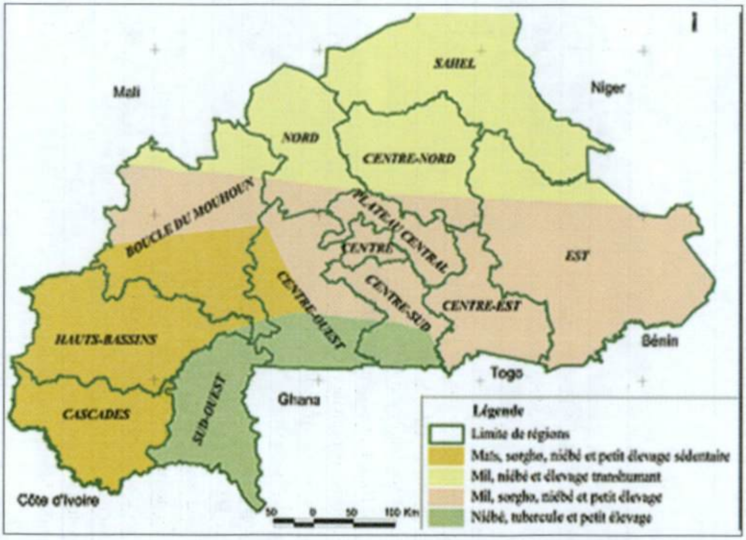


Figure 5: Production systems or homogeneous areas on the map of the «PAPSA intervention areas» where appropriate technologies are applied (MARHRH, 2009)

3.1. Technological package number 1

TABLE 16 : **Performance of the technological package in zone 1**

	CENTER			WEST / SOUTH-WEST				SAHEL	
	Sorghum	**Millet**	**Cowpea**	**Maize**	**Sorghum**	**Millet**	**Cowpea**	**Millet**	**Cowpea**
Reference yield	750	500	300	1000	800	500	400	500	400
Yield resulting from the package (kg/ha x 1000)	1,2	0,9	0,6	3,5	1,5	0,9	0,6	0,8	0,6
Selling price by the producer	125	175	225	150	125	175	225	175	225
Value of production (x 1000)	150	148,75	135	525	187,5	157,5	135	140	135
Production cost									
Quantity of organic manure per year (kg/ha x 100)	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5	2,5
st of organic master (FCFA/kg)	5	5	5	5	5	5	5	5	5
Total cost of organic matter (FCFA/kg x 1000)	12,5	12,5	12,5	12,5	12,5	12,5	12,5	12,5	13
Quantity of Burkina phosphate (kg/ha)	200	200	200	200	200	200	200	200	200
Cost of Burkina phosphate (FCFA/kg)	40	40	40	40	40	40	40	40	40
Total cost of Burkina phosphate (FCFA/ha x 1000)	8	8	8	8	8	8	8	8	8
Seed quantity (kg/ha)	12	10	20	20	12	10	20	10	20
Purchasing price of seed per producer (FCFA/kg x 1000)	0,6	0,6	1	0,6	0,6	0,6	1	0,6	1
Seed cost (FCFA/ha x 1000)	7,2	6	20	12	7,2	6	20	6	20
Cost of seed treatment (FCFA/ha x 1000)	1	1	2	2	1	1	2	1	2
Cost of phytosanitary treatment + paying off (FCFA/ha x 1000)			7				7		7
Cost of rock bunds (FCFA/ha x 1000)	15	15	15	15	15	15	15	15	15
Work cost (soil preparation, upkeep, harvest) (x 1000)	45	45	45	60	45	45	45	45	45
Total production cost FCFA/ha x 1000)	88,7	87,5	109,5	109,5	88,7	87,5	109,5	87,5	109,5
Margin after deduction o inputs (FCFA/ha x 1000)	61,3	61,25	25,5	415,5	98,8	70	25,5	52,5	25,5

Source: data adjusted with INERA, DVRD, CICB during the PAPSPA development workshop at INERA on 14/02/2009

3.2. Technological package number 2

TABLE 17 : **Performance of technological package in zone 2**

	CENTER			WEST / SOUTH-WEST				SAHEL	
	Sorghum	Millet	Cowpea	Maize	Sorghum	Millet	Cowpea	Millet	Cowpea
Yield due to package number 2 (kg/ha x 1000)	1,5	1	0,75	4,5	1,8	1,1	0,75	1	0,75
Selling price by the producer (FCFA/kg)	125	175	225	150	125	175	225	175	225
Value of production (FCFA/ha x 1000)	187,5	175	168,75	675	225	192,5	168,75	175	168,75
Cost of production of package 2									
Quantity of NPK (kg/ha)	100	100	100	150	100	100	100	100	100
NPK price (FCFA/kg)	500	500	500	500	500	500	500	500	
NPK cost (FCFA/ha x 1000)	50	50	50	75	50	50	50	50	50
Quantity of urea (kg/ha)	50	50	0	100	50	50	0	50	0
Price of urea (FCFA/kg)	500	500	500	500	500	500	500	500	500
Cost of urea (FCFA/ha x 1000)	25	25	0	50	25	25	0	25	0
Fertilizer spreading cost (without microdose) (FCFA/ha x 1000)	2	2	2	2	2	2	2	2	2
Total fertilizer cost (FCFA/kg x 1000)	77	77	52	127	77	77	52	77	52
Total production cost package 1 (FCFA/ha x 1000)	88,7	87,5	109,5	109,5	88,7	87,5	109,5	87,5	109,
Total cost of package 2 (package 1 + fertilizers) (FCFA/ha x 1000)	165,7	164,5	161 ;5	236,5	165,7	164,5	161 ,5	164.5	161,
Margin after deduction of inputs in package 2 (FCFA/kg x 1000)	21,8	10,5	7,25	438,5	59,3	28	7,25	10,5	7,25

Source: data adjusted with INERA, DVRD, CICB during the PAPSPA development workshop at INERA on 14/02/2009

3.3. Technological package 3

TABLE 18 : **Performance of the technological package in zone 3**

	CENTER			WEST / SOUTH WEST				SAHEL	
	Sorghum	**Millet**	**Cowpea**	**Maize**	**Sorghum**	**Millet**	**Cowpea**	**Millet**	**Cowpea**
Yield due to package 3 (kg/ha x 1000)	2	1,5	1	5	2,5	1,5	1	1,5	1
Value of the production of package 3 (FCFA/ha x 10 000)	25	26,25	22,5	75	31,25	26,25	22,5	26,25	22,5
Cost of production of package 3									
Cost of tillage by animal traction (FCFA/ha x 1000)	15	15	15	15	15	15	15	15	15
Weeding by animal traction (FCFA/ha x 1000)	15	15	15	15	15	15	15	15	15
Ridging by animal traction (FCFA/ha x 1000)	15	15	15	15	15	15	15	15	15
Ridging by tractor/harvest (FCFA:ha x 1000)	5	5	5	10	5	5	5	5	5
Mechanization cost (FCFA/ha x 10 000)	50	50	50	55	50	50	50	50	50
Cost of package 2 (FCFA/ha x 1000)	165,7	164,5	161,5	236,5	165,7	164,5	161,5	164,5	161,5
Total production cost of package 3 (FCFA/ha x 1000)	215,7	214,5	211,5	291,5	215,7	214,5	211,5	214,5	211,5
Margin after deduction of inputs and equipment under package 3 (FCFA/kg x 1000)	34,3	48	13,5	458,5	96,8	48	13,5	48	13,5

Source: data adjusted with INERA, DVRD, CICB during the PAPSPA development workshop at INERA on 14/02/2009

Tables 16, 17 and 18 show that the various systems generate very attractive profits for the producer (after deduction of inputs). The profit margin of package 1 is high. In particular, maize responds well to the various technological packages.

4

A few post-harvest technologies

4. A few post-harvest technologies

4.1. Storage of cowpea using the triple bottom bag

Weevils cause damage to cowpea seeds. They lay eggs on grown cowpea pods from the field or when drying. After 4 to 7 days, the eggs hatch larvae that penetrate the seed where they grow rapidly by consuming the seed. Losses may reach 100%.

The scientific basis of the new technology jointly developed by INERA Burkina Faso and Purdue University in the United States is the fact that the insect is sensitive to changes in environmental factors such as temperature, humidity and above all air. It is therefore possible to control its proliferation by depriving the insect of air.

The triple bagging technology therefore consists in storing the seeds in two plastic bags of 80 microns of thickness, put into one another. The two bags are in turn put into an ordinary usually woven, protective nylon bag. Insects rapidly absorb the little air trapped between the seeds in the bag and then get into lethargy and die after some time.

Tested in over 3500 villages in Burkina Faso in 2008 and 2009, these bags have been entirely satisfactory; seeds are kept in good condition, without treatment with insecticides. They replace the old methods with the similar principle: drums, cans, oil packaging, empty bottles etc.

4.2. IRSAT multi-cereal (rice and fonio) threshing and cleaning machine

4.2.1. Operation

The sheaves are loaded onto the feeding platform from which the operator feeds the threshing cage. Once in the threshing cage, the sheaves are threshed.The grain and chaff go through the grid of the thresher concave and fall onto the cleaning platform, while the chaff is ejected along a parabolic trajectory. Fonio grain is separated from the chaff when it moves on the shaken and ventilated grids. The clean grains are collected at the main outlet and grains mixed with chaff are collected at the secondary outlet. This equipment can thresh rice and fonio.

Photo 36:

IRSAT multicereal threshing and cleaning machine

(Photo, IRSAT/DM)

4.2.2. Technical Specifications

Powers available: 12 hp, 15 hp.

Grain output at 12 hp: the threshing capacity and quality depend on the operator's experience (speed and regularity of feeding), the condition of the crop to be threshed, the length of the straw (mowing height), the moisture content of the straw, ease of threshing (varieties easy or difficult to thresh). The indicative output is:

- For rice: 150 to 250 kg/h of grain depending on the condition and variety of the crop - Cleaning: about 95%
- for fonio: Indicative output: 150 to 200 kg/h of grain depending on the condition and variety of the crop - Cleaning: about 90%

4.3. IRSAT Multi-cereal threshing machine (maize and sorghum)

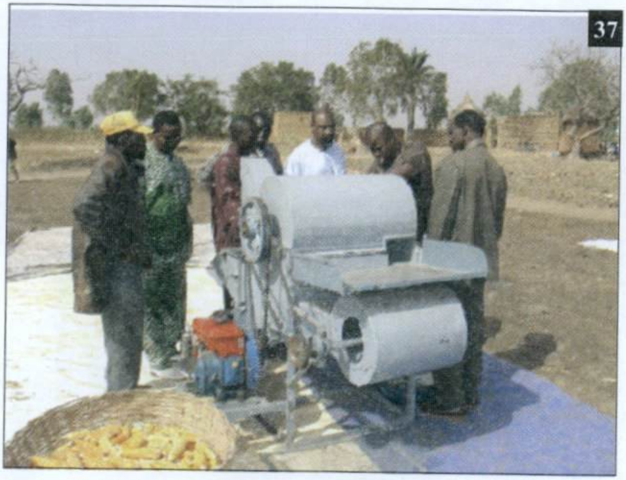


Photo 37:
IRSAT multi-cereal threshing machine

(Photo, IRSAT/ DM)

The IRSAT multi-cereal threshing machine is used for threshing and cleaning maize and sorghum grains.

4.3.1. Description of the equipment

It consists of a frame which supports: the feeding platform on which the product to be threshed is loaded; the cylindrical threshing cage is composed of a threshing rotor and a concave or stator; the winnowing system consists of a fan and a cleaning platform; the 5 hp diesel engine.

4.3.2. Operation

The product loaded onto the feeding platform is introduced into the threshing cage by the operator. The rotor is driven by the engine through a belt beats the product against the stator. The grains released and containing a lot of impurities fall on the cleaning platform, which under the combined action of the back and forth movement of the air flow produced by the fan separates the grains from the impurities. The clean grains go through the grids of the platform and fall onto the collector which direct them towards the collection hole. Grains containing impurities are collected and directed towards the secondary hole. On the other hand, empty panicles and cobs are blown off by the ejector as they come out of the threshing cage.

4.3.3. Technical Specifications

Output

Maize grains: 200 to 350 kg/h with a threshing rate of over 95%
Sorghum grains: 200 to 250 kg/h with a threshing rate of over 98%

4.4. IRSAT versatile cleaning shoe

Photo 38:

IRSAT cleaning shoe *(Photo, IRSAT/DM)*

4.4.1 Description of the equipment

It is a slightly inclined horizontal trommel. It is composed of the following: a frame supporting all the functioning parts; a receiving hopper with a trap for regulating output at its bottom; a separation cage with a rotor - a cage consisting of a rotating shaft, grid holders, a semicylindrical folding upper cover and an independent frame and engine assembly attached to the main frame by screwing.

4.4.2. Operation

The cleaning shoe can be used to clean and screen cereals (fonio, maize, sorghum, millet, etc.) and other products by selecting the appropriate grids. It can be used in the manual or motorized version. When the rotor is rotating, products of smaller size than the grains go through the first grid (fine impurities, dust, fine sand, etc.).The clean grains are collected under the second grid. Oversize marerial is collected at the opposite end of the shoe's feeding platform. These are impurities bigger than the grains to be processed. Roration speed depends on the product. Depending on the product to be processed, grids and rotation speeds are adjusted.

4.4.3. Technical Specifications

Engine: 1.5 kW; engine shaft rotation speed: 1500 to 2600 rpm;
Feed rate for fonio: 194 kg/h manual version and 263 kg/h for motorized version.

5

Contraints to the adoption and dissemination of food agricultural practices

5. Contraints to the adoption and dissemination of good agricultural practices

The promotion and dissemination of agricultural technologies is hindered by several constraints including mostly:

5.1. Accessibility of actors to research findings

5.1.1. Low supervision ratio

Since the end of the national agricultural research and development projects (PNRA, PRSAP, PNDSA II) the classic system of dissemination of findings is no longer working.

Research under PNDSA II tried an experience of introducing innovations with farmer organisations (FOs). This very enriching experience have however the following limitations: weak organisation/structuring of FOs and the low self-management capacity of FOs.

The supervision network of the different Ministries in charge of promoting agro-forestry-pastoral experienced a sharp decline in recent years. In addition to the low number of supervision agents, we note that these supervision agents are currently unable to do their job due to the low resources allocated to the sector.

5.1.2. Indequate linkage between Research & Development

The formal collaboration framework of this linkage exists but implementation is greatly hindered by the inadequacy and even the lack of resources, difficulties of operation relating to the low organisational and technical capacities of farmers; difficulties in identifying and planning farmers' needs of agricultual technologies.

5.2. Difficult access to factors of production

These are mainly inputs particularly fertilizers, improved seed varieties, pesticides. The problem lies in physical accessibility (sales outlets mainly located in 2 big urban centers Ouaga and Bobo, availability) and the affordability due to the low economic power of small producers who represent the majority;

5.3 Weakness of processing and marketing

The virtues of the steering principle cannot be verified owing to the weakness of the market, hazardous producer prices and the lack of added value resulting in a transformation process which is almost at an embryonic stage or even absent depending on areas.

5.4 Weak structuring of sectors

Outside the cotton sector other sectors are still trying to find their bearings. Their weak structure does not allow them to be competitive nationally and regionally.

5.5 Land security problems

The necessary investment required for the implementation of some technologies (CES/DRS/AGF) is hampered by land ownership insecurity of many farmers.

5.6 Not very inciting farm credit and financing policies

The financing structures of economic agents (banks, micro finance institutions) are barely involved in the financing of agricultural activities and tend be located in urban areas. Banks and micro finance institutions and decentralized micro finance institutions are affraid of, and/or are reluctant to finance agricultural activities on the grounds that the (climate, market, crop infestation, etc.) risk is high. Moreover interest rates are high and time for processing applications relatively long. This results in critical lack of funding for agricultural enterprise promotors.

5.7. Illiteracy of farmers and low availability of educational materials in national languages

Illiteracy is handicaps for most rural farmers who cannot access knowledge on technologies documented in data sheets even less capitalize them. This situation is worsened by the low availability of technology dissemination materials translated into local languages.

6

Proposals for improving the dissemination and adoption of technologies

6. Proposals for improving the dissemination and adoption of technologies

6.1. Building producers' capacities as a priority action

For farmers to take ownership of technologies, training is necessary for good control of technologies. Therefore, in the short to medium term, it is necessary to undertake the following activities:

- train and educate farmers on agricultural technologies: technical nature, stakes involved, advantages and benefits of technologies;
- promote new approaches regarding advisory support to producers (board of management, agricultural innovation platforms ...);
- support networks of innovative farmers in order to promote endogenous innovations;
- build the capacities of (governmental and NGOs) extension and research services, etc.;
- increase on-farm experiments using several tools such as windows, tests, demonstrations, field schools, etc.);
- facilitate and promote financing technology.

6.2. Organization and structuring of actors

The weak organization of farmers hinder their access to factors of production (equipment and inputs). Moreover, producers are faced by processing and marketing problems. Several actions can be proposed for the short and medium term. These include:

- supporting the structuring of promising sectors;
- developing and implementing financing mechanisms for family farms;
- developing and implementing a communication strategy.

6.3. Revoval of limiting socio-economic factors and development of policies to support production

Several socio-economical and political factors limit the dissemination of agricultural technologies. Actions that could solve these constraints are the following:

- developing and strengthening decentralized financing systems;
- facilitating access to credit and up scaling micro finance;
- supporting solution to land security problems;
- strengthening literacy training of producers;
- making flexible and promoting a legislative, regulatory and institutional framework conducive to the development of agricultural sectors.
- offering at community level a quality input (seeds, fertilizers) supply service
- stimulating and supporting the development of markets for agricultural products

6.4 More participatory technology generation and validation processes

Consisting in:

- better involving farmers in the research and development process;
- ensuring the adaptation of technologies at farm level through the development and implementation of an appropriate behavior change communication (BCC) strategy;
- developing participatory research to specifically promote the use of improved varieties;
- strengthen the research-extension linkage by the DPT
- seek the involvement and participation of all stakeholders through the integrated research approach for development through the establishment of innovation platforms (see SNVACA) capable of
- developing knowledge and validating technologies

- identifying and analyzing the constraints to the performance and sustainability of technologies;
- supporting the dissemination of efficient technologies.

6.5 Technology transfer tools

Several tools which could contribute to promoting agricultural technologies may be recommended. These strategies include:

6.5.1 Farmer field schools

The Farmer Field School (FFS) approach consists in establishing a framework for exchange and sharing between producers and facilitators. It is based on training through discovery in the field. The content of the training will take into account the constraints identified after a diagnosis. Conducting field experiments will enable farmers to easily take ownership of results. The farmer field schools will serve as demonstration workshops on various aspects covered in this project. Facilitators will provide guidance and cohesiveness to the groug within the FFS. These facilitators would be agents of supervising structures.

6.5.2 Tests

A test is an on-farm experiment intended to verify the performance of a technology in different ecological conditions or to seek other alternative solutions to local ones (feasibility, conditions of transfer).

A test can be designed through Research or Research/Development.

6.5.3 Demonstration

The demonstration is an extension and advisory support operation, intended to show and practically teach a technology to farmers, to present and compare the results of the new technology with existing practices.

6.5.4 Guided tour (GT)

This is an activity aimed to train and exchange comparative experiences of any practice intended to show the benefits and explain the technical itinerary followed. It usually takes place around an achievement in a specific area.

6.5.5 Demonstration Day (DD)

The demonstration day is a large-scale GT. It is organized across a model farmer's field or on a large portion of this field hosting demonstration items on various topics.

6.5.6 Communication

Communication and communication strategies play a significant role in the information, awareness raising, and education of farmers and consequently in the dissemination and promotion of technologies. It is essential to rely on national radio stations, or community associations and national television through an appropriate program schedule; use forum theatre; translate into local languages the data sheets and extension materials.

CONCLUSION

At the end of this study, we can note that in Burkina Faso in the Central Plateau, significant efforts to generate technologies and innovations have been developed through Research, the services of the Ministry of Agriculture, the private sector, NGOs and innovative farmers. Agricultural technologies and innovations which can be used to promote crops in a context of climate change are manifold and varied. The harvest of this study, which targeted the agricultural technologies and innovations relating to the 4 main food crops in the central part of Burkina Faso, has been bountiful certainly because of increased need for food security in the area.

Even if the technologies and innovations identified are related to the improved varieties developed mainly by INERA, many more are technologies and innovations used for the conservation, protection and restoration of natural resources, lands, soil aimed to achieve optimal agricultural production. Considering their performance, these technologies and innovations are real alternatives and opportunities for farmers to adapt to climate change, improve food security and incomes.

However, in the final analysis, serious constraints stand in the pathway of scaling-up these technologies. These are namely, not very inciting policies, land use insecurity, low processing and marketing of agricultural products, weak linkage between research and development, lack a real communication strategy.

Therefore, suggestions for improvement are focused on:

- developing policies and funding incentives for securing the land use of farms which would guarantee benefits from soil defence and restoration actions;
- focusing on participatory processes involving producers and other actors such as technological innovation platforms: all actors of the sector acting synergistically can definitely boost agricultural productivity and production;
- implementing a communication strategy specifically tailored for the various stakeholders (policy makers, sectors of Ministries of rural develop-

ment, financial institutions and donors, producers, processors, traders, projects and NGOs, etc.);

- building the technical and organizational capacities of technical services and farmer organizations for the identification and planning of technology needs;
- providing outreach services for the provision of inputs and the equipment necessary for the implementation of technologies;
- expanding the markets for agricultural products;
- developing and implementing incentive policies for funding and supporting the two sectors downstream: the processing and marketing of agricultural products.

This is the price to pay for agriculture in the Central Plateau of Burkina Faso and in other similar regions of semi-arid zones of Africa to adapt to climate change, and moreover, it could be a powerful driving force of economic development.

Bado. BV. 2002. Rôle des légumineuses sur la fertilité des sols ferrugineux tropicaux des zones guinéennes et soudaniennes du Burkina Faso. Thèse de Ph.D Département des sols et Environnement, Université Laval, 145 p.

BARRO A., MANICHON H., REMY J. C., 2000. Diagnostic de la culture du sorgho dans la région de SARIA. CNRST (Eds) Actes du FRSIT 2000 Les communications Tome 2, «sécurité alimentaire», 3-8 avril 2000, Ouagadougou, Burkina Faso. 153-162.

Bationo A., Lompo F. and Koala S. 1998. Research on nutrient flows and balances in West Africa: state of the art. Agriculture, Ecosystems and Environment 71:19-35.

Bikienga, M et Sédogo, M. P, 1982, utilisation agricole des phosphates de Haute Volta ; synthèse des travaux d'expérimentions agronomique sur le volta phosphate et les phosphates améliorés, 62p

Biotech Echo. 2007 (Janvier-octobre). Le bulletin de biotech Echo association. BBA/ISAAA. Burkina Faso.

Bonzi M., 1989 - Etude des techniques de compostage et évaluation de la qualité des compostes : effets des matières organiques sur les cultures et la fertilité des sols. Mémoire d'ingénieur du développement rural, ISN/IDR-UO, 66p.

Bonzi M., 2008. Experiences and opportunities for human excreta fertilizers in improving small scale agriculture, presentation from the world water week in Stockholm, august 17-25, 2008

Casenave A. et Valentin C. 1989 : Les états de surface de la zone sahélienne. Influence sur l'infiltration . Collection didactique, ORSTOM, Paris, France, 230p.

CEAS. 2004. Le compostage pour l'amélioration de la fertilité des sols et de la production agricole au Sahel. CEAS/SATEP. Burkina Faso. 31 pages.

Dickey J., Bertelsen M., Robins E., Taonda S.J.B., Sohoro A., Kambou F., Kaboré D., Ouédraogo S., 1994. Potentialités des mesures de conservation des eaux et des sols dans le Namentenga Burkina Faso. In.Agricultural Research and Training Support project, Burkina Faso, 1990-94. J. M. B. J. Lowenberg-DeBoer, J. Dickey & E. Robins, Rapport Technique. Purdue University andWinrock International, IN, 38-48

Ecosan, 2009. Document de capitalisation des activités du projet Ecosan-UE

INERA (2003). Recherche sur des technologies de lutte contre la désertification au sahel et étude de leur impact agro écologique. Département GRNSP. 91 pp.

INERA. 2000. Bilan de 10 années de recherche. 1988-1998. CNRST/INERA/CTA. Burkina Faso. 114 p.

INERA. 2004. Actes de l'atelier sur les bonnes pratiques agricoles dans l'ouest du Burkina Faso. Bobo-Dioulasso 18-20 Mars 2004.

Lavigne-Delville. 1996. Gérer la fertilité des terres dans les pays du Sahel. Diagnostic et Conseil aux paysans. Collection « Le Point sur », 397p.

Lompo F. 1995.- Etude de cas au Burkina Faso de l'initiative phosphates naturels. Rapport provisoire. 36 p.

Lompo F., Sedogo M. P., Hien V. 1994..- Impacts agronomiques du phosphate naturel et de la dolomie du Burkina Faso. Acte du séminaire «utilisation du phosphate naturel pour une agriculture durable en Afrique de l'Ouest pp 60-72.

MAHRH, 2007. Document guide de la révolution verte. Septembre 2007.98 p.

Nicou, R. and C. Charreau. 1985. Soil tillage and aer conservation in semi-arid West Africa. P. 9 – 2. IN Ohm, H.W and J.G. Magy (eds). Appropriate Technologies for Farmers in Semi-Arid Africa. Purdue Univ., West Lafayette, IN

Ouedraogo, E., Mando A. and Zombré N.P. 2000. Use of composts to improve soil properties and crop productivity under low input agricultural system West Africa. Agriculture, Ecosystems and Environment 1675:1-8.

Pieri C. 1989. Fertilité des savanes. Bilan de trente ans de recherches et de développement agricole au sud du Sahara. Ministère de la coopération, CIRAD, Paris, 444p.

Reij C., Scoones I. and Toulmin C. (1996). The Zaï a traditional technique for the rehabilitation of degraded land in the Yatenga, Burkina Faso. Sustaining the Soil; Indigenous Soil and Water Conservation in Africa London: Earthscan. 264 pp.

Roose E. 1994. Introduction à la gestion conservatoire de l'eau, de la biomasse et de la fertilité des sols (GCES). Bulletin Pédologique FAO, n°70, 420p.

Sanou J., 2009a. Bilan de la crétion variétale de maïs au Burkina Faso, actualisation 1996, INERA/CT-Ouagadougou, 8p

Sanou J., 2009a. Variétés de maïs vulgarisées au Burkina Faso, actualisation 2009, INERA/CT-Ouagadougou, 1p

Sanou J., 2009b. Participatory development and transfer of high yielding maize varieties in Burkina Faso to improve food security and increase farmers' incomes. INERA/AGRA project, 44p

Segda Z., V. Hien et M. Becker. 1999. Mucuna cochinchinensis dans les systèmes d'associations et de rotations culturales: cas de la zone cotonnière du Burkina Faso. Communication présentée au Séminaire International, «la jachère en Afrique Tropicale», du 13 au 16 avril 1999, Dakar, Sénégal.

Segda Z., V. Hien, et M. Becker. 1998b. Contribution de Mucuna cochinchinensis dans le contrôle des adventices et dans l'amélioration des rendements de riz pluvial. Communication présentée à la 8[e] conférence de l'Association Africaine de la Fixation Biologique de l'Azote (AAFBA), 23-27 novembre 1998, CapeTowm, Afrique du Sud.

Sperling M. 2008. Socio-economic performances of Maradi famers agroforestry practices. Advances in integrated soil fertility management in sub-saharian Africa: challenges and opportunities. Springer, the Netherlands.

Taonda, S. J. B. 1995. Evolution de la fertilité des sols sur un front pionnier en zone nord-soudanienne du Burkina Faso, INPL, Nancy : 133.

Taonda S.J.B, ILBOUDO B. 2000. Fiche technique sur l' Amélioration des systèmes de cultures à base de mil pour les petits fermiers du Sahel Burkinabè, INERA- CRREA/Saria-Burkina-Faso, 6p

Taonda S.J.B., Yagho E ., Soubéiga J., Kabré A. , 2008. Projet Transfert de la technologie de fertilisation par microdose et des variétés tolérantes à la sécheresse pour la prospérité des petits producteurs agricoles du sahel, Rapport final

Traoré K., Bado V., Hien V. 1998. : effet du mucuna associé sur la nutrition en N et la productivité du maïs et du coton. In Cover crops for natural resource Management in West Africa IITA and CIEPCA Cotonou, Benin.

Traore O·, Traore K., Koulibaly B., Traore T. 2007. Compostage aérobie des tiges de cotonnier. INERA. Burkina Faso.

Zombré N. P., Mando A. et Ilboudo J. B. 1999. Impact des conservations des eaux et des sols sur la restauration des jachères très dégradées au Burkina Faso. In La jachère en Afrique de l'Ouest. Rôles, Aménagements et Alternatives. Floret et Pontanier (éd., 2000), vol. 1 : pp. 771-777.

Zougmoré R., 1999. Plantes de couvertures et lutte contre l'érosion des sols : test de comportement d'espèces de légumineuses dans la zone centre du Burkina Faso.

Zoumoré R., Kaboré D., Lowenberg-Deboer J., 2000. Optimal Spacing of Soil Conservation Barriers: Example of Rock Bunds in Burkina Faso, Agronomy Journal 92, N°2: pp. 361-368.

ANNEX

ANNEX 1: Terms of reference for the compilation of an inventory of agricultural technologies in Burkina Faso

Rationale

The mission of the African Union specialized Office for the Promotion of Agricultural Research and Development in semi-arid Africa (AU/SAFGRAD) based in Ouagadougou, is to contribute to the advancement of agricultural research, the transfer and commercialization of technologies, and the management of natural resources by promoting and coordinating the use of the skills of agricultural research systems (NARS), international agricultural research centers (IARCs) and scientific research organizations- for food security the promotion of irrigated agriculture in rural and peri-urban areas of semi-arid regions.

In partnership with international agricultural research institutions including ICRISAT and CIAT as well as the NARS of Ghana (SARI) and Burkina Faso (INERA), AU/SAFGRAD is facilitating the implementation of project no5 on the «Challenge Program on Water and Food » titled «Increasing efficient use of rainwater and nutrients for improving agricultural production, farmers' income and the welfare of the Volta Basin population.» The specific objectives of this project are to promote wide-scale popularization of improved agricultural technologies through effective information and improved management of dissemination mechanisms. As part of this program, the AU/SAFGRAD has already conducted a comparative study of extension methods on a large scale in Ghana and Burkina Faso.

Following this first study, the AU/SAFGRAD wants to conduct a second study to identify record and document the main adaptive agricultural technologies to climate change in semi-arid Africa. The first part of this study will be focused on Burkina Faso. Therefore, the Office wants to engage an independent consultant to conduct that study.

II. Objectives of the study

The study aims primarily to identify, characterize, relevantly inform, the various agricultural technologies of adaptation to climate change under way in Burkina Faso. A directory will be compiled in hard and electronic format. The study will indicate precisely the best strategies for wide-scale dissemination of these technologies in semi-arid zones of Africa.

III. Specific objectives

More specifically the Expert Consultant will be responsible for the following tasks:

- Identify, document and describe the various agricultural adaptive technologies to climate change such as ZAI, MICRODOSING, TIED RIDGING, etc. proven in use in Burkina Faso;
- Identify the main sites and geo-ecological zones in which these technologies are being used;
- Show the strengths, weaknesses, opportunities and challenges in the success and wide-scale dissemination of these technologies;
- Seek the views of the various actors (farmers, researchers, development partners, etc.) on the interest of using these technologies;
- Identify the various crops linked to such technologies;
- Identify appropriate strategies for disseminating and popularizing such technologies;

IV. Conduct of the study

Most of the study will be conducted through reviewing the existing literature and consultation with key stakeholders (producers, researchers, extension workers, development partners, NGOs, etc.).

An inception meeting with the commissioners of the study will be organized. This briefing will discuss the methodological note for the conduct of the study that each consultant will suggest.

The Expert Consultant will present the findings of the study during a validation workshop. Comments and observations of the seminar will be considered by the Consultant in the final report which will incorporate all comments.

V. Indicative schedule and deliverables

The consultant will produce the following within the prescribed deadline:

A first report to be submitted to AU/SAFGRAD within 14 days of contract signing. The report must indicate the method used by the consultant to carry out the assignment and the necessary documentation and visits to be made as part of the fulfilment of the task. The AU/SAFGRAD will send to the consultant its comments on the report within five days of receipt of the report;

An interim report must be submitted 35 days after the beginning of the contract on the work done, any findings and problems encountered. Upon receipt of the report, the AU/SAFGRAD will send its comments on the report to the consultant within 7 days;

The first draft report should be submitted within 50 working days. The report will be presented to the AU/SAFGRAD and discussed with the consultant so that the comments be immediately taken into account. The consultants and the AU/SAFGRAD will present the first draft report at a validation workshop. The consultant will take into account the conclusions of the workshop for the finalization of the report;

The final report will be submitted in five original copies and an electronic version to the AU/SAFGRAD as at the 60th working day.

VI. Qualifications and skills required

The consultant should have the following skills:

- Be an expert in the design, implementation and evaluation of agricultural policies particularly on specific issues of strategies for disseminating cropping technologies, information dissemination and farmers capacity building technologies;

- Have a good knowledge of agriculture in semi-arid agro-ecosystems mainly of the Sahel region and of Burkina Faso
- Have excellent report writing skills
- Have a good command of French or English and knowledge of the other language.
- Have at least a master's degree in relevant fields;
- Have relevant experience in conducting studies in the agricultural sector.
- Have sufficient knowledge in database development and management and if necessary assisted by a specialist in this area.

ANNEX 2 : Latest technologies available: What are the new drought-resistant maize varieties currently grown? Latest technologies available: What are the new drought-resistant maize varieties currently grown?

Technologies	Name	Charactéristics	Density and Fertilization Recommended	Zone
Maize varieties adapted to the context of climate change: reduced rainfall and increased drought risk	Wari	Yellow corn, early (91 d), high protein content. Drought resistance by retaining 75% of its potential after 15 days of stress; Potential of 6.4 t/ha ; Resistance to several diseases (Viral, fungal diseases) fieldcorn, extra early (88d);	65,750 plants/ha obtained with the following spacings: 0.80 m x 0.38 m, 2 plants/hole In-depth fertilization: NPK: 28-46- 58 (i.e. NPK: 200 kg+50g/ha of K2SO4) Coverage fertilization N-P-K: 59-0-0 (i.e. fractionated input of Urea: 150kg/ha)	Zone 800-1100 mm, semi-intensive and intensive farmers
	Barka	Drought resistance by retaining 75% of its potential after 15 days of stress; Potential of5.5 t/ha . Resistant to fungal diseases and Streak	Density: 85,250 plants/ha obtained with the following spacings: 0.80 m x 0.30 m, 2 plants/planting hole In-depth fertilization: NPK: 28-46-58 (i.e. NPK: 200 kg+50g/ha of K2SO4) Coverage fertilization N-P-K 59-0-0 (i.e. fractionated input of Urea: 150kg/ha)	600-950 mm Traditional semi intensive, intensive farmers

Source : Sanou, 2009 (a)

ANNEX 3 : Latest technologies available: New stand density techniques, suitable for early and extra early maize varieties allowing their use as intensive crops

Technologies	Name	Charactéristics	Recommended Densities	Types of farmers
Stand density adapted to the context of the intensification of early and extra-early varieties	Density for early maize varieties (example: KPB, KPJ, FBC6, Wari)	Spacing beween spacing: 0.80 m seed hole: 0.38 m Sowing: 3 grains/hole Thinning: 2 plants/planting hole	65.750 plants/ha	Semi-intensive and intensive
	Density for Extra early maize varieties (example: KEJ, KEB, Barka)	Spacing beween Lines: 0.80 m Hole : 0.30m Sowing: 3 grains/hole Thinning: 2 plants/planting hole	83.250 plants/ha	Semi-intensive and intensive

Source : Sanou, 2009 (a)

NB: the cost-effective cropping density of intermediate varieties (95-110d) is already widely adopted (62,500 plants/ha).

ANNEX 4: ACTUAL STATUS OF THE MAIZE VARIETIES BRED BY INERA MAIZE PROGRAM ANNEXES

N°	Varieties	Varietal type	Maturity (day after sowing)	Yield	Actual status (t ha(-1))
1	NCB	OPV	95 - 110	3	RfR because of MSV
2	IRAT 171	OPV	95 - 110	3,5	RfR because of MSV
3	Poza Rica 7822	OPV	95 - 110	3,9	RfR because of MSV
4	IRAT 200	OPV	95 - 110	4	RfR because of MSV
5	Massayomba	OPV	95 - 110	2,8	RfR because of LY
6	IRAT 80	Synthetic	95 - 110	4	RfR because of MSV
7	JFS	OPV	70 - 84	2	RfR because of MSV and LY
8	Jaune de Fô	OPV	95 - 110	3	RfR because of MSV and LY
9	Maka	OPV	85 - 94	3	RfR because of MSV and LY
10	FBPC 1	OPV, pop corn	95 - 110	2	OR
11	FPBC 2	OPV, pop corn	95 - 110	1,5	OR
12	FBMS 1	OPV, sweet maize	95 - 110	2	OR
13	FBMGS 1	Hybrid, green maize	95 - 110	3	OR
14	Obatanpa	OPV, QPM, SR	95 - 110	3,8	OR
15	FBH 1	Hybrid	95 - 110	5	OR but not grown all this time due to farmers' technical level
16	FBH 33	Hybrid	95 - 110	7	OR but not grown all this time due to farmers' technical level
17	FBH 33 ST	Hybrid, ST	95 - 110	7,5	OR but not grown all this time due to farmers' technical level
18	FBH 34 ST	Hybrid, ST	95 - 110	6	OR but not grown all this time due to farmers' technical level
19	Bondofa	Hybrid, SR	95 - 110	6,5	OR but not grown on more than 100 ha/year due to farmers' technical level
20	Oba super 2	Hybrid	95 - 110	5,7	OR but not grown all this time due to farmers' technical level
21	IRAT 81	Hybrid	110 - 120	6	RfR
22	IRAT 178	Hybrid	95 - 110	6	RfR
23	KEB	OPV	70 - 84	3,1	OR
24	KEJ	OPV	70 - 84	3,2	OR
25	KPB	OPV	85 – 94	3,4	OR
26	KPJ	OPV	85 – 94	3,4	OR
27	FBC 6	OPV, QPM, SR	85 - 94	5,6	OR
28	SR 22	OPV, SR	95 - 110	4,2	OR
29	SR 21	OPV, SR	95 - 110	5,1	OR
30	Espoir	OPV, QPM, SR	95 - 110	6,5	OR
31	Wari	OPV, QPM, DR	85 – 94	6,5	Newly release
32	Barka	OPV, DR	70 - 84	5,5	Newly release

Source: Sanou, 2009 (b)

LEGEND: OPV: open pollinated variety (composite); QPM: quality protein maize; SR: streak resistant; ST: streak tolerant; DR: drought resistant; MSV: maize streak virus; LY: low yield; RfR: removed from release; OR: on release; NY: newly release

ANNEX 5 : Recommendation for updating fertilization formulas in West and Central Africa

In most African countries, recommendations of fertilizers have often been developed over a decade ago in best cases. However, the use of fertilizers is sensitive to global changes (climatic, socio-economic ...) which are increasingly evident. For this reason, participants in the validation workshop on the study of agricultural technologies in Burkina Faso, organised in Ouagadougou, on 30th July, 2010 by the African Union Specialized Office for the Promotion of Agricultural Research and Agricultural Development in semi-arid zones of Africa (AU/ SAFGRAD) recommend that policy makers and donors support programs of periodic updating of crop fertilization formulas, in a harmonized manner, in countries of West and Central Africa.

ANNEX 6 : Recommendation for further studies on agricultural technologies in other regions of Burkina Faso

- Considering the significance, relevance and quality of the study presented on the state of agricultural technologies in Burkina Faso,
- Considering that the study covered only the country's central plateau,
- Given the specificities of the western and the Sahel regions of Burkina Faso,

The participants in the validation workshop on the study of agricultural technologies in Burkina Faso, held in Ouagadougou, July 30, 2010 by the African Union Specialized Office for the Promotion of Agricultural Research and Agricultural Development in semi-arid zones of Africa (AU/SAFGRAD), recommend that the study be extended to the western and the Sahel region of Burkina Faso in order to make a complete inventory of agricultural technology in Burkina Faso.

ANNEX 7 : Recommendation for a study on the use and adoption of agricultural technologies

- Whereas many agricultural technologies exist and are disseminated,
- Whereas the adoption and use of agricultural technologies are insufficiently documented,
- Considering that it will be difficult for the agricultural sector to develop without an adoption and consistent use of appropriate technologies,

The participants in the validation workshop on the study of agricultural technologies in Burkina Faso, held in Ouagadougou, on July 30, 2010 by the African Union Specialized Office for the Promotion of Agricultural Research and Agricultural Development in semi-arid zones of Africa (AU/SAFGRAD), recommend that a study be conducted on the adoption and use of agricultural technologies in Burkina Faso.

ANNEX 8 : LIST OF STRUCTURES AND RESOURCE PERSONS VISITED

INSTITUTIONS	RESSOURCE PERSONS	TELEPHONE E-MAIL
1. Direction Régionale de l'Agriculture, Hydraulique et Ressources Halieutiques des Hauts Bassins BP 577 Bobo-Dioulasso	M. TRAORE T. Maurice	Tel : 20 97 11 48 Cel : 70 26 12 09 Fax : 20 97 18 23 E-mail : mauricesilorola@yahoo.fr haubas@fasonet.bf
2. Alliance Technique d'Assistance au Développement (A.T.A.D.) BP 135 Kaya	M.ZANGO Constant	Tel : 40 45 03 84 Cel : 70 27 62 32 / 70 22 53 48 E-mail : constantzango@yahoo.fr atadsdl6@yahoo.fr
3. Union Nakolbzanga de Nagréongo Oubritenga	M. SINARE Mahamoudou	Cel : 76 68 87 04 E-mail : zanganakoglb@yahoo.fr
4. Comité Interprofessionnel Des Céréales du Burkina CIC-B BP. 1837 Bobo Dioulasso	M. SANOU Soumaïla	Tel : 20 96 66 85 / 50 34 06 34 Cel : 70 33 40 94 E-mail sanou_togo@yahoo.fr
5. Agence Nationale de Valorisation des résultats de la Recherche (ANVAR/CNRST) 03 BP. 7047 Ouagadougou	Dr. ZANGRE G. Roger	Tel : 50 36 59 12 Cel : 70 33 31 90 E-mail : gr_zangre@yahoo.fr
7. Réseau MARP-Burkina 02 BP 5657 Ouagadougou 02	M. OUEDRAOGO M. Mathieu	Tel : 50 39 32 33 Cel : 70 14 44 62 / 76 94 14 74 E-mail : ommb@fasonet.bf patemathieu@yahoo.fr
8. INERA 01 BP 476 Ouagadougou 01	Dr. BILGO Ablassé	Fax : 50 34 02 71 Cel : 70 24 70 91 E-mail : ablassebilgo@yahoo.fr
9. IN.E.R.A/Farako-Bâ 01 BP 910 Bobo Dioulasso	Dr. SANOU Jacob	Cel : 70 28 37 97 76 21 55 87 / 78 48 42 39 Fax : 20 97 01 59 E-mail : jsanou24@yahoo.fr
10. Institut de Recherche en Sciences Appliquées et Technologies (IRSAT)/CNRST 03 BP 7047 Ouagadougou 03	Dr. SON Gouyahali	Tel : 50 36 37 86 Cel : 70 24 58 08 E-mail : dm@fasonet.bf
11. Fédération Provincial des Professionnels Agricoles de la Sissili (FEPPASI) BP 131Léo Province de la Sissili	M. DAGANO Moussa Joseph	Tel : 50 41 34 56 - Cel : 76 60 96 29 E-mail : mjdagano@gmail.com feppasi.leo@gmail.com
12. Centre International pour la Fertilité des Sols et le Développement Agricole (IFDC) 11 CMS BP 82 Ouaga 11	M. YOUL Sansan	Tel : 50 37 45 03/05/Fax : 50 37 49 69 Cel : 70 26 45 38 E-mail : syoul@ifdc.org www.ifdc.org

ANNEX 9 : Websites consulted

- www.fasopresse.
- www.ifdc.org
- www.reseaucrepa.org
- www.warda.org

AFRICAN UNION SAFGRAD
261 rue de la culture
01 BP 1783 Ouagadougou 01 BURKINA FASO
TEL. 226 50 31 15 98 / 226 50 31 15 86

2010-08

Agricultural technologies in Burkina Faso

AU-SAFGRAD

AU-SAFGRAD