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Patancheru 502 324, Andhra Pradesh, India

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Abstract

This paper is part of a continuing research effort at ICRISAT to explore innovative strategies to accelerate adoption of improved technologies in the semi-arid tropics. Earlier studies in West and Central Africa have indicated that seed supply systems there function poorly and are therefore a major constraint to adoption of improved varieties. However, uptake of improved varieties and profitability of seed systems significantly differ from country to country and from crop to crop. This analysis attempts to assess the factors explaining these differences in seed sector performance, especially of groundnut and pearl millet in Niger and Senegal. It also draws useful lessons that could serve donors and policymakers in strengthening the capacity of these systems to meet the needs of small-scale farmers.

Research results show that the Senegalese formal seed system performs relatively better at supplying seed of improved groundnut varieties to small-holder farmers and is comparatively more financially sustainable than its Niger counterpart. However, in the case of pearl millet, the seed systems of both the countries performed poorly. These differences are largely explained by the level of development of the seed distribution network and the degree of input-output market integration. Interlinked credit and trade contracts for input and output markets can enhance adoption of new varieties by small-holder farmers.

Results also indicate that the informal seed systems in both these countries provide access for small-scale farmers to a large range of existing varieties. These systems supply most of the seed sown by farmers at low transaction costs, and the seed quality is surprisingly good. These systems could be strengthened by ensuring access to seed of new varieties, and possibly by improving seed flows from surplus to deficit regions after drought.

Formal seed systems do not perform well unless they are linked with satisfactorily functioning product markets. While these systems will remain the major source of new improved varieties, an element of targeted subsidy may be needed to improve access to new varieties. Otherwise, seed markets need to be built on the foundation of seed supply of more commercialized crops.

Résumé

Le présent article fait partie des efforts de recherche, constamment déployés à l'ICRISAT, pour rechercher des stratégies novatrices permettant d'activer l'adoption des technologies améliorées dans les tropiques semi-arides. Des études antérieures, menées en Afrique de l'Ouest et du Centre, ont montré que les systèmes de distribution de semences ne fonctionnent pas bien dans ces régions et constituent, de ce fait, une contrainte majeure à l'adoption de variétés améliorées. Toutefois, l'acceptation de ces variétés et la rentabilité des systèmes de distribution de semences varient considérablement selon les pays et selon les cultures. La présente analyse tente d'évaluer les facteurs qui expliquent les différences entre les résultats obtenus par le secteur semencier, notamment pour l'arachide et le mil, au Niger et au Sénégal. L'article tire, par ailleurs, des enseignements utiles dont pourraient s'inspirer les donateurs et les décideurs pour renforcer la capacité de ces systèmes à répondre aux besoins des petits paysans.

Selon des résultats d'études, le système formel de distribution de semences du Sénégal obtient des résultats relativement meilleurs à celui du Niger quant à l'approvisionnement des petits paysans en semences améliorées d'arachide et est comparativement plus viable au plan financier. Toutefois, pour le mil, les systèmes de ces deux pays obtiennent des résultats médiocres. Ces différences s'expliquent, en grande partie, par le niveau de développement du réseau de distribution des semences et le degré d'intégration du marché des intrants et celui des produits. Le couplage des contrats de crédit et de commercialisation concernant les marchés d'intrants et des produits peut améliorer l'adoption de nouvelles variétés, par les petits paysans.

Des résultats d'étude montrent également que, dans ces deux pays, les systèmes informels de distribution de semences permettent aux petits paysans d'avoir accès à un large éventail de variétés existantes. Ces systèmes fournissent aux paysans une bonne partie des semences qu'ils utilisent, à des coûts de transaction relativement faibles et, chose surprenante, la qualité de ces semences est bonne. On pourrait renforcer ces systèmes en garantissant l'accès aux semences de nouvelles variétés et en améliorant peut-être l'écoulement des semences des zones excédentaires vers les zones déficitaires, après la sécheresse.

Les systèmes formels de distribution des semences ne donnent de bons résultats que s'ils sont reliés à des marchés qui fonctionnent bien. Ces systèmes resteront la principale source de distribution des nouvelles variétés améliorées, cependant il faudra probablement une subvention ciblée pour améliorer l'accès à ces variétés. Autrement, les marchés de semences doivent être basés sur la distribution des semences de cultures plus commercialisées.

Contents

Introduction

During the last 20 years, bilateral and international donors have invested more than US$ 45 m in Niger and US$ 36 m in Senegal in variety development, and seed multiplication and distribution projects (Table 1). As a result, 17 improved pearl millet [*Pennisetum glaucum* (L.) R. Br.] and 9 improved groundnut *(Arachis hypogaea* L.) varieties have been developed and released in Niger; and 4 pearl millet and 13 groundnut varieties in Senegal (Tables 2 and 3). In addition, a number of state production, processing, and distribution centers have been established and human resources trained. In Niger, for example, six seed production centers (SPCs) equipped with seed laboratories and seed processing units were established. In Senegal, seven seed production and processing centers and nine seed laboratories were established.

However, these investments have largely failed in Niger. The formal seed sector—consisting of state SPCs—has consistently supplied less than 1% of the total national need for pearl millet seed. Low supply of breeder seed, poor demand estimation, and poor distribution systems have limited farmers' uptake of new varieties (Ndjeunga 1997; Mazucatto and Ly 1993). During and after the establishment of seed projects, state SPCs have operated with heavy losses, and have always been subsidized and thus financially unsustainable. During the same period, the private sector showed little

Table 1. Past and ongoing seed distribution and multiplication projects in Niger and Senegal[1].

Project	Period of involvement	Donor	Investment ('000 US$)
Niger			
Niger Cereal Project (PCN)	1976-1986	USAID[2]	17583
Support to Agricultural Production (PAPA)	1982-1989	USAID, FED[3], ACDI[4], IBRD[5]	25537
Development of seed activities in Niger (PDASN)	1990-1992	USAID	2292
Total			45412
Senegal			
IRHO[6] project	1972-1976	FED	NA[9]
DPCS/IRHO/CIRAD[7]	1982-1990	FED	1500
Plan Triennal Semencier (PTS)	1985-1990	CFD[8]/FED	11500
Agricultural Support Project (APS)	1988-1992	USAID	20000
Projet Autonome Semencier (PAS)	1990-1994	CFD	2900
Total			35900

1. Currently, in Niger, there are no ongoing seed projects. In Senegal, however, the European Union through the "STABEX" funds, is financially supporting private sector initiatives. In effect, starting in 1999, the Union interprofessionnelle des producteurs de semences (UNIS) will receive operational funds estimated to be about US$ 200 000 per year for three years. Similarly, the seed division will receive "STABEX" funds in support of spot checks for seed quality.
2. USAID = United States Agency for International Development.
3. FED = Fond Europeen de Developpement.
4. ACDI = Agence Canadienne de developpement international.
5. IBRD = International Bank for Reconstruction and Development.
6. IRHO = L'Institut de Recherches pour les Huiles et Oleagineux.
7. CIRAD = Centre de cooperation international en recherche agronomique pour le developpement.
8. CFD = Caisse Francaise de Developement.
9. NA = Not available.

Sources: Direction de la production et du contro1e des semences (DPCS), Ministere de l'Agriculture du Senegal, and Direction des etudes et projets (DEP), Ministere de 1'agriculture du Niger.

Table 2. Pearl millet varieties released in Niger and Senegal.

Variety	Rainfall (mm)	Crop cycle (days)	Average yield (t ha^{-1})	Year of development	Institution
Niger					
HKP	350-500	80-90	2.0	1975	INRAN[1]
HKP 3	280-350	70-75	1.5	1983	INRAN
P3Kollo	500-600	90-95	2.5	1962-77	INRAN
CIVT	450-600	80-90	2.5	1977	INRAN
3/4HK	450-600	70-75	2.0	1975	INRAN
MORO-P1	200-300	90-95	1.8	1985	INRAN
GR-P1	450-600	70-75	2.5	1985	INRAN
ANK-P1	300-350	70-75	1.0	1985	INRAN
HKB-Tift	<300	70-75	2.0	1982	INRAN
H-80-10-GR	300-400	80-85	2.3	1980	INRAN
T-18-L	≥250	85-95	2.0	1982	INRAN
ITMV 8304	300-400	80-85	2.5	1983	INRAN
ITMV 8002	300-400	80-85	2.5	1980	INRAN
ITMV 8001	400-500	80-85	2.5	1980	INRAN
SOUNA III	≥600	80-85	2.0	1982	ISRA[2]
ZATIB	300-600	80-85	1.5	1981	INRAN
HKB-P1	≥300	80-85	2.0	NA[3]	INRAN
Senegal					
SOUNA III	≥600	80-85	2.0	1982	ISRA
IBMV 8402	450-800	85-95	2.4-3.5	1983	ICRISAT[4]/ISRA
IBMV 8001	300-750	75-85	2.5-3.0	1983	1CRISAT/ISRA
IBMV 8004	300-750	75-85	2.5-3.0	1983	ICRISAT/ISRA

1. INRAN = Institut national de recherches agronomiques du Niger.
2. ISRA = Institut Senegalais de recherche agricole.
3. NA = Not available.
4. ICRISAT = International Crops Research Institute for the Semi-Arid Tropics.

Sources: MDRH/DA/DS 1994, INRAN 1994.

interest in multiplying and distributing seed of cross- or self-pollinated crops such as pearl millet and groundnut, respectively.

Experience with seed systems in sub-Saharan Africa indicates that even in countries such as Zimbabwe where the formal seed system is comparatively advanced, seed companies concentrate on crops where they can achieve higher profit margins (e.g., maize, sunflower, soybean) in order to obtain competitive returns on their research and marketing investments. For millet, sorghum, and groundnut, mostly nonimproved cultivars and farmers' saved varieties are used (Neuendorf 1995).

However, in Senegal formal seed supply and distribution of improved groundnut varieties has been relatively successful. Since 1989, the Senegalese government has gradually shifted to a private mode of seed multiplication and distribution. Groundnut seed is produced and distributed by a combination of parastatal and private entities. Pearl millet seed is multiplied and distributed solely by individual farmers, and farmers' groups or associations. Although farmers' seed purchase for groundnut is poorly justifiable compared with pearl millet seed (Table 4), all groundnut cropped area in Senegal is sown with improved varieties. The Senegalese formal seed system supplies, distributes, and sells a higher quantity of improved groundnut seed than pearl millet seed. In contrast, in Niger,

Table 3. Groundnut varieties released in Niger and Senegal.

Variety	Crop cycle (days)	Average yield (t ha^{-1})	Year of development	Institution
Niger				
55-437	90	2.0-3.0	1955	IRHO[1]
T-169-83	90	2.5-3.5	1977	IRHO
T-181-83	90	2.0-3.0	1977	IRHO
TS 32-1	90	2.5-3.5	1976	IRHO
796	90	2.0-3.0	1976	IRHO
KH 149-A	90	3.5	1973	IRHO
47-16	120	3.5	1977	IRHO
40-16	120	3.5	1940	IRHO
57-422	120	3.5	1957	IRHO
Senegal				
28-208	120	1.5-2.5	1928	IRHO
55-437	90	1.5-2.0	1955	IRHO
57-313	125	1.5-2.5	1957	IRHO
57-422	105-110	2.0-2.5	1957	IRHO
69-101	125	1.5-2.5	1969	IRHO
73-30	95	1.5-2.0	1973	IRHO
73-33	105-110	2.0-2.5	1973	IRHO
GH 119-20	110-120	1.5-2.0	1920	IRHO
73-27	120-125	1.5-2.5	1972	IRHO
756-A	125	NA[3]	1951	IRHO
73-28	120-125	1.5-2.0	1972	IRHO
Fleur 11	85	1.9-3.0	1988	ISRA[2]
GC 8-35	75-90	NA	1989	ISRA

1. IRHO = L'Institut de Recherches pour les Huiles et Oleagineux.
2. ISRA = Institut Senegalais de recherche agricole.
3. NA = Not available.

Sources: MDRH/DA/DS 1994. INRAN 1994.

Table 4. Comparative suitability of groundnut and pearl millet for informal seed systems in Niger and Senegal.

Characteristic	Groundnut	Pearl millet
Breeding system (pollination)	Self-pollinated	Cross-pollinated
Rate of genetic deterioration	Very slow	Medium
Multiplication factor	Low (10)	High (100)
Sowing rate (kg ha^{-1})	High (125)	Low (10)
Seed replacement (years)	Varied (6)	3(1[1])
Suitability of informal system	High	Low
Justification for purchase	Very poor	Variable

1. Annual replacement for hybrids, and every three years for open-pollinated varieties.

Source: Adapted from Cromwell 1996.

farmers' uptake of seed of improved varieties is dismally low for both crops. Pearl millet has a high multiplication factor, and is thus easier for the formal sector to deal with because fewer multiplications are required and at each stage there are smaller quantities to process, store, and distribute. Because of the low seed rate (5-10 kg ha^{-1}), the purchase cost to farmers as a proportion of the total production cost ha^{-1} is very low. Therefore, it is feasible to charge a higher price. In contrast, groundnut is characterized by a low multiplication factor and high seed sowing rate. Therefore, it is less attractive for commercial seed companies to handle. In addition, because of its autogamous nature, varietal deterioration occurs over a period of several years without affecting purity. Therefore, there is a relatively poor justification for groundnut seed purchase than pearl millet in which varietal genetic deterioration is faster.

Primary indicators of seed sector performance in Niger and Senegal show that the Senegalese seed sector supplies relatively more improved seed to end-users than the Niger system; and comparatively more improved groundnut seed (28% of the total seed sown) than pearl millet (3.8%). On the contrary, the Niger seed sector supplies a negligible share of the total seed sown to both crops (0.4% for pearl millet and 1 % for groundnut) by small-scale farmers. In addition, the average cost of producing seed in Niger has been estimated to vary from 880 F CFA kg^{-1} to 1633 F CFA kg^{-1}, largely above seed prices. To break even, seed production centers subsidize about 86% of the total production costs. In Senegal, farmers' groups could earn a positive profit margin on groundnut seed of 14 F CFA kg^{-1} and up to 42 F CFA kg^{-1} on pearl millet seed. What factors explain these differences in formal seed sector performance between the two countries and crops? What lessons can be learned that could enhance the adoption of improved pearl millet and groundnut varieties? This study analyzes and compares the performance of groundnut and pearl millet seed systems at supplying and distributing seed of improved varieties to small-scale farmers in Niger and Senegal, and presents a number of lessons learnt and highlights strategies to enhance seed systems in countries located in the semi-arid tropics of West Africa.

Background

The economies of Niger and Senegal are dominated by agriculture. In 1997, this sector contributed 39% and 20% of the GDP, and employed 91 % and 76% of the total labor force respectively in Niger and Senegal. Niger has a land area of about 1 267 000 km^2—more than six times as large as Senegal—but only 10% of it is agriculture land, against 28% in Senegal. Pearl millet and groundnut are important food or cash crops for millions of small-holder farmers in these two countries. Both countries are located in the semi-arid tropics receiving annual rainfall of 250-1100 mm. There are four main agroclimatic zones: the Sahelian Zone (less than 350 mm of rainfall), the Sahelo-Sudanian Zone (350-600 mm), the Sudanian Zone (600-800 mm), and the Sudano-Guinean Zone (800-1100 mm). Within these broad agroclimatic zones, farmers have adapted to microvariations with highly flexible management practices. In areas where soils tend to be sandy, such as the Sahelian Zone, farmers grow millet and fonio *(Digitaria exilis)* and migratory livestock rearing is significant. In the Sahelo-Sudanian Zone, where soils receive a little more rainfall, farmers grow millet often intercropped with cowpea, groundnut, and sorghum as secondary crops. The Sudanian Zone is an area of transition between millet- and sorghum-based systems. Maize, groundnut and cotton are also cultivated. Finally, in the Sudano-Guinean Zone, a wide range of crops is grown including cotton, maize, rice, cowpea, groundnut, and vegetables. About 98% of the cultivated area in Niger is located in the Sahelian and Sahelo-Sudanian Zones; in Senegal it is 40%. On the basis of climatic endowments, there are more opportunities for crop and variety diversification in Senegal than in Niger.

In 1995-1997, pearl millet accounted for about 80% of the total cereal grain production in Niger and 60% in Senegal. Niger is the second largest pearl millet producer in West Africa, following Nigeria. Pearl millet is sown in over 5 million ha with a total production estimated at 1.8 million t with yields averaging 340 kg ha^{-1}. Senegal is also a major pearl millet producer with an area of 0.89 million ha, total production of 0.57 million t, and yields averaging 630 kg ha^{-1}. Senegal is the second largest groundnut producer in West and Central Africa following Nigeria. Groundnut is sown in 0.86 million ha with a total production of 0.69 million t, and yields averaging 800 kg ha^{-1} (average of 1994-96). In contrast, Niger has limited groundnut production sown in about 0.23 million ha with a total production of 93 000 t and yields averaging 400 kg ha^{-1} (Freeman et al. 1999). As can be seen from the figures above, crop productivity is higher in Senegal than in Niger. The difference in crop productivity can be explained by the relatively higher use of mineral fertilizers, systematic rotation, and high-density intercropping in Senegal than in Niger. On an average, the quantity of plant nutrient used in Senegal is estimated to be 8 kg ha^{-1} against 1 kg ha^{-1} in Niger (FAO 1998). Other than management and labor, seed is the most important input in crop production. The availability of high quality seed in sufficient quantities is a necessary condition for these crops to compete in the crop portfolio of farmers in these production systems.

Analytical Framework

A country's seed system can be defined as a set of institutions involved in variety development, multiplication, processing, and distribution of seed. The system consists of the formal and informal sectors. The formal seed sector can be defined as a framework of institutions linked together by their involvement in or influence on the multiplication, processing, and distribution of improved seed. These institutions include those directly involved in the actual multiplication and distribution activities—ranging from agricultural research to farmer uptake—and other institutions which, while not integral components of the sector itself, exert an important influence on the sector performance (Fig. 1, Appendix). These latter often constitute the supporting legal, infrastructural, and policy environments that could influence seed sector performance.

The informal seed sector consists both of individual farmers retaining seed from the previous harvest and farmer-to-farmer seed exchange based on barter, social obligations, etc., by which farmers fulfill their seed requirements. This sector often accounts for the majority of seed sector activity in most developing countries and involves well-established and elaborate mechanisms for the diffusion of seed over relatively wide areas (Cromwell 1992). The formal and informal sectors both contribute to the supply and distribution of seed to farmers, and both should be considered when analyzing the seed system as a whole.

Farmers' uptake of improved seed is a function of how well a series of interlinked activities such as agricultural research, seed multiplication, quality control, storage, processing, and marketing are undertaken. In addition, a set of causal factors such as the extent of varietal adaptation to cropping systems, macroeconomic and agricultural policies, seed legislation, and agricultural services influence the uptake of improved seed by small-scale farmers (Fig. 1, Appendix). The primary and measurable indicators of seed uptake by farmers or of the performance of seed sectors include the quantity of improved seed actually used by farmers relative to the optimal annual requirement; and, the degree of financial sustainability of the seed system. The latter can be measured by the margins over the cost as a proxy for economic efficiency (Cromwell 1996).

Supplying high quality seed of improved varieties preferred by farmers in sufficient quantities in a timely manner to accessible locations at affordable prices is often a national development objective pursued by governments as an effort toward increasing production. In addition, they also pursue an economic efficiency function by supplying seed in an efficient manner. In order to compare seed sector performance across countries, one needs to examine how well the activities along the seed chain are performed.

Differential performances of activities are likely to explain differences in farmers' uptake of improved seed or the profitability of the system. For example, the number of varieties developed and released that are suitable to a wide range of agroecological zones is used to assess the output of agricultural research. Similarly, improved seed coverage, i.e., the quantity of improved seed produced relative to the total national seed need as set by government, is used to compare the performance of seed production. The number of distribution outlets and the average radius to a distribution[1] outlet are used as criteria for evaluation of performance in seed distribution and accessibility. Germination rate, moisture content, and physical purity are the set of criteria used to assess seed quality. The percentage of farmers failing to obtain enough seed after a drought is used as an efficiency indicator for seed security stocks. Finally, the margin over the cost of production is used as a proxy for financial

1. This measure assumes that the distribution of store outlets is uniform and outlets are equally accessible.

efficiency. Institutions that carry out these activities may also affect performance by their effect on the costs of exchange and production. Together with the technology employed, they determine the transaction and transformation (production) that make up the total cost. The specification of exactly what the institutions are and how they influence transaction and production costs are the keys to this analysis (Douglas 1990).

Methodology and Data Collection

This study was undertaken in Niger and Senegal, countries located in the semi-arid tropics of West Africa (WASAT), and both producers of groundnut and pearl millet. The choice of these countries was prompted by a rapid rural appraisal tour in the subregion, which indicated that these countries had different pathways with regard to the development of seed systems and were representative of seed systems in the WASAT. Some similarities were found between the seed systems of Burkina Faso, Niger, and Chad, which are at an early stage of commercialization and are dominated by the public sector. In contrast, Senegal has a relatively advanced seed system with a strong involvement of the private sector. Groundnut and pearl millet were the chosen crops because of the perceived difference in their commercial values. Groundnut in the WASAT is considered a cash crop while pearl millet is taken to be a subsistence crop with low commercial value with the assumption that higher commercial value is associated with uptake of improved varieties.

The seed sector performance of the two countries was compared using data sets at the institutional and rural household levels. At the institutional level, data were gathered on all formal institutions involved in seed multiplication and distribution; and on their linkages and their operational procedures. These institutions included research centers, state seed production units, seed processing centers, seed laboratories, cooperatives, parastatal companies, nongovernmental organizations (NGOs), farmers' groups, and traditional extension services[2]. Data on fixed costs of seed production were drawn from secondary sources of information in Niger (FAO 1996). Data on variable costs were obtained from SPCs. In Senegal, data on costs of seed production were gathered from five GEE[3] (Groupes d'interet economique) groundnut seed producers. Grain prices were drawn from market information systems in Niger and Senegal (SDVI/OPVN 1998; CSA/CEI/SIM 1997).

At the rural household level, structured surveys were conducted in June and July 1997 in Niger and August 1997 in Senegal with the main goal of gathering information on the households' seed sources and transactions, seed selection and storage methods, seed quality traits preferred by farmers, and village capacity to meet seed security needs for the years 1996 and 1997. The year 1995 was relatively good in terms of rainfall quantity and distribution compared to 1996. Therefore, this study was an opportunity to make a comparison of seed purchase behavior in each year in the context of weather risks.

A total of 58 villages were selected in Niger. In each village, 3 to 10 households were chosen depending upon the population of the village. Overall, 302 rural households were chosen[4] (Fig. 2,

2. Specifically, 3 pearl millet breeders and I groundnut breeder, 5 managers of seed production units, the head of a seed division, 2 NGOs' representatives, 1 private seed grower, the director of the cooperative union (UNCAs), and the director of extension were interviewed in Niger. In Senegal, 5 national scientists, 5 GIE managers, 2 marabouts, the director of the cooperative union (UNCAs), the director of the parastatal groundnut company (Sonagraines), the head and deputy head of the seed division, the secretary-general of Inter-professional union for seed (UN1S), 3 seed collectors and 4 contract seed growers from Sonagraines, and 5 groups of seed producers were interviewed.

3. Groupes d'interet economique (GIE) are groups of farmers that were initiated by the Projet Autonome Semencier (PAS) project. The main objective of the project was to initiate farmers' groups into multiplying, collecting, distributing or selling seed with the understanding that these groups will gradually undertake the entire seed activities.

4. The survey was undertaken in three departments of Niger which are the largest producers of pearl millet or groundnut. These three departments accounted for more than 58% of the total national pearl millet production and 73% of groundnut production in 1997. Within each department, villages were selected using a stratified random sample with agroecological zone and accessibility as criteria for stratification. A total of 58 villages were selected of which 17 were in the Dosso department, 16 in the Tillabery department, and 17 in the Maradi department. Twenty percent of the respondents were selected from the more drought-prone areas [length of growing period (LGP) less than 75 days]; and the remaining from environments with LGP more than 75 days.

Appendix). In Senegal, 52 villages were selected. Within these villages, a minimum of 5 households were randomly chosen from a census list provided by the agricultural statistics office (Fig. 3, Appendix). Overall, a total of 304 households were randomly selected[5].

5. The survey was undertaken in four semi-arid tropical regions of Senegal which are the largest producers of pearl millet or groundnut. The number of villages drawn from each department was a function of its population. Accordingly, 19 villages were selected in the department of Louga; 20 villages in Kaffrine; 14 villages in Bambey, and 9 villages in Tiavouane. Louga is a drought-prone area located in the northwest, receiving 300-600 mm of rainfall. Tiavouane and Bambey receive 500-600 mm of rainfall. Kaffrine is a favorable zone with rainfall of 600-800 mm.

Organization of Formal Seed Supply Systems

Seed systems in Niger and Senegal vary substantially in their institutional and legal aspects and in their operational procedures. In Niger, plant breeding and breeder seed production are undertaken by the national agricultural research system, Institut National de Recherches Agronomiques du Niger (INRAN). Breeder seed are bulked into foundation seed by the SPC of Lossa. Foundation seed are multiplied further into registered or commercial seed by four other seed multiplication centers through contract farmers. Seed is distributed through a few sales points located in the capital cities of departments, research centers, and seed production units, and to a lesser extent, NGOs. Seed quality control activities for breeder seed and basic seed are performed by the SPC of Lossa and for other seed classes by the other SPCs. Seed processing, storage, and control are undertaken by the SPCs in their laboratories and processing units. Overall, the mode of seed provision is dominated by the public sector and has remained so since 1975 when the first seed project (the Niger Cereal Project, PCN) was launched. The only major change in the system occurred in 1989 when seed production planning, distribution, and price-setting decisions were decentralized at the departmental level. Currently, almost all activities are still performed by government agencies.

In Niger, variety evaluation and release are the responsibility of INRAN. However, these tasks are not systematically conducted due to lack of funds. There are seed laws, policies, and a national seed committee with regard to strategic seed reserves in case of severe droughts. But these institutions are not operational and the laws are not implemented and enforced. Since 1997, an emerging private sector has been involved in the production of seed but private companies are not interested in producing seed of low commercial value such as pearl millet. More recently, in 1999, a professional union of private seed producers (the Association des producteurs prives des semences du Niger, APPSN) was created with a total of 30 members with the main objective of revitalizing seed production by undertaking most of the seed activities in Niger.

In Senegal, prior to 1989, all seed activities were carried out by public sector agencies. Since 1989, with a seed project (PAS) jointly funded by the United States Agency for International Development (USAID) and French Development Cooperation (CFD), the Senegalese government started a gradual shift toward a private mode of seed supply and distribution. Breeder seed is bulked into foundation seed by groups of private seed growers (GIE). The different classes for pearl millet seed are entirely produced by GIE, whereas commercial groundnut seed is produced by both the parastatal groundnut company (Sonagraines) and GIE. Seed distribution is through more than 400 outlets and is managed by GIE or private seed collectors from the parastatal company, Sonagraines or the private company Novasem. Seed quality remains the sole responsibility of the government and is handled by the seed division (the Division des producteurs de semences, DISEM). In addition, internal quality control is actively pursued by GIE through technicians trained by the seed division but paid for by GIE.

In order to fill the institutional gap created by the government's disengagement from seed multiplication and distribution in the 1990s, an interprofessional union of seed producers (the Union national interprofessionnelle des producteurs de semences, UNIS) was created in 1992 with the responsibility of planning seed production, setting seed price, or acting as moral guarantor for credit extended to seed producers by the agricultural bank (the Caisse nationale de credit agricole, CNCA). Since 1992, this institution has not been fully operational due to lack of funding and a clear mandate provided by the government. It is only since 1997 that the linkages and roles of institutions involved in seed activities have been formalized in a series of three presidential decrees: decree no. 97-616 regulating seed production, certification, commercialization, and seed imports; decree no. 97-603 creating a national consultative seed committee; and decree no. 97-602 formalizing the inception of a

catalog for varieties and plants. This was followed by a tripartite agreement signed between the government, the parastatal groundnut company, and the private sector represented by the national interprofessional committee for groundnut (the Comite national interprofessionnelle de l'arachide, CNIA). The agreement defined the roles and activities of each party in the groundnut seed production and distribution chain (Senegal 1997).

The Senegalese seed sector has gradually evolved from a public mode of seed supply to a more market-oriented scheme with a set of sustainable institutions with clearly defined roles operating within a set of well-defined laws. This system may be considered as a rapidly evolving commercialization and diversification system. In this system, a growing proportion of commercial seed is provided by the private sector, seed distribution systems are more varied, and seed certification is well-developed. In contrast, the Niger seed system is evolving slowly from being largely state-controlled toward commercialization. At this stage, the broad majority of small-holder farmers typically remain outside the formal seed sector, still relying upon themselves or their neighbors or village markets for much of their seed requirements (Jaffee and Srivastava 1992).

Overall, the seed systems of Niger and Senegal significantly differ in their institutional and legal contexts and the level of private sector involvement. However, the impact of the institutions on economic performance or farmers' uptake of varieties cannot be assessed because it is only recently that the institutions and their roles and linkages were clearly defined and started to be operational in Senegal. For example, UNIS—initiated by the private sector—has started to be active only recently after receiving some seed money as operational funds from the European Union (STABEX funds). Therefore, differences in the seed sector performance or farmers' uptake of improved seed in these two countries cannot be attributed to the institutional and legal environment.

Along with formal institutions, there is an active informal seed sector supplying seed to end-users in the two countries. This sector is less institutionalized, with indigenous structures regulated by traditional social laws, with more flexible exchange mechanisms and modes of organization. The common features of this sector include free transactions and operations within small communities that share the full information set on members' activities. Such environments offer transactions at low costs and are likely to be sustainable.

Performance of Groundnut and Pearl Millet Seed Systems

This section presents and compares the primary indicators of performance of seed systems in Niger and Senegal. The factors likely to explain these differences in seed sector performances are also examined.

Primary Indicators of Performance

National Requirement of Improved Seed in Niger and Senegal

Table 5 shows the trends in commercialized production of pearl millet and groundnut seed in Niger and Senegal. It also indicates the annual national requirement of improved seed (average 1990-98). The annual seed requirement for each crop was computed using the area sown to the crop, and the

Table 5. Trends in commercialized production (in t) of pearl millet and groundnut seed in Niger and Senegal, 1990-98.

	Pearl millet		Groundnut[1]	
Year	Niger	Senegal	Niger	Senegal
1990	31	41	0	10 232
1991	228	29	22	16 781
1992	42	65	0	15 176
1993	54	31	0	22 898
1994	270	74	313	11 265
1995	87	59	52	9 967
1996	26	85	0	6 106
1997	65	NA[2]	6	15 523
1998	70	NA	0	NA
Average[3] seed production[4] (1990-98)	97	55	44	15 217
Average cultivated area (ha)	4 797 512	888 530	177 526	831 051
Government-recommended replacement rate (years)	3	3	4	3
Expected government national seed need[5] (t)	7 796	1 481	5918	27 792
National government seed coverage (%)	1.21	3.71	1.0	54.93
Expected farmers' rate of seed market entry (years)	10.708	4.535	4.297	1.529
Expected farmers' national need (t)	4 480	980	4131	54 353
Farmers' seed coverage (%)	2.17	6	1.07	28

1. Refers to shelled groundnut.
2. NA = Not available.
3. Average refers to 1990-1998 average where applicable.
4. In Niger, the total seed production reported does not include seed produced on the state farms. For e.g., in 1997 about 85 t of pearl millet seed were produced by CFJA (Centre de formation des jeunes agriculteurs) in the Maradi Department; 5 t by farmer seed producers in Zinder, and about 85 t in Tahoua. Comparable data for other years were not available. In Senegal, to fill the seed supply gap, the government often purchases and recycles the first generation of certified seed. These amounts are not included here.
5. Expected need for pearl millet seed was computed taking into account the sowing rate used by farmers in Niger and Senegal (10 kg ha^{-1} and 5 kg ha^{-1} respectively), farmers' rate of market entry (proxy for renewal rates) or government recommended rates, and the average cultivated area. For groundnut, the seed sowing recommended rate was estimated to be about 100 kg ha^{-1} of shelled groundnut.

Source: WCA-ICRISAT Survey 1997.

recommended sowing and replacement rates for the crop. In both countries, a replacement rate[6] of three years is recommended for pearl millet. For groundnut, a four-year replacement rate is recommended in Niger, and three years in Senegal. On an average, between 1990 and 1998, the formal seed systems in both countries produced a negligible share of the total seed sown to pearl millet. In Senegal, for example, seed produced and sold accounted for 3.7% of the total cropped pearl millet area. In Niger, the quantity of seed produced could cover about 1.2% of potential seed needs. As only 30% of the production is actually sold in Niger, farmers' uptake of improved pearl millet varieties is estimated to be about 0.4% of the total pearl millet cropped area. The Senegalese seed sector performs better at supplying seed of improved groundnut varieties to small-holder farmers. Seed production and sales cover about 55% of the total groundnut cropped area. In contrast, in Niger, only about 1% is covered by improved groundnut seed. In 1997, for example, no groundnut seed was multiplied by SPCs. Overall, the formal seed systems of Niger and Senegal perform poorly at supplying improved pearl millet seed to end-users.

Government estimates of national seed requirement may often be under- or over estimated due to the arbitrary seed replacement or sowing rates set by governments, which do not account for actual figures of farmers' seed sowing rates or frequency of market entry. Rural household surveys done in Niger indicate that farmers enter the pearl millet seed market once every 10-11 years which is largely below the government's recommended rate of once every 3 years. However, the frequency of farmers' market entry for groundnut is consistent with the government-recommended replacement rate. In Senegal, household surveys show that farmers enter more frequently the groundnut seed market than assumed by the government (once every 1.5 years against 3 years), but less frequently the pearl millet seed market (4.5 years against 3 years). Based on farmers' frequencies of seed purchase as proxies for seed replacement rates, seed needs in Senegal were largely underestimated for groundnut (Table 5). Seed coverage for groundnut is estimated to be 55% at the government-recommended rate, but is only about 28% when using the farmers' rate of purchase. Therefore, the potential demand for improved groundnut seed may be higher or lower than the estimate. This calls for a better assessment of seed demand in both countries. Overall, the Senegalese seed sector supplies more improved pearl millet and groundnut seed to small-holder farmers than the Niger seed system.

Formal Seed Sector Efficiency

The primary and most important function pursued by the Niger seed system is a national development function. Supplying seed in an economically efficient way has always been given a low priority. During the period of involvement of seed projects, the average cost of production of registered improved pearl millet seed was estimated to be 1720 F CFA kg^{-1}, whereas it was sold to contract farmers at 100 F CFA kg^{-1} (Rachmeler 1991). In 1996, after the period of involvement of seed projects ended following the decentralization of seed multiplication centers, SPCs still operated with huge losses. The average cost of producing seed in the SPCs in Niger was estimated to vary from 880 F CFA kg^{-1} to 1633 F CFA kg^{-1} with negative profit margins ranging from 755 F CFA kg^{-1} to 1383 F CFA kg^{-1}. For a dollar invested in producing seed, to breakeven, SPCs would have to subsidize about 86% of the total production cost. The SPCs have been and are still operating with huge losses. With the current production scheme and the poor economic efficiency record, it is unlikely that the SPCs will ever be sustainable (Ndjeunga 1998b).

6. Replacement rate is the number of years a farmer can use the certified commercial seed without a significant decline in varietal performance and significant changes in maturity and phenotypes.

In Senegal, pearl millet seed is produced by GIE and NGOs. The GIE have indicated that certified or commercial seed production was marginally profitable. However, out of the 40 GIE operational in 1997, only 5 were engaged in pearl millet certified seed production. The GIE claimed that the cost of producing pearl millet seed is high because of the large processing and transport costs it required. In effect, it costs 100 F CFA kg^{-1} to process 1 kg of pearl millet seed, representing about one-third of the total production cost. As there is only one seed conditioning center that processes pearl millet seed, the GIE incur huge transport costs to ship the seed from the farm gate to the processing unit and back. However, relative to pearl millet grain production, it was estimated that the GIE could earn a margin of 42 F CFA kg^{-1} on the pearl millet grain price.

In Senegal, groundnut seed is produced by contract farmers of the parastatal company Sonagraines, or the private groundnut company, Novasem, and the GIE. An analysis of the financial profitability of five GIE in Senegal indicated that groundnut seed production is financially profitable. Calculated profit margins ranged from a negative 25 F CFA kg^{-1} to a positive 14.6 F CFA kg^{-1}. This wide range is attributed to management and the scale of operation. In effect, the GIE that produce more than 100 t annually were likely to be financially profitable. This is consistent with the feasibility studies undertaken by the Union interprofessionnelle des semences and the rural bank of Senegal. This explains why the GIE which request and receive credit from the rural bank produce more than 100 t of groundnut seed (Ndjeunga 1998a). The formal seed system in Senegal is relatively more financially efficient than the formal seed system in Niger.

Overall, farmers' uptake of improved seed is higher in Senegal than Niger, and seed is more efficiently produced in the former country. The following sections review the variables that likely explain the differences in seed sector performance in both countries.

Explanatory Variables

Variety Development and Availability

In Senegal, variety development started some 70 years ago at the research station of Bambey led by a French research institute, IRHO. The institute conducted plant breeding in the Bambey research station to serve the whole of West and Central Africa. Applied and adaptative research were then carried out in other countries. Breeding research was essentially focused on export crops such as groundnut and cotton to serve French companies, and little emphasis was placed on cereal crops such as pearl millet and sorghum.

In the 1980s, a joint research effort between the Senegalese national research institute (ISRA) and ICRISAT led to the development of three pearl millet varieties. So far, 13 groundnut and 4 pearl millet varieties have been developed and released in Senegal. During the last ten years, two groundnut varieties have been released (GC 8-35 and Fleur 11) but none of pearl millet. In Niger, since 1975, national and international agricultural research centers have carried out an aggressive breeding program as a result of which more than 17 pearl millet varieties were developed and released. However, little emphasis was placed on groundnut breeding, but several adaptation tests were carried out on varieties developed by IRHO. This led to the release of 9 groundnut varieties suitable to a range of agroecological zones. During the last ten years, 7 pearl millet varieties have been developed and are awaiting release[7] but none of groundnut. The performance of agricultural research has been mixed in both countries. Nonetheless, pearl millet and groundnut varieties are available and are suitable to a wide range of agroecological zones in both countries. However, breeding research efforts will yield higher returns only if varieties are actually used by farmers.

Although the Niger seed system offers a large range of improved pearl millet varieties, only a few of these are found at the village level. Household survey results indicate that farmers grow up to 33 different pearl millet varieties of which only three are improved (HKP, CIVT and P3Kollo). Similarly, only one improved groundnut variety, 55-437, is being grown of the 10 found at the village level. In contrast, in Senegal, all respondents reported sowing improved groundnut varieties. All pearl millet varieties except IBM V 8402 were found in farmers' fields. At the village level, a few local pearl millet or groundnut varieties were found in Senegal. Overall, the uptake of new varieties is higher in Senegal than in Niger.

Seed Multiplication

Despite the large investments in seed multiplication and distribution projects in Niger, the formal system has consistently supplied only a negligible share of the total seed requirement. Between 1990 and 1998, it supplied a little over 2% of the total pearl millet seed sown by farmers and about 1 % of the improved groundnut seed (Table 5). During this period, seed production was limited to 4 out of the 17 pearl millet varieties, and two of these varieties (HKP and CIVT) accounted for 97% of it. Similarly, only one groundnut variety, 55-437, was actually multiplied, out of the nine improved ones available. These results are consistent with rural household survey findings. In 1997, 3% of the total pearl millet seed transactions (Table 6) representing about 2% of the total seed sown by farmers was supplied by the formal sector (Table 7).

7. These varieties include: GB 8735, ICMV 89305, ICMV 92222, ICMV 94206, MTDO 92, NITTY 92, and CTO-V.

Table 6. Proportion (%) of rural households in Niger and Senegal obtaining pearl millet or groundnut seed from various market sources.

	Niger		Senegal	
Seed sources	1996	1997	1996	1997
Pearl millet				
Own stocks	94	89	65	58
Family and friends	8	15	0	3
Village markets	6	13	36	44
Formal sector	2	3	3	5
Groundnut				
Own stocks	63	67	50	41
Family and friends	6	11	1	2
Village markets	30	38	46	47
Formal sector	3	1	14	22

Source: WCA-ICRISAT Survey 1997.

In Senegal, the situation is somewhat different. All improved groundnut varieties are multiplied and made available to farmers. On an average, between 1990 and 1997, it was estimated that 28% of the groundnut seed sown was supplied by the formal sector. In contrast, only about 6% of the total pearl millet seed sown by farmers was provided by the formal seed sector (Table 5). These results are consistent with survey findings which indicate that about 25% of the total groundnut seed sown by farmers was supplied by the formal sector in 1997. Similarly, it was estimated that 3% of the total pearl millet seed sown was supplied by the formal seed sector (Table 7).

Overall, the seed coverage for improved varieties is higher in Senegal, where the private sector (GIE) accounts for about 25% of the total improved groundnut seed produced. However, both countries perform poorly at supplying pearl millet seed. The differences in the levels of seed production are explained by government and private sector commitments to supplying high quality

Table 7. Proportion (%) of pearl millet and groundnut seed sown from various market sources in Niger and Senegal.

	Niger		Senegal	
Seed sources	1996	1997	1996	1997
Pearl millet				
Own stocks	93	82	66	57
Family and friends	2	7	0	1
Village markets	5	9	31	39
Formal sector	0	2	2	3
Groundnut				
Own stocks	89	82	54	36
Family and friends	3	4	0	1
Village markets	8	14	28	38
Formal sector	0	0	18	25

Source: WCA-ICRISAT Survey 1997.

seed to farmers and the degree of input-output market integration in the two countries. In Senegal, because of the need to supply the parastatal groundnut company (Sonagraines) or the private groundnut company (Novasem) with high quality grains, either for the oil refinery or the confectionary divisions, investments have been made by the government and the private sector in the production of all seed classes in order to ensure the supply of high quality seed of the preferred varieties. The relationship between producers and users has been well-established through input credit (seed and fertilizers) and grain contracts, which ensure access to inputs and a guaranteed forward price for the groundnut grain. This contractual scheme provides a linkage between the input and output markets and motivates producers to use seed of improved varieties. In Niger, the situation was somewhat identical prior to 1982, when three oil refineries (SECCO in Maradi, SNH in Matameye, and Sepani in Magaria) were operational. Since these companies were phased out in the mid-1980s, there has been less incentive for farmers to use seed of improved varieties because there is no guaranteed market for groundnut.

The production of pearl millet seed in both countries is relatively low. While in Niger this is the case for both crops, in Senegal, the production of groundnut seed is relatively poor although it has a poorer justification for seed purchase. The basic difference between pearl millet and groundnut crops in Senegal is that groundnut has a well-organized output market as opposed to pearl millet. In contrast, in Niger, there is no well-organized output market for either groundnut or pearl millet. In Senegal, groundnut has a higher commercial value than in Niger. The poor commercial value of pearl millet may partially explain the low intake of improved seed and the lack of private sector interest in its seed production.

The informal seed sector is the main seed provider in both countries. Farmers' own stocks are the primary source of seed. Only if this source is insufficient will farmers look to others such as family and friends, local village markets, or the formal seed sector. In 1997, for example, 89% of the rural households in Niger and 58% of them in Senegal drew pearl millet seed from their own stocks (Table 6). Local village markets are the second most important source of seed contributing 39% of the total pearl millet seed sown in Senegal in 1997 and 9% in Niger. This compared to 5% and 2% contributed by formal seed sources in Senegal and Niger respectively. Similarly, village markets remain the main source of groundnut seed. In Senegal, 38% of the total groundnut seed sown was bought from the local village markets in 1997; and only 14% in Niger (Table 7).

Overall, the informal seed sector still remains the main seed supplier in both countries. But the relative magnitude of this sector varies with the commercial value of the crop. While the informal seed sector provides the entire groundnut seed sown by farmers in Niger, about 25% of the seed sown by farmers in Senegal is purchased from the formal market. Groundnut holds a higher commercial value for rural households in Senegal than in Niger as it is a cash crop with well-organized input and output markets.

Seed Distribution

In the formal seed sector, most of the seed produced is actually sold in Senegal compared to less than 30% of the pearl millet seed in Niger (except in years following droughts). This difference can be attributed to the degree of development of the seed distribution network. In Niger, there are only 20 formal distribution outlets located in the headquarters of seed production units, research station or the regional directorate of agriculture. To reach one of these, a farmer travels an average of 62 km. For such distances, transaction costs are likely to be high, therefore discouraging farmers from purchasing seed, and thus limiting access to seed of improved varieties. In Senegal, more than 400 distribution outlets (SECCO) are available throughout the country, and farmers need to travel only about 12 km to purchase seed. Senegal is endowed with a relatively well-developed formal seed distribution network than Niger.

Table 8. Proportion (%) of farmers participating in the village seed markets in Niger and Senegal, 1996-97 sowing seasons.

	Niger		Senegal	
Type of participation	1996	1997	1996	1997
Pearl millet				
Net seed suppliers	44	26	8	11
Net seed buyers	11	26	31	42
Groundnut				
Net seed suppliers	8	8	5	4
Net seed buyers	23	41	58	68

Source: WCA-ICRISAT survey 1997.

The informal seed trade is not clearly differentiated from the grain trade. In the informal seed sector, farmer-to-farmer seed exchange remains the main distribution channel in both countries. Household survey results indicate that in 1997 about 26% of the respondents in Niger and 11% in Senegal were pearl millet seed suppliers (Table 8). In 1997, these households supplied an average of 35 kg of pearl millet to seed buyers in Niger and 25 kg in Senegal. Similarly, these households supplied an average of 9 kg and 95 kg of groundnut seed to seed buyers in Niger and Senegal respectively in 1997.

Most seed supply transactions are made in the form of gifts, free trade or barter. In 1997, 89% and 71% of pearl millet seed transactions were made free followed by barter transactions in Niger and Senegal respectively (Table 9). The type of seed transaction varies with the commercial value of the crop. On the demand side, in Niger, about half the pearl millet transactions are barter or free trade and the remaining cash transactions. In Senegal, more than 95% of the pearl millet seed transactions are made in cash or credit (Table 9). This result is different from that for groundnut. More than 90% of the demand seed transactions were market transactions in both countries. Seed transactions were found to be more flexible in Senegal than in Niger. The prevalence of input credit contracts provides incentives for farmers to use improved groundnut varieties. In effect, Sonagraines and Novasem provide input

Table 9. Type of pearl millet and groundnut seed supply transactions in Niger and Senegal, 1996-97 sowing seasons.

	Niger		Senegal	
Type of transactions	1996	1997	1996	1997
Pearl millet				
Gifts	32.7	35.0	1.0	3.1
Barter	6.1	11.4	2.1	0.8
Credit	2.0	3.3	1.0	0.8
Cash	59.2	50.4	95.8	95.2
Groundnut				
Gifts	0.0	7.9	0.0	1.4
Barter	0.0	0.0	0.5	0.0
Credit	0.0	3.2	21.5	32.9
Cash	100.0	88.9	78.0	65.8

Source: WCA-ICRISAT Survey 1997.

credit in the form of seed and fertilizers to farmers. This is recoverable at harvest with the sale of groundnut grain. In Niger, all groundnut seed transactions are made in cash, and farmers purchase seed mainly from the village markets.

Seed Selection, Storage, and Quality

Due to the perishability of seed as living organisms and the seasonality of both seed production and use, seed storage is a critical function. Inadequate seed storage results in losses of seed quality (e.g., viability and germination rates), and in higher operating costs for the seed enterprises. The performance of seed systems can be partly evaluated in terms of the quality of seed selection and storage practices, because these may affect the quality of seed (purity of seed stocks, intensity of varietal erosion, spread of diseases, and rates of germination).

Seed selection. Seed selection to ensure good seed quality takes place in the field before harvest through standard plant selection procedures. The formal seed systems in Niger and Senegal do not differ on seed selection criteria. Standard seed selection practices focus on plant and grain types. Farmers can select seed based on an observation of plant type as well as the quality of grain, and there is a likelihood of reduced infestation if the grains are immediately treated and stored.

Groundnut seed selection in the field is practised by about 62% of the farmers in Senegal and 41 % in Niger. The remaining farmers select their seed right before sowing. The selection criteria include, in order of importance, large pod size, large grain size, and low disease or insect attacks on pods or grains. Plant selection is less widely practised for pearl millet. In Niger, only about 3% perform plant selection and more than 96% of the farmers select the best panicles after harvest. In Senegal, about 28% perform plant selection and the rest select good panicles after harvest. The common practice is to select big and long panicles, large grain size, and low incidence of apparent diseases and insect damage. In both countries, few households were found to select seed from their grain stocks, except in years following drought. Seed selection criteria are relatively similar in both countries. Therefore, it is unlikely that differences in seed sector performance are attributable to farmers' knowledge of best selection practices.

Seed storage. In the formal system, seed storage practices do not significantly differ between the two countries. After seed has been treated, it is stored in polyethylene bags and packaged in large or small jute bags which are stored in a cool dry place. In the informal seed system, in Niger for example, 95% of the respondents reported that they store seed in the form of panicle bundles in the granaries. In contrast, in Senegal, seed is stored in a variety of forms and locations. About 31 % of the farmers stored seed in the form of grain in a warehouse or in their house, 31% in the form of panicles, and only 17% in granaries. In addition, about 18% of the respondents were found to hang panicles in a tree or on the roof (Table 10). In Niger, about 22% of the rural households reported treating pearl millet seed with insecticides while 32% did so in Senegal.

In Niger, about 90% of the farmers store their groundnut seed in shells and in the granaries. In contrast, there is a wide range of storage practices in Senegal. Groundnut is stored in the form of seed or pods packaged in barrels or bags in warehouses or houses. About 73% of the respondents store their seed in the form of decorticated grain in their house or warehouse, while 22% of them only store seed in the form of shelled groundnut. Few farmers treat their groundnut seed in Niger (16%). In Senegal, about 56% of the rural households treated their seed with insecticides and 3% wrapped it in special leaves. The prevalent forms of packaging were found to be bags (75%), and barrels (11%) and the remaining were in loose form. Overall, in both countries, farmers did not complain of seed losses from

Table 10. Alternative pearl millet and groundnut seed storage methods in Niger and Senegal.

Form and location of storage	Niger	Senegal
Pearl millet		
Panicle bundles in house	0	19
Grain in the house	0	12
Panicle bundle in granaries	95	17
Panicle bundle in warehouse	0	12
Grain in warehouse	0	19
Hang panicles on tree	0	11
Panicle bundles on the roof	0	5
Others	5	7
Groundnut		
Groundnut in shells in house	0	8
Decorticated grains in house	0	28
Groundnut in shells in warehouse	0	14
Decorticated grains in warehouse	0	45
Groundnut in shells in warehouse	10	0
Groundnut shells in the house	89	0
Others	1	4

Source: WCA-ICRISAT Survey 1997.

storage, signaling that they did not perceive any germination problems with their seed. Future studies should concentrate on seed viability under different storage methods.

In the informal sector, in both countries, few farmers complained of loss of viability of seed, implying that there are no significant losses from storage or that farmers did not experience any losses due to poor germination. These findings are consistent with the partial results of pearl millet seed quality tests performed in Niger or the groundnut seed quality tests performed in Senegal. These results corroborate those from a study on traditional seed selection and conservation methods in Niger (Ouendeba et al. 1998).

Inadequate attention to seed selection and suboptimal storage practices are likely to affect seed quality, resulting in seed with poor vigor or germination rate, poor varietal and physical purity, low resistance to diseases and insects, and low yield potential. In both countries, the formal sector defines quality in terms of the International Seed Trade Association (ISTA) standards. High germination rate (98%), low moisture content (12%), and high level of physical purity (98%) are the main criteria pursued by the formal seed sector. In addition, genetic purity of about 98% is required to be achieved through field inspections. These standards differ from those pursued by farmers in the informal sector. Observable grain characteristics such as inert matter content, uniformity of grain color, large grain size, and low insect/disease attack are the main criteria pursued by farmers. Although germination rate is an important quality standard in the informal market, respondents did not encounter major problems of germination. This in turn may be due to three factors: fairly low moisture content in the seed, low ambient humidity (dry), and absence of factors that favor the incidence of fungal attacks. In addition, relatively high seeding rates are used by farmers, which may compensate for poor germination.

Results from standard formal quality tests showed that germination rate, moisture content, and percentage of impurities were in line with ISTA standards. In the informal seed sector, standard quality tests were performed on farmers' seed stocks in Niger. Results indicate that farmers' seed stocks have acceptable levels of germination and moisture content and low incidence of seedborne fungal diseases,

consistent with their set of standards. Viability tests on samples obtained from farmers showed germination rates averaging 88% (range 77-98%) and moisture content averaging 9% (range 7-17%). Farmers' seed stocks were found to be in good health. Incidence of fungi was low in the surveyed areas. The proportion of seed attacked by fungi per seed lot was estimated to average 8% (range 0-26%). Fungal attacks do not appear to cause serious germination losses because these pathogens are just contaminants present only on the surface and do not infect the embryo. Therefore, seed viability is unlikely to be affected. With regard to analytic purity, few damaged grains or inert matter were found. On an average, 5 out of 100 grains were found to be damaged per seed lot. In Niger, pearl millet farmers' seed stocks were of acceptable quality. Similar results were reported for sorghum seed quality in Zambia. Quality tests on farmers' sorghum seed stocks indicate germination rates of 89% for the Senanga district and 84% for the Kalomo district. Only a few samples fell below the recommended 70% cutoff set by the FAO quality declared seed system (Tripp et al. 1998b; FAO 1993). In Ghana, farmers' pearl millet and sorghum seed stocks had acceptable germination rates (average 70%) (Tripp et al. 1998a).

In Senegal, results from a seed quality test on farmers' groundnut seed stocks performed by the Seed Division showed they were of acceptable quality. In 1996/97, results indicate a varietal purity between 93% and 100%, and germination rates between 76% and 100% with low incidence of disease and pests (MA/DA/DSA 1997). These results are consistent with similar studies on groundnut farmers' seed stocks done in Zambia. Germination rates averaged 79% for the Senanga district and 89% for the Kalomo district with very few samples below the recommended minimum of 60% (Tripp 1998b; FAO 1993). Although the results are not comparable between countries, the tests provide some evidence that farmers' pearl millet and groundnut seed stocks may be of relatively good quality. In effect, farmers' indigenous seed care skills and technologies appear consistently to produce seed of equal or better quality than that produced by the formal seed sector with minimal investment in storage costs (Cromwell et al. 1993). Results from this study indicate that the performance of the seed system cannot be attributed to the quality of seed produced and distributed.

Seed Security Stocks

One significant and difficult issue seed systems have to deal with is how to provide seed to households with limited or no seed stocks in the year following a drought. There is considerably less incentive for private firms to maintain significant reserve seed stocks of food crops to compensate for a drought or other natural event which greatly diminishes the availability of seed. Only in mature systems would we expect firms to maintain multiyear seed stocks in order to keep their market shares during the period of seed shortage. For crops whose seed is normally retained by farmers, there would be little opportunity for profit in long-term seed storage. The holding of reserve seed stocks is thus expected to be a function undertaken by the public sector or else contracted out to a private firm by a public organization or left to local village seed systems.

In contrast to the existence of or attempts by governments at providing seed security stocks in these countries, there is little effort to ensure seed availability in a sustainable manner in case of natural disasters. In Senegal, for example, governments often purchase the first generation of commercial seed from large and reputed farmers, to add to the certified groundnut seed stocks. There are no schemes that deal with pearl millet seed security stocks. In Niger, governments through food security schemes assume that households that produce less than 50% of their total cereal grain needs are de facto seed-insecure. Often, governments or special projects purchase grains from the local village markets and distribute it as seed to grain-insecure households. Such free distribution has an

inherent danger. If the grain purchased is not from the same locality or similar in maturity and phenotype to the species grown in the region, there is a danger that the completely nonadapted material may not produce any yield, or is of lower quality. Often, seed security needs are overestimated. In 1997, for example, it was estimated that about 30% of all villages in Niger had no seed to sow (MAG/EL 1998), whereas rural household surveys indicated that only one village (Garbey Gomande) out of the 58 surveyed had completely run out of seed. In both countries, there is little emphasis on seed security needs in case of severe droughts. This could be partly explained by the capacity of local village seed systems to partially deal with seed security needs.

To assess the severity of seed security constraints, farmers were asked to specify the year when they last ran out of seed for sowing; the primary seed sources in years of drought, and sources where farmers are sure to always find pearl millet seed irrespective of drought. In Niger, 35% of the respondents and about 58% in Senegal reported that they never had run out of pearl millet seed. Seed insecurity is high during the years following a drought. In 1984, following the drought of 1983 about 15% of the rural households in Niger and 8% of rural households in Senegal were short of seed (Table 11). Similarly, in 1997, following the 1996 drought, 10% of the rural households in Niger were seed-insecure.

In both countries, local village markets are the primary sources of seed security stocks. In Niger, for example, 93% of the farmers depend on them during drought years and 95% of the respondents considered them as a place where they would always find seed. This proportion is lower in Senegal. In effect, this may be explained by the level of development of the formal sector. In Senegal, about 26% of the households considered the formal sector as their primary source of pearl millet seed and 23% of them said it was where they were always sure to find seed. The demand for seed in the formal sector is high during the year following a drought (Table 12). In any case, the local village market is the primary source of pearl millet seed in case of an unforeseen event.

Governments in both countries have no seed security stock policy. For groundnut in Senegal or pearl millet in Niger, grain is bought from the market, conditioned and distributed as seed. Therefore, the difference in seed sector performance between the two countries cannot be attributed to a better

Table 11. Years in which households (%) last ran out of pearl millet seed in Niger and Senegal.

Year	Niger	Senegal
Prior to 1983	6	8
1984	15	1
1985	2	1
1986	0	0
1987	3	2
1988	1	0
1989	1	1
1990	5	1
1991	2	3
1992	5	2
1993	4	3
1994	5	5
1995	4	5
1996	2	4
1997	10	2
Never ran out of seed	35	58

Source: WCA-ICRISAT Survey 1997.

Table 12. Primary seed security sources for farmers in Niger and Senegal.

	Niger	Senegal
Seed sources during drought years		
Village markets	73	93
SECCO	10	NA[1]
Family and friends	1	0
Formal sources	16	7
Where farmers are always sure to find seed		
Village markets	77	95
SECCO	9	NA
Family and friends	1	0
Formal sources	13	5

1. NA = Not applicable.

Source: WCA-1CRISAT Survey 1997.

seed security stock policy. Local village seed systems are relatively more efficient at dealing with seed security needs than governments, and the private sector has no incentives to carry stocks of seed of crops that have uncertain demand. This is evidenced by the high proportion of farmers depending on local village markets to supplement their seed stocks during years following droughts. Therefore, investments aimed at enhancing the capacity of local village seed systems to manage seed security stocks is warranted.

Seed Prices

The price of improved seed was not cited by farmers in Niger and Senegal as a major constraint to seed uptake. Rather, all farmers cited poor access to seed as the main constraint to uptake of improved seed. In Niger, for example, pearl millet seed prices are set by the government a little above the grain price in the local village markets. In 1996, the seed price was set at 130 F CFA kg^{-1} by the SPC of Magaria compared to the grain price averaging 113 F CFA kg^{-1} in Zinder[8]. In Guecheme, the seed price was set at 175 F CFA kg^{-1}, i.e., 4% below the grain price in the local village market. In Senegal, on an average, groundnut seed was priced 20% higher than grain and pearl millet seed 186% higher than grain (Table 13). Current experiences with hybrid sorghum in Niger indicate that farmers are willing to purchase seed at prices more than eleven-fold higher than grain prices. In 1997, hybrid seed growers and INRAN sold hybrid sorghum seed at prices between 800 F CFA kg^{-1} and 1500 F CFA kg^{-1} compared to the grain price estimated at 137 F CFA kg^{-1}; and there was no hybrid seed stock left. Similarly in Senegal, seed price was not cited as the main constraint to seed uptake, but rather seed accessibility. The Union interprofessionnelle des producteurs de semences sets seed prices taking into account the farm input and processing costs. In 1997, the pearl millet seed price was estimated to have been three to four times higher than the grain price; and all GIE seed producers as well as the NGO World Vision reported that they had no seed stock left. Similarly, groundnut seed price is set a little above the grain price. In both countries, the higher seed price is not a disincentive for farmers to adopt or use improved seed. Thus, because of the willingness of farmers in investing in seed of good quality, the seed price does not explain the current difference in the seed sector performance in Niger and Senegal.

8. The June-July 1996 average consumer price in the nearest local village market.

Table 13. Trend in pearl millet and groundnut seed and grain prices[1] in few selected markets in Senegal and Niger.

	1995	1996	1997
Senegal			
Groundnut			
Certified seed prices (F CFA kg^{-1})	320	360	400
Grain prices (F CFA kg^{-1})			
Bambey market	298	287	349
Ndiagne market (Louga)	265	270	353
Dioli Mandhakh (Kaffrine)	254	258	328
Touba Toul (Tiavouane)	265	285	354
Pearl millet			
Certified seed prices (F CFA kg^{-1})	250	350	400
Grain prices (F CFA kg^{-1})			
Bambey market	128	134	135
Ndiagne market (Louga)	134	139	137
Dioli Mandhakh (Kaffrine)	116	121	109
Touba Toul (Tiavouane)	138	152	136
Niger			
Pearl millet			
Range in certified seed prices in SPCs (F CFA kg^{-1})[2]	90-105	80-120	85-105
Grain prices (F CFA kg^{-1})			
Maradi market	56	98	150
Zinder market	67	113	154
Katako market	88	135	170
Tillabery market	97	152	185
Dosso market	88	130	182

1. Grain prices reported here are average consumer prices from May to July in Niger and from June to August in Senegal. These months span the sowing period in both countries.
2. This represents the range of certified improved seed prices in the seed production centers of Kourugousso, Guecheme, and Magaria.

Sources: SIM/OPVN in Niger and CSA/CEI/SIM in Senegal.

Summary and Conclusions

The informal seed systems still remain the main seed sources for almost all small-holder farmers in both Niger and Senegal. In both countries, these systems perform fairly well at supplying seed to end-users, distributing seed at relatively low cost, and maintaining acceptable levels of seed viability and health. They are also able to maintain a wide access to a large range of improved varieties at low transaction costs. However, they have difficulty meeting seed security stock needs. Donors and governments should invest more resources in enhancing the capacity of the informal seed systems for managing seed security stocks, ensuring access to new varieties, and possibly improving seed flows from surplus to deficit regions after droughts.

The formal seed systems perform differently in regard to supplying and distributing seed to end-users. The primary performance criteria indicate that pearl millet and groundnut seed coverages are higher in Senegal than Niger. The seed production and processing centers operate with high financial losses in Niger and are not sustainable. In contrast, in Senegal, seed is produced by the private sector and is marginally profitable.

Differences in the performances of the formal seed sectors in the two countries were not reflected in their institutional and legal settings, variety availability and suitability, seed selection and storage, seed quality, and seed security stocks management. However, significant differences were found in the level of development of their seed distribution network, the degree of integration of their input-output markets, and private sector involvement in the seed industry (Table 14). In effect, the poor seed distribution network, public sector inefficiencies, and limited integration of the input-output markets for both pearl millet and groundnut in Niger have limited the uptake of improved seed. In Senegal, the relatively well-developed seed distribution network, and well-integrated input-output markets for groundnut have induced the uptake of improved seed. Formal seed systems do not operate well unless linked with well-functioning product markets. An element of targeted subsidy may be needed to

Table 14. Seed infrastructure and legal environment in Niger and Senegal.

Variable	Niger	Senegal
Number of improved pearl millet varieties available	17	4
Number of groundnut varieties available	9	13
Number of pearl millet varieties actually multiplied	4	4
Pearl millet improved variety coverage (%)	2.17	3.57
Groundnut improved variety coverage (%)	1.06	28
Number of seed distribution and sale outlets	20	400
Average radius from distribution outlet (km)	62	12
Number of seed conditioning centers	0	4
Seed quality control	Low	High
Number of GIE seed producers	0	115
Private sector involvement	Very low	Medium
Well-defined national seed policy	No	Yes
Existence of national seed service	No	Yes
Existence of seed laws	No	Yes
Existence of national seed committee	No	Yes
Existence of seed security stock policy	Yes	Yes
Implementation of seed security stock policy	No	No

Source: WCA-ICRISAT Survey 1997.

improve access to new varieties. Alternatively, seed markets need to build on the foundation of seed supply of more commercialized crops. Several examples from the semi-arid tropics of West and Central Africa support the latter claim. Groundnut and rice in Senegal have enjoyed well-developed product markets and the demand for seed of the two crops is high. Similarly, in Burkina Faso, the uptake of groundnut varieties is high due to a well-developed product market. Conversely, pearl millet which still remains a subsistence crop with a poorly developed product market faces thin demand for seed in all countries in the SAT of West Africa.

Several lessons could be drawn from this study. These could be used to enhance the uptake of new varieties.

- Crops of low commercial value such as pearl millet are more suitable for informal seed systems. To increase seed uptake, one should focus on improvement of the informal sector.
- Input-output trade contracts help stimulate the uptake of the so-called crops of low commercial value. Groundnut which has a low justification for seed purchase has a higher seed coverage in Senegal than pearl millet. In contrast, in Niger, both pearl millet and groundnut have a very low seed coverage.
- Easy access for farmers to selling points could stimulate the uptake of improved varieties. The Senegalese seed system is endowed with a relatively well-developed seed distribution network. All seed produced is sold. Whereas, less than 30% of the seed supplied by SPCs in Niger is sold, thus adding to the losses incurred by the public sector.

Future trends in seed sector development will likely lead to the establishment of sustainable institutions driven by the private sector. The development of institutions with clearly defined roles operating in a flexible legal environment are likely to increase the uptake of new varieties. The private sector will continue to be less interested in crops of low commercial value. This void should be filled by promoting local village seed systems whereby more efficient farmers or groups of farmers can be encouraged to multiply and disseminate improved varieties.

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Appendix

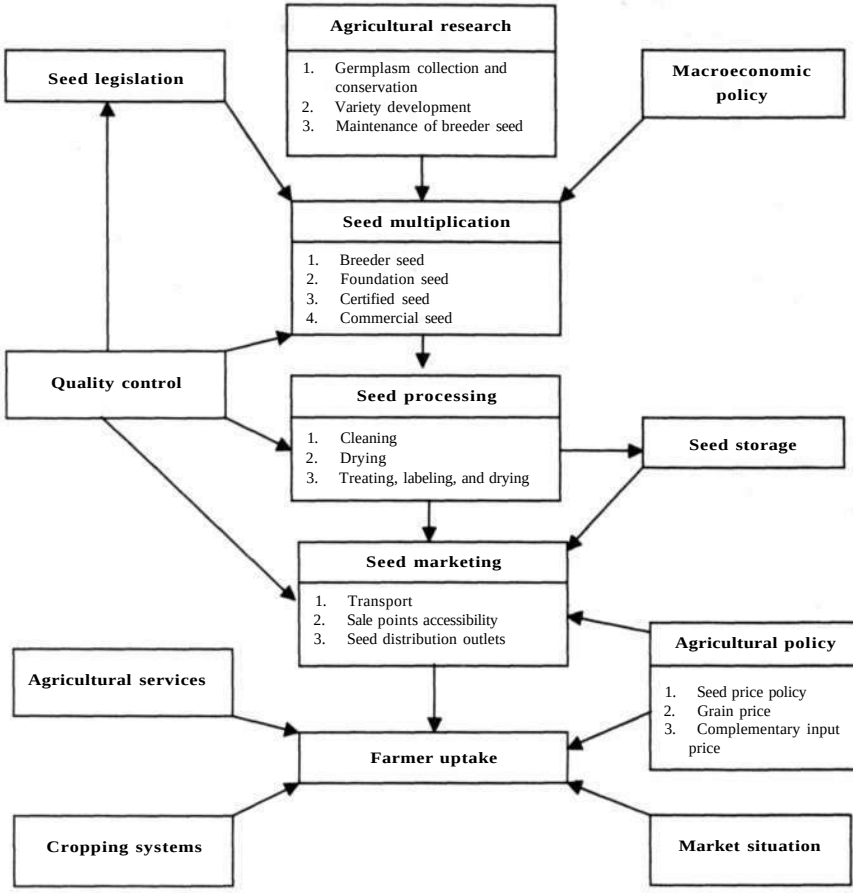

Figure 1. Components of a seed system (Cromwell 1996).

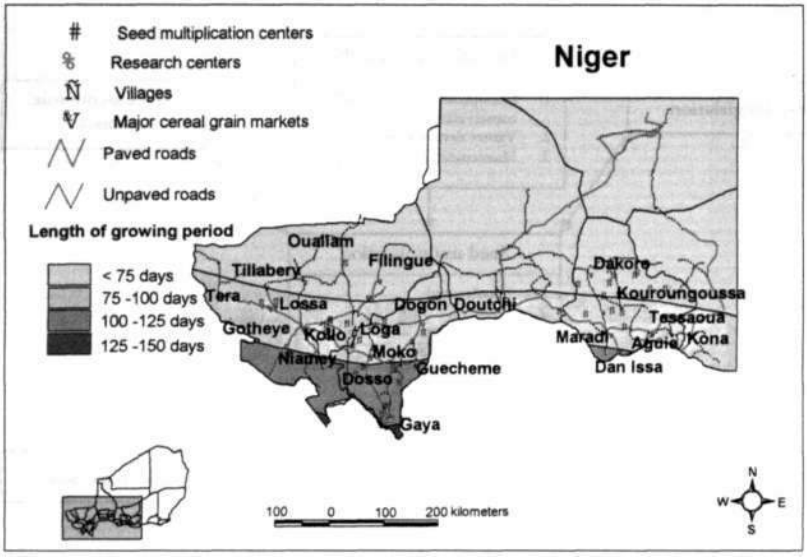

Figure 2. The location of the surveys conducted in Niger

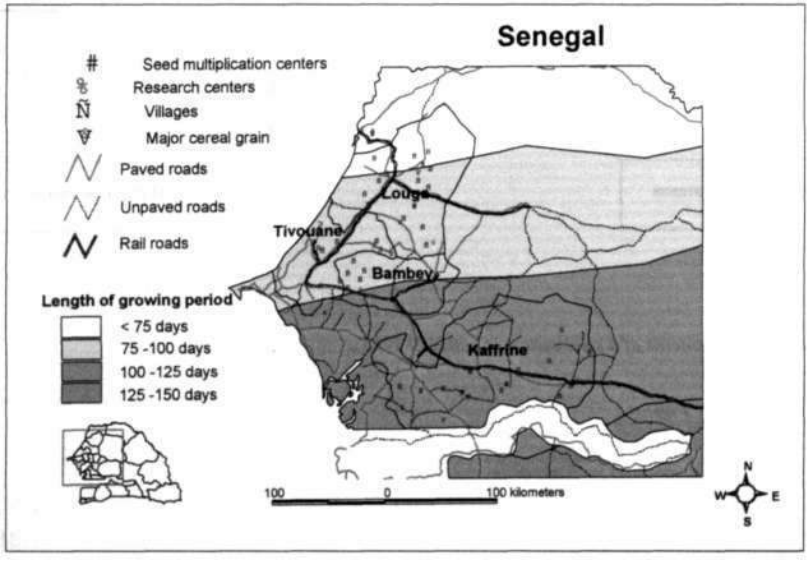

Figure 3. The location of the surveys conducted in Senegal.

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 16 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank.

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