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Development of the Vegetable Seed Sector in Mali and Opportunities for Irrigated Seed Production

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June 2021

World Vegetable Center

The World Vegetable Center, an international nonprofit institute for vegetable research and development, mobilizes resources from the public and private sector to realize the potential of vegetables for healthier lives and more resilient livelihoods. WorldVeg's globally important genebank, improved varieties, production, and postharvest methods help farmers increase vegetable harvests, raise incomes in poor rural and urban households, create jobs, and provide healthier, more nutritious diets for families and communities.

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Publication No. 21-1035

Front cover: Farmers in Mali testing a WorldVeg released pepper variety, January 2019

Suggested citation
Dembélé S, Tignegre JB, Diarra BG. 2021. Development of the Vegetable Seed Sector in Mali and Opportunities for Irrigated Seed Production. World Vegetable Center, Shanhua, Taiwan. Publication No. 21-1035. 39 p.

Funding Statement

This publication was partly made possible through support provided by Feed the Future Innovation Lab for Small Scale Irrigation through the U.S. Agency for International Development, under the terms of Contract No. AID-OAA-A-13-00055. The opinions expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Agency for International Development. The authors also acknowledge long-term strategic donors to the World Vegetable Center: Taiwan, UK aid from the UK government, U.S. Agency for International Development (USAID), Australian Centre for International Agricultural Research (ACIAR), Germany, Thailand, Philippines, Korea, and Japan.

Acknowledgment

We acknowledge the contributions of Kabirou Ndiaye, Marwan Benali, Pepijn Schreinemachers and Rosaine Nerice Yegbemey to this study. We are grateful to all interviewed stakeholders in Mali's vegetable seed sector who made their time available.

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Acronyms and abbreviations

AOPP	Association of Professional Farmers' Organizations / Association des Organisations Professionnelles Paysannes
APS	Association of Seed Producers / Association des Producteurs de Semences
ASSEMA	Seed Farmers' Association of Mali / Association Semencière du Mali
OPIB	Baguineda Office for Irrigated Perimeters / Office des Périmètres irrigués de Baguida
CANAEVV	National Catalog of Plant Species and Varieties / Catalogue National des Espèces et Variétés Végétales
CEA	Economic Commission for Africa / Commission Economique pour l'Afrique
CHV	Variety Homologation and Registration Commission / Commission d'Homologation et d'Inscription des Variétés
CILSS	Inter Sahelian Committee for the Fight against Drought in the Sahel / Comité Inter Sahélien de Lutte Contre la Sécheresse dans le Sahel
CIP	International Potato Centre
CIRAD	Centre for International Cooperation in Agricultural Research for Development / Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CNS	National Seed Committee / Comité National des Semences
COAFEV	West African Catalog of Plant Species and Varieties / Catalogue Ouest Africain des Espèces et Variétés Végétales
COPROSEM	Seed Production Cooperative / Coopérative de Production de Semences
CORAF/ WECARD	West and Central African Council for Agricultural Research and Development / Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricole
CRRA	Regional Center for Agronomic Research / Centre Régional de Recherches Agronomiques
CRS	Regional Seed Committee (of ECOWAS) / Comité Régional des Semences (de la CEDEAO)
CSLP	Strategic Committee for the Fight against Poverty / Comité Stratégique de Lutte contre la Pauvreté
DLCP	Legislation and Phytosanitary Control Division / Division Législation et Contrôle Phytosanitaire
DNA	National Directorate of Agriculture / Direction Nationale de l'Agriculture
DUS	Distinctness, Uniformity and Stability
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization of the United Nations
FCFA	West African CFA franc
GDP	Gross Domestic Product
IER	Institute of Rural Economy / Institut d'Economie Rurale
IITA	International Institute of Tropical Agriculture
IPR/IFRA	Rural Polytechnic Institute for Training and Applied Research / Institut Polytechnique Rural de Formation et de Recherche Appliquée
IRD	Research Institute for Development / Institut de Recherches pour le Développement
KII	Key Informant Interview
LABOSEM	National Seed Certification Laboratory / Laboratoire des Semences
MPC	Mali Protection des Cultures (import company) / Mali Protection des Cultures
NGO	Non-Governmental Organization

OMA	Agricultural Market Observatory / Observatoire du Marché Agricole
ODR	Rural Development Operations / Opération de Développement Rural
OPSS	Operation for Production of Selected Seeds / Opération Production de Semences Sélectionnées
OPV	Open pollinated variety
PAFISEM	Mali Seed Sector Support Project / Projet d'Appui à la Filière Semencière du Mali
RTS	Flexible hose ramp (Rampe à tuyau souple)
SOC	Official Control and Certification Service / Service Officiel de Contrôle et de Certification
SOGEBA	General agricultural business company / Société Générale de Business Agricole
SOPROSA	Improved Seed Production Company / Société de Production de Semences Améliorées
SRCSS	Section for Research and Control of Selected Seeds / Section de Recherches et de Contrôle des Semences Sélectionnées
SSN	National Seed Service / Service Semencier National
UNCPM	National Union of Cooperatives of Planters and Market Gardeners of Mali / Union Nationale des Coopératives de Planteurs et Maraîchers du Mali
URG	Genetic Resources Unit (of IER) / Unité des Ressources Génétiques (de l'IER)
USB	Basic Seeds Unit (of IER) / Unité des Semences de Base (de l'IER)
VCU	Value for Cultivation and Use
WAEMU	West African Economic and Monetary Union
WHO	World Health Organization
WorldVeg	World Vegetable Center

Summary

The vegetable sector in Mali has grown very rapidly over the last decade. Vegetables are produced by small-scale farmers across the country with the main areas located in Sikasso, Ségou, Kayes, Koulikoro and Bamako. Vegetables of high economic importance include okra, shallot, tomato, chili pepper, onion, lettuce, squash, eggplant, cucumber and cabbage. Farmers' seed demand for these crops has been largely met with seed imports while the informal sector (that is, seed saved by farmers for own use and local exchange) is the main source of seed for most other vegetables, particularly traditional vegetables. Only small amounts of vegetable seed are produced by the formal sector in Mali. This study's objective was to review the development of local vegetable seed production in Mali and to identify key challenges as well as entry points to its development. Particular attention was given to the potential of irrigation to stimulate local seed production. The study focused on the formal vegetable seed sector, consisting of seed companies, seed cooperatives and agrodealers, however, without ignoring the informal and semi-formal sectors. Data were collected through a review of available literature and over 70 interviews with government officers, seed companies, seed cooperatives, individual seed producers, agrodealers and seed distributors.

The results identify a range of factors constraining domestic production of vegetable seed. While there has been much progress in organizing individual seed producers into cooperatives and associations of seed producers, these organizations face a range of constraints including low technical capacity of staff, limited access to finance, lack of seed processing and packing equipment, and lack of irrigation technologies that often limit seed production to the wet season. Agrodealers mentioned that locally produced seed does not look as attractive as imported seed packs. Imported seed requires a phytosanitary certificate and germination testing, but does not require variety registration. Locally produced varieties are subjected to multilocation and multi-season trials for Value for Cultivation and Use (VCU) and Distinctness, Uniformity and Stability (DUS) to be registered in a national catalogue of plant varieties before they can be released. Furthermore, local vegetable seed production is subjected to mandatory seed certification and formally requires 4-5 field visits by government inspectors, although in practice they tend to visit only once due to capacity constraints. Such requirements disadvantage local vegetable seed production relative to seed imports. The problem is further compounded by the fact that many seed imports escape phytosanitary and custom inspection. Some of these challenges could potentially be addressed by regional harmonization of seed laws, but Mali's seed laws are still not fully aligned, standards have been agreed only for tomato and onion, and a list of quarantine pests and diseases is not available—all of which limit the effectiveness of regional harmonization.

It is recommended that the vegetable seed sector is given higher priority in government policies. Seed laws and regulations need to be revisited to take the specific nature of vegetable seed into account. Requirements related to variety registration, seed certification, and basic seed production may need to be eased for vegetables to make local seed production more competitive. The technical capacity of local seed producers also requires strengthening and they need access to seed processing and packaging equipment, storage, improved irrigation equipment, and finance. Finally, there is a need to invest in local vegetable breeding research to increase farmers' choice of locally adapted varieties.

1 Introduction

Agriculture in Mali employs more than 80% of the working population. The potential of arable land for agricultural production is estimated at 2.2 million hectares (ha) with water supplied by the Niger/Bani and Senegal river systems (Diarra 2002). The area of small-scale vegetable production ("maraîchères" in French), including potato, sweet potato and cassava increased from 10,000 ha in 2007/2008 (DNA 2008) to more than 200,000 ha in 2018/2019 (DNA 2019): a twenty-fold increase over a decade.

Vegetables are produced in all parts of the country where water is available (**Table 1**). The main vegetable producing areas are in Sikasso, Ségou, Kayes, Koulikoro and Bamako. The south of Mali (Sikasso region) accounted for more than 35% of vegetable output and 40% of the vegetable area in 2019. In the Office du Niger zone, vegetable production generated a turnover of nearly 30 billion FCFA (~56 million USD) (Drabo 2017), with shallot being the main vegetable. A lot of the country's shallot production also comes from the Dogon Plateau in Mopti and from the Sahelian areas. Onion, tomato, okra, chili pepper, and leafy vegetables (cabbage, lettuce) are grown in all regions of Mali from Kayes to Kidal via Koulikoro, Sikasso, Ségou, Mopti, Timbuktu and Gao. Potato is mainly produced in the Sikasso basin, but also in Ségou and Koulikoro and on the oasis sites of Kidal where there is access to groundwater. Nevertheless, the production of vegetables is often concentrated around urban centers, in particular in the vegetable production belts of Bamako, Baguineda, Kati and Samanko.

Table 1: Area and production of vegetables by administrative region of Mali in 2019

Region	Leafy vegetables		Fruit vegetables		Root, tuber and bulb vegetables		Total	
	Area (ha)	Production (tons)	Area (ha)	Production (tons)	Area (ha)	Production (tons)	Area (ha)	Production (tons)
Kayes	855	10,573	3,954	58,476	704	11,731	5,513	80,780
Koulikoro	3,431	37,389	33,785	368,097	15,615	235,273	52,831	640,759
Sikasso	4,920	64,891	45,965	535,671	31,144	513,150	82,074	1,113,88
Ségou	707	11,329	28,334	569,542	12,905	316,825	41,946	897,696
Mopti	666	8,471	3,422	37,170	3,832	97,875	7,920	143,516
Timbuktu	217	2,633	1,127	13,842	5,446	99,816	6,790	116,291
Gao	68	739	407	3,537	1,972	35,434	2,447	39,710
Kidal	-	-	93	1,668	-	-	93	1,668
Menaka	-	-	-	-	-	-	-	-
Taoudenit	-	-	-	-	-	-	-	-
Bamako	2,263	34,159	1,171	18,941	571	13,651	4,005	66,751
Total	13,126	170,183	118,258	1,606,94	72,189	1,323,75	203,573	3,100,88

Source DNA 2019. Note: Leafy vegetables: cabbage, lettuce, parsley, cowpea leaf, sweet potato, celery, spinach; Fruit vegetables: eggplant, jaxatu, okra, tomato, pepper, chili, cucumber, melon, squash, green bean, watermelon, strawberry. Root vegetables, bulbs and tubers: onion, shallot, garlic, carrot, beetroot, radish, turnip, cassava, yam, sweet potato, potato, taro.

Cultivation is practiced in the rainy season as well as in the dry season under irrigation. Vegetables are produced in the off-season after rice in developed areas such as the Office du Niger, the Baguineda irrigated perimeter office, and particularly in Sikasso. Vegetables are also found in village perimeters, often with rudimentary irrigation systems. Vegetable production in Mali involves many women and young people earning an income from it.

The consumption of vegetables contributes to the nutritional status of the population. Mali is faced with high levels of food insecurity and malnutrition (FAO et al. 2019; FAO and CEA 2018). This is partly the result of low vegetable consumption. In fact, the national level of vegetable consumption is only 116 g per person per day, which is well below the standard of 240 g (about 3 portions) per person per day as generally recommended (FAO 2018). Population growth (~2.8% per year) and rapid urbanization, have led to a sharp increase in consumer demand for vegetables. The past two decades have therefore seen a growing interest in vegetable production.

The productivity of vegetables, as that of all crops, depends to a large extent on the quality of the seed that is used. Yet, the supply of quality seed is one of the weak points of Malian agriculture. The rate of use of improved seeds varies from 15-35% for cereals, despite significant investments in the formal seed sector (Haggblade et al. 2015). Past efforts have mainly focused on improving seed supplies of staple food grains. However, these crops, with the exception of corn and sorghum hybrids, are not the most attractive crops for the formal seed sector. For vegetables, the rate of use of seeds of improved varieties was estimated at 75% in 2013 (Diakité et al. 2014). This high rate can be explained both by the massive import of improved seed and by local seed production. Indeed, vegetable seed has become an important business of private seed companies and input distributors. The value of vegetable seed per gram is 10-100 times higher than that of improved cereal seed, sometimes even more. According to the Agricultural Market Observatory (AMO) in 2014, the price of 100g seed of selected vegetables sold on the Bamako market was: 7,500 FCFA for onion (*Violet de Galmi*), 26,000 FCFA for chili pepper, 60,000 FCFA for hybrid tomato seed, and 40,000 FCFA for hybrid cucumber seed.

Despite the good business opportunity it offers, the seed sector in Mali, as in many West African countries, is characterized by the coexistence of several systems: the traditional or informal system, the semi-formal system, and the formal system (Dembélé et al. 2018). The traditional or informal system dominates seed supplies for many vegetables, despite imports. Some of the imported seed escapes controls and is comparable in quality to that of the semi-formal system. The informal system produces many traditional varieties to which consumers remain attached. Local seed production in the informal sector is characterized by low volumes, uncertified seeds, and the use of varieties that are not listed in the national catalogue. It also involves seed exchange between farmers (Dagnoko and Asiedu 2016). Alongside this traditional system, a more formal or semi-formal system exists, characterized by the use of improved varieties and certified seeds which supply vegetable producers. The establishment of seed companies and cooperatives has given a significant boost to this system. The varieties introduced and in particular the hybrids help to strengthen this system.

Another characteristic of vegetable and seed production in Mali concerns the heavy reliance on rainfall (Kane et al. 2018). As a result, seed producing cooperatives find it difficult to produce seed throughout the year. They are generally dependent on seed production during the rainy season

due to limited access to irrigation (Mele et al. 2011). Initiatives to support seed producers' access to irrigation have been developed in certain regions of the country, notably in Koulikoro and Mopti (Kane et al. 2018). Such initiatives are likely to create a more constant seed supply throughout the year and to increase farmers' engagement in seed production (CABI 2017).

The interest in the vegetable seed sector is growing and there are an increasing number of players. These include local seed companies such as Faso Kaba, Camara Semences, Soprosa, cooperatives like COPROSEM, umbrella companies like the National Union of Cooperatives of Planters and Market Gardeners of Mali (UNCPM), the Association of Professional Farmers' Organizations (AOPP), individual seed producers, and seed sellers. Foreign seed companies are also increasingly present, and include Technisem, Tropicasem, Bejo Zaden, Solivo, Sakata, SK Phytosem, Advanta, Bakker Brothers, and Gopex Germicopa among others. They are represented by local importing companies, such as Mali Semences, Mali Protection des Cultures (MPC), Société Générale de Business Agricole (SOGEBA), Green Seed, and Agri Sahel. These importers and distributors take the largest share of the formal vegetable seed market in Mali.

The vegetable sector in Mali is of great importance to achieving food and nutritional security and reducing poverty. However, the vegetable seed sector in Mali has not reached the level of performance found in many other African countries, especially the Maghreb and East Africa. The quantities of certified seed are relatively low and insufficient to meet farmers' demand (Dagnoko and Asiedu 2016). Local seed production is struggling to take off and production does not always meet the desired quality. Local production faces competition from imported seed, which look more attractive on the sellers' shelves. The national agricultural research system of Mali needs reinforcement in the capacity for vegetable variety development. To date it has mainly done this in partnership with the World Vegetable Center (WorldVeg), which has resulted in the introduction of new varieties, mainly of onion, tomato, pepper, okra, amaranth, shallot and African eggplant.

This study is a review of the vegetable seeds sector in Mali. It takes stock of the situation and makes recommendations for strengthening the sector. The objective is to assess the development potential of a strong vegetable seed sector in Mali and to identify challenges as well as entry points to do this. The study also addresses the potential of irrigation for the development of local vegetable seed production. The study focuses on the formal vegetable seed sector, without ignoring the important role of the informal or semi-formal sectors.

2 Methods and data

The study uses both primary and secondary data, collected using a range of methods. We used stakeholder mapping to select key informants involved in vegetable seed production in the major production areas, including the regions of Koulikoro, Sikasso, Segou, the district of Bamako, and the regions of Kayes and Mopti. Stakeholders included: (i) government organizations, including extension services, inspection and certification services, research institutes; (ii) seed producers including seed companies, seed cooperatives, individual seed producers; (iii) seed sellers; and (iv) commercial vegetable producers. Where necessary, the study focuses on selected vegetable crops, namely onion, shallot, tomato, pepper and African eggplant, which are among the most important vegetables in Mali.

Primary data were collected using key informant interviews (KII) and focus group discussions (FGD). A list of questions was used, covering the main topics and themes to be addressed and affecting the entire seed supply chain (e.g., variety development, seed production and packaging, marketing, production environment). The study covers three main parts:

Part 1: Situational Analysis of the Vegetable Seed Sector in Mali

This part was based on an analysis of documents from government agencies, specialized service providers and research institutes. Key research questions included:

- How did the vegetable seed sector develop after the liberalization of seed production in the 1990s?
- Who are the key players in the vegetable seed sector (foreign and local seed companies, seed associations, farmers' cooperatives)?
- How is basic seed production structured? Does it work well?
- How is seed certification organized? Does it work well? How much does it cost?
- What is the source of the vegetable varieties and the source of seeds?
- What are the opportunities and constraints for vegetable seed companies?
- What are the main problems farmers face with vegetable seeds?
- What is the potential for strengthening national seed production?
- What is the potential for local seed production and local variety development?
- To what extent is counterfeiting/fake seeds a problem in the vegetable seed sector?
- What is the legislative and regulatory framework of the seed sector in Mali?

Part 2: Potential of irrigation to enhance vegetable seed supplies

This part was based on interviews and group discussions with key actors (farmers, extension officers, farmer cooperatives and seed companies). Information was also drawn from interviews with local experts in water management and rural development. Key questions included:

- To what extent is vegetable seed production rainfed or irrigated?
- Which irrigation methods are used? What are the types of pumps and energy sources? What are the sources of irrigation water?
- To what extent is the lack of irrigation a barrier to seed production and for which crops?
- Would the increased use of irrigation in seed production be financially profitable?

Part 3: Interventions to strengthen the vegetable seed sector

This part was based on information and data collected from public institutions, cooperatives, seed companies, non-governmental organizations, development organizations and research institutes. Questions included:

- What changes in the regulatory environment are needed to strengthen the vegetable seed sector?
- Will improved irrigation methods for seed producers be cost-effective and scalable?
- What actions, technological or institutional, are needed to strengthen the vegetable seed sector?

- Which organizations or stakeholders can implement these interventions?

Questionnaires were developed for each category of stakeholders. A stakeholder workshop was held on 2 July 2020 at the World Vegetable Center regional office in Samanko, Mali. Workshop participants reflected on the objectives of the study, the research questions and the draft survey tools, which were revised based on the feedback provided.

Respondents included: 9 government organizations, including directorates of agriculture, research and training institutes, seed laboratories; 26 seed companies/enterprises, including cooperatives, umbrella organizations and individual producers; 21 agrodealers, which generally also sell other agricultural inputs (fertilizers, pesticides) though the largest ones are representatives of foreign seed companies; and 15 vegetable producers, interviewed through 9 focus group discussions (each consisting of about 5 people) and 6 key informant interviews.

The main characteristics of the seed producer group are shown in **Table 2**. It shows that almost all of these are licensed seed producers that are permanent entities with an average of 13 years of experience in seed production; 89% also produced seed of other crops, but vegetable seed accounted for about 53% of their sales.

Table 2: Characteristics of the interviewed seed producing companies and cooperatives

Feature	Percentage
Licensed company/organization (%)	92.3
Permanent entity (%)	92.3
Years of experience in seed production	12.7
Number of permanent staff (active)	16.6
Cultivate seed of crops other than vegetables (%)	88.9
Share of vegetables in total sale value (%)	52.7

3 Study results

3.1 Mali's vegetable seed sector

The vegetable and vegetable seed sector in Mali

Table 3 confirms the importance of vegetable production in Mali with the planted areas exceeding 200,000 ha and annual production exceeding 3 million tons. It also shows the high diversity of vegetables produced (32 species reported in 2019). From 2010 to 2017, vegetable production increased substantially despite year-on-year fluctuations. This growth was also confirmed by stakeholders during the interviews. The consumption of vegetables is increasing, especially in urban areas. The sector is recognized as profitable and the domestic market and even the export market are increasing for certain vegetables, especially after the devaluation of the FCFA in 1994, which stimulated Mali's vegetable exports.

Table 3: Vegetable area and production in Mali, 2019

Leafy vegetables			Fruit vegetables			Bulb, root and tuber vegetables		
Crops	Area (ha)	Production (tons)	Crops	Area (ha)	Production (tons)	Crops	Area (ha)	Production (tons)
Lettuce	6,874	79,772	Eggplant	5,591	81,644	Onion	7,144	135,116
Cabbage	4,188	78,294	Okra	46,741	512,856	Shallot	17,007	387,881
Parsley	386	2,085	Tomato	10,550	159,978	Garlic	1,025	14,954
Cowpea leaf	932	6,676	Bell pepper	2,212	29,998	Carrot	1,093	15,940
Potato leaf	596	2,688	Cucumber	5,047	72,945	Beetroot	819	11,632
Chive	54	252	Melon	3,068	40,393	Radish	42	454
Celery	61	308	Squash	5,884	80,917	Turnip	73	1,141
Spinach	34	109	Green bean	405	3,433	Cassava	5,905	70,313
			Chili pepper	9,374	42,850	Yam	4,959	63,936
			Watermelon	27,032	551,194	Sweet potato	19,807	312,478
			Jaxatu	2,354	30,726	Potato	13,459	303,258
			Strawberry	1	10	Taro	857	6,651
TOTAL	13,126	170,183	TOTAL	118,258	1,606,943	TOTAL	72,189	1,323,754

Source: DNA (2019)

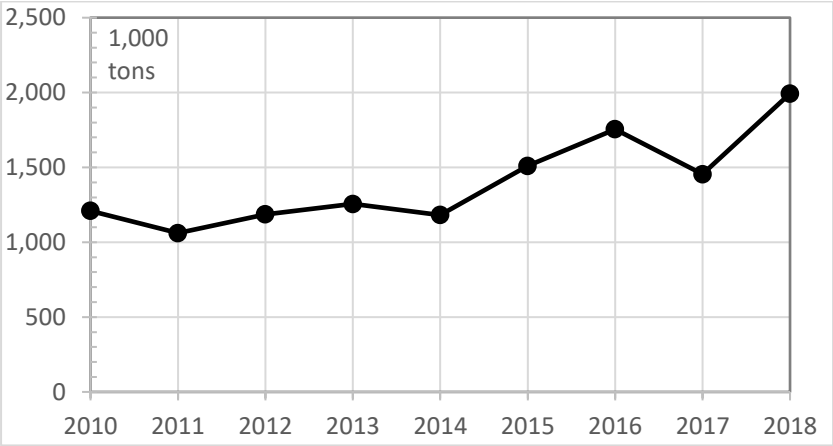

Figure 1: Vegetable production in Mali, 2010-2018

Data: FAOSTAT (2020) and refers to 12 main horticultural crops, including onion, shallot, okra, tomato, eggplant, cabbage, lettuce, potato, watermelon, chili pepper and sweet potato.

From the production data we estimated the overall vegetable seed requirements in Mali (**Table 4**). Government data on certified seed production in 2019 showed okra seed production of 40.1 tons in 2018/2019, which is 14% of the total seed requirement. For onion this was 4.3 tons or 12%, for shallot bulbs it was 237.5 tons or 2.2%.

Another source, shown in **Table 5**, shows the seed production data recorded by Malimark in 2016. It should be noted that these data represent only the production listed by Malimark from the crop declarations made to Laboratoire des Semences (Laboratory for Seeds; LABOSEM). This also confirms that local seed production only covers a fraction of the seed requirement. These data

show a high concentration of seed production in and near Bamako. Only for okra is there some seed production outside Bamako.

Table 4: Estimated seed requirements for selected vegetables in Mali, 2019

Vegetables	Area (ha)	Seed rate (kg/ha)	Seed requirement (kg)
Okra	46,741	6.0	280,446
Onion	7,144	5.0	35,720
Watermelon	27,032	1.0	27,032
Tomato	10,550	0.3	3,165
Chili pepper	9,374	0.4	3,750
Eggplant	7,945	0.3	2,383
Lettuce	6,874	0.35	2,406
Cabbage	4,188	0.25	1,047
Bell pepper	2,212	0.25	553
Cucumber	5,047	0.8	4,038
Melon	3,068	0.9	2,761
Squash	5,884	1.0	5,884
Sub-total	**136,059**	**-**	**369,185**
Shallot (bulbs)	17,007	625	10,629,375
Potato (mini tubers)	13,459	500-1000	6,729,500

Table 5: Seed production for some vegetables by region in 2015/2016, in kg

Species	Bamako	Kayes	Koulikoro	Sikasso	Ségou	Total
Onion	3,533	0	0	0	0	3,533
Okra	3,884	59	132	14	151	4,240
Tomato	1,110	0	0	1	0	1,111
Chili pepper	500	0	0	0	0	500
Cabbage	142	0	0	0	0	142
Lettuce	1,505	0	0	0	0	1,505
Carrot	194	0	0	0	0	194
Melon	175	0	0	0	0	175
Total	**11,043**	**59**	**132**	**15**	**151**	**11,400**

Source: Malimark (2016)

Historical development of the vegetable seed sector in Mali

The liberalization of the seed sector took place in the early 1990s according to the Ministry of Agriculture and various other sources of information. **Table 6** shows major changes in Mali's seed sector. In addition to these benchmarks, significant changes have occurred in the seed sector after liberalization as explained by the stakeholders interviewed and described in the following.

Table 6: Some highlights before and after liberalization of the seed sector

Year	Highlights
1960	Institute of Rural Economy (IER) created with role in variety development, production of pre-basic and basic seed, seed certification, management of seed farms, monitoring of seed producers.
1977	Creation of the Selected Seeds Production Operation (OPSS): Collection of requirements for the production of certified seed; storage and distribution of seeds
1987	Adoption of the National Seed Plan • Development of a national policy on selected seeds
1991	Creation of the National Seed Service: • Replaced OPSS • Coordination of seed activities of the public sector • Identification of the seed needs and communication of this to IER • Marketing of certified seed (R1 and R2)[1]
1995	Establishment of seed companies in Mali: • Seed regulations (governing production, certification, marketing, listing of varieties in the catalogue, etc.); increased accountability
1996	Creation of the General Directorate of Regulation and Control: • Controls and certifies seeds
2002	Creation of the Mali Seed Association: • Information, awareness of stakeholders • Advocacy, defending the interests of the profession; education
2003	Implementation of the Seed Sector Support Project (PAFISEM): • Creation of a network of seed producers in each region • Equipment and strengthening of LABOSEM, support for its decentralization • Creation of storage infrastructure for certified seeds
2006	Implementation of the Agricultural Orientation Law: • General guidance on seed policy • Recognition of the importance of the sector (production and sale of certified seed) • Encouragement of private investment in seed production
2009	• End of PAFISEM
2009	• Emergence of new seed cooperatives • Decentralized cooperatives under the aegis of SSN • Cooperative associations under the aegis of the AOPP
2009	New seed policy: New guidance on national seed strategies
2010	Advent of seed law no. 10-032 of July 12, 2010: • Seed regulations (production, certification, marketing, listing of varieties in the catalogue, etc.); accountability
2014	Recognition of the harmonized seed regulation of West Africa: • Seed production, quality control and certification, import-export, registration

[1] R1 is certified seed of first reproduction; R2 is certified seed of second reproduction.

End of government-controlled seed production

Before liberalization of the seed sector in the 1990s, seed production was carried out under government control. After the creation of Rural Development Operations (ODR) in the 1970s, the drought that characterized the beginning of these years exacerbated the need for seeds in Mali. The organizations in place lacked capacity. Restructuring took place at the end of the 1970s and during the 1980s. OPSS was created in 1977, responsible for the production, collection, storage and dissemination of seed. Regulation and control were entrusted to the Section of Regulation and Control of Selected Seeds (SRCSS) within the Institute of Rural Economy (IER). Faced with persistent difficulties in the supply of selected seeds, a National Seed Plan defining the broad lines of a national policy on selected seeds was drawn up in 1987. This plan established the National Seeds Council and the National Species and Varieties Committee. They are responsible for the design, coordination, implementation and management of seed production. A seed policy implementation structure was also created in 1991, replacing the OPSS, called the National Seed Service.

The creation of the SSN corresponded to the start of liberalization and the start of the policy of transferring skills to producers. The withdrawal of the government from seed production marked a decisive turning point in the seed sector. The period thus marked the beginning of the participation of producers in seed activities as stakeholders. This development is cited by the stakeholders interviewed as being among the major changes in the seed sector in general and in vegetables in particular. However, it must be recognized that the creation of SSN or OPSS did not primarily concern vegetables.

End of the basic seed production monopoly by national research institutions

This measure was one of the major changes after liberalization. The Malian seed law and that of the Economic Community of West African States (ECOWAS) allow all actors to produce basic seed. Still, national and international research institutes continue to assume a large part of this production, even if the quantities of basic seed produced remain limited due to the lack of funds and the weak connection with seed producers (R1 and R2). In general, basic seeds for exotic vegetable crops such as tomato and onion are produced by farmers supervised by the Institute of Rural Economy (IER). Those of traditional crops such as okra are usually obtained from informal channels of farmers and non-governmental organizations. The private sector as a whole is not well equipped to ensure this production for lack of technical skills. Ultimately, the changes in seed laws have not yet produced all the expected effects in terms of private sector seed production.

Grouping of seed producers in associations and cooperatives of seed producers

Since 2002, small-scale seed producers have emerged. In most cases, these are members of larger cooperative organizations or central associations that coordinate and defend their interests at the national level. Different types of seed-producing cooperatives play an important role within the seed supply chain. Cooperatives are increasingly recognized as producers of certified seed. They frequently collaborate with national or even international research institutes to select and test improved varieties, and with seed companies to distribute seed nationwide.

In 2016, nearly 3,000 seed producers for various crops were identified by Malimark (2016). These producers are grouped into associations of seed producers (APS) and cooperatives. They often

engage in commercial crops as well as other crops, in particular cereals and legumes. It is worth mentioning a few cooperatives engaged in vegetable seed production:

- **COPROSEM**, based in Kayes, has brought together 101 producers since 2013. It produces seed of onion (in particular the variety *Violet de Galmi*) and of okra. COPROSEM has a packaging line to produce seed in bags, unlike many other cooperatives.
- **Demeso Cooperative** has brought together 60 producers for 20 years and produces shallot and onion seed.
- **OPS de Samanko** is a cooperative that brings together 43 producers of okra seed. It has been active as a cooperative since 2006.
- **APS Bewani** has brought together 24 farmers since 2004. It produces seed of okra, tomatoes, chili peppers, sweet peppers, potatoes and leafy vegetables, among others.

Some associations and cooperatives are organized into umbrella organizations. Among the most significant are:

- **Association of Professional Farmers 'Organizations (AOPP)**: it brings together 250 farmer organizations involved in seed production in Mali. It is active in seed production of okra, onion, tomato and eggplant. It encourages seed certification among its members.
- **National Union of Cooperatives of Planters and Market Gardeners of Mali (UNCPM)** brings together 15 regional and local cooperatives and 4,000 farmers. It has operated since 1985. It mainly produces seed of onion, tomato and potato, but also of okra and chili pepper.

Rapid expansion of seed companies and seed distributors

New seed companies and distributors are emerging, along with cooperatives and groups. The Mali Seed Association (ASSEMA) estimates that there are more than 1,000 players at present. Vegetable production represents 5-30% of their activities depending on the companies surveyed. Among the key vegetable seed companies in the market are:

- **Faso Kaba**: established in 2009, it works with 26 cooperatives and devotes 35% of its activities to vegetables (okra, onion, tomato, eggplant, bell pepper, watermelon, chili pepper, lettuce and other vegetables).
- **Camara seeds**: established in 2015 and works on the main vegetables including tomato and onion; 10% of its activities are devoted to commercial vegetable seed production.
- **SOPROSA**: created in 2012, with its main activities including the production, processing, treatment and sale of quality seeds for improved varieties in West Africa.

Several other seed companies are active in the market; and 19 of the most important ones were listed in Access to Seed Index (2019). The expansion of players is due to the strong enthusiasm for the vegetable sector, which is recognized as profitable, despite several difficulties, as vegetable demand is increasing, especially in urban areas.

Agrodealers are also an expanding group of players. There are no good data on this group, but there are many distributors in urban centers and in vegetable production areas. In most cases, these also distribute other inputs such as fertilizers and pesticides.

Created in 2002, ASSEMA is a professional association to which all actors in the seed sector can join. Its mission is to serve as a framework for consultations, exchange of information and experiences in the field of the seed industry in Mali and elsewhere, and to represent, defend, develop and consolidate the interests of the Malian seed industry through strengthening the organization of the seed industry, awareness raising, and training of seed producers. ASSEMA had 63 members at the end of 2020.

Emergence of a formal vegetable seed sector

The growth of the formal vegetable seed sector is reflected in the increasing proportion of certified seed for crops such as onion, shallot, okra and watermelon. LABOSEM statistics do not specify the proportion of certified seeds produced locally vs imported. According to ASSEMA, and for all crops combined, the quantity of certified seeds increased from 500 tons in 2002/2003 to 11,052 tons in 2016/17; yet, vegetable seed accounts for only 11.4 tons of this volume.

Improved varieties have increased total production and productivity of vegetables. Varieties adapted to rainfed and irrigated conditions have made it possible to produce more vegetables year-round. The advent of F1 hybrids is an important innovation in commercial vegetable production. For some vegetables, hybrids constitute a large proportion of imported seeds, in particular tomatoes, onions, cabbage, bell peppers, cucumbers and chili peppers. Hybrids, if adapted to local growing conditions, have a higher production potential than open-pollinated varieties (OPVs).

The creation of the national catalogue of plant species and varieties precedes the period of liberalization. However, a national catalogue of vegetable varieties has not been published regularly. World Vegetable Center and LABOSEM produced a catalogue in 2011, which covered 33 varieties of 8 vegetable species. Another version supported by FAO included 40 varieties of 9 crop species. However, the 2020 version produced by LABOSEM only included 23 varieties of onion, shallot and tomato. The ECOWAS catalogue of plant species and varieties was first published in 2016 and updated in 2018. However, the only vegetables included are onion and tomato (and potato).

Informal and semi-formal sectors continue to dominate

One of the consequences of liberalizing the vegetable seed sector was that imported seeds started flooding the market. Many of the imported varieties, including F1 hybrids, improve productivity, but they compete strongly with local production despite a 18% import tax levied on imported vegetable seed (except potatoes). Yet, often, seed imports circumvent customs and supply the informal seed sector. The quality of such seed is therefore not controlled by the government, in particular LABOSEM.

Key players in the vegetable seed sector

Key players in the vegetable seed sector include public and private sector organizations as explained in the following.

Ministry of Agriculture

The Ministry of Agriculture defines the national seed policy and implements seed laws and seed regulations together with various other government organizations. Among these, the National Directorate of Agriculture (DNA) has a key role. DNA departments executing seed policy include the Legislation and Phytosanitary Control Division (DLCP), the Seed Laboratory (LABOSEM), and the National Seed Service (SNN). These departments are involved in seed production, variety registration, the national catalogue of plant species and varieties, seed quality control and certification, promotion of new seed production techniques, supervision of and support for seed producers, and capacity building.

LABOSEM plays the role of the Official Control and Certification Service (SOC). Through sample analysis the SOC supports DLCP in phytosanitary control. It has two laboratories, one in Bamako and one in Segou. LABOSEM carries out field inspections through 146 phytosanitary control officers. SSN, which used to be in control of seed production before liberalization, is no longer involved in seed production and is awaiting reorganization and a redefinition of its purpose.

Research Institutes

The Institute of Rural Economy (IER) is the public institution in charge of agricultural research. Its portfolio includes a fruit and vegetable research program. The program works on varietal selection and experimentation as well as entomology and agronomy. There are three Regional Agronomic Research Centers (CRRA) doing research on vegetables: the CRRA in Bamako Region is focuses on vegetables; the CRRA in Sikasso focuses on potato; and the CRRA of Niono focuses on shallot, okra, and eggplant. The capacity of IER in fruit and vegetable research is quite limited as it only has six researchers working part of their research time on fruit and vegetables.

The research mandate of IER is to make new high-performance technologies available. It is testing new varieties that it receives from organizations such as the World Vegetable Center (WorldVeg) and the International Potato Center (CIP). It includes these varieties in the national catalogue after testing, thereby authorizing them for seed production. It also organizes the production of basic seed, especially for shallots, okra and tomatoes. The fruit and vegetables research program of IER does not have the resources to carry out substantial work on vegetable breeding. IER also houses the Genetic Resources Unit (URG), which is responsible for the collection and conservation of plant genetic resources. The unit has difficulties in maintaining its collection and therefore collaborates with international research organizations such as WorldVeg, which conserve their collection and provide it to them when needed. URG has a Basic Seeds Unit (USB), but this unit lacks resources to do much basic seed production.

International research organizations such as the WorldVeg support IER's vegetable research program with most vegetable varieties registered in Mali coming from WorldVeg. WorldVeg also supports the production of basic seed and its distribution to stakeholders. It also provides training for seed producers (cooperatives, associations) in seed production and conservation techniques. CIRAD and the International Institute of Tropical Agriculture (IITA) also work on vegetables and have collaborations with national research organizations in this area.

The Rural Polytechnic Institute for Training and Applied Research (IPR/IFRA) provides diploma training for technical managers. It has a plant biotechnology laboratory which engages in the

production of potato seed by micro-propagation. The in vitro culture of meristems makes it possible to obtain virus-free planting material for potato, onion and banana. Although the technology is available, it is not widely adopted because of difficulties in the transfer of the technology to the actors and a low volume of orders.

Seed Producers

Seed producers and distributors are the backbone of the seed sector by ensuring the multiplication and distribution of seed to farmers, companies and NGOs. Seed producers in Mali comprise a diverse group of seed companies, individual producers, producer groups, cooperatives, unions of cooperatives and umbrella organizations of various kinds.

Companies produce, process and package seed for sale. There are six seed companies in Mali with packaging units, including COPROSEM (in Kayes), Faso Kaba (Bamako), Camara Semences (Kassela 40 km from Bamako), SOPROSA (Sikasso), Agri Sahel (Segou) and Faba Tiere (Niono). Most of these companies are also seed distributors. They sell directly to customers as well as through agrodealers. They usually sell seed of a diverse range of crops. This diversity increases their turnover, given that the quantities of vegetable seeds produced are generally small, except for seed bulbs of potato, shallot, and onion. Seed companies most often work with networks of seed producers that produce on contract.

Cooperatives, producer associations, cooperative unions, and umbrella organizations are types of organizations of individual seed producers. Like seed companies, many cooperatives produce seed of a diverse range of crops. However, some are specialized such as COPROSEM which mainly produces onion seed. Cooperatives help their members in the sale of their output. Some cooperatives are grouped in a union or umbrella organization such as UNCPM, AOPP and others.

Seed companies and cooperatives contribute to increasing the quantity of certified seeds. This is the case, for example, with the AOPP, which covers the cost of the certification and distribution of certified seeds (Access to Seed Index 2018).

Seed distributors

Seed distributors or agrodealers are not engaged in seed production. The largest and most active agrodealers are representatives of foreign seed companies established in Mali. Agrodealers mainly sell seed to vegetable farmers, NGOs, government departments and other clients. They are also supply smaller seed stores, the number of which is increasing on the outskirts of vegetable producing areas. In this way they provide users with easy access to inputs. Distributors also include most of the companies and cooperatives that produce and sell their produce to both agrodealers and directly to farmers.

Small-scale vegetable farmers

They are the end users of the seed. Their needs in terms of seed quantity and quality are important for vegetable seed sellers. A large proportion of vegetable farmers are women and youth. Small-scale vegetable production enables them to be occupied during the dry season and reduces the rural exodus.

Inter-governmental organizations

CILSS, ECOWAS, UEMOA, CORAF/WECARD are all active in the vegetable seed sector. CILSS, ECOWAS and UEMOA established the harmonized seed regulation for West Africa in 2008. It has been adopted in Mali since 6 June 2014, though not all current seed laws and regulations are in compliance, which creates some ambiguity.

Non-governmental organizations

Many non-governmental organizations are active in the vegetable sector, including Syngenta Foundation for Sustainable Agriculture, Sasakawa Global 2000, Afrique Verte, and others. They do not exclusively focus on vegetables but may support research, production and access to seeds through development or cooperation projects and programs.

3.2 Basic seed production

Mali's current seed law and ECOWAS seed regulations allow public and private organizations to engage in basic seed production, based on their capacities and skills. However, seed producers must receive government approval and must have sufficient land, sufficient technical staff and also the required facilities and equipment. Such requirements effectively prevent many organizations to enter basic seed production.

Public sector organizations involved in basic seed production of vegetables include IER and IPR/IFRA. They produce pre-basic seed of the varieties they maintain. Production takes place on the basis of needs expressed by users including seed companies, cooperatives and NGOs. The request for basic seed must be expressed at least one year in advance to plan for the production. However, the public system is unable to accurately predict seed demand for many crops, which is a key bottleneck of the current system. In 2019, IER produced small quantities of basic seed at the request of customers, in the order of 100 kg each for okra, onion, shallot and tomato. IPR/IFRA produced a record 120,000 mini-tubers in 2010, but current demand is very low as nearly all potato seed is imported.

As for the private sector, few if any organizations are involved in the production of basic seed. High seed quality requirements and low demand for locally produced seed mean that this activity is not very profitable and therefore does not motivate the private sector to invest. Lack of technical knowledge also prevents the private sector from producing basic seed.

The large import of vegetable seed means that there is no strong link between basic seed production and farmers' seed supplies. Challenges in the production of basic seeds are:

- There is no mechanism to accurately estimate seed demand in order to plan seed production
- Public research organizations have the mandate to produce pre-basic seed but do not have the financial resources to do this, which limits production
- The per unit production cost is high because of low seed demand
- Imported seed is preferred over locally produced seed for many vegetables
- Pest and diseases in certain crops (e.g., *Ralstonia solanacearum* in potato production) constrain quality seed production

Vegetable seed certification

Organization of seed certification

Seed quality control and seed certification are important aspects of the formal seed sector. According to the Malian seed law and the ECOWAS harmonized seed regulation, only varieties registered in the national or regional catalogue can be certified. Varieties included in list A of the ECOWAS catalogue may be multiplied and the seed certified and marketed in ECOWAS Member States. In principle, seed produced and certified in one of the seventeen countries can be exported to the other countries without the need for re-certification. Only a phytosanitary certificate and the indication of the seed category are required.

Certification is done on the basis of crop-specific technical regulations involving field inspections carried out by SOC inspectors who draw up an inspection report after each visit. Three to four visits are made at different stages of the crop: before sowing, before flowering, during fruiting and during ripening before harvesting. The purpose of these visits is to check the conditions in which the crop is grown (previous crop, isolation of the plot), the varietal purity and the state of health of the crop. Furthermore, laboratory analyses are carried out on the harvest sample taken by the inspectors during the last visit and the sprouting rate, varietal purity, specific purity and health status of the seed lot is determined. On the basis of these observations, seed lots are either certified or rejected.

The certification is carried out by LABOSEM. The Legislation and Phytosanitary Control Division (DLCP) is also involved in the process as its phytosanitary agents carry out inspections of the seed plots. As of 2020, there are 146 phytosanitary agents employed, including 32 women. They are distributed over the country. DLCP also checks packaging centers, warehouses and sales outlets.

Our enquiry showed that LABOSEM has many challenges in carrying out this task, due to the centralization of the service and the limitation of its staff. There are only two seed laboratories in Mali (in Bamako and in Segou). Seed producers deplore the slowness of the operation and the delay in receiving the certification labels. They also mentioned that while regulations stipulate 3-4 field inspections of seed production fields, in practice, usually only one inspection in conducted.

Cost of certification

Most seed producers (companies, cooperatives, individual producers) state that the cost of certification is very high; however, the figures they put forward varied widely. According to LABOSEM, the certification cost consists of:

- the cost of travel of the inspection team to the field site, calculated at a rate of 500 FCFA/km per inspection;
- travel expenses of the inspection team at 20,000 FCFA per night for 2-3 persons per inspection;
- laboratory analysis costs per batch at a rate of 7,250 FCFA per sample;
- 160 FCFA for the cost of labels per batch.

Thus, the average cost per inspection per plot amounts to 77,250 FCFA (~142 USD) not including the accommodation and per diems of the seed certification agents. The cost can be reduced if seed plots are large or if several nearby plots are inspected at the same time. Many of the seed

producers interviewed considered the cost very high. Yet, considering that a single inspection is usually carried out, the actual cost would be 3-4 times higher if all inspection were carried out. Understandably, seed producers did not mind the low number of inspections. Many seed producers were in favor of the need for seed certification as it added value to their products.

Quantity of certified vegetable seed in Mali

The quantity of seed tested by LABOSEM over the last four years is shown in **Table 7** and shows strong year-on-year variations. These data include certification of locally produced seed but also germination and purity tests of imported seed. LABOSEM indicated that less than 10% is local production and more than 90% is seed imports. It was also mentioned that importing companies tend to under-declare their import volumes to avoid customs duties and taxes, so the actual quantity of imported seed is likely to be larger.

Table 7: Quantity of vegetable seed tested by LABOSEM, 2016-2019, in kg

Species	2016/17	2017/18	2018/19	2019/20
Onion	6,128	5,333	17,594	10,603
Shallot	5,120	47,400	903	1,158
Okra	1,777	224	15,010	1,923
Tomato	1,857	555	94,786	1,881
Chili pepper	-	16	32	357
Bell pepper	44	-	628	734
Cucumber	317	202	4	1,285
Cabbage	65	183	100	719
Lettuce	284	8	3,117	494
Eggplant	-	-	16	371
Beetroot	250	903	170	1,864
Watermelon	1	120	-	815
Carrot	117	80	55	401
Zucchini	-	-	2	88
Amaranth	14	359	57	50
Green bean	-	80	170	-
Celery	-	-	57	-
Moringa	50	-	-	-
Sorrel	2	-	-	-
Turnip	25	-	-	-
Total	**16,060**	**54,718**	**132,474**	**22,743**

Source LABOSEM. The data include testing of imported seed as well as certification of local seed.

Vegetable varieties used

Source of varieties by vegetables

Government organizations (9) and the seed producers (26) were asked to indicate the origin of varieties used by local vegetable farmers as shown in **Tables 8** and **9**. The distribution of varieties appears fairly balanced between the different sources. Researcher-developed varieties ranked first

(about a third), followed by farmers' varieties for just over a quarter of the varieties. Imported varieties (with or without local adaptation) each accounted for about 20% of all cultivated varieties.

Table 8: Origin of vegetable varieties according to government organizations, in % of seed used

Crop	Developed by farmers (local varieties)	Developed through local research	Introduced to Mali with adaptation testing	Introduced to Mali without adaptation testing
Onion	-	60.0	-	40.0
Shallot	42.9	42.9	14.3	-
Tomato	22.2	33.3	22.2	22.2
Okra	33.3	33.3	33.3	-
Eggplant	30.0	30.0	20.0	20.0
Chili pepper	42.9	14.3	28.6	14.3
Cabbage	20.0	20.0	20.0	40.0
Lettuce	20.0	20.0	20.0	40.0
Average	**26.4**	**31.7**	**19.8**	**22.1**

As for the distribution by species, the situation is as follows:

- **Onion:** the varieties mainly come from research (IER), with some foreign introductions without local adaptation. The most popular onion variety among seed producers is *Violet de Galmi*.
- **Shallot:** varieties come equally from local research and farmers (43% each).
- **Tomato and okra:** Researcher, farmer and imported varieties each account for about a third of all seed used.
- **Eggplant:** farmers' and researcher varieties are important. Imported varieties make up about 40%.
- **Leafy vegetables (lettuce, cabbage):** Most varieties are imported, though local varieties and locally developed varieties each account for about 20% of seed used.

Table 9 shows the sources of varieties according to 13 seed producers that answered this question. Nearly all seed producers obtained varieties from multiple sources with introductions from outside Mali without adaptation testing being the most important source. Still, 8 of the 13 seed producers also used varieties developed locally.

Table 9: Origin of vegetable varieties according to seed producer organizations, in % of varieties

Origin of variety	Seed producers (n=13)	% of seed producers
Developed by farmers (local varieties)	3	23.1
Developed locally through research	8	61.5
Introduced to Mali with adaptation testing	12	92.3
Introduced to Mali without adaptation testing	8	61.5

Note: Seed producers obtain varieties from more than one source.

Crops grown by seed producers

Of the 26 seed producers surveyed, 13 indicated which vegetable seeds they produced (**Table 10**). Several crops are grown simultaneously, the most common being okra, onion and tomato. The second group consists of eggplant (African and European), cabbage, lettuce, chili pepper and shallot. However, some producers specialize in one or two crops. For example, COPROSEM produces only onion seed and seed producers near Samanko only produce okra seed.

Table 10: Vegetable crops grown by seed producers

No.	Crop	No. of seed producers (n=13)	% of seed producers
1.	Okra	12	92.3
2.	Onion	10	76.9
3.	Tomato	7	53.8
4.	Lettuce	4	30.8
5.	Cabbage	4	30.8
6.	Chili pepper	4	30.8
7.	Bell pepper	3	23.1
8.	Shallot	3	23.1
9.	African eggplant	3	23.1
10.	European eggplant	2	15.4
11.	Watermelon	1	7.7
12.	Potato	1	7.7
13.	Carrot	1	7.7
14.	Zucchini	1	7.7
15.	Cucumber	1	7.7
16.	Green bean	1	7.7
17.	Parsley	1	7.7
18.	Celery	1	7.7
19.	Beetroot	1	7.7
20.	Celery	1	7.7

Types of varieties used

All local varieties are open pollinated varieties (OPVs) while imported varieties are both OPVs and hybrids. For OPVs, seed is produced with a single parent. Farmers can save the seed and use it for subsequent sowing. OPVs are generally better adapted to production conditions, but they are can give a lower yield than hybrids. Hybrids are the result of the crossing of two parents chosen for their complementary characters. They are more vigorous and productive than either of their parents because they benefit from hybrid vigor (or heterosis effect). Yet the seed of hybrid plants should not be sown again, as it will degenerate into plants that are different from those of the hybrid variety. Hybrids can be found in most fruiting vegetables. Hybrids lend themselves well to the intensification of production, but the price of this type of seed is higher as seed production is much more costly. Public research at present is not investing in hybrid technology for vegetable crops.

According to UNCPM, hybrids represent about 1/3 of the current seed market. They estimated that hybrid varieties make up 70% of cabbage varieties, 60% of lettuce and pepper varieties, 40% of

tomato and European eggplant varieties, and 30% of onion varieties. A respondent from Dounkafa seed company estimated that hybrids account for 100% of tomato and pepper varieties, 50-100% of okra varieties, 30-50% of onion, shallot and watermelon varieties.

Vegetable varieties multiplied

Table 11 shows the status of variety entries in the national and sub-regional catalogues. Species whose varieties are listed in the national catalogue are chili pepper, bell pepper, tomato, eggplant, onion, shallot, okra, amaranth and sorrel. Only 40 varieties appear in Mali's 2013 catalogue. As for the 2020 national catalogue, it only included tomato (11 varieties) and onions/shallots (12 varieties). It appears that some older varieties were dropped from the previous catalogue, but the reasons are not entirely unclear. It could be that older varieties were dropped when newer varieties with a better performance were added. **Table 12** provides a list of varieties produced by seed producers in 2020. It is clear that many of these species and varieties are not listed in the 2020 national catalogue.

Table 11: number of vegetable varieties registered in catalogues of Mali (2013 and 2020) and ECOWAS (2016).

Crop	Mali National Catalogue 2013	Mali National Catalogue 2020	ECOWAS-UEMOA-CILSS Catalogue 2016
Onion	3	12	43
Shallot	9		
Okra	5		
Tomato	8	11	60
Bell pepper	3		
Eggplant	2		
Chili pepper	5		
Potato			36
Amaranth	2		
Sorrel	3		

Table 12: Indicative list of the main vegetable varieties used by seed producers in 2020

Crops	Varieties
Onion	Violet de Galmi, Red Coach, Somadrine Safari, Damani, Caribon, Ares, Avon
Shallot	Tropix, Tatadiaba, Gounkourouni Diaba, Ngalamakoro, Sabarila, Saboula, Safiatou, Clochard, Merena, Gombouka, Safiatou Jaba
Okra (Gombo)	Ire, Kirikou, Wassa, Indiana, Cleproduction de semenceson, Yodama Sassilon, Batoumambe, Yelen, N'Gankourouni, Djitaba Sabalibougou, Keleya, Indiana *Gansourouni,* Divo, Gombo long, Gombo Court, Konni
Tomato	Cobra 26, Cobra 34, Savana, Kiara Mona, Topaz, Roma Vf, UC 82, Rio Grande, Rossol, Randah, Sodagar, Paipai, Roman, Mikon, Ronde, Mangal, Cobra, Caraibo, Buffalo
Bell pepper	Nikita, Simbad, Ulus, Jackson, Yellow California Wonder, Mildred, Clair, Andréa, F1 Granad
Eggplant	*Meguetan*, Ngalan, Kermidao, So, L10, *Jaxatu*, Calanda, Black Beauty, Gloriana, Bemecia, Kacron, Marche De Copenhague, Le Bouake, *Djema, Ngoyo*, Violet Long, Maroua

Crops	Varieties
Chili pepper	Bafarima, West Indian, Canisafe, Taiwanese, *Kelekele Misseni, Forotobani* Cayenne, Habanero, Nisondia, Safi, Efia, Gros Piment Local, Kani, Nafama
Lettuce	Blonde De Paris, Pierre Benite, Great Late, Eden, Brava
Cabbage	Supercron, Tropicacron, Fortune, Kakacron, Africacross, Madiba F1, Africa Cross
Watermelon	Charleston Grey, Greybell, Kaolack, Sugar Baby, Simson, Gribel
Potato	Sahel, Soumta, Barcelona, Montreal, Montecarlo, Toronto

Sources of vegetable seed

Seed systems

In Mali there is on the one hand the traditional or informal seed system and on the other hand the formal seed system. Multiplied varieties in the informal system are usually local varieties that are not listed in the national catalogue and seeds are not certified. The seed in the informal system is used directly by the famers themselves or exchanged between them. This system does not guarantee seed quality according to government standards. While the informal system is dominant for cereal crops, the situation is complex for vegetables due to seed imports, which should increase the share of the formal system. The reality, however, is different in that most of these seed imports are not inspected for quality.

The formal system involves research to develop improved varieties, formal approval of variety performance, seed certification and marketing through formal channels. This system is likely to increase the production of quality seed and create jobs along the seed value chain. The main actors involved are government and control agencies, research organizations, seed companies and cooperatives, contract growers, distributors, agrodealers and farmers. A failure in one segment of the seed value chain can lower the overall performance of the overall sector.

The formal sector is regulated by laws and regulations implementing standards and rules to be respected in all seed-related activities in Mali and the West African sub-region. It is based on various technical regulations drawn up to guarantee the purity of sold varieties, germination rate and overall seed health. In this system, seeds are classified into five categories:

- Foundation seed (G0)
- Pre-basic seed (G1 to G3)
- Basic seed (G4)
- Certified seed of first reproduction (R1)
- Certified seed of second reproduction (R2)

Hence, seed production moves from foundation seed to certified seed in steps.

Semi-formal systems are cases where improved varieties are used, but which do not follow government-specified quality controls. Much of the local seed production of cooperatives and even some seed companies fall within this category. Semi-formal systems also concern imported seed that escape quality control.

Sources of seed

Table 13 shows the source or pre-basic and basic seed used by the 26 seed producers interviewed in 2020. According to the researchers themselves, a small amount of pre-basic and basic seed is

produced by public research organizations. This is the case with onion, shallot, okra and tomato. Production is carried out in Niono. The quantities produced in 2020 are 100 kg of pre-basic for onion and okra, 50 kg for tomato, and 10 tons for shallot seed bulbs. It is noted that the World Vegetable Center in Samanko also provides basic seeds to seed producers (e.g., for onion, okra, amaranth, tomato, African eggplant, chili pepper).

Table 13: Pre-basic and basic seed sources according to seed producers, in % of respondents that confirmed using a particular source.

Crop	Farmer saved seed	Cooperatives	Local businesses	Foreign companies	Public organizations
Onion	100	25	62.5	71	
Shallot	60.8	80		100	
Tomato	47.5	20	73.3	84.3	
Chili pepper	53.3	46.3	42.5	76.7	20
African eggplant	100			100	
European eggplant	10	35	53.3	72	
Leafy vegetables	38.3	15	79	60	
Okra	100	40	46.6	77	100
Potato	100			100	
Watermelon	10	10	30	75	

Information provided by private seed producers and government organizations showed that most of the vegetable seeds used come from foreign seed companies; this is the case for onion, tomato, chili pepper, eggplant, okra, watermelon and leafy vegetables (cabbage, lettuce). Yet, for shallot and African eggplant, more seed is supplied by farmers themselves. For potatoes, both foreign seed companies and farmers' seeds are important. Seed cooperatives and especially local enterprises play a significant role in the supply of seed for onion, shallot, tomato, eggplant, leafy vegetables, and okra.

However, there are clear differences between organizations. For example, Faso Kaba indicated that it works more with local seed producers, but companies representing foreign firms and large agrodealers (e.g., Mali Semences, SOGEBA, MPC, Eastern agriculture, Agri Plus) almost exclusively import all the seed they sell. Smaller agrodealers, on the other hand, source their seed from local producers with whom they have established a relationship of trust.

Vegetable farmers purchase seed from agrodealers and seed companies, but often also use their own produced seed or exchange seed with other farmers (e.g., for lettuce, turnip, okra, chili pepper, amaranth).

Size of the vegetable seed market

We only got partial information on the size of the formal vegetable seed sector in Mali. From 1 January to 14 October 2020, a hundred import permits for vegetable seeds were granted to local companies according to DNA. Local seed producers were largely unable to estimate the market size and if they were able to provide an estimate than these varied enormously between respondents. Therefore, it was not possible to get good estimates of seed imports and local seed

production. **Table 4** provided an estimate of the seed requirements for the main vegetables, which gives an indication of the overall size of the seed market. It shows a total annual seed requirement of 369,000 kg, excluding shallot and potato.

Opportunities and constraints of vegetable seed companies

Strengths and opportunities in the vegetable seed sector

Locations suitable for vegetable seed production are spread over Mali, from Kayes to Kidal. Irrigation possibilities are numerous. The niche is therefore promising and the margins for improvement seem significant. This motivates businesses to enter the sector. The number of seed companies, enterprises and cooperatives involved in vegetable seed is estimated at several thousand (Malimark 2016), including various types of seed producers. However, the sector also has challenges. **Table 14** lists some of the weaknesses, opportunities and risks identified.

Table 14: Cross analysis of the situation of the vegetable seed sector in Mali.

Strengths	Weakness	Opportunities	Threats
• High land availability • Water is available in many areas (rainfall, ponds, river, groundwater) • Labor is relatively cheap • Relatively well-organized distribution of vegetable seed • Significant investment potential in the sector • High diversity of vegetables produced	• Weak organization of the sector • High price of vegetable seed for farmers • Local seed producers have limited access to basic seed • Poor packaging and storage • Suggested planting dates are not indicated on seed packs • Weak technical capacities of stakeholders including national research system • High tax (18%) on imported vegetable seed affects farmers • Certification of local seed production is costly and poorly implemented	• High price of vegetable seed attracts investors • Strong growth in vegetable demand, especially in urban areas • Individual seed producers can organize into cooperatives to strengthen market position • ECOWAS harmonized seed regulation can facilitate regional sales	• Local production under threat from seed imports • Lack of government intervention to address fake seed and fraudulent seed imports • Weakness of government support in the implementation of seed policy (research, supervision, organization of stakeholders, investments)

Rainfed vegetable production is found throughout the country. Water sources are diverse and some of the seed producers said that the water constraint is more a problem of mobilization rather than availability. Also, varieties are increasingly better adapted to local conditions, which allows extending the production period. The availability of labor is well assured in the countryside and in

peri-urban small-scale vegetable producing areas. Vegetable production is recognized as a lucrative activity that contributes to reducing the rural exodus.

Key opportunities mentioned by seed companies and cooperatives included the high price of vegetable seed, allowing for decent profits. Increasing demand for vegetables was widely recognized as an important opportunity, which is largely driven by urbanization and changing consumer habits in cities. Seed companies like Camara Semences and Faso Kaba and others are therefore increasing their investment. The organization of seed producers into cooperatives and umbrella organizations (e.g., AOPP, UNCPM, APS) is also a strength of the sector. Furthermore, the country has a decent supply of a diverse range of vegetable seed and the distribution through many agrodealers is working well.

According to respondents from DNA, the vegetable sector faces several structural constraints, including the weak organization of the sector, the high cost of seed for farmers, the lack of seed processing, packaging and storage equipment, and agrotechnical constraints including damage from pests and diseases. The survey ranked these constraints based on the number of respondents reporting each constraint. The most common constraints are listed in **Table 19** for seed producers, in **Table 20** for agrodealers, and in **Table 21** for vegetable farmers.

Key challenges for seed producers included processing, packaging and storage of seed as many companies and cooperatives lack seed processing and seed packaging lines. COPROSEM is one of few cooperatives that sell onion seed in good quality bags. The packaging must be both sturdy and attractive to customers. Local seed production is disadvantaged according to agrodealers because of its poor presentation on the shelve.

Another difficulty mentioned by many seed producers is the lack of funds, which limits the size of the sowing area, but also limits access to equipment and infrastructure such as irrigation. The first seed packing lines were installed with the government providing a 70% subsidy on the investment. At the moment, there is a lack of government support for the vegetable seed sector.

Several seed producers, agrodealers and farmers mentioned difficulties with product sales and access to markets. Stakeholders also indicated difficulties in accessing government procurement of seed. One agrodealer mentioned, however, that two seed companies got a UEMOA contract worth 500 million CFA francs to supply vegetable seed to a community support program in the context of COVID-19. Almost all respondents also reported problems with the low technical capacity of stakeholders in the vegetable seed sector.

Problems with low seed quality were reported by agrodealers and farmers. It relates to low varietal purity, low germination and counterfeit seed. For seed sellers, poor seed quality is the result of long delays in the delivery of orders and transport conditions for imports. Farmers mentioned the lack of good packaging and inappropriate storage conditions. Another constraint for farmers was the high cost of seed, especially of hybrids, which limits access for many vegetable producers.

Table 15: Constraints identified by the 26 seed producers interviewed, 2020

Constraint	Details mentioned	Number of respondents
Difficulties in accessing basic seed	– -	4
Difficulties with seed treatment, packaging and storage	– Lack of infrastructure and equipment for packing, storage and conservation	8
	– Difficulties with seed packaging	4
	– Conservation difficulties due to the cost of electricity	3
Low technical capacity	– No mastery of seed production techniques	9
	– Difficulty to produce certain seed such as parsley, celery, turnip, beetroot, carrot	1
Financial constraints	– Very high value added tax on vegetable seed causing competition from neighboring countries	5
	– High bank interest rates, limited funds, difficulties in pre-financing operations	5
	– High cost of certification exacerbated by small land areas	3
	– Transport costs and distance from production areas	2
	– High price of imported hybrids	2
	– High electricity cost for cold storage	1
Sales and market problems	– Difficulties of access to government seed procurement	6
	– Competition from imported hybrids, but also fake seed	4
	– Seed sales	3
	– Small formal market	1
Pests and diseases	– Viral diseases of tomatoes	2
Limited promotion of seed varieties	– Ignorance of local production	2
	– Little access to advertising	2
	– No variety promotion policy and lack of knowledge of local varieties	1
Lack of organization of the profession	– Non-compliance with rules among stakeholders (non-professionalism)	2
	– Poorly structured profession of seed producers	1
	– Lack of information on seeds	1
	– Lack of professionalism	1
Property issues	– Land tenure insecurity for seed producers in peri-urban areas	2
Lack of training	– Lack of training to master the trade	1
Lack of adapted varieties	– Seasonality of potato seed production	2
	– Limited number of breeders for vegetables	2

Table 16: Constraints identified by the 22 agrodealers interviewed, 2020

Constraint	Details mentioned	Number of respondents
High cost of seeds	– Relatively high seed prices, especially for imported and good quality seeds.	6
Low seed quality	– Loss of germination during storage and transport	4
	– Expiry date often close	1
Sale, market	– Difficulty in the flow of products	3
	– Failure to enter the hybrid seed market	1
Weak promotion of locally produced seed	– Lack of strategy to promote new varieties, encourage local production of quality seed	3
Unattractive packaging, lack of packaging equipment	– Local seed packing problem	3
	– Difficulties in packaging and storage	2
Poorly equipped sales outlets	– Few input shops and lack of equipment	3
Poor organization of the profession	– Difficulties in ordering seed from seed producers	3
	– Long delivery time for orders	2
	– Lack of networking with cooperatives	1
	– Lack of approval from some seed companies	1
Low technical capacity of agrodealers	– Lack of seed training	2
Financial constraints	– Lack of financial support from government and technical and financial partners	2
	– Lack of government subsidies to support seed activity	1

Table 17: Constraints identified by the 15 vegetable farmers interviewed, 2020

Constraint	Details mentioned	Number of respondents
Poor quality seeds: low purity, germination, fake seed	– Fake seeds especially among poor quality imported seeds	7
	– Low germination, especially for poorly packaged or poorly stored local seeds	4
	– Production and expiry date not indicated on the package	1
	– Potato mini-tubers is often not available at the right time	1
	– Low varietal purity	1
High price of seed, especially hybrids	– Expensive seeds, especially hybrid seeds	6
Weak technical capacity of producers	– Lack of knowledge of the varieties causing a drop in yields	4
	– Lack of knowledge of nursery techniques	1
Financial issues	– Difficulties in accessing government funding and subsidies for access to quality seeds	3
Inadequate packaging and packing	– Problems with self-produced seed conditioning, packaging, point of sale, seed conservation	3
Poorly performing or unsuitable varieties	– Need for early varieties adapted to the rainy season and high temperatures.	2

Constraint	Details mentioned	Number of respondents
	– Varietal degeneration and low varietal purity	2
Agro-technical constraints	– Pests, diseases, access to inputs	9
Difficulties in flow of vegetable produce	– Difficulties in product flow	6
	– Fluctuating vegetable markets	4
Land tenure insecurity	– Land insecurity for plots	6

Potential for strengthening local vegetable seed production

There appears to be much room for growth in local vegetable seed production. Strengthening local seed production will have to be carried out both at the level of the production environment and at the level of individual stakeholders. Stakeholders interviewed expressed their ambition to increase production if some of their challenges could be addressed. However, only few seed producers have a coherent business plan for expansion.

Strengthening vegetable research programs

The role of research is to offer seed producers a choice of varieties meeting consumer demand, pest and disease resistance, climatic tolerance and good shelf-life. It is necessary to have a critical mass of vegetable researchers and enough funds for research. Many researchers in the public sector tend to switch positions regularly, which limits the accumulation of knowledge and continuation of research. The development and release of more varieties will create opportunities for local seed production to compete with seed imports. Continued cooperation with international research organizations such as WorldVeg, IITA and CIRAD is important.

Capacity building of seed producers

There is a strong demand for training and technical support for seed producers at all levels. The stakeholders deplored the lack of knowledge of local varieties and modern seed production techniques for certain vegetable species. ASSEMA is active in informing its members and UNPCM has a long experience in the organization of farmers' cooperatives. Technical support program could link to these platforms.

Reducing the production cost of certified seed

Seed certification must be improved by increasing the number of field inspectors and having more seed laboratories across the country. At present, many vegetable seed producers are far from the two laboratories in Bamako and Segou and are therefore disadvantaged in the certification process. A better division of inspection tasks between LABOSEM and DLCP could reduce costs and speed up the work. Given the limited capacity of public organizations in seed certification, it may be considered to involve the private sector in this area and to reduce certification requirements for vegetables.

Updating the regulatory system

The regulatory system must take into consideration the specific nature of vegetable seed, which constitutes a group that is botanically diverse. For species likely to be exploited for commercial purposes, clear rules for the maintenance of varieties (to avoid their deterioration), registration

and quality control must be defined. For other species greater flexibility (or even exemption from standards) is needed and these could be categorized as "farm-saved seeds".

The harmonized sub-regional regulation needs to be revised in this light. Specific technical regulations have yet to be drawn up for all species of vegetables other than tomato and onion. Procedural manuals for the import-export of seed have yet to be finalized, including a regional list of quarantine pests.

As for the seed import sector, the current rules for phytosanitary certificates, indication of seed category (basic seed, R1, R2, F1 hybrids) are necessary. Germination tests of random seed lots need to be expanded to all seed imports.

Access to equipment (treatment, packaging, storage)

Many seed producers do not have access to packaging lines. This constraint causes real losses, even if the quality of local seed production is good. Some seed companies with packaging lines have benefited from government support, but there is a need to also support other companies. It is clear that the low volume of vegetable seed production is an unfavorable factor for the acquisition of such processing equipment. Companies and cooperatives could work together and pool their resources to acquire such equipment.

Access to irrigation

Surveys sufficiently underline that the problem of access to irrigation prevents the development of local seed production in many areas. It limits both the expansion of seed production and the diversity of crops. Access to irrigation water is an important measure for securing production. Support to seed producers should cover studies of irrigation potential, facilitation of access to sources of finance and the financing of irrigation projects. A good organization of local producers (in associations) can facilitate access to finance. Advisory support for seed producers is needed in this context.

Access to land

Land tenure is increasingly becoming a concern in peri-urban areas due to uncontrolled urbanization. Vegetable farmers are sometimes dispossessed of their land. The government has intervened in some cases to allocate land to farmers on the outskirts of Bamako. There is a need to allocate permanent and secure production areas to vegetable farmers. Farmers will only invest in irrigation and plot development if their land titles are secure.

Access to credit

Seed producers and other actors are keen to receive financial support from the government and financial institutions to expand their business. To realize this, there is a need for cooperative organizations to group together, to develop sound business plans, and reduce business risk by investing in irrigation, customer relations, and production lines.

Potential for local seed production and variety development

Seed produced from local varieties mostly feed into the informal or semi-formal seed systems. A large part of this production is destined for own use or for exchange with other farmers. The quantities produced are generally small and not certified. A small proportion goes into the formal

system at the level of cooperatives or producer associations that serve seed companies or at the level of producers under umbrella organizations such as AOPP, UNCPM or ASSEMA. The formal vegetable seed system comes in part from imports of varieties and seeds from countries outside ECOWAS, WAEMU and CILSS. A large proportion of these imports fall back into the semi-formal system because of the lack of control.

Development of vegetable varieties to support local production

Local varietal development is essential for boosting local vegetable seed production. Producers will be attracted by locally available varieties that are good yielding, are resistant to pest and diseases and are preferred by consumers. However, the size of the market for each crop will justify the research efforts that could be made. For vegetables with strong market and consumer demand, such as onion, shallot, okra, tomato, and African eggplant, efforts to create new varieties are possible. For minor vegetables, evaluation and selection of local and imported varieties may be sufficient. In order to bring local seed production out of the informal sector, efforts should be made to register local varieties or evaluate varieties in the catalogue of varieties.

Problems related to false and counterfeit vegetable seed

Most stakeholders recognize the issue of fake or counterfeit seed. These problems affect all crops (cereals, pulses, vegetables). For vegetables in particular, producers and agrodealers particularly mentioned problems in tomato, okra, lettuce, watermelon, onion and cucumber. OPVs as well as hybrids are affected. According to the respondents, false seed manifests itself in the form of falsified labels, contents of boxes or packets that differ from what is indicated on the package or mixed contents. In grain crops, food grains are sold as seed. Seed sellers explained that popular varieties are generally more affected.

The proportion of seed sales affected is imprecise, with estimates of respondents varying from 5-30%. The use of false or counterfeit seed results in problems with low germination and heterogeneous plants, which lead to low yields and adversely affect the income of farmers. The problem appears to receive low priority from the government. The DLCP has difficulties in controlling the points of sale. Some agrodealers carry out germination tests at the time of seed purchase with wholesalers to ensure the quality of the lot. On the whole, they state that they are powerless in the face of the situation. Agrodealers nevertheless expressed the need for stricter government control.

Legislative and regulatory framework of the seed sector

National Seed Policy

The national seed policy was adopted in 2009 and provides a framework for seed production, quality control and distribution for all stakeholders in the seed value chain. The objective of the national seed policy is to create professionals in the seed sector and to promote the development of efficient seed enterprises.

Act No. 10-032 of 12 July 2010 relating to the legislation on seeds of plant origin in Mali

This law covers the production, importation, control, certification and marketing of seed of plant origin in Mali. It also specifies farmers' and breeders' rights as well as the protection of national

plant resources. It is supplemented by decree No. 10-428/P-RM of 9 August 2010, which sets out the terms and conditions of application. Decree 756 of 30 September 2019 established the National Catalogue of Plant Species and Varieties (CANAEVV) and specifies the process of variety registration. The seed law allows any organization approved by DNA to produce basic seed.

The organizations involved in the implementation of the national policy on plant seeds are:

- The **National Directorate of Agriculture (DNA)** and in particular the **Legislation and Phytosanitary Control Division (DLCP)** are responsible, among other tasks, for the phytosanitary quality control of inputs including imported seeds.
- The **National Seed Committee (CNS)** is an advisory body to the Ministry of Agriculture assisting in the implementation of the national seed policy. It includes the **Variety Approval and Registration Commission (CHV)** and **LABOSEM**, which maintains the **National Catalogue of Plant Species and Varieties** and does the seed certification together with DLCP officers.
- **IER** carries out crop breeding research and proposes varieties to be included in the national catalogue to CNS. This is done based on tests for Distinctness, Uniformity and Stability (DUS) and Value for Cultivation and Use (VCU). IER is also involved in the production of pre-basic and basic seeds. The IER houses the **Genetic Resources Unit** which has a gene bank that includes some species of vegetables in its collection.

<u>The C/REG.4/5/2008 on the harmonization of rules governing quality control, certification and marketing of plant seeds and seedlings in the ECOWAS area</u>

The ECOWAS harmonized seed regulation was agreed on 18 May 2008 in Abuja, Nigeria. It covers the 15 ECOWAS member countries as well as Chad and Mauritania. Mali adopted this regulation on 6 June 2014 by publishing it in the Official Gazette. The regulations define standards for quality control and seed certification for 11 crops: millet, groundnut, yam, cassava, potato, onion and tomato. Standards for other vegetables have not been defined.

It also established the **West African Catalogue of Plant Species and Varieties (COAFEV)**, which consists of all varieties registered in national catalogues. For a variety to be registered in COAFEV, it must have a denomination accepted by a National Seed Committee; be approved through a DUS and VCU test two years. However, VCU tests are not a mandated for vegetables.

Hence, a variety included in this catalogue can be multiplied and distributed throughout region. Similarly, seed produced and certified in one of the seventeen countries can be introduced into Mali with only a phytosanitary certificate needed. A regional list of quarantine pests is being established. The harmonized seed regulation recommends all countries to set up a National Seed Committee while it also established a Regional Seed Committee (RSC).

<u>Procedural manuals</u>

Two procedural manuals (Act n°10-032 of 12 July 2010 and of the harmonized sub-regional regulation) include: (a) procedural manual for the registration of varieties in the national catalogue of plant species and varieties; and (b) procedural manual for the certification of plant seed origin and for accreditation. A third procedural manual on imports-exports is in preparation.

3.3 Potential of irrigation

Agriculture in Mali is highly dependent on rainfall, which leads to strong seasonal variations in the production of vegetables (Diakite et al. 2014). Price spikes in times of market shortages are common. On the Bamako market, the price of fresh shallots can triple and that of fresh okra can double when the market is in short supply. To allow a more regular market supply of vegetables and other crops, the Ministry of Agriculture in 2007/2008 developed the National Irrigation Development Strategy (SNDI) (PASSIP 2019). The strategy outlines some of the challenges facing community-based irrigation, including:

- the high cost of irrigation infrastructure;
- insufficient funding to develop irrigation;
- variability of water supplies linked to the spatial and temporal distribution of rainfall;
- poor design and poor maintenance of irrigation infrastructure as well as poor management often leading to their abandonment;
- staff shortages and low level of training;
- unsuitable strategies for agricultural production, storage and processing;
- land insecurity and land scarcity in urban areas;
- lack of water for irrigation in some places, leading to the use of poor-quality water, especially in urban areas;
- the lack of skills in the use of irrigation equipment and techniques; and
- limited access to markets, credit and services in rural areas.

The country has a tradition of using irrigation for vegetables. Here we highlight the situation for some of the key vegetable production areas.

In **Kayes**, tomato is cultivated on the upper parts of the valley during the winter season. After harvesting the lowland rice, small-scale vegetable production (onion, tomato, eggplant) is carried out intensively with small motor pumps installed on shallow wells. Onion (*Violet de Galmi*) is the main irrigated vegetable produced in the region. Okra is also cultivated in the off-season. Some farmers have specialized in seed production.

In **Koulikoro** many women's organizations are involved in small-scale vegetable production. They use surface water (sumps) or boreholes equipped with solar pumps. The developed plains of the Selingue dam and the irrigated perimeter of Baguineda are used for vegetable production in the off-season. The California watering system or motor pumps take water from various sources (wells, micro-dams, pounds, and rivers) and are used by producer groups near Koulikoro, Kati, Kolokani and Dioïla. Vegetables of economic importance include onion, shallot, tomato, potato and okra as off-season crops.

In **Sikasso**, the expansion of cotton cultivation has been an element leading to the diversification of agricultural production. Small-scale vegetable production is a popular activity among women in this region with potato as one of the most popular irrigated crops produced in the lowlands, which is said to give better returns than cotton.

In **Segou**, in the Office du Niger zone and on river banks, vegetable production is practiced during the off-season when no rice is produced. Gravity irrigation and motor pumps are used. The dominant crops in this region are potato, okra, onion/shallot and chili pepper.

In **Mopti, Dogon country**, there are large areas irrigated from the reservoirs of small dams. Modern irrigation techniques in vegetable production are being introduced. Small motor pumps have recently appeared to take water from the reservoirs. It is the most important production area for shallots in Mali.

Water regime of vegetable seed production

Generally speaking, vegetable production is either rainfed or irrigated, or rainfed with the use of supplementary irrigation. Interviews with government organizations and seed producers assessed the potential of irrigation adapted to local production systems, identified gaps and constraints encountered and the expectations of producers to increase vegetable seed production.

According to seed producers and government organizations, the following observations can be made for the main vegetables in Mali:

- onions, shallots and tomatoes are mostly irrigated;
- okra, amaranth and watermelon are mostly rainfed; and
- African eggplant, chili pepper and some leafy vegetables such as cabbage and lettuce are grown in both rainfed and irrigated fields.

A few other observations were made: First, many crops can be cultivated under rainfed and irrigated conditions, depending on the location and access to water and irrigation equipment. Second, new varieties have allowed farmers to better distribute their production throughout the year. This is the case with tomatoes, for example. Crops that were previously only produced during the rainy season are nowadays also produced in the cool or dry seasons, and vice versa. The adaptation of varieties to the different seasons allows farmers to get better returns and reduces the need to preserve vegetables. Third, seed production can be done in all seasons, depending on the water availability. Fourth, cereal crops are usually produced during the rainy season, which is important to consider because cereals compete with vegetables for labor. More vegetable seed is therefore produced during the off-season after the winter crops in rice growing areas or in the dry and cool season after the cereal harvest.

Irrigation methods applied and water sources

Irrigation methods

There are essentially two categories of irrigation systems in Mali, including open canal networks and pressure pipe networks. Pressure pipe irrigation systems are classified according to the pressure required for their operation, the method of water distribution to the plant and the type of installation (fixed or temporary).

Irrigation methods include sprinkler irrigation (above the crop), surface irrigation (e.g., furrow, basin, bed) and micro-irrigation (localized irrigation), which does not distribute water over the entire surface, but is applies it in low doses to a limited area around the plants (PASSIP 2019).

Our data show that irrigation methods applied by seed producers depend on the available water source (type, depth, abundance), the condition of the plot (layout, topography) and the financial capacity of the producer as well as the availability of labor. **Figure 2** shows the importance of the various irrigation systems in different regions of the country. The main irrigation methods used by the vegetable seed producers surveyed included:

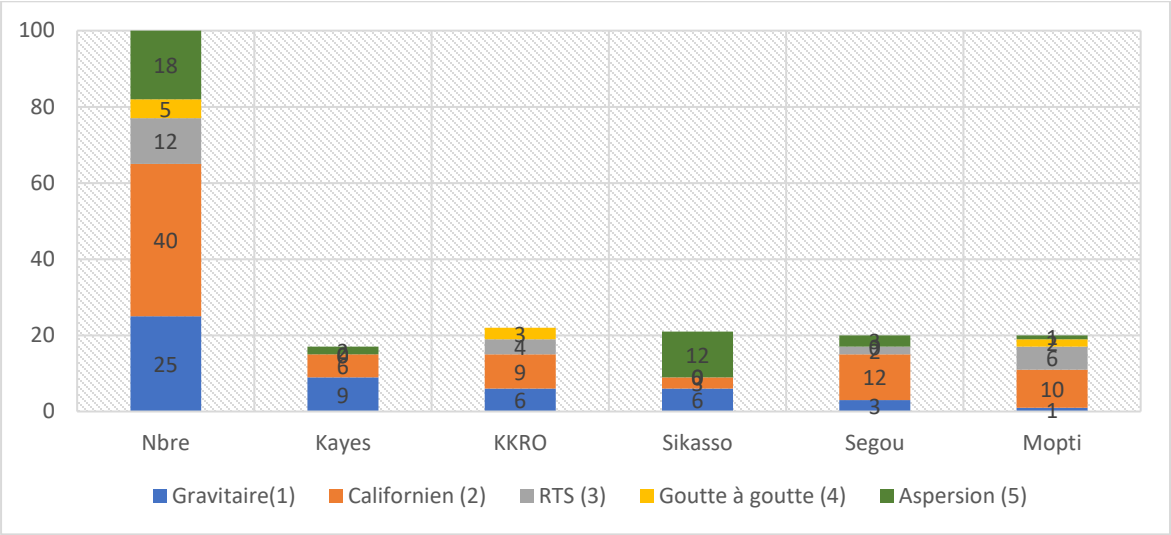

Figure 2: Distribution of irrigation techniques per region

Source: PASSIP, 2019. Note: This is for all crops, not just vegetables.

Watering can irrigation (RTS): This traditional system requires a lot of physical effort which limits the surface to be covered. Shallow wells are dug inside the plots and water is taken from the wells or pumped up by gasoline-fueled motor pumps. Generally, the plots are small in size (a few m² to a few dozen m²). This is generally used for off-season crops. The method was applied by the largest number of individual seed producers surveyed. They are common in areas that are not located in the immediate vicinity of water bodies or built-up areas.

Gravity irrigation (gravitaire): It has the advantage of being inexpensive to install, if we exclude the work needed to flatten and grade the field. The practice is widespread in large vegetable production areas, particularly in irrigated areas near villages, in villages along rivers, and near water reservoirs and in lowlands. This is also the case in the Office of Niger zone and in the irrigated perimeters of Baguineda, Segou and Selingue.

Drip irrigation (goutte à goutte): Drip irrigation does not require any particular layout of the plot. The water must have decent pressure for the system to work properly and must be clean enough for it not to block the system. The practice is common in areas far from water bodies. A borehole equipped with an electric or solar pump and a water tank is in most cases installed, to which the drip device is connected. The method can be applied wherever there is access to ground or surface water and has a good technical efficiency (Kane et al. 2018). However, the system is not widespread because only few producers can afford it, although there is an increasing interest in using it.

Californian system: In this system the water is transported by pipes buried in the soil and water hydrants are installed in the higher parts of the plot. The method was not used by any of the seed producers interviewed, but some vegetable farmers near urban areas prefer using it (Kergna et al. 2018). It seems to have a high technical efficiency for the production of many vegetables.

Sprinkler irrigation (aspersion): This method was rare among the vegetable seed producers surveyed.

Studies in the Koulikoro and Mopti regions indicated that some crops are more suitable for particular irrigation technologies than others (Kane et al. 2018). As based on the opinions of the respondents, it appears that drip irrigation is more suitable for tomato and shallot seed production; sprinkler irrigation is better for potato and shallot seed production; and the Californian irrigation system is suitable for shallot and potato seed production.

Energy sources

Energy sources depend on the irrigation methods used, the source of water and the financial costs and returns. The main sources and their use are:

- Fossil fuels are widely used to power motor pumps or generators that run pump. The main constraint for producers is the cost of fuel.
- Solar energy is used to pump up groundwater. The investment cost is an important barrier that limits adoption among seed producers.
- Electrical energy can be used when a power grid is available. It can supply pumps immersed in surface and groundwater, but may not always be profitable for producers.
- Human physical energy is required for watering with a watering can. The amount of labor available limits the area that can be irrigated.

Water sources

Two sources of water are available: surface water (wells, ponds and rivers) and groundwater. Regarding surface water, wells are widespread where the water table is shallow. The water is pumped up manually or by motor pump. Farmers taking water from ponds and rivers generally use motor pumps. Storage reservoirs can also be built from these water sources to water vegetable production sites. Rivers are commonly use to irrigate vegetable production. The banks of the Niger and Senegal rivers and their tributes are suitable for vegetable production. Groundwater is abundant in many parts of the country. However, access depends on the depth of this water. It is brought to the surface using a submersible pump (electric or solar).

Consequences of the lack of irrigation on vegetable seed production

During the winter season (from May to September), it is often necessary to use supplementary irrigation when water stress occurs during sensitive periods of the vegetative cycle (especially the fruiting phase). This is an important to secure seed production and seed quality. In the rainy season, several seed producers grow crops such as okra, amaranth, watermelon, African eggplant, chili pepper, and potato. Most rainfed seed production plots do not have back-up irrigation.

Many seed plots are sown at the end of the rainy season, during the off-season in the Office du Niger zone and in village irrigated areas. The crops grown include shallots, onions, African eggplant,

chili and leafy vegetables (lettuce, cabbage), but also potatoes. Producers ensure that water is available during the whole crop cycle.

All vegetables can be affected by water shortages. For seed plants, the fruiting and ripening phases are critical as water stress may result in poor seed maturation and seed may be good enough for certification. For plants with bulbs (shallot) or tubers (potato), water stress at the crucial moment of bulb and tuber formation causes remain small. Therefore, quality seed production strongly depends on the availability of water throughout the crop cycle. It is a factor of productivity, quality and ultimately the profitability of seed production.

Improvement of irrigation and profitability of vegetable seed production

For most seed producers, improved water supply is associated with higher profits. However, seed producers explained that there is a need to choose the right irrigation method and to adjust it to the possibilities of the producer. The cost of the investment must be taken into account and compared to the added benefit. The rationalization of water management to limit water losses can reduce the cost of seed production. In the case of sprinkler irrigation or manual watering, the cost of labor can quickly become a constraint, even in situations of abundant water. Seed producers thought that farmers can reduce irrigation costs by using good varieties and intensive cultivation techniques. The price of seed was also cited as an important factor justifying the use of irrigation.

3.4 Interventions to strengthen the vegetable seed sector

Required changes to the regulatory environment

Stakeholders interviewed thought that seed regulations in Mali are good, but that regulations are not always correctly applied. Mali has adopted ECOWAS regulations on plant seeds. However, technical standards for inspection and certification have only been defined for onion and tomato. These standards need to be extended to crops such as okra, chili pepper, eggplant and many other crops, but this appears to receive low priority. Also, there is still no regional list of quarantine pests. Furthermore, the effective alignment of the Malian Plant Seed Law with harmonized regional regulations remains to be done.

Seed certification is a contentious issue. Many seed producers appeared satisfied with the way seed certification operates currently with LABOSEM carrying out a single inspection visit. However, seed producers are concerned about the high cost and about delays in obtaining certificates. However, other stakeholders denounced current practices as they do not comply with regulations. Furthermore, there is a need to strengthen the SOC with qualified staff and adequate resources. Seed testing laboratories of LABOSEM are needed outside the ones in Bamako and Segou. Initially, priority could be given to the Kayes and Sikasso regions.

Another key weakness of the vegetable seed sector is that only few vegetable species have been included in the 2020 national catalogue and it requires updating. A greater effort is need to develop local varieties and cataloguing them. Variety registration must be a continuous process for researchers and the Variety Registration Commission and a catalogue needs to be published regularly (at least every two years, and preferably online) in accordance with the provisions of the harmonized seed regulation.

Many local stakeholders including seed companies and cooperatives are not knowledgeable about current seed laws and regulations. There is a need to provide training and to disseminate information in the local languages.

Current seed laws and regulations in Mali do not take into account the particular nature of vegetables. Furthermore, there is a need to distinguish between traditional vegetables, whose seeds are produced and exchanged by farmers in small quantities, and exotic vegetables produced or imported by the formal seed sector. Farm-saved seed of traditional vegetables can be exempted from regulations, in particular the requirement for registration and certification and also regulations about the minimum areas of the different vegetable species and the minimum size of seed lots.

Stimulating the use of improved irrigation methods

In the opinion of seed producers, improved irrigation systems are those that minimize the use of physical labor, allow use on large areas, and improve the efficiency of water use. According to seed producers, the profitability of irrigation methods depends on several factors such as the plot layout, the scale and intensity of production, and the water source. Land insecurity, especially in peri-urban areas, reduces incentive for seed producers to invest in irrigation. Vegetable seed producers who do not own their land are reluctant to invest in a sustainable way. Small land sizes, high cost of equipment and insecure output markets were mentioned as key constraints to adopting improved irrigation methods.

Technological or institutional interventions

Seed producers reported low technical knowledge in several areas of their profession. For example, seed production methods are not known for many vegetables and seed producers rely on traditional methods that do not always deliver quality seed. Others mentioned the lack of knowledge of new varieties that are flooding the market. Hybrids are often mentioned among these innovations. Some producers also indicated their lack of knowledge of improved irrigation tools. Small individual seed producers are the most disadvantaged.

There is a need for targeted interventions to provide seed producers with up-to-date knowledge and technical skills. All respondents in the vegetable seed value chain, including companies and enterprises, individual producers, cooperatives, and agrodealers expressed the need for training in seed production. Low yields and poor diversification of production are the result of producers' lack of access to new production, storage and packaging technologies.

There is also a great need for research to develop new vegetable varieties adapted to the different seasons and agroclimatic conditions in Mali and with consumer-preferred traits. Post-harvest management, modern packaging and crop preservation technologies are key areas that require support. Seed producers are also asking for capacity building in the field of vegetable seed production, in particular, the production of F1 hybrids and to introduce these to seed producers.

Upgrading of equipment is necessary for many companies and enterprises, and even some cooperatives. It concerns packaging materials and equipment, as well as storage infrastructure. The development and expansion of irrigation, where possible, will allow intensification and diversification of seed production.

4 Conclusion

The vegetable sector in Mali has much expanded since the country's economy opened-up in the 1990s. A turning point for the vegetable seed sector was when the government loosened its control of seed production, ended its monopoly of basic seed production, and allowed the private sector to participate. This led to the creation of seed producers grouped into seed cooperatives and associations. Foreign seed companies and their local distributors have been able to seize these opportunities by selling imported vegetable seed in Mali. This has given Malian farmers more choice of vegetable varieties, including hybrids. However, the price of seed for local small-scale vegetable farmers is high, not all varieties perform well, and there are extensive problems with low quality seed (including mislabeled and counterfeit seed).

Local vegetable seed production in the formal seed sector, consisting of seed companies, cooperatives, associations and public organizations, has struggled to keep up with this development, even though many new businesses have entered the sector—attracted by the high price of vegetable seed and the growing seed demand from farmers. Local seed business (production and distribution) remains concentrated around urban centers, particularly the city of Bamako and is focused on a narrow range of economically important vegetables such as onion, shallot, eggplant, okra, and tomato. Seed production is carried out by individual producers, associations and cooperatives that supply local seed companies. Seed of traditional vegetable species is mostly produced by farmers in the informal sector. In the formal sector, basic seed continues to be produced by public research organizations (despite liberalization), but is appears to be poorly connected to customers and receives only few orders annually.

There are clear weaknesses in the certification of locally produced seed as the cost is high (according to small-scale seed producers), government inspectors do not regularly inspect production sites, and there are significant delays in handing out certificates. Furthermore, locally developed varieties must be registered in the national variety catalogue before release, and this requires multilocation and multi-season testing including VCU and DUS. As a consequence, the role of locally produced vegetable seed remains small and seed companies prefer to import seed than to produce it locally, especially because imports only require a phytosanitary certificate and germination test but do not require registration in the national variety catalogue. Regional harmonization of seed laws has potential, but national seed laws are still not fully aligned, standards have so far been agreed for only two vegetables (tomato and onion), and a list of quarantine pests is still not available, which limit the effectiveness of regional harmonization.

Public research organizations in Mali have very limited resources to develop new vegetable varieties. There are very few researchers working on vegetables. Still, new varieties have been released for okra, African eggplant, shallot and tomato in collaboration with WorldVeg and this collaboration could potentially lead to the introduction of many other varieties for local seed production. However, while these varieties are well-adapted, the seed supply chain is weak as only few seed producers have the necessary equipment to produce sealed seed packs and have cold room storage necessary to maintain seed quality. Agrodealers also mentioned that the locally produced seed packs do not look as attractive as imported seed packs. It is noted that a few companies and cooperatives (e.g., COPROSEM) are making progress in this area.

The following actions could be undertaken to strengthen the role of local seed production in Mali:

Regulatory environment:

1. At the regional level, standards for vegetable seed need to be developed for crops other than onion and tomato to facilitate the regional trade in vegetable seed.
2. Regulations need to distinguish vegetables from other crops (e.g., cereals), and within the vegetable category they need to distinguish between seed of economically important vegetables handled by the formal sector and seed of traditional vegetables that are of little interest to the formal sector and are likely to remain in the informal sector. Strict requirements of registration and certification should not be applied to these traditional vegetables as this would undermine their production.
3. There is much ambiguity in the application of existing regulations, particularly with respect to certification as current practices do not comply with regulations. The government may want to consider allowing the private sector to involve in seed certification of vegetables to address the capacity constraints of the public sector. Stricter control is needed for seed imports as much appears of dubious quality and escapes inspection.
4. The process of variety registration and seed certification increase the cost of local variety development and seed production and favors seed imports over local production. The government should revisit these requirements and try to ease them for vegetables. For instance, it may not be necessary to require multi-location and multi-season VCU and DUS testing for vegetables.
5. There is a need to professionalize the production of the national catalogue of vegetable varieties as it requires a transparent process of registering new (and removing old) varieties, regular updating, and online publication.
6. The role of the Official Control and Certification Service (SOC) needs to be strengthened and LABOSEM needs to be decentralized to better serve seed production in different parts of the country. There is also a need for more regional seed laboratories.
7. Given the potential of vegetable production to contribute to food and nutritional security and poverty alleviation, it is imperative that the government gives higher priority to developing the vegetable seed sector.

Infrastructure and institutions:

8. Local seed production is limited by access to improved irrigation systems, despite the abundance of surface and groundwater in many areas. The issue is compounded by land insecurity in peri-urban areas, which reduces the incentive among seed producers to invest and also creates difficulties for them to access loans and financial services. There is also a need to strengthen the technical capacity of local seed producers in various irrigation methods.
9. Local seed companies and cooperatives require better equipment for seed processing, packaging and storage and support in developing professionally looking seed packs. This would enhance the value of locally produced seed.
10. Seed producers are increasingly organizing themselves by grouping together as cooperatives and seed companies rely on these to supply seed for selling. Further

strengthening of seed cooperatives is important to overcome some of the key technical constraints to seed production and marketing, including seed processing and packaging.

Capacity building:

11. There is a need for more investment in local vegetable breeding research to increase the choice of locally adapted varieties. Public sector research is very limited at the moment while there is no significant capacity in vegetable breeding research in the private sector.
12. There is a great need for capacity building among all actors in the vegetable seed sector. For instance, seed producers expressed their need to learn about good production practices, pest and disease management, seed conservation and storage, and innovative irrigation practices; and agrodealers expressed their need to better understand seed quality, storage conditions, trade and import-export procedures. There is also a general need among actors to become more effective in product promotion and sales.
13. Many local stakeholders including seed companies and cooperatives are not knowledgeable about current seed laws and regulations. There is a need to provide training and to disseminate information in the local languages.
14. There are clear capacity constraints in the public sector to handle the production of pre-basic and basic seed of vegetables. The government needs to revisit this and consider expanding the role of the private sector in this area.

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