

Strengthening national seed systems for household food security in developing countries

Practical experiences and a framework for policy makers to build effective seed systems

Experiences from Central Asia, West Asia and Africa

Acknowledgments

Writing and reporting — Peter Fredenburg. Prepared by Zewdie Bishaw, Abdoul Aziz Niane and Michael Devlin (ICARDA).

This report is a synthesis of the research and development work done in past years by ICARDA's Seed Section of Biodiversity and Integrated Gene Management, with a number of partner countries in Africa and Asia to improve the performance of national seed system, both formal and informal, in seed production and marketing to support their national and household food security strategies.

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Key words:

Seed Systems, formal seed sector, informal seed sector, policy and regulatory framework, fast track variety testing and release, accelerated seed production, village-based seed enterprises, rebuilding agriculture post conflict, mitigating wheat rusts

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International Center for Agricultural Research in the Dry Areas (ICARDA)




[E-mail: ICARDA@cgiar.org](mailto:ICARDA@cgiar.org) www.icarda.org

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International Center for Agricultural Research in the Dry Areas (ICARDA), PO Box 114/5055, Beirut, Lebanon

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Seed systems:building agriculture on a strong foundation

Contents

Key Messages	3
Executive summary	4
1. Seed systems: the status quo	2
1.1 The need for seed systems.....	2
1.2 Current seed systems	4
2. A framework for effective national seed systems	6
2.1 Formal seed sector	7
2.1.1 Policy and regulatory framework.....	7
2.1.2 Variety development, evaluation and release	10
2.1.3 Seed production, processing and storage.....	11
2.1.4 Seed marketing and distribution.....	13
2.1.5 Seed quality assurance.....	14
2.1.6 Strengthened capacity for seed sector.....	14
2.2 Informal seed sector	15
2.2.1 Recognizing the role of informal sector.....	15
2.2.2 Alternative seed delivery through farmer-based seed enterprises	15
3. ICARDA's expert support in strengthening seed systems	17
3.1 Seed system research	17
3.1.1 Functioning of seed system	18
3.1.2 Variety release mechanisms	22
3.1.3 Wheat commercial behavior and varietal choices in Ethiopia	23
3.1.4 Wheat seed sector in Pakistan.....	25
3.2 Promoting village-based seed enterprises	27
Organizing village-based seed enterprises	27
3.3 Restoring and safeguarding seed systems	29
3.3.1 Assessment of seed security in Greater Horn of Africa.....	30
3.3.2 Supporting seed system recovery in Afghanistan	31
3.3.3 Agro-biodiversity conservation and use in West Asia.....	34
3.4 Establishing/strengthening seed units	37
3.5 Mitigating wheat rusts in Africa and Asia	38
3.5.1 Accelerated seed multiplication to counter threat of stem rust in wheat	42
3.5.2 Rapid deployment of yellow rust resistant varieties in Ethiopia	44
3.5.3 Wheat productivity enhancement program in Pakistan.....	49
3.5.4 Support to wheat seed sector in Iraq	49
3.6 Fostering regional cooperation to promote seed trade	51
3.6.1 Regional seed network.....	51
3.6.2 Harmonization of seed sector in ECO region.....	51
3.6.3 Establishing ECO seed association	52
3.7 Human resource development for the seed sector	52
Appendix	55

Key Messages

1. An important bottleneck for developing countries and their development partners to ensure national and household-level food security is the lack of robust and flexible systems for seed delivery. The primary constraints for many countries are the need to improve the effectiveness of the national seed systems to deliver quickly new crop varieties to the majority of farmers. This requires policies that are adapted to the reality of countries' situations — that improve the efficiency of seed delivery through more flexible government practices and that encourage partnering with the private sector to provide a more market-based approach to seed delivery.
2. The proposed restructuring of formal seed systems emphasizes the need for countries to put in place flexible policies and laws, rapid variety evaluation and release, and accelerated seed multiplication, as well as harmonizing laws, regulation and procedures to encourage varietal and seed movement across regions. National seed systems can speed the delivery of new varieties by engaging the private sector, providing access to public varieties and include them in production planning, seed production, and seed promotion and distribution to farmers.
3. Many farmers remain beyond the reach of formal seed sectors, especially those who work marginal land in remote communities of the world's dry areas, therefore decentralized farmer-based seed enterprises are essential to seed systems' achieving broad coverage particularly for crops and regions where neither the public sector nor the private sector is able to operate. Experience shows that the sustainability of such enterprises depends on their pursuit of profit.
4. The recent spread of a new and virulent race of wheat stem rust (black rust) and stripe rust (yellow rust) in Africa and West Asia have highlighted the need to build and maintain strong national seed systems to safeguard agriculture against this widening epidemic and other threats to farm productivity and sustainable food security. This would be of paramount importance in the face of climate change.
5. Critical factors that low income countries can embrace to improve the performance of their seed systems include: adoption of the good practice of fast-tracking variety testing and release including regional variety release; accelerating seed multiplication by introducing flexible approaches and optimizing crop management practices; extending multiplication into the off-season with irrigation; strengthening national capacity for seed multiplication; and increasing investments in agricultural extension.
6. ICARDA's global links and expertise in generating international public goods to improve agriculture in the dry areas make it a partner of choice for restoring and strengthening national seed systems in dry areas of Asia and Africa. Drawing on more than three decades of experience, ICARDA's Seed Section has devised a framework that can make seed systems more effective and resilient.
7. National seed system performance can be measured by many factors including the existence of stable enabling policy and regulatory environments; institutional and organizational strengths and configurations; and the technical capacity in terms of the quantity and quality of seed delivered at the right place and at the right time and at an affordable price to meet the 'effective' demand of farmers. A sustainable seed system can't be built without strong institutions; and adoption and impact can't be realized without adequate investment on seed delivery to achieve tangible outputs. Within research for development continuum, developing sustainable seed system should combine both research components along the seed value chain to analyze system constraints and seek solutions and developmental components to strengthen existing or creating new institutions, to facilitate technology generation and transfer to ensure adoption and diffusion through provision of quality seed of new crop varieties.
8. Seed technology is a relatively new discipline and in contrast to other disciplines in agricultural sciences there are very limited numbers of institutes which are active in training the manpower requirement and offer diverse courses for various levels of studies. As a result, most seed specialists are experienced in the art, and not trained in the field. It is a discipline which blends science, business and management. Strengthening human resources should be one of the key objectives which would lead and manage the national seed sector and meet the challenges and opportunities.

Executive summary

Healthy agriculture depends on good seed. Farmers' access to the high-quality seed of well-adapted and farmer/consumer preferred crop varieties is central to boosting agricultural production and productivity, improving rural livelihoods, and ensuring food and nutritional security in rural and urban areas alike. The timely production and distribution of good seed depends on strong national seed systems. Successful seed systems are typically led by the private sector, working in partnership with agricultural research and governments. As with any other market, understanding the seed market is crucial to providing the right products and services at the right price, making available in sufficient quantities at the right time and place, and promoted through the right media. However, the seed systems in many developing countries have failed to involve and learn from the private sector.

This report examines the common shortcomings of national seed systems and proposes a framework to overcome them. It shows the International Center for Agricultural Research in the Dry Areas (ICARDA) to be the partner of choice for building and restoring resilient seed systems in the arid zones of tropical and subtropical Asia and Africa, where ICARDA has generated international public goods through highly productive partnerships for more than a third of a century. ICARDA has convened and led international initiatives to conserve agro-biodiversity; restore seed systems destroyed by conflict, notably in Afghanistan; and safeguard agriculture threatened by future conflicts, climate change, natural disasters and crop disease epidemics.

Seed system improvement has recently become an urgent priority to counter Ug99, a virulent strain of wheat stem rust now spreading across Africa and West Asia and threatening to snowball into a global pandemic. Further, strong seed systems help agricultural economies devastated by conflict to revive more quickly. This can prevent much of the suffering endured by post-conflict farm communities and the urban populations that depend on them for supplies of affordable food.

While many countries invest significantly in crop breeding and other areas of agricultural research, these activities lack strong links with agricultural extension services, which are typically underfunded and unsystematic. Red tape causes unnecessarily delays in variety approval. Technical stumbling blocks, such as failure to multiply seed in the off-season using irrigation or to optimize crop management, deprives farmers of the timely delivery of sufficient certified seed to meet demand. The slow release of new varieties translates into low rates of varietal replacement and diversity, undermining agricultural productivity in the best of times and inviting disaster as pests and pathogens evolve and spread. The proposed framework for building effective seed systems addresses both formal and informal systems alike.

For formal systems, the timely dissemination to farmers of quality seed efficiently and effectively engaging both the public and the private sector depends on (1) an appropriate policy and regulatory framework governing the variety release mechanism, plant variety protection, seed certification, and domestic and international seed trade; (2) the development, evaluation and release of well-adapted varieties preferred by farmers and consumers; (3) appropriate procedures and adequate facilities for producing, processing and storing seed; (4) seed marketing and distribution networks that deliver seed to locations from which farmers can

readily fetch it; (5) seed quality assurance to protect producers and users alike; and (6) capacity strengthening for national seed system.

Importantly, the informal seed systems that still serve the vast majority of farmers — especially those working less-favorable land in remote locations beyond the reach of formal seed systems —are best strengthened through village-based seed enterprises. Organizing such enterprises for effective seed promotion and profitability can spur many of them to evolve into commercial contributors to local agro-industries. The pursuit for regional seed networks, regionally harmonized regulations, regional seed trade associations, etc. are key for easy movement of varieties and seeds across national boundaries. This would help regional integration and create opportunities for seed market attracting private sector investment.

1. Seed systems: the status quo

Good seed is the foundation of productive agriculture. It is also a primary catalyst of change, as most agricultural innovation in the field starts with farmers' adoption of improved crop varieties. Farmers' access to the high-quality seed of well-adapted crop varieties is central to boosting agricultural production and productivity, improving rural livelihoods, and ensuring food and nutritional security in rural and urban areas alike. Without good seed, the other aspects of a healthy agriculture sector — crop management, postharvest handling, marketing and distribution — cannot ensure adequate incomes for farmers or resilient food security for the larger society. The production and distribution of good seed depends on the establishment and maintenance of strong national seed systems.

1.1 The need for seed systems

A hallmark of a rich society's highly efficient and bountiful agriculture is a strong seed system built by many hands. Geneticists conserve and curate agricultural genetic resources, crop breeders develop varieties adapted to current growing conditions in particular localities, administrators and policy makers secure in a timely way official approval and certification of these varieties, extension personnel and other communicators educate farmers on trends regarding pest and disease risks to guide their choice of appropriate seed for the coming season, public and private institutions and progressive farmers multiply seed efficiently and quickly to fully meet demand, and marketing networks distribute seed cost-effectively to keep this invaluable input within farmers' reach.

Successful seed systems are typically led by the private sector, working in partnership with agricultural researchers and governments. In contrast, the seed systems of many developing countries fail to engage the private sector effectively and therefore fall short of their potential. In the least-developed agricultural economies, smallholder farmers save a portion of their crop every season to use as seed in the next. This is the tradition through which agriculture has come down through the ages (see Box 1).

Box 1: The evolution of seed systems

Traditional agriculture integrates at the farm level the conservation and use of genetic resources, crop improvement, seed supply, and crop production. Farmers manage genetic resources by selecting seed and landraces adapted to their environment. Farmers possess a wealth of indigenous knowledge and experience that informs on-farm seed management toward maintaining and improving seed quality by carefully selecting, cleaning, treating and storing seed.

In modern commercial agriculture, by contrast, plant breeding, seed production and grain production have evolved into separate specializations. The modern seed industries now common in developed countries are the result of seed enterprises going through several stages of consolidating into ever larger corporations dealing with diverse product portfolios in addition to seed.

Seed systems in developing countries have evolved differently, emerging initially as top-down seed projects. Following the Green Revolution in the 1960s, international development agencies financed many projects to organize national seed systems in developing countries. They introduced formal seed systems modeled on those in developed countries and designed to channel to farmers high-quality seed of new varieties developed through agricultural research. These projects established key components of seed programs, including facilities for seed production, processing, storage and quality assurance.

However, governments typically implemented these projects through government seed departments or public companies mandated to pursue national policies that were primarily social and developmental. These departments and companies were often subsidized monopolies working to fulfill official planning objectives. Effective management, financial efficiency and marketing were neglected, and the distribution of seed was often closely linked to extension programs and credit schemes, supplying to farmers large quantities of seed — but limited to staples such as wheat, maize and rice and reaching only the luckier farmers in favorable environments. Only a small minority of farmers had access to the seed of improved varieties and benefited from the findings and products of national and international agricultural research. Inflexible public sector agencies were ill-equipped to serve smallholder farmers in remote areas with less-favorable environments.

In the mid-1980s, international development agencies began to change their policies, calling for less government control and a greater role for the private sector. Reforms in the seed sector varied widely from country to country. They depended on each country's broad economic policies and factors particular to agriculture such as the predominant crops and their importance to the national economy; the ratio of irrigated to rainfed fields; the relative importance of commercial and subsistence agriculture; and farmers' access to new crop varieties and seeds, other agricultural inputs including credit, and the rural infrastructures and markets that enable farmers to market their production. The box table traces the emergence of Pakistan's private seed sector.

Evolution of the national seed sector in Pakistan

Year(s)	Number of new seed companies established		Remarks
	Public	Private	
1947-1960			Department of Agriculture (ad hoc arrangement)
1960-1972	1		West Pakistan Agricultural Development Corporation (1960-72); later dissolved
1972-1976	1		Agricultural Supply Organization (1972-76); established as a transition
1976-1980	2		National Seed Industry Project started by World Bank; Two public seed corporations (SC): Punjab SC and Sindh SS; National and Provincial Seed Councils; National Variety Registration Department; and Federal Seed Certification Department established
1981-1982	4	3	National private seed companies registered; one in 1981 and two in 1982
1984-1991		3	Multinational seed companies registered: Cargill in 1984, Pioneer in 1989 and Syngenta in 1991
1993		14	National seed companies established
1994		10	National seed industry policy formally declared
1995-2000		226	One multinational (ICI in 1996) and 225 national seed companies established
2001-2007		409	One multinational (Bayer Crop Sciences) and 408 national seed companies established
Total	4	665	Two public seed corporations (Punjab and Sindh); Agricultural Development Authority (KPK); Department of Agriculture (Balochistan); 660 national private seed companies; and 5 multinationals,

Source: Ahmad and Bishaw, 2008

Reviving widespread dependence on farmer-saved seed may have romantic appeal, but turning back the clock is not a viable option in today's increasingly integrated world. Planting saved seed of the same varieties season after season, year after year, exposes farmers to crop loss as insect pests and disease pathogens spread into previously unaffected areas, or as local pests and pathogens evolve to overcome crops' natural resistance to infestation. The lost harvests caused by such crop plagues — or by other natural disasters, civil strife or war — can leave hungry and destitute individual farm families, larger agricultural communities and even whole regions. A failed crop that leaves no seed with which to plant the next crop perpetuates hunger and privation over the medium term.

Many developing countries have advanced their agricultural economies from basic reliance on farmer-saved seed, at least in their more favorable and accessible rural districts amenable to commercialized agriculture. Most of these seed systems nevertheless suffer inefficiencies that can be overcome with well-directed interventions.

The purpose of this report is to identify the causes of seed systems' failure to operate at their full potential, describe a framework for effective seed systems and illustrate by example how policy makers can enhance their national seed systems.

The improvement of seed systems has recently been recognized as an urgent priority to counter Ug99, a virulent strain of wheat stem rust first identified in Uganda in 1999 (hence its name). Ug99 is spreading rapidly across East and Southern Africa and West Asia and threatens to become a global pandemic. Some 90-95% of the wheat varieties grown in affected areas are susceptible to the fungus and therefore must be quickly replaced with resistant varieties. This requires seed systems much stronger and more comprehensive than those found in most developing countries. Further, stronger seed systems allow agricultural economies devastated by conflict or natural disaster to revive more quickly, thus preventing much of the suffering experienced by rural communities and the urban populations that depend on them for affordable food supplies. The risk of future conflicts and disasters compounds the urgency made starkly evident by the spread of Ug99. So does the need to adapt to climate change. The time to strengthen and streamline seed systems is now.

1.2 Current seed systems

Most national agricultural research systems, national seed programs and extension services are poorly set up for expeditiously identifying new varieties, testing and approving them and multiplying, marketing and distributing seed of these varieties. While many countries invest significantly in agricultural research and crop breeding, these activities lack strong links with agricultural extension services and other avenues for popularizing new crop varieties, which are typically underfunded and unsystematic.

In addition to hobbling farmer uptake of new technologies, including improved seed, such disjointed and uncoordinated systems fail to pursue options that can speed the development and delivery of new varieties. Under prevailing

conditions, farmers may have to wait 8 years for a new crop variety, as variety selection and approval typically takes 2-4 years, followed by another 2-4 years for seed production and delivery. One reason the process is inadequate policy that, for example, restricts to a government-controlled corporation the role of multiplying seed and denying access to private sector. Another reason is the common practice of limiting breeding and seed multiplication to the crop's main growing season, thereby slowing the process of its completion.

The slow release of new varieties translates into low rates of varietal replacement. The average age of prevalent wheat varieties, for example, may exceed 14 years in some developing countries. Large areas of wheat planted with relatively few and sometimes obsolete varieties that are susceptible to newly emerging diseases. Especially for widely planted staples (e.g. wheat) speedier varietal replacement is urgently required to counteract the threat of crop disease epidemics and ensure food security.

The formal sector supplies seed of some important food crops to farmers in favorable areas, but neither the public nor the private sector has worked out how to serve smallholder farmers in less-favorable environments. Perversely, recent policy shifts toward promoting liberalization and privatization in the seed industry have substantially reduced how much seed government-run agencies and companies produce and market, while failing to spark private sector interest in providing seed to subsistence farmers, because of low profits.

Delays caused by bureaucratic complications or technological shortcomings can severely hobble responses to emergencies such as the spread of Ug99, for which time is of the essence. Meanwhile, the efficient operation that gears seed systems to respond promptly to emergencies also pays dividends year to year when no emergency is present. Turning necessity into opportunity, the need to counter the spread of Ug99 can become a catalyst for building effective national seed systems that are better able to serve farmers and government objectives regarding rural livelihoods and national food security, delivering dividends long after the Ug99 challenge has been met. National seed systems can accelerate their improvement by learning from the private sector and by engaging private firms in partnerships that allow enterprises to do well while doing good, benefitting farmers and corporate bottom lines alike.

Contingency planning is critical to any seed system to shorten delivery times in emergencies. Such planning should include fast-tracking variety evaluation and release, accelerated seed multiplication, and speedy distribution to farmers. Systems can be more effective and comprehensive if they combine the large, formal seed sectors governments operate (ideally with private partners) and the proven strengths of traditional informal systems of farmer-to-farmer exchange. The formal systems enjoy economies of scale as they improve seed delivery primarily to farmers in favorable agricultural environments with good roads and other means of access. Meanwhile, the informal system of seed exchange farmer to farmer that is prevalent in less-favorable or inaccessible environments can be strengthened through the creation of farmer based seed enterprises.

The following section spells out the components of a framework for rapidly delivering seeds to safeguard farmers' incomes and national food security.

2. A framework for effective national seed systems

The seed systems in most developing countries have a formal component organized by the government and an informal component of traditional seed exchange from farmer to farmer. The formal seed system produces and distributes seed through officially regulated mechanisms that are operated by public corporations or private companies and supervised by government agencies. Ideally, formal seed systems entail partnership with private firms and are commercial or partly commercial in orientation (Figure 1). They receive improved crop varieties from national agricultural research systems (NARS), then produce the seed and market it to farmers. The formal seed system is governed by national policies, laws and regulations to guarantee seed quality.

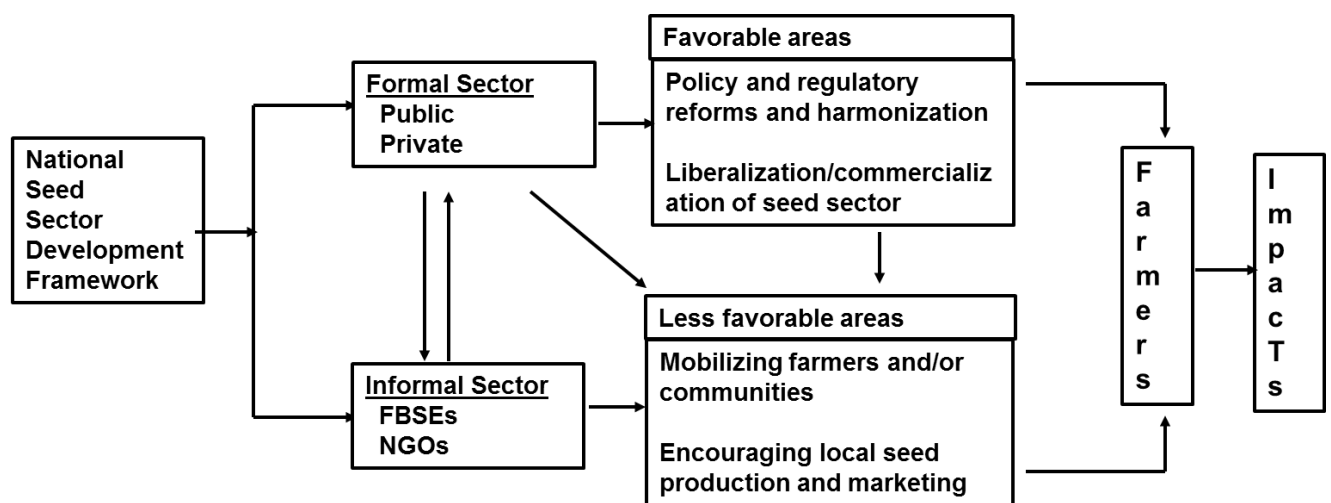


Figure 1: National seed sector development framework

The informal seed system is basically what the formal seed is not, carrying seed distribution beyond the reach of the formal system. In the informal system, farmers exchange the seed of traditional varieties and recycle previously released improved varieties, using seed saved from their own harvest. The exchange is through barter in the community or purchase at local markets. In developing countries, the informal seed system handles the seed from which 80-90% of food grains grow. In the poorest and most vulnerable agricultural communities, especially those so remote and inaccessible that they still subsist on their own crop production, the informal seed system are the only system. Policy makers cannot afford to overlook its significance.

Developing countries need to optimize their formal and informal seed systems alike to maximize the productivity and sustainability of agriculture and to ensure resilience in the face of natural disasters, crop pandemics such as Ug99 and emerging climate change. Advances in agricultural research in general and in plant breeding in particular lay a strong foundation for building such resilience. The rapid development, diffusion and farmer adoption of modern, improved crop varieties is enabled by informed rural development policies, the efficient identifi-

cation of farmer-preferred varieties, rapid seed multiplication, more appropriate and better-targeted agricultural extension and public awareness campaigns, are more effective and economically sustainable for establishing effective seed delivery system.

2.1 Formal seed sector

The timely dissemination to farmers of quality seed depends on (1) an appropriate policy and regulatory framework governing the variety release mechanism, plant variety protection, and domestic and international seed trade; (2) the development, evaluation and release of well-adapted varieties preferred by farmers and consumers; (3) appropriate procedures and adequate facilities for producing, processing and storing seed that engage both the public and the private sector; (4) seed marketing and distribution networks that deliver seed to locations from which farmers can readily fetch it; (5) seed quality assurance to protect producers and users alike; and (6) capacity strengthening for seed delivery systems.

2.1.1 Policy and regulatory framework

The beginning of scientific crop improvement enabled skilled breeders and farmer-breeders to develop new crop varieties, but maintaining varietal and seed quality identity and purity became a great challenge for the emerging seed industry. Systematic plant breeding thus laid the foundation for standardized varietal release mechanisms and seed certification schemes. The Association of Official Seed Certifying Agencies (its forerunner since 1919) and the Organization for Economic Co-operation and Development (1958), both had established evaluation, registration and release procedures for accepting and listing eligible varieties, as well as standardized certification schemes to strictly control generation and maintain varietal purity, identity and seed quality, forming the early legal framework for the seed industry. Although many governments likewise enacted national variety and seed regulations along the same line, some developed countries enacted comprehensive variety and seed regulations only fairly recently. The emergence of organized seed system led to the development of national policies, laws and regulations in variety testing and release; plant variety protection; seed quality assurance and certification; domestic and international seed trade; and sanitary and phytosanitary measures to name the least. The international conventions and treaties such as CBD, IT-PGTFA and Biosafety laws are recent additions with significant impact on the national, regional and global seed industry.

In developing countries, meanwhile, an array of policy, regulatory, institutional, organizational and technical constraints affect the performance of national seed industries. In response to the challenges posed by the accelerating commercialization of agriculture, development of private seed industries, emergence of intellectual property rights in agriculture, and continued decline in public sector agricultural research, many countries must revisit their policy and regulatory frameworks for variety development, evaluation, registration and release to seed production, marketing and quality assurance. Policy and regulatory reform must strike a balance that satisfies public sector interests, provides opportunity for private enterprise and protects consumers.

Box 2. National seed policy-some basic principles

- A national seed policy should have an overall objective and subsidiary objectives for each of its policy elements. Objectives will vary from one country to the other depending on specific needs and circumstances.
- A seed policy could be considered to be a vision of the seed sector that is shared by all of the sector's stakeholders.
- The overall purpose of the seed policy is to improve the quality, diversity and security of the supply of seed to farmers in all parts of the country.
- The seed policy may also have other purposes, such as promoting food security, creating employment or stimulating an export industry, depending on the needs and vision of the country.
- The policy is meant to inspire action and should provide the guiding principles for all present and future actions for seed sector development.
- A seed policy can be particularly useful in the early stages of national seed sector development by providing a guide for transition and growth.
- By guiding decisions and resource allocation along the seed chain, from breeding to use by farmers, a seed policy provides a long-term vision and framework for the development of the seed sector. It is essential that the policy be endorsed by the government according to national legal procedures.
- The seed policy and its action plan should be harmonized with other strategic documents for agriculture, rural development and the wider economy.
- The seed policy should define the roles of the public and private sectors, and facilitate coordination (and seed flow) among institutions, companies and NGOs, where these exist.
- The seed policy should be monitored and periodically reviewed to reflect changing trends, maintain validity and relevance, and introduce new alignments as necessary.

Source: Draft guide for national seed policy formulation (http://www.fao.org/fileadmin/templates/agphome/documents/PGR/ITWG/ITWG7/info_docs/CGRFA-WG-PGR-7-14-Inf2_en.pdf)

Box 3: Key regulatory frameworks for the seed sector

Seed regulatory frameworks are the rules and regulations, and the norms, guidelines and standard practices, associated with crop variety development, seed production, seed marketing and quality control. It includes regulations that determine the type of products (varieties and seeds) available to farmers; and regulations that control the quality of these products when they reach markets. Each country has a basic Seed Act and subsidiary regulations for its implementations which include the following:

Variety release mechanism: Variety regulations that determine the norms, procedures and standards for testing and release of new crop varieties. The primary purpose is to protect the farmers and consumers against release of varieties of no agricultural and commercial value.

Plant variety protection: Variety regulations that determine the norms, procedures and standards for granting rights over new crop varieties. The primary purpose is to protect plant breeders against unauthorized use of their varieties and protect their investments in plant breeding.

Seed certification: Seed regulations that determine the norms, procedures and standards that need to be met for quality seed production and commercialization. It protects farmers against sale of low quality seed.

International seed trade: Seed trade regulations that determine the norms, procedures, and standards for importing or exporting seed of agricultural crops. It protects the users and provides arbitration during disputes for seed moving in international trade.

Quarantine laws and regulation: Quarantine laws and regulations are the norms, procedures, and standards for sanitary and phytosanitary measures for importing or exporting agricultural products including seeds for planting purposes. It restricts the introduction of pests of quarantine significance and to protect the national agriculture.

The basic principles for these regulations include: Protection-seed consumers/farmers against market failures; Standards-setting norms against which quality can be measured; Monitoring-ensure that regulations are adequately observed; and Enforcement-capacity to impose sanctions in case regulations are violated. The main purpose of regulation is to encourage diversity of the seed system not to stifle its growth. Therefore, reforming and harmonizing regulations are necessary to be in tune with seed sector developments where ICARDA can provide specialist advice.

2.1.2 Variety development, evaluation and release

National breeding programs should aim to develop and release a wide range of varieties with diverse genetic backgrounds to achieve and maintain durable resistance to an array of pests and diseases. Of course, new varieties must satisfy the yield and other agronomic requirements of farmers, consumers' expectations, and the demands of marketing and processing industries, but the resulting tendency of one superior variety or a few to become overly dominant in a geographic area must be resisted, in part by offering attractive varietal diversity.

Public versus private crop breeding. In developed countries, plant breeding advances largely as corporate product development under a strategy that vertically integrates varietal development, seed production and seed marketing to recoup research investments. In contrast, in many developing countries publicly funded agricultural research dominates and has sole responsibility for setting national research and crop-improvement strategies and priorities. Government policies in developing countries have tended to support public over private plant breeding, often restricting the operations of private sector participants, be they domestic or foreign, particularly regarding crops that are considered strategic. To better exploit synergy and make available to farmers a wider choice of varieties, it is important for governments to encourage public-private partnership in agricultural research and variety development.

Crop breeding in many developing countries continues to depend heavily on the breeding materials from international agricultural research centers such as ICARDA which regularly distribute international nurseries to NARS partners. In many countries, public seed companies have exclusive access to new varieties from NARS. However, limited access to new publicly bred varieties and inadequate quantities of basic seed impede the desired participation of private seed companies. Such companies need access to varieties and sufficient quantities of early-generation seed if they are to fulfill the roles envisioned for them in improved national seed systems.

Variety evaluation and release. Lengthy and slow variety testing remains a critical bottleneck hampering the speedy release of new varieties. Most countries require promising new crop varieties to undergo standard testing and release procedures before they can be multiplied and distributed to farmers. Testing for variety registration concerns its distinctness, uniformity, and stability to establish its varietal identity; performance testing considers the value for cultivation and use. While Ethiopia and some other countries operate release systems that depend purely on performance testing conducted by agricultural research authorities and approval from release committees, most countries, including Egypt, Pakistan, India and Turkey, have well-defined compulsory procedures for both variety registration and performance testing.

National varietal testing systems should actively share varietal data from international information sources and consider adopting policies for joint release within regions. As many NARS across regions evaluate similar

breeding materials, the joint or harmonized regional release of varieties is an opportunity waiting to be exploited. Streamlined regulatory and phytosanitary protocols can contribute to the regional harmonization of variety and seed rules and regulations and to diversifying the portfolio of varieties released and seed trade across countries within a region. In the absence of a regional release system, national authorities should consider a clause exempting from compulsory registration useful varieties from similar agro-ecologies outside of the country.

2.1.3 Seed production, processing and storage

Seed production follows a generation system as it moves from NARS to seed providers and eventually to farmers. Generally two schemes are commonly used i.e. AOSCA and OECD although variations exist in some countries. There are two critical stages in seed production: early generational seed production (breeder, pre-basic, basic (foundation)); and large-scale certified seed production (certified 1 (registered) and certified 2). The main purpose is to ensure regular and reliable seed supply to farmers through the activities of the formal sector, which requires that the breeder seed be multiplied into basic seed even before the variety is released. Then the basic seed is multiplied into certified seed in a systematic manner.

Accelerated early generation seed production. The usual practice in developing countries is to begin multiplying seed only after the official release of a new variety. This needlessly delays the availability of basic seed and so is not the approach followed in developed seed industries, which normally undertake pre-release seed multiplication to bring the new variety more rapidly to the market. National authorities should adopt this fast-track procedure. Further, they should take advantage of the off-season to shorten the time required to produce sufficient stocks of basic seed. These measures allow the large-scale production of certified seed to begin as soon as the variety is officially released.

Despite huge investments in variety development, most NARS pay only limited attention to producing early-generation seed. This shortcoming occurs for lack of funding or incentives and because seed units have insufficient land, irrigation facilities, machinery and other inputs. Early-generation seed production requires specialized field equipment such as planters, harvesters, and seed cleaners and treaters; irrigation for off-season seed production; and facilities for seed storage, in particular cold storage. Creating functional seed units, and strengthening them where they already exist, can institutionalize early-generation seed production on a sustainable basis. A variety licensing system may generate additional funds to strengthen these units. It further enables countries to respond effectively to emergencies.

Accelerated large-scale certified seed production. National strategies are required for multiplying and distributing certified seed. Basic seed should be made available to seed multipliers in the public and private sectors and to farmer- and community-based seed initiatives for further multiplication. Producing two crops per year instead of one doubles seed

multiplication, but it requires irrigation and in situations of emergency perhaps cooperative agreements with countries that have complementary growing seasons. Importing large quantities of basic seed from reliable sources can kick-start seed multiplication or, in urgent crises, supply seed for direct distribution to farmers.

Achieving higher seed multiplication rates. The multiplication factor, or the ratio of seed produced to seed planted, partly determines how quickly seed can be multiplied and made available to farmers. The factor differs by crop and variety and is influenced by the production environment and crop management. Several technical options exist to boost multiplication factors. Studies at ICARDA using different seeding rates for wheat show that reducing the seed rate from 186 kilograms per hectare (kg/ha) to 17 kg/ha increases the multiplication factor from 20 to 204 under dry conditions, with little variation among the five wheat varieties tested. A similar situation can be observed for barley as well. Rapid seed multiplication has been reported elsewhere, with 1.36 tons of seed multiplied to 15,000 tons in 2 years, for a factor of 105. Rapid multiplication can be achieved by widening the space between rows and within rows, using lower seeding rates of 25 kg/ha to multiply breeder seed, 50 kg/ha for basic seed, and 100 kg/ha for certified seed. This approach requires well prepared seed beds; precision planting; superior soil fertility management, irrigation, and pest and weed control; and timely harvesting.

Production planning. A number of years would be required to multiply the breeder seed to produce sufficient quantity of certified seed demanded by farmers. However, how much certified seed to produce is a major concern to seed companies and public authorities managing the seed sector. Careful planning should be made for production of each seed class to meet the desired end. Forecasting 'effective' seed demand is complex and a challenge but still one can use historical data on seed sales; entry and withdrawal of new varieties; promotional efforts to be undertaken with some adjustments for seed certification, etc. Contingency planning for emergencies should include a well-coordinated system for rapid seed multiplication, as rapid seed multiplication is integral to fast-track variety evaluation and release.

Seed import and distribution.

The urgent provision of seed to cope with emergencies such as the spread of Ug99 may require direct imports from neighboring countries with similar agro-climatic conditions for direct release. This eventuality is facilitated by harmonizing rules and regulations regionally, especially regarding variety release and protection, seed certification, and plant quarantine. Such harmonization is under way in several regions of Africa, Americas and Asia. In Central and West Asia, a seed association has been established under the Economic Cooperation Organization as a forum for dialogue toward developing regional seed industries and promoting regional seed trade. This association in the long-term may play a crucial role in establishing procedures and processes for harmonizing seed rules and regulations and thereby facilitating the movement of seed across boundaries.

Table 1: Relationship between seed rate and multiplication factor for wheat and barley

Seed rate (kg ha ⁻¹)	Multiplication factor	
	Wheat	Barley
25	157	157
50	98	103
75	69	68
100	49	57
125	44	46

Seed processing and storage facilities. Seed processing i.e. cleaning, treatment and packaging of seed for marketing should be carried out within reasonable period of time between harvesting and planting. Adequate seed processing facilities (stationary or mobile) should be made available at strategic locations for timely operation and delivery of seed. The seed of many crops, especially staples, can be effectively stored if well-established precautions are taken. Keeping the seed as dry and cool as possible in clean stores slows seeds' physiological processes and damage caused by fungi and insects. Wheat, for example, can be safely stored if its moisture content is below 13%, the relative humidity is below 60%, the ambient storage temperature is not excessive and insect infestation is minimal. Adequate seed storage facilities are particularly important for maintaining and managing carryover stocks of early-generation seed and certified seed. Small quantities of seed can be stored cost-effectively for long periods in cold rooms.

2.1.4 Seed marketing and distribution

Most seed programs in developing countries were launched in close association with governments and implemented using grants and concessionary loans from development partners. Some countries had the ministry of agriculture undertake this work directly through a seed department, while others established a new state-controlled seed company for the purpose. Either way, seed marketing and distribution were strongly influenced by government policies and pursued objectives that were primarily social and developmental. Improved seed was regarded as a strategic input to agriculture and therefore naturally the responsibility of government. Subsidies were provided to promote seed use, with little application of marketing theory or practice. However, as with any other market, understanding the seed market is crucial to providing the right products and services at the right price, available in sufficient quantities at the right time and place, and promoted through the right media. Distinction should be made between potential theoretical seed requirement based on total crop area and effective demand what farmers are willing to buy for planting, the latter dependent on a marketing plan that includes delivering the seed to appropriate distribution points readily within the reach of farmers.

Variety awareness and promotion. Developed seed industries are highly commercial, with variety development oriented to clients and strong product promotion. Their crop breeders generally have a good idea of what farmers need, and effective marketing makes farmers aware of what is available and enables them to use new technologies. Variety creation in many developing countries is much more complex because of the range of agro-ecological zones and crops grown. Agricultural extension is often weak, undermining efforts to alert farmers of the vulnerability of their obsolete varieties and of the benefits of adopting improved varieties. NARS, national extension services, farmer organizations and other nongovernmental organizations must show in demonstration plots varieties developed through formal breeding schemes to make farmers aware of them and of appropriate crop management. Farmer field days held at seed-production plots can popularize and promote varieties toward creating demand for seed. Demonstrations should be linked to training on how to manage the crop and monitor it to detect pest and disease infestations.

Participatory varietal selection has proven value in facilitating communication between plant breeders and farmers and in speeding the adoption of improved varieties, particularly among smallholders with limited access to formal seed systems. In emergencies, subsidizing the purchase of seed can speed the dissemination of resistant crop varieties. Where an acute threat exists, farmers can receive small seed packs sufficient for a quarter of hectare of new varieties to plant for comparison alongside currently used varieties. Farmers should be encouraged to share seed with other farmers to facilitate farmer-to-farmer diffusion (as elaborated in the section below on informal seed systems).

2.1.5 Seed quality assurance

The production of high-quality certified seed requires that national seed certification agencies ensure its inspection, testing and certification. Facilities such as seed-testing laboratories may need to be established or upgraded to meet demand and could also implement regionally harmonized regulations on variety release, phyto-sanitary standards and the seed trade. The databases of national variety registries, seed certification agencies and plant quarantine services should be strengthened to include information pertinent to emerging challenges and to facilitate regional seed trade.

2.1.6 Strengthened capacity for seed sector

National seed systems are constrained by resource limitations, which become even more acute when the rapid multiplication of large quantities of seed is required to meet emergencies.

Farm machinery and seed equipment. Existing resources and facilities need to be used more efficiently, and additional investments may be necessary.

Seed production is a specialized task requiring special equipment as plot planters and plot harvesters, and seed cleaners and treaters, as well as appropriate irrigation, buildings for seed processing and storage, and other facilities for producing early-generation seed in both the main growing season and the off-season. Provision of necessary equipment and facilities should be undertaken to avoid constraining prompt seed multiplication and delivery.

Human resource development. From the outset, a manpower with broad technical and managerial capacity is critical to implement effective and efficient seed systems. Specific knowledge and practical experience are needed to produce quality seed adhering to highest standards. Short courses are appropriate for technical managers and subject matter specialists, focusing on the principles and techniques of seed production, processing and quality assurance. These managers and specialists train in turn technical staff. Finally, seed producers need practical training on the nuts and bolts of producing seed and maintaining its quality. For policy makers and senior managerial staff, workshops or seminars can create awareness of the policy and regulatory issues that affect seed systems.

2.2 Informal seed sector

Informal seed systems are indispensable for distributing the seed of widely planted staple grains in agricultural communities beyond the reach of formal systems. They also distribute the seed of other crops often ignored by formal seed systems. Informal seed systems stretch back to the beginning of agriculture 10,000 years ago but may not reliably ensure the nutritional and economic well-being of the agricultural communities they continue to serve. Despite international efforts since the 1960s to strengthen national seed programs, and the recent emphasis on commercializing seed industries, over 80% of the crops grown in developing countries are planted using seed saved by farmers.

In general farmers have four major sources of seed for planting: (1) own saved seed from the previous years' harvest; (2) seed obtained from other farmers (relatives, neighbors); (3) seed purchased through local trading (local markets or grain traders); and (4) seed purchased from the formal sector which is certified. There is interplay of many technical and socio-economic factors to obtain seed from a particular source including anticipated benefits and household food security; availability of reliable information on source, quantity and quality of the product; proximity and timely availability; and price and risks associated with it.

2.2.1 Recognizing the role of informal sector

Currently, in developing countries, most of the seed used for planting comes from the informal sector. Despite this fundamental fact few countries have recognized and elaborated the important role of the informal sector in their national seed policy and strengthening it as complimentary approach to formal sector. The Ethiopian national seed policy is probably the first with explicit statement of the role of informal sector in its national seed supply (Bishaw et al, 2008). There are restrictive legislations and bureaucratic mindset which equates seed from the informal sector with 'inferior quality' and argue that any farmer-based seed production should be 'qualified' within the norms and standards of formal sector or otherwise not marketed as seed. This is even true in circumstances where there is no formal seed production from either the public sector or the private sector. Several authors long argued for a policy environment which should recognize the complimentary roles of formal and informal sector and devise a strategy to equally support and integrate both systems and create space for the informal sector (Alemkinders and Louwaars, 2002; Bishaw, 2004; Thijssen et al, 2008; Louwaars and de Boef, 2012). Such policy support would enable the establishment and operationalization of alternative seed delivery systems from the grassroots levels working with farmers and nurture its growth.

2.2.2 Alternative seed delivery through farmer-based seed enterprises

Where inadequate infrastructure limits the reach of formal seed systems, informal seed systems need to be improved. Kugbei and Bishaw (2002) described different forms of small-scale enterprises which can potentially produce and market seed in a profitable and sustainable manner. In the context of seed delivery, a small-scale enterprise is a business that is owned and managed by either one person or few people, who are engaged not only in production, but marketing of seed as well. At the community

level, these may be individual farmers, group of farmers, traders or merchants, cooperatives, farmers' organizations or associations. Louwaars and de Boef (2012) indicated that local seed businesses emerge at different levels of proficiency, sitting at the intersection between advanced informal and emerging formal. The ICARDA Seed Section works with NARS and local stakeholders to establish village-based seed enterprises (VBSEs) to complement formal seed systems. VBSEs enable farmers in remote, marginalized agricultural communities to build on informal seed systems, creating better-organized and more-effective systems able to supply participants and their neighbors with better seed of staple crops such as grain legumes. To be effective, VBSEs must engage local stakeholders who know what characteristics would make crop varieties more valuable to farmers than the crops they currently grow. What makes VBSEs organized with ICARDA's assistance more sustainable than those arising from previous initiatives is their emphasis on marketing. This focus is designed to make VBSEs profitable and thereby give stakeholders concrete incentives to keep them in business.

VBSEs introduce improved crop varieties and associated technologies to farmers by demonstrating them in the field. They also multiply and market high-quality seed of crop varieties adapted to local growing conditions and farmers' preferences. Such enterprises supply improved varieties that have been developed, tested and selected either through conventional plant breeding or with the participation of farmers. They also handle local landraces, thereby advancing the conservation of agricultural genetic resources while promoting their use.

Several attributes contribute to the effectiveness and durability of VBSEs. Because they are participatory, they mobilize and engage their target beneficiaries, instilling in smallholder farmers in unfavorable environments and remote areas ownership of the enterprises. Decisions are decentralized, and varieties for seed multiplication and marketing are selected based on farmers' preferences in target areas. This local input ensures that VBSEs are market-oriented enterprises that respond to local demand. Because VBSEs operate locally they are cost effective, enjoying low transport, marketing and distribution costs that allow healthy profit even while selling seed at low prices. They use technology appropriate to their environment, operating low-cost cleaning and treatment equipment at the farm level to improve seed quality to a standard that satisfies local demand. VBSEs' autonomy and marketing for profitability reinforce their sustainability and set the stage for their evolution into small, privately owned seed companies.

3. ICARDA's expert support in strengthening seed systems

Over more than three decades, ICARDA has gained extensive experience in helping low-income countries improve the performance of their seed system and is uniquely qualified to help nations, regional and communities rebuild seed systems that have been destroyed by conflict or natural disaster –restoring them to efficient operation. This expertise includes on-going partnerships with countries to ensure continued strengthening of national systems over the long term.

ICARDA is a member of the CGIAR Consortium, the partnership of international research centers, countries and donors that conducts and coordinates agricultural research together with developing countries.

ICARDA is the only CGIAR center with a Seed Unit, whose primary objective is to strengthen national seed systems to improve seed supply to farmers throughout the dry areas, using both formal and informal seed systems. The Seed Section pursues a broad range of activities, from designing alternative seed-delivery systems to diversification and commercialization of the seed sector through private sector participation to harmonizing regulatory and policy frameworks toward creating and strengthening competitive seed industries in partner developing countries. As a recognized center of excellence on seed issues, the ICARDA Seed Section consults for national, regional and international organizations on issues related to seed program development. The section applies its extensive experience to inform seed policy reform, promote seed trade and ensure seed security in the dry areas.

Since its creation in 1977, ICARDA has played a central role in restoring and strengthening national seed systems in many African and Asian countries, notably Afghanistan. Today, the center is on the front line of the global effort to prevent a collapse of wheat harvests caused by the virulent stem rust fungus Ug99.

There is strong interface between crop improvement and seed supply within the research-for-development continuum. ICARDA's Seed Section is involved in diverse and broad range of activities that collectively addresses seed system in an integrated holistic approach working with different programs at ICARDA and with diverse stakeholders at national, regional and international levels. Some, not all, research and developmental activities are highlighted here as examples for lessons learnt.

3.1 Seed system research

National seed system performance can be measured by many factors including the existence of stable enabling policy and regulatory environments; institutional and organizational strengths and configuration; and the technical capacity in terms of the quantity and quality of seed delivered at the right place and at the right time and at an affordable price to meet the 'effective' demand of farmers. A

sustainable seed system can't be built without strong institutions; and adoption and impact can't be realized without adequate investment on seed delivery to achieve tangible outputs. Within research for development continuum, developing sustainable seed system should combine both research components along the seed value chain to analyse system constraints and seek solutions and developmental components to strengthen existing or create new institutions to facilitate technology generation, transfer, adoption and diffusion through provision of quality seed of new crop varieties.

3.1.1 Functioning of seed system

ICARDA conducted a pioneering work on understanding the performance of seed sector particularly the informal sector with reference to farmer's seed sources, on-farm seed management practices and quality of seed planted by farmers. A total of 304 wheat seed samples from four major wheat growing areas in Ethiopia and 206 wheat and 200 barley seed samples from three major wheat and barley growing areas in Syria were collected for the study. The highlights of these findings are reported here.

Farmer's varietal replacement

The decision by farmers to change varieties already adopted is termed variety replacement. According to Brennan and Byerlee (1991), the optimal period for varietal replacement, depends on yield gain of new varieties, yield loss of old varieties, and risk of changing the variety. The rate of varietal replacement is estimated by the age of varieties in farmers' fields, measured in years since releases and weighted by the area under each variety (Brennan and Byerlee, 1991). In Ethiopia, the five top wheat varieties were grown by 56% of the sample farmers and these varieties were planted on 80% of the total wheat area. In Syria the five top wheat cultivars occupied 81% of the wheat area and were grown by 78% of the sample farmers. In the case of barley one single local landrace was grown almost in the entire survey area. The weighted average age of wheat varieties was high at 13.8 years for bread wheat in Ethiopia and 10.8 years for wheat in Syria showing low varietal replacement by farmers in both countries (Bishaw, 2004). The varietal replacement rate shows the strength of both the variety development and seed system. A rapid rate of varietal replacement leads to higher returns to plant breeding research by increasing adoption of new varieties but also increase genetic diversity if varieties are from diverse parentage.

Farmer's seed replacement

The decision to obtain fresh seed stocks of the same variety is termed seed renewal. Heisey and Brennan (1991) listed factors that farmers perceive as important for changing seed such as improvements in production potential of certified seed, deterioration in seed retained from the grain crop, seed and grain prices, base yield levels, interest rates, learning costs, and risk premium. The number of years seed was retained on farm varied from crop to crop and depended on the farmers' decision to change seed and the availability from external sources (Table 2). The majority of farmers, however, kept their seed within five years showing a higher seed replacement rates from various sources. Seed of local landraces or obsolete varieties were kept on the farm for longer period than modern varieties. Such high rate of seed replacement is quite useful provided new varieties are released frequently and the seed is available on the market. Sourcing seed from

the formal sector appeared to be a strategy for acquiring a new variety (varietal replacement) or for the renewal of old seed (seed replacement).

Table 2. Number of years wheat seed saved by farmers in Ethiopia and Syria

Ethiopia-wheat			Syria-wheat			Syria-barley		
Years	No of response	%	Years	No of response	%	Years	No of response	%
0	91	20.8	0	111	41	0	35	18
1	133	30.4	1	95	35	1	23	12
2	66	15.1	2	37	14	2	21	11
3	60	13.7	3	22	8	3	13	7
4	14	3.2	4	3	1	4	15	8
5	19	4.3	5	2	1	5	20	10
6 to 9	20	4.6	> 5	3	1	6 to 9	19	10
≥10	35	8	Total	273	100	≥10	54	28
Total	438	100				Total	200	100

Farmer's seed sources

In general farmers have four major sources of seed for planting: (a) own saved seed from the previous years' harvest; (b) seed obtained from farmers (relatives, neighbors, other farmers); (c) seed purchased through local trading (local markets or grain traders); and (d) seed purchased from the formal sector. There is interplay of many technical and socio-economic factors to obtain seed from a particular source including anticipated benefits and household food security; availability of reliable information on source, quantity and quality of the product; proximity and timely availability; and price and risks associated with it. It should be noted that the informal sector is a default seed supplier for any given year and also major source of new varieties through lateral spread from farmer-to-farmers (Table 3).

Table 3. Informal sector as a main seed source of new varieties and seeds

Initial seed source for new varieties			Seed source during survey year		
Seed source	No of farmers	% response	Seed source	No of farmers	% response
Ethiopia-wheat (n=436/438)					
Formal sector (RAB, ESE, research)	183	42	Formal sector	36	8.2
Relatives	30	6.9	Neighbors/ other farmers	41	9.4
Neighbors/other farmers/state farms	156	35.7	Traders/local markets	15	3.4
Traders/local markets	67	15.4	Own saved seed	346	79
Total	436	100	Total	438	100
Syria-wheat (n=272/273)					
Formal sector (ACB, GOSM, Coops)	162	59.6	Formal sector	65	23.8
Relatives	2	0.7	Neighbors/other farmers	34	12.5
Neighbors/other farmers	73	26.8	Traders/local markets	12	4.4
Traders/local markets	35	12.9	Own saved seed	162	59.3
Total	272	100	Total	273	100
Syria-barley (n=200)					
Formal sector ¹	27	13.5	Formal sector	-	-
Relatives	65	32.5	Neighbors/farmers	22	11
Neighbors/other farmers	71	35.5	Traders/local markets	13	6.5
Traders/local markets	37	18.5	Own saved seed	165	82.5
Total	200	100	Total	200	100

Source: Bishaw, 2004; ¹In Syria, formal sector used to distribute seed of improved barley landrace called Arabi Aswad

Farmers' seed management

On-farm seed management practices are often the reflection of farmer's perception and the value they attach to seed planted to raise the next year crop. The majority of farmers (over 90%) recognize the difference between grain and seed and attributed these differences to physical purity, freedom from weeds, intact seed with good germination, big kernel size, no disease or insect damage and no admixture with seed of other varieties. Farmers' positive perception of seed influences them to practice different seed management approaches to maintain the quality of their wheat and barley seed through selection, cleaning, treatment, storage or direct/indirect assessment of seed quality (Table 4). The most characteristic practice is a wide spread use of on-farm chemical treatment of wheat seed in Syria. The responsibility to manage and execute these operations on the farm was shared between men and women, who have a distinctive role to play.

Table 4. Farmers' perception of seed quality and on-farm seed management

	Ethiopia- Wheat (n=304) %	Syria-Wheat (n=206) %	Syria-Barley (n=200) %
Farmers' perception			
Recognize differences between seed and grain	92.0	97.6	98.5
Purity (cleanliness from dirt, etc)	60.2	53.2	17
Free from weeds/other crops	18.1	30.5	1
Intact seed (with good germination)	18.4	6	2
Big kernel size	11.5	12.9	9.5
No disease/insect damage	10.2	8.5	-
No admixture with other varieties	3.3	-	-
Seed Management			
Seed selection	67.1	53.9	45.5
Seed cleaning	82.8	90.3	91
Seed treatment	3.5	90.3	6.5
Separate storage	64.8	64.1	76
Check germination*	33.9	4.4	3

NB: * Mostly indirect assessment

Farmer's seed quality

Understanding farmers' seed quality problem will enable to devise strategies to improve quality at the farm level. In general significant differences in seed quality were observed for seed samples collected from different regions and districts for wheat and barley crops in both countries rather than marginal differences for seed sources. It appeared that the physical and physiological quality of seed did not differ significantly between different sources for individual crops in respective countries except for germination of wheat in Ethiopia and barley in Syria (Table 5). The formal sector seed occasionally had higher average quality compared to seed from informal sources such as retained seed or seed obtained through local exchange mechanisms. In Ethiopia, the quality of wheat seed from the informal sector was comparable to that from the formal sector both in terms of physical purity and germination where most of the samples (93%) met the minimum standards set for commercial seed (when % purity and % germination are combined). In Syria, slightly more than half of the wheat seed samples (54%) reached the minimum commercial seed standard because of low quality of seed from informal sources. The seed quality of barley seed was the lowest particularly in terms of physical quality where only 10% of the samples met the minimum requirement for commercial seed. However, as

most seed samples were marginally lower than the minimum requirement of the formal sector seed, adjusting the standard slightly downward would make all samples to meet the requirement.

Farmers used local seed management practices, such as seed selection, cleaning, treatment, or separate storage to improve or maintain seed quality.

A large number of seed samples managed differently by farmers met the minimum physical purity and germination standard for certified seed 2, producing seed comparable to those from the formal sector. However, there is an underlying weakness in the physical quality of seed from the informal sector where traditional cleaning techniques are ineffective in removing most of the contaminants. Contamination with weed seed remains a major problem where most of the samples failed to reach the quality standards prescribed by the national seed program. Introducing appropriate on-farm cleaning techniques could improve quality and minimize contamination particularly with noxious weeds. It is imperative that national seed policies equally recognize the role of both formal and informal sectors and provide support to create an integrated seed system catering to the needs of a diverse group of farmers.

Table 5. Seed quality (purity and germination) of wheat and barley seed from different sources

Seed sources	Wheat (Ethiopia)					Wheat (Syria)					Barley (Syria)				
	No. of samples	Purity		Germination		No. of samples	Purity		Germination		No. of samples	Purity		Germination	
		%	No. of samples > 97%	%	No. of samples > 85%		%	No. of samples > 98%	%	No. of samples > 85%		%	No. of samples > 98%	%	No. of samples > 85%
Formal sector	15	99.4	15	96	15	45	99.0	43	88	33	-	-	-	-	-
Farmers	16	98.6	14	94	15	27	97.9	18	86	22	22	95.0	0	88	18
Traders	10	98.9	10	97	10	7	99.3	7	92	6	13	95.4	1	92	11
Own saved	263	98.9	249	96	255	127	96.9	77	87	101	165	95.5	19	85	115
Total	304		288		295	206		145		162	200		20		144
Mean		98.9		96			97.6		87			95.5		86	
% standard ¹			95		97.6			70.4		78.2			10		72

Note: ¹% of seed samples that meet certified seed standards for purity and germination

Analysis of the health quality of wheat and barley seed samples showed significant differences between regions and seed sources (except in Syria). Interestingly, more seed health quality problems were observed in wet or high rainfall areas compared to the drier regions showing the influence of the environment on diseases infection. However, certified seed consistently showed less infection for most seed-borne pathogens. Contamination with common bunt and infection with loose smut were found across regions and seed sources.

In Syria, wheat seed health was better than of barley in terms of frequency and rate of infection probably due to widespread use of on-farm seed treatment. However, all seed samples infected with loose smut of wheat or barley were in excess of minimum standards for seed certification across West Asia and North Africa, showing fundamental weaknesses in seed health from both formal and informal sources. National seed programs should set realistic standards and introduce routine testing to produce healthy seed.

From the wheat and barley results it can be concluded that: (1) the seed from the formal sector may have the highest physical purity compared to seed obtained from other farmers/neighbors, markets/traders or own saved seed; (2) the seed from the formal sector although has high physical purity, it performs relatively less in terms of physiological quality (germination); (3) the seed obtained from the informal sector may have lower physical purity, but performs relatively better in terms of germination; (4) seed from the informal sector could exhibit high quality that could be comparable to that of the formal sector; (5) Seed health quality appeared to be low for barley as compared to wheat in Syria which is associated with chemical treatment and (6) on-farm seed management practices such as harvesting methods and chemical treatment showed significant influence on seed quality.

3.1.2 Variety release mechanisms

The term 'variety release' is used to cover all the procedures and actions that take place from the time when a breeder decides to enter a promising new line/variety for official testing until the time when the new variety is made available for multiplication as a first step on the road to general cultivation by farmers. In this context, variety release can be seen as the point of transition of new genetic material from its place of generation (in research) to its place of utilization (in agriculture) and within which the following main stages and activities may be identified (Bishaw and van Gastel, 2009): (1) identifying promising lines with preferred traits for further evaluation from advanced variety trials; (2) testing of new promising lines for registration (Distinctness, Uniformity, Stability = DUS) and performance (Value for Cultivation and Use = VCU) by a competent independent authority; (3) approval of the new varieties for commercial use by a release committee; (4) inscription of the varieties in the national catalogue; and (5) making available breeder seed of new varieties for further commercial seed production and distribution. The ideal release system should accomplish all the above stages and activities in the shortest possible time so that farmers can benefit from the genetic innovations achieved by breeders.

ICARDA conducted studies on variety release mechanism to get insight of current practices in Egypt, Ethiopia and Pakistan. The main purpose is to analyze the issues that arise in variety release and to make recommendations for 'good practice' that may be useful to those who manage the variety release system. A synthesis of experience gained from studies carried out is being prepared as a working document on variety release mechanism. The synthesis covers the full range of activities that occur from the identification of promising lines by the breeder until early-generation seed is available for multiplication and providing recommendations for good practices. In Pakistan, ICARDA organized in 2012 a national consultation meeting on the draft report and broader issues on seed production systems that highlighted the need to strengthen public-private partnership in research, create new and more effective seed legislation, and improve the capacity of all partners in the country's seed sector.

3.1.3 Wheat commercial behavior and varietal choices in Ethiopia

In Ethiopia, from policy makers to local administrators, from federal governmental institutions to 'Woreda' (District) Bureaus of Agriculture, from national to international NGOs and donors, all are preoccupied with seed issues. There is strong drive with greater emphasis on seed supply side with little attention for the demand side. There is limited understanding about the farmers' commercial behavior and varietal perceptions and implications on the wheat seed sector in general and seed demand and supply in particular. The study was based on the primary data collected from 524 wheat farmers in the major wheat growing areas covering 22 districts in 11 zones in Amhara, Oromia, SNNPR and Tigray regions of Ethiopia.

Farmers' commercial behaviors of wheat seed

Though, the performance of the formal seed system is still low, it is playing key role for increased productivity especially for key commodities like wheat. Among others, the limited understanding about the commercial behavior of farmers in inputs in general and seed in particular has been a key challenge for improved performance of the input /seed system. The study documents the commercial behaviour of small-scale farmers in wheat seed along with identification of the determinant factors of those behaviours. It also presents the implication of these behaviors in wheat seed demand assessment and marketing.

The commercial behavior of a household can be defined taking into consideration different perspectives. From household's market participation perspectives, the commercial behavior can be defined in relation to Net Market Position (NMP) or Absolute Market Position (AMP) of a household either from agricultural outputs or inputs side. For output side, NMP is defined as the ratio of the value of agricultural outputs sold to the total value of agricultural outputs produced by a household, and from the input side, it is defined as the ratio of the value of agricultural inputs acquired from the market to the total value of agricultural production of a household (Von Braun and Kennedy, 1994; Strasberg et al., 1999).

In this study, the commercial behavior in wheat seed is described based on the market position estimated using Absolute Market Position (AMP), which is quantified by comparing the quantity of wheat seed sold and/or quantity of wheat seed purchased over a year. Although six types of AMPs were identified, these market positions are categorized into three classes as (1) autarky, no selling or buying; (2) selling position by merging market position of only sellers, net sellers and those who are equally sellers and buyers; and (3) buying position by merging market positions of only buyers and net buyers.

From a total of sample farmers, about 69% of the farmers use seed of improved bread wheat varieties; and among these 36% use own saved while 33% use purchased seed i.e. 16% certified seed and 17% non-certified seed (Table 6). The remaining 31% of farmers use landraces or old varieties and source seed equally from own saved seed or purchased locally.

The commercial behavior of farmers in wheat seed indicates that 25% are in autarkic, 26% in buying and the rest 49% are in buying market position (Table

7). This implies the important role of farmers themselves in seed supply and it is only about 50% of the farmers that the formal seed sector can target in any given year. The key determinants of each of the commercial behavior in wheat seed were related with wheat production characteristics mainly land allocated for wheat production, resources owned in terms of land size in rain fed and irrigated areas and livestock, access to credit, and wheat yield level achieved. This implies the need for differentiated approach in seed demand assessment taking into consideration the different typologies of farmers (production characteristics, resource ownership, etc.).

Table 6. Wheat variety adoption and seed sources

Variety	Adoption (%)	Seed source	%
Improved variety	69%	Certified seed	16
		Purchased seed	17
		Own saved	36
Local variety	31	Own saved seed	16
		Purchased	15
Total	100		100

Table 7. Commercial behavior of wheat farmers in wheat seed (% of respondents)

Market Position	% of wheat producers	Category of market position	Variety used (%)	
			Local	Improved
Autarky (n=129)	24.67	Autarky (25 %)	5	20
Seller only (n=60)	11.47	Selling position (26 %)	4	22
Net seller (n=73)	13.96			
Equally buyer and seller (n=4)	0.57			
Buyer only (n=253)	48.37	Buying position (49 %)	22	27
Net buyer (n=5)	0.96			

Source: survey, 2012

Farmers' perceptions on attributes of bread wheat varieties

The national agricultural research system has a *carte du jour* of improved bread wheat varieties with different attributes in terms of yield and grain quality, resistance/tolerance to biotic (rusts) and abiotic stresses (drought) and consumer preferences (taste, cooking and nutritional quality). Currently, 53 bread and 31 durum wheat varieties are in the national variety register. Farmers have subjective preferences for different varietal characteristics and their varietal demand is significantly affected by their perceptions of the attributes of the varieties. One of the major challenge is the limited consideration of farmers perceptions in the process of seed demand assessment and delivery.

In order to elicit farmers' preferences, two steps were followed. First was identifying the list of attributes that helps farmers to characterize the wheat varieties. Accordingly, the identified attributes include grain yield, grain size, grain color, early maturity, drought resistance, rust (yellow or stem) resistance, threshability, bread taste/food quality, marketability, straw yield, and straw quality. Second was eliciting farmers' perception using these attributes both for the currently grown local and improved bread wheat varieties. Farmers' perceptions about different bread wheat varieties using these attributes were elicited using an empirical approach applied by Sall et al. (2000). The approach uses an index that provides how well a certain variety attributes meet farmers' preferences:

(1) Demand Index measures farmer's perception about importance of particular attributes. 1 indicates all farmers perceive an attribute as very important; (2) Supply Index measures farmer's perception how well an attribute is embodied in a variety. 1 indicates that all farmers perceive an attributes supplied as very good; and (3) Attainment Index provides a measure of how well farmers' perception of varietal attributes matches farmers' perceptions of how well it is being supplied in the variety. 1 implies a perfect match.

What farmers wanted in terms of the different varietal attributes is reflected in the demand indices. Grain yield and resistance to rusts (yellow and stem) are attributes that are desired most compared to other attributes. It is evident from the supply indices that what was demanded by farmers is more supplied by improved varieties than the landraces. The results showed that improved varieties had high value of the attainment indices compared to landraces, which shows how the demanded characteristics are embodied more in the improved ones (Table 8). There is high variability in the attainment indices among improved varieties for the different attributes, which suggests the need to target varieties for the different circumstances including yield and tolerance to disease and drought. However, it was found that in some attributes like straw yield and quality, landraces have better attainment indices compared to some of the improved varieties. The formal sector needs to consider diversifying the supply of seed of different bread wheat varieties and increase its capacity to respond to emerging challenges to effectively address farmers' preferences.

Table 8. Demand, supply, and attainment indices for bread wheat varieties in Ethiopia

Variety attributes	Local			Kubsa (1995)			Kakaba (2010)		
	DI	SI	AI	DI	SI	AI	DI	SI	AI
Grain yield	0.99	0.18	0.18	0.99	0.74	0.73	0.99	0.88	0.88
Grain color	0.84	0.29	0.26	0.73	0.85	0.63	0.88	0.86	0.81
Early maturity	0.83	0.18	0.15	0.76	0.86	0.66	0.97	0.86	0.84
Drought tolerance	0.88	0.47	0.41	0.85	0.50	0.44	0.90	0.86	0.79
Yellow rust resistance	0.91	0.32	0.30	0.92	0.30	0.27	0.88	0.74	0.66
Stem rust resistance	0.92	0.33	0.31	0.91	0.33	0.29	0.90	0.74	0.67
Threshability	0.83	0.32	0.29	0.77	0.90	0.69	0.87	0.88	0.77
Bread taste/food quality	0.89	0.51	0.45	0.88	0.83	0.74	0.88	0.86	0.77
Marketability	0.87	0.20	0.18	0.81	0.86	0.70	0.90	0.86	0.78
Straw yield	0.86	0.64	0.56	0.83	0.73	0.64	0.84	0.91	0.78
Straw quality	0.87	0.65	0.57	0.83	0.69	0.60	0.86	0.88	0.80

3.1.4 Wheat seed sector in Pakistan

The study provides an over view of wheat seed sector in general and the empirical evidence on wheat seed use, varietal and source choices, demand and impact at farm level derived from a comprehensive primary data through a national level survey. Wheat producing districts were grouped under different cropping zones and 26 major wheat producing districts falling within specific production system from each province across the country were selected: Punjab (12), Sindh (5), Khyber Pakhtunkhwa (5) and Balochistan (1). A total sample of 632 farmers, including 471 from Punjab, 68 from Sindh, 52 from Khyber Pakhtunkhwa and 41 from Balochistan was selected using multistage sampling technique representing different cropping systems and regions. Descriptive analysis was used to provide the general picture whereas probit model was used to estimate the determinants of certified wheat seed use. Ordinary Least

Squares was used to estimate the determinants of area under wheat, and demand of wheat seed. The stochastic frontier model was used to study the differences in Technical, Allocative and Economic Efficiencies of the formal seed and informal seed along with overall efficiency in wheat production. Finally the impact of formal seed sources on household welfare was estimated using a Propensity Score Matching Approach.

Wheat varietal adoption

In Pakistan variety development is exclusively managed by the public sector. About 126 wheat varieties were released up to April 2012: 59 varieties by different institutes in Punjab, followed by 37 in KP, 20 in Sindh, 7 in Balochistan and 3 by federal research institutes. The private sector has not developed even a single variety of wheat so far.

Varietal adoption and spread is important for research and development. Wheat appeared to be the major crop in winter season across all the regions and cropping systems. At national level, it was found that about 40% of sample farmers grew Sehar 2006 on 50% of the wheat area (Table 9). The variety appeared to be dominant across Punjab and Balochistan. Similar kind of varietal adoption trends were found for Pak-81 and Inqlab-91 during 1980's and 1990's. In all other provinces varieties released from Punjab are predominantly grown except in Sindh showing a better organized variety development and seed supply in the Punjab province. In Sindh province variety TD-01 is predominant while in KPK Bhakar 02 is predominant. High yield, quality and taste, grain and ear size, straw yield, resistance to diseases, lodging, drought, shattering and pest were also highlighted important elements for a variety to be adopted. Other aspects like early maturity, grain color, number of tillers, marketability in terms of liking by consumers and storability (less storage pests etc.) were also considered for varietal preferences.

Table 9. Wheat varieties grown and adopted in Pakistan in 2012 crop season

Variety	No of farmers	% of farmers	% wheat area covered	Remarks
Sehar-2006	252	39.8	49.3	Punjab (46-60% of wheat area); Balochistan (44%)
Inqlab-91	57	9.0	7.2	
Faisalabad08	37	5.9	5.7	
Watan-94	30	4.7	5.6	
Bhakar-02	23	3.7	3.1	KPK (33% of wheat area)
TD-01	29	4.6	4.4	Sindh (47% of wheat area)
Abdul Sattar	24	3.8	3.5	
Shafaq 06	19	2.9	2.8	
Lasani-08	20	3.2	2.5	
New varieties	39	6.3	4.5	AARI11, Aas11, Punjab11
Others	102	15.9	11.3	
Total	632	100	100	

Wheat seed sources

The wheat seed sources across the country were presented in Table 10. Farmers' own seed from previous crop, seed exchanged or bought from fellow (neighboring) farmers and purchased from grain traders appeared the main

seed source for wheat planting. The formal seed sources from seed dealers, research stations and extension department provide the balance. Overall own farm produced seed saved from past year crop appeared to be the major source of seed and it covered half of the wheat area; and with the seed from fellow farmers and grain traders, the informal sector covered 73% wheat area.

The share of certified seed from formal sector increased from about 10% (1999/00) to about 29% (2011/12) with major share shifting from public sector to the private sector. To date the private sector contributes almost three fourth of the total certified seed in the country.

Table 10. Farmers' wheat seed sources in Pakistan in 2012 crop season

Seed system	Seed sources	No of farmers	% of farmers	% of wheat area covered
Formal sector	Seed dealers	143	23	25
	Agricultural research	13	2	1
	Agricultural Extension	13	2	1
	Sub-total	169	27	27
Informal sector	Own saved seed	312	50	52
	Fellow farmers	88	14	14
	Grain dealers	56	9	7
	Sub-total	456	73	73
	Total	625	100	100

3.2 Promoting village-based seed enterprises

Organizing village-based seed enterprises

The first step in organizing a VBSE is to consult with stakeholders and thereby identify target areas and groups with a high probability of successful organization. Farmers selected for participation form seed-producer groups and identify seed-production sites. With guidance provided by seed experts, member farmers prepare a business plan and undergo training on financial management and best practices in seed production (varietal choice, seed sourcing, land selection, planting, fertilization, weed control, rouging [removing off-type plants from production plots], harvesting and threshing); seed processing (cleaning, treatment and packaging), storage (fumigation) and marketing (promotion); quality control (field inspection, seed testing and labeling). Experts provide further assistance to arrange access to credit and source (foundation) seed and other inputs, including such machinery as tractors, threshers, sprayers, and mobile seed cleaners and treaters, with the project providing machinery by grant where necessary. Experts also help establish links with other VBSEs toward establishing mutually supportive networks and with local agro-industries to carve niches in the agricultural economy for the VBSEs to fill. VBSEs are proving successful in producing substantial amounts of seed for commercial sale to farmers. In Afghanistan, the most progressive and experienced VBSEs are not only tapping into the market for seed but also diversifying their activities to increase and stabilize revenues. One constraint on VBSEs is competition from fraudulent dealers offering cut-rate cleaned grain as seed. Another is limited credit and seed stores required to allow VBSEs to hold seed and sell it at higher prices at the next planting time.

Profitability and sustainability of village-based seed enterprises

ICARDA's pilot VBSE program operates in many countries across the dry areas of Central and West Asia and North Africa including Afghanistan, Eritrea, Morocco, Tunisia, Palestine, Yemen, etc. In total, 21 VBSEs under RAMP and 17 VBSEs under ALP/E were supported (in Nangarhar, five former VBSEs established by RAMP were also retained, bringing the total to 17 VBSEs) in Afghanistan.

Under the RAMP, 21 VBSEs were established in five target provinces over a three-year period. Each VBSE allocated on average, more than 20 ha of land and produced over 100 tons of quality seed of four major food crops (wheat, rice, mung bean, and potato) for income diversification (Table 11). Assessment of profitability demonstrated a total net income of US\$ 0.85 million for 17 VBSEs in 2004/05 and US\$ 2.3 million for the 21 VBSEs in 2005/06 through production and marketing of quality seed. The marginal rate of return (%) for wheat, potato, rice and mung bean was 239, 193, 163 and 190, respectively (Table 12).

Table 11. Amount of seed produced and marketed by VBSEs (tons) under RAMP from 2004-2006 crop seasons

Year	Active VBSEs	Wheat	Rice	Potato	Mung bean	Total
2003 /04	6	753	525	-	-	1,278
2004 /05	17	2,188	651	752	325	3,916
2005 /06	21	3,533	2,352	3,784	186	9,855
Total	21	6,474	3,528	4,536	511	15,049

Table 12. Area planted, seed produced and revenues by VBSEs under RAMP in 2005/06 crop season

Item	Wheat	Potato	Rice	Mung bean
Number of active VBSEs	17	14	9	7
Total area (ha)	542	45	139	264
Total production (t)	2,188	752	651	325
Average production (t/ha)	4.04	16.7	4.7	1.23
Average price (farm gate Afs/t)	17,000	8,946	17,460	21,300
Gross revenues (Afs/ha)	68,680	14,9398	82,062	26,199
Production cost (average Afs /ha)	20,205	51,000	31,190	9,025
Net average marginal income (Afs /ha)	48,475	98,398	50,872	17,174
% Marginal income	239	193	163	190

Under ALP/E project, 17 VBSEs (including 5 retained from RAMP project in Nangarhar) were established in three provinces in eastern Afghanistan. They collectively produced about 3,856 tons of quality seed over the three year period (Table 13). In terms of technical performance, from total area planted an average of 85% was approved for wheat, rice, mung bean and potato during field inspection. The average cleaned seed recovery was 95% for all crops. For example, in 2007/8, the average purity and germination of VBSE seed samples were 98.1 and 91%, respectively, showing that VBSEs are capable of producing high quality seed for marketing.

The profitability analysis showed that the net profit margin was US\$315,531 for

15 VBSEs in 2006/07 and averaged US\$ 21,035.4 per VBSE. In 2007/8, the net profit for 17 VBSEs was surged to US\$1,311,060 from seed business and services with an average of US\$77, 121 per VBSE. The marginal rate of return (%) for wheat (QDS), Wheat (CS), potato, rice and mung bean was 504, 259, 269, 278 and 251, respectively (Table 14). All VBSE seed operations were assessed as being economically viable, with 15 VBSEs earning a combined profit of US\$315,531 in 2006/07 and profits for 17 VBSEs surging to US\$1,311,060 in 2007/08.

Table 13: Amount of seed produced and marketed by VBSEs (t) under ALP/E from 2006-2008 crop seasons

Crop year	Active VBSEs	Wheat	Rice	Mung bean	Potato	Total
2005/06	6	626	-	-	-	626
2006/07	15	955	94	11	-	1,060
2007/08	17	1,445	593	91	41	2,170
Total	17	3,026	687	102	41	3,856

Table 14: Area planted, seed produced and revenues by VBSEs under ALP/E in 2007/08 crop season

Item	Wheat (QDS)	Wheat (CS)	Potato	Rice	Mung bean
Number of active VBSEs	15	6	6	12	15
Total area (ha)	261	59.6	3.7	102.2	48.3
Total production (t)	1,224	220.7	41.5	593.1	91.1
Average production (t/ha)	4.7	3.7	11.4	5.8	1.9
Average price (farm gate US\$/t)	800	850	230	446	714
Gross revenues (US \$ /ha)	4,107	3,692	2,610	2,893	1,570
Production cost (US \$ /ha)	680	1,029	707	766	447
Net marginal income (US \$ /ha)	3,427	2,663	1,903	2,127	1,123
% marginal income	504	259	269	278	251

Note: QDS=quality declared seed; CS=Certified seed

Farmer entrepreneurs in Algeria, Morocco, and Tunisia had established VBSEs for producing and marketing durum wheat seed in less-favorable areas. Efforts are now under way to expand the pilot program into dryland areas where the formal sector is less operative in terms of less favorable marginal environments, remote regions and crops such as grain legumes.

3.3 Restoring and safeguarding seed systems

The Fertile Crescent — which extends up the Tigris and Euphrates rivers and then down the eastern shore of the Mediterranean into the lower Nile Valley —is celebrated as the cradle of civilization. Crops originating in the Fertile Crescent provide 38% of the human diet globally, especially in the temperate latitudes, making their wild relatives and land races enormously important genetic resources. The Fertile Crescent is the center of a region stretching from the Indian subcontinent to the Horn of Africa that is affected by conflict and other disasters, both man-made and natural, causes, arising from high population growth, unsustainably intensive grazing and tillage, drought, plant diseases and

pests. This delicate situation threatens to render extinct invaluable plant genetic resources and threatens the well-being of hundreds of millions of people who depend on agricultural biodiversity for their food security.

With its long expertise in the Fertile Crescent, and serving all the world's dry areas, ICARDA has been in the vanguard of efforts to safeguard genetic resources, especially in West Asia, North Africa, Central Asia and parts of South Asia and sub-Saharan Africa - to restore damaged or destroyed seed systems and strengthen existing ones.

3.3.1 Assessment of seed security in Greater Horn of Africa

Both natural and man-made disasters can have devastating effects on agricultural systems and the environment. There is an increasing trend in man-made disasters (e.g., war or civil strife) worldwide and emergency assistance to regions affected by such stresses. Among natural disasters, drought is a threat in many dry areas of the world including some countries of the WANA region. During such disasters, farmers may be forced to deplete their meager seed stocks, resulting in the loss of well-adapted farmers' varieties, which could lead to erosion of valuable genetic diversity that is the building block for rehabilitation and restoration of agricultural systems.

'Seed security' is an important component of food security but relatively little information is available either on local practices or national strategies for emergency seed supply. A concerted effort is required to rehabilitate agriculture to a sustainable level to assist farmers affected by disasters. Such undertaking needs a partnership among the farmer communities, national governments, NGOs and international community.

ICARDA undertook, a Seed Security Assessment in the Disaster Vulnerable Areas of the WANA region funded by the Office of Foreign Disaster Assistance, Bureau for Humanitarian Response, Agency for International Development, USAID. The study was intended to include Eritrea, Ethiopia, Sudan and Yemen in the one hand and Afghanistan and Pakistan in the other hand in the WANA region. In the absence of study from Afghanistan due to security problems the main focus is on the countries of the Nile Valley and Red Sea region.

The report covers the extent of drought-prone areas in the countries under study. In addition, the national seed sector is reviewed in relation to crop research, variety development (release and registration), seed production and supply (quantity, processing and storage facilities), seed quality control (seed certification), seed/grain trade (import-export) regulations and quarantine regulations. An attempt was made to provide lists of crop varieties, seed producers and available facilities; agencies responsible for seed quality control, seed/grain trade and quarantine; and NGOs involved in agricultural development and emergency seed supply. The role of government and NGOs was discussed focusing on the status of seed security for drought-prone areas. Moreover, the report also suggested possible future interventions and recommendations to strengthen seed supply in less favored and marginal areas prone to disasters.

The following measures were proposed to support a sustained seed

security system in the countries studied:

- Develop a strong information system among WANA member countries on seed availability (crop, variety, source, etc.)
- Conduct cooperative trials on varieties suitable for drier areas which are developed by IARCs, NARS and from other sources possibly coordinated by the IARCs
- Keep a database of variety register by ICARDA including commercial and pedigree names of varieties used in the WANA region
- Promote farmer-managed seed systems operating on a commercial basis serving localized farm community with a view for eventual transformation into formal small-scale seed enterprises
- Maintain emphasis on local landraces in farmer-managed seed production and supply systems where improved varieties have not been developed
- Develop or harmonize seed certification schemes by setting minimum field and seed standards to facilitate seed trade within the WANA region
- Encourage more on-farm trials by NARS in drought-prone areas to gather more and better information on variety adaptation to farmers' conditions
- Develop a mechanism for seed security in each country to overcome unpredictable shortage of seed on national or regional levels

Some readers will recall the terrible and highly publicized drought that hit the Horn of Africa in 1984/85, coinciding with the culmination of Eritrea's separation from Ethiopia. Despite renewed hostilities between Eritrea and Ethiopia in 1998, and a long-running civil war in Sudan that brought independence to South Sudan in 2011, famine has not returned to the Horn of Africa with the vengeance of the mid-1980s. Ethiopia, Eritrea and Sudan participated in an ICARDA-led assessment of seed security conducted in 1996-1998 toward finding ways to mitigate food insecurity in drought-prone areas.

Today, this part of Africa is on the frontline of efforts to contain and eradicate Ug99, the virulent race of the wheat stem rust fungus that was first identified in Uganda in 1999. ICARDA, being the Center which serves the most drought prone areas of the world is expected to continue playing an important role both in crop genetic resources and seed system development on a national, regional and global basis through its genetic resources and seed Networks which have very strong links to NARS and national seed systems.

3.3.2 Supporting seed system recovery in Afghanistan

In January 2002, ICARDA brought together, with the support of the United States Agency for International Development (USAID), 74 experts from 34 organizations including CGIAR centers, other research institutes, relief and development organizations, nongovernmental organizations (NGOs), universities, donors, and the Afghanistan Ministry of Agriculture and Livestock to create the Future Harvest Consortium to Rebuild Agriculture in Afghanistan (Box 3).

Box 3: Lessons learned from emergency seed relief in Afghanistan

- The large joint effort to provide farmers in Afghanistan with emergency seed supplies and to rebuild the nation's seed system yielded a number of lessons to apply in subsequent emergencies:
- Emergency seed supply following disasters must conform to national and local conditions in terms of farmers' seed demands and needs in terms of quantities and types; a one-solution-fits-all approach will not work.
- Advance knowledge of distribution logistics is essential to achieve the timely distribution of seed.
- Availability of locally adapted varieties are essential to avoid costly attempts to import misfit varieties and the resulting crop failures.
- Flexible but efficient seed import regulation is important for responding to emergency situations.
- Emergency response differs from development interventions, requiring more flexibility to ensure timely relief operations.
- Coordination of relief suppliers is necessary to avoid unproductive competition among partners.
- Coordination highlights the important regulatory role of the government, which was absent in Afghanistan in the early stages of relief. The 2002 code of conduct for seed import by international development agencies provided timely guidance toward rectifying a chaotic situation.
- Monitoring should occur throughout project operation, with evaluation and impact assessment following in the post conflict period.
- Donors must be regularly updated in such highly visible and accelerated operations to ensure support and funding for future operations.

Emergency seed relief operations: Using part of a USAID grant of US\$9.52 million, the consortium procured 3,500 tons of improved wheat seed and coordinated its transport and distribution to 70,000 farm families in time for the spring planting in April of that year (Table 15). For the autumn planting in September, instead of simply shipping wheat seed from other countries as it did in April, the consortium had staff of ICARDA and other partners provide training in seed production and contracted Afghan farmers to produce seed for autumn distribution. A rigorous quality assurance program included the removal of off-type plants, postharvest cleaning and treatment and proper packaging techniques as well as field inspection and seed quality testing.

The autumn 2002 Wheat Seed Campaign enabled Afghan farmers to produce nearly 5,000 tons of wheat seed for distribution to 90,000 farmers in 11 provinces, which yielded more than 100,000 tons of wheat in 2003. Experience has shown that well-meaning aid donors and NGOs must avoid indiscriminate seed giveaways because they undermine local seed enterprises. Providing poor farmers with vouchers with which to buy seed from local suppliers helps support local institutions and social networks, building local resilience and food security.

Table 15: Wheat seed distributed for spring planting in Afghanistan, 2002

Organization	Seed distributed (t)	Number of beneficiaries	Target provinces (districts)
Focus	210	4,200	Badakhshan
Ghazni Rural Support Program	222	3,080	Ghazni, Uruzgan
International Medical Corps	1,215	16,800	Kapisa, Ghazni, Parwan, Wardak
Mercy Corps	400	4,400	Uruzgan (Gezab, Kejran, Khas Uruzgan)
Ministry of Agriculture and Livestock	200	1,000	Ghorband (Surkh Parsa, Sheikh Ali, Seya Gerd, Shinwari)
Solidarity	750	10,500	Wardak
Agence d'Aide a la Coopération Technique et au Développement	170	3,400	Takhar (Khowaja Ghar)
Food and Agriculture Organization of the UN	330	6,600	
Total	3,500	49,980	

Repatriation of genetic resources: As looters had destroyed Afghanistan's largest crop seed collection — including wheat, barley, chickpea, lentil, melons, pistachio, pomegranate, and other fruit and pasture crops — the consortium repatriated seed from duplicate collections around the world. In autumn of 2002, ICARDA shipped 53 tons of germplasm of Afghan origin and foundation seed of bread and durum wheat, barley, chickpea, lentil and vetch for on-station testing, large-scale evaluation and pre-release multiplication. Several trials were planted to test yield, drought and cold tolerance, and disease resistance in an array of crops. In addition, it organized collection trips to replace lost germplasm, notably of almond, pistachio, pomegranate and melon. Fruit tree nurseries established on research stations produced grafted saplings for distribution to farmers. In 2005, ICARDA itself established 95 orchards in northeastern Afghanistan. Sufficient seed and planting material of appropriate cash crops such as fruits, nuts, vegetables and food legumes — and of forages to support dairy, meat and hide production — are essential to weaning Afghan farmers from dependence on growing opium poppies.

Rehabilitation of infrastructure: Afghanistan's administrative structures had, like its physical infrastructure, suffered serious damage, leaving farmers with unsuitable varieties and poor-quality seed. Agricultural research centers were rehabilitated to ensure development of varieties, and seed testing laboratories were established to ensure seed quality.

Development of code of conduct: To ensure the production of high-quality seed in Afghanistan, guidelines were needed to regulate the production, import and distribution of seed and planting materials. ICARDA was instrumental in drawing up the 2002 code of conduct for seed import by international development agencies to avoid introducing inappropriate varieties, or of seed that carries quarantine diseases, pests or weeds. The Badam Bagh Seed Testing Laboratory in Kabul became fully restored and equipped with facilities to test seed health and quality. As Afghanistan's national seed laboratory, it enforces standards to foster safe national and global exchanges of seed.



Afghanistan: Emergency seed distribution (spring 2002)



Emergency repatriation of germplasm from ICARDA's Genebank to Afghanistan (2002)

Apart from the code of conduct for seed import developed for emergencies, ICARDA prepared a draft seed policy that formed the basis, in 2005 with support from the Food and Agriculture Organization of the United Nations, of the national seed policy, further drawing up a legislative act that became in 2009 the basis of the national seed law. A meeting in March 2012 for launching the revised seed policy attended by experts representing ICARDA and many other stakeholders consulted on how to make the seed sector less dependent on government and donor subsidies, promote variety development and evaluation, ensure varietal protection and quality control, improve extension and marketing links, rationalize import and export regulations, and ensure seed supplies in emergencies.

Rebuilding the seed system: Two short-term, high-impact initiatives funded by USAID grant were the Rebuilding Agricultural Markets Program (RAMP) and the Alternative Livelihoods Program/Eastern Afghanistan (ALP/E), both administered by ICARDA from 2003/04 to 2007/08 to facilitate the development of village-based seed enterprises (VBSEs, one of which is described above in section 3.2). Another project ICARDA implemented jointly with the CGIAR's International Potato Center provided seed of improved potato varieties and trained farmers, development agents and NGO staff on best practices for integrated crop and disease management, tissue culture, and marketing. This spurred an average potato yield increase of 30% in four provinces and introduced autumn seed production to allow two crops per year.

The project Strengthening Seed Systems for Food Security in Afghanistan, funded by the International Development Research Center, researched local seed systems in rainfed areas of northern Afghanistan toward establishing farmer-participatory crop breeding, strengthening local seed systems and developing a mechanism to link them to the formal system. A stakeholders' meeting in 2004 identified three areas for intervention: (1) improving farmers' access to improved and local crop varieties; (2) improving seed market assessment of demand, promotion and marketing; and (3) promoting farmer organizations and VBSEs. The project collected 677 accessions of wheat, barley, mung bean, cowpea, kidney bean, rice, melon, flax and other crops.

The project Community-based Research on Agricultural Development and Sustainable Resource Management in Afghanistan, funded by the OPEC Fund for International Development, screened and identified new varieties of cereals and food legumes and produced early-generation seed of wheat varieties adapted to Afghan conditions. Since 2003 the project has re-established a program to screen and identify new varieties and to produce early-generation seed.

3.3.3 Agro-biodiversity conservation and use in West Asia

The Fertile Crescent is the center of diversity of wheat, barley, lentil, and several food and feed legumes and fruit trees domesticated in the past 10,000 years. Farmers still use landraces of durum wheat, barley, lentil and vegetable crops, and fruit trees in traditional farming systems often under harsh conditions. These landraces appear to be well adapted to low-input agriculture and harsh conditions and are preferred as better suited for the preparation of traditional



Afghanistan: Village-based seed enterprise seed production fields for training courses and field days in Afghanistan



Afghanistan: A mobile seed cleaner being used by village-based seed enterprises

foods. However, their acreage is diminishing, which threatens their eventual loss to farmers and to breeders who could tap these valuable genetic resources.

Dryland agro-biodiversity continues to sustain the livelihoods of most farming and herding communities in the arid mountains of the Caucasus, Central Asia, West Asia and North Africa. ICARDA is fully involved in promoting in situ conservation of tropical dryland agro-biodiversity, including landraces and wild relatives of its mandated crops, rangeland and pasture species, dryland fruit trees, and medicinal and herbal plants.

ICARDA has since 1999 developed a holistic approach to community-driven conservation of dryland agro-biodiversity. Implemented in Jordan, Lebanon, Palestine and Syria, this approach has emphasized low-cost technological options, value-adding technologies, alternative sources of income, institutional options and policy recommendations. ICARDA's Dryland Agro-biodiversity Project trained farmers and supplied them with machines to clean and treat seed in Jordan, Lebanon, Palestine and Syria. This equipment and help in organizing the farmers' seed-supply systems enabled them to continue to produce and exchange local genetic resources, thus conserving local landraces while perpetuating their use.

Promoting on-farm conservation and use of landraces in Palestine

Agriculture continues to be a major activity of the Palestinian people and a major sector of the economy, providing jobs for Palestinians and contributing to food security. Cereals, food legumes and fruit trees are major crops. Agricultural productivity has declined due to limited access to funding and the supply of such inputs as seed, fertilizer and pesticides under occupation.

Palestine does not have well-functioning crop improvement programs or a formal sector to supply high-quality seed or improved varieties of cereals, legumes and vegetables. Most farmers use their own seed or buy improved varieties introduced from Israel. However, the walling off of the West Bank has limited access to these seeds and other inputs. The challenge is to determine what can be done to disseminate and apply the knowledge and practices at the appropriate scale to strengthen formal and informal seed systems and to promote the conservation and use of crop landraces.

In response, ICARDA is implementing, in partnership with the Ministry of Agriculture and other institutions in Palestine, and with financial support from the Arab Fund for Economic and Social Development, the project "Development of community-based informal seed production enterprises for promoting the conservation of field crop landraces in Palestine." The project promotes the on-farm multiplication of crop landraces still grown in Palestine and aims to initiate farmers' participation in crop improvement and establish a business-oriented seed production and supply system in villages.

Three seed-producer groups were initiated, in the governorates of Jenin, Tubas and Ramallah, with 10 farmers participating. The project provided 3,230 kilograms of seed of four priority wheat landraces (Khatat, Hietia Beda, Nabaliamal and Nursi) and one of barley (Nabawi), as well as training on technical aspects of seed production, processing and storage to maintain quality. Half of the participating farmers have produced seed that is sufficiently pure and true to

type to meet quality standards. At harvesting, farmers were provided with mobile cleaners and bags for packaging and advised on the proper conditions for seed storage. The 6,300 kilograms of wheat and barley landrace seed that the project produced were distributed to farmers for the next crop season.

A draft technical guideline for seed production and marketing was developed to assist the seed-producer groups. In addition, two project staff providing technical support participated in a regional train the-trainers course in seed production and quality assurance as well as seed, enterprise development and marketing. A review of existing policies and legislation on seed production and opportunities for farmer-based seed production and marketing yielded recommendations that were submitted to National Agriculture Research Center to initiate a national dialogue with policy makers of the Ministry of Agriculture and other national stakeholders.

Promoting on-farm conservation and use of landraces in Yemen

The Rainfed Agriculture and Livestock Project in Yemen is funded by the World Bank and executed by the Social Fund, Agricultural Research and Extension Authority, General Seed Multiplication Corporation, University of Sanaa, and University of Aden. With five target provinces, the project conserves germplasm, improves landraces and locally produces seed with the participation of farmers. ICARDA provides technical backstopping and strengthens the capacity of human resources in these three areas of focus.

The crops of interest to the project are barley, wheat, sorghum, millet, maize, faba bean, lentil, fenugreek and sesame, samples of which it collected from 20 districts in the five governorates of Al-Mahweet, Al-Hodeida, Hajja, Lahj and Sanaa, providing more than 2,600 accessions for conservation in the genebanks of the Agricultural Research and Extension Authority and of Sanaa University. The ICARDA genebank has so far received 450 duplicate accessions to further guarantee their conservation.

Conservation should be coupled with the improvement and use of adapted landraces with farmer participation. Apart from participatory landrace improvement, 70 seed-producer groups were established by Social Fund for Development under five seed associations, one in each governorate.

Participating farmers contribute to improving prominent landraces, then engage to produce the seed of improved landraces. Farmers market the seed collectively through the seed associations, which oversee seed production, processing, storage and quality assurance, as well as the large-scale dissemination of seed along with other inputs. At the end of 2012, seed-producer groups had 428 member farmers, who produced more than 180 tons of high-quality source seed. The benefits of participatory improvement of landraces, seed production, processing and treatment were demonstrated to farmers by yield gains of at least 30%. The project is expected to establish a self-reliant informal seed supply system that can ensure the availability of high-quality seed and contribute to the dynamic on-farm conservation and sustainable use of diverse landraces adapted to major biotic and abiotic stresses, including those arising from climate change.

3.4 Establishing/strengthening seed units

Variety release is not an end in itself, but should be followed by a decision to multiply seed of a variety in order to launch it in the market. Variety maintenance and early generation seed production are critical steps in initiating the seed chain for moving varieties from research stations to large-scale certified seed producers and eventually to farmers' fields. In many public breeding institutions of developing countries, systematic variety maintenance and early generation seed production (breeder to basic/foundation) remains a major constraint due to lack of adequate physical, financial and human resources. Moreover, there is lack of clarity on institutional arrangements whether some of these activities particularly basic/foundation seed production need to be done by the research or seed producers or by a separate and independent agency.

ICARDA advocates for creating functional seed units, and strengthening them where they already exist, which can institutionalize early-generation seed production on a sustainable basis. A review of technical capacity for variety maintenance and early generation seed production were carried out with selected NARS in Afghanistan, Ethiopia, Eritrea, Iraq, Morocco and Pakistan. Apart from recommendations on 'best practices', list of critical equipment such as plot planters, plot harvesters, threshers, seed cleaners, seed testing equipment, etc. have been identified and provided within the scope of the project objectives and resources to strengthen NARS capacity in seed production.

In Arabian Peninsula, ICARDA initiated an extensive research and technology transfer program on identifying and promoting local production and utilization of indigenous plant species for feed production and range rehabilitation. The ultimate goal of the program is to save the scarce water resources in the region and minimize degradation through conservation and use of local plant flora and biodiversity. Most of these local species are from the wild and there is limited knowledge on the dormancy, seed quality, maturity, harvesting time, seed processing and seed quality attributes and its evaluation. A list of forage species identified and their seed production technology developed to support seed production and distribution. ICARDA has established well-equipped seed technology units in United Arab Emirates, Oman, Saudi Arabia, Qatar and Yemen. The units aimed at promoting the target species by maximizing seed yields through improved crop management practices, appropriate post-harvest technologies and operations and extensive capacity building.



A seed technology unit and seed multiplication experiments of native grass species in UAE

A functional seed system with an effective variety maintenance program and early generation seed production (breeder, pre-basic and basic) linked to an efficient large scale certified seed production and marketing operating under sound policy and regulatory frameworks is critical for seed sector development. ICARDA, apart from providing regular courses, is developing a manual on variety maintenance of major cereal and legume crops. This manual is aimed at providing practical guidelines on variety maintenance and breeder seed production to maintain varietal purity and identity of new crop varieties. This would ensure quick commercialization to produce sufficient quantities of certified seed by public and/private seed sector. The manual provides information on physical, financial and human resources as well as the organization and management of such unit within NARS.

Linked to maintenance is the list of released varieties in national catalogue. While variety description is the essential part of the variety release system some developing countries lack the technical capacity of conducting DUS testing to describe their varieties before release for the purposes of maintenance, seed production and certification. ICARDA assisted countries such as Afghanistan, Ethiopia and Syria to describe their varieties and establish a national variety catalogue.

3.5 Mitigating wheat rusts in Africa and Asia

International agricultural research has a long history with wheat stem rust. A stem rust epidemic that swept across North American wheat fields in the early 1950s, destroying as much as 40% of the continent's spring wheat crop, prompted a new form of international cooperation among wheat scientists worldwide. Led by wheat scientist Norman Borlaug, the initiative pushed stem rust to the sidelines and started Borlaug down the road to the Nobel Peace Prize and the sobriquet "father of the Green Revolution." Wheat resisted stem rust for more than 4 decades, supporting rural incomes and global food security but also breeding complacency as farmers and crop scientists all but forgot about the disease.

Then, in 1999, a new and virulent race of wheat stem rust was identified in Uganda. Ug99 stirred widespread alarm because an estimated 90-95% of current wheat varieties were susceptible to it. As wheat accounts for 30% of global grain production, 44% of cereals used as food, and 55% of the carbohydrates and 20% of the food calories humans consume every day, the potential for famine was almost unthinkable.

Ug99 and its derivatives have since been confirmed in Sudan, Ethiopia, Eritrea, Yemen and Iran to the north and east of Uganda, and in Tanzania, Mozambique, Zimbabwe and South Africa to the south. All of South Asia is considered at risk of infection, as is China. The ease with which the wind-borne fungus spreads, means that even the major wheat exporters across the sea in Australia and the Americas are not immune.

The best strategy to protect wheat from Ug99 is to replace susceptible varieties with new high-yielding, resistant varieties. ICARDA was a prime mover in establishing in 2005 a global effort, now dubbed the Borlaug Global Rust Initiative, to do just that. Under the initiative, ICARDA, its CGIAR sister International Maize

and Wheat Improvement Center, and a number of NARS in developed and developing countries have screened thousands of wheat germplasm accessions in Kenya and Ethiopia, identifying elite lines with adequate resistance to Ug99 and up to 15% higher yield.

But breeding resistant varieties is one thing, distributing them to poor farmers in Africa and Asia before their fields are overwhelmed by Ug99 is another. A pressing challenge is to find innovative and flexible approaches to fast-track variety release and accelerate seed multiplication to ensure the quick delivery of resistant varieties for wide adoption. Key to the rapid dissemination of varieties resistant to wheat rust are (1) fast-tracked variety evaluation and release, (2) streamlined regulatory frameworks, (3) promotions and demonstrations to create farmer awareness of rust and rust-resistant varieties, (4) accelerated seed multiplication, (5) strengthened infrastructure for seed delivery, and (6) strengthened capacity in NARS and national seed systems (Figure 2).

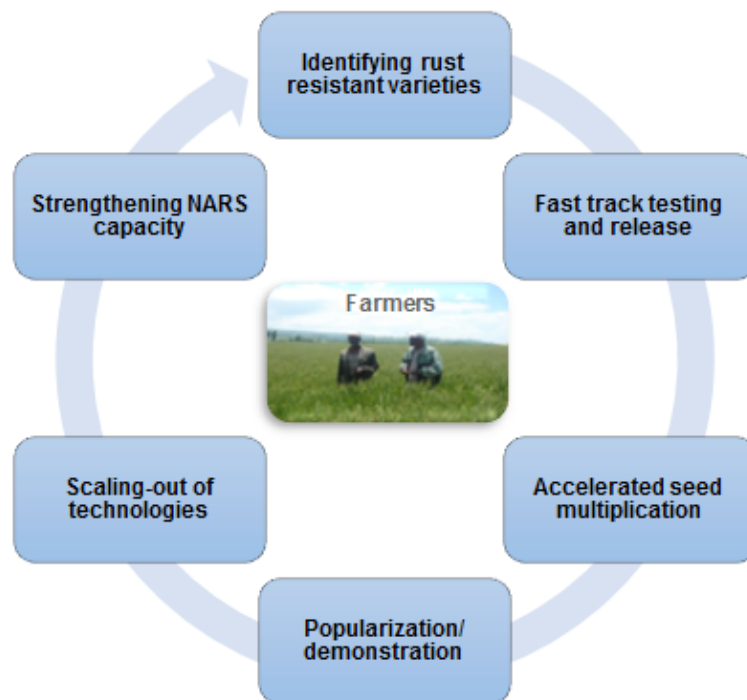


Figure 2. Approach in fast-track testing and accelerated seed multiplication

A flexible approach of 'pre-release' seed multiplication was initiated to overcome the legal and technical hurdles of early generation seed production. As a result multi-location variety trials, pre-release seed multiplication and variety popularization were carried out simultaneously (Figure 3). Seed multiplication was initiated much earlier to assure that at the time of release sufficient quantities of basic (foundation) seed are available for large-scale seed multiplication and eventual distribution to farmers. The project provided direct support for pre-release seed multiplication of early generation (breeder, pre-basic and basic seed) in target countries. Moreover, NARS continued to carry out variety maintenance

and early generation seed production once varieties were officially released for commercial production.

The project played a catalytic role in supporting early generation seed production and linking that to large-scale seed production by existing public seed enterprise and/or private seed companies (Figure 3).

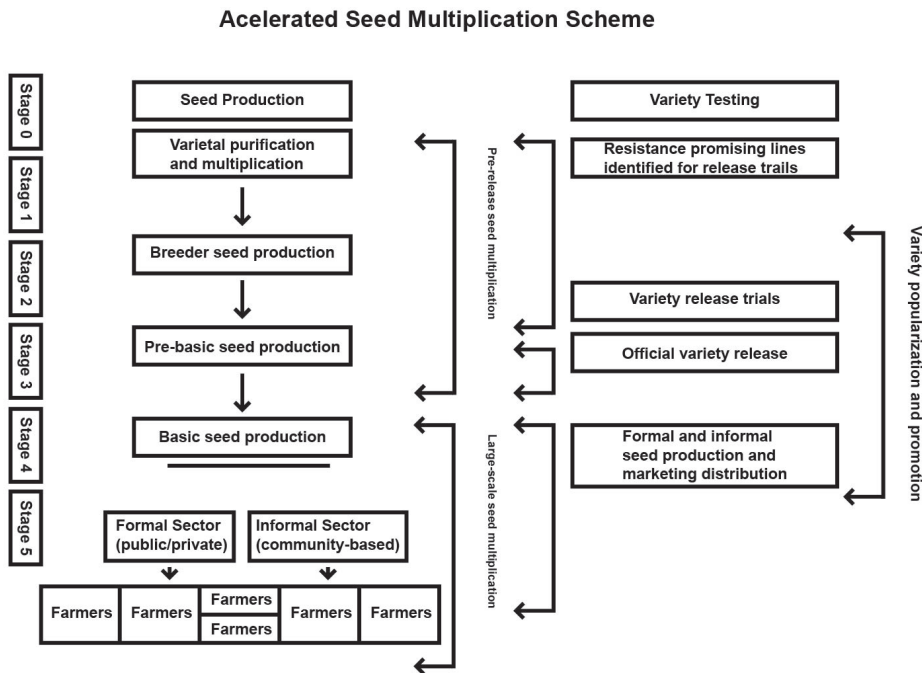


Figure 3. Framework for accelerated seed multiplication (Source: Osborn and Bishaw, 2009)

The unprecedented effort to combat Ug99 has important knock-on benefits for global wheat production. The same initiatives launched to counter Ug99 can help contain outbreaks of a new strain of yellow rust, or stripe rust, in Central and West Asia, the Caucasus, and North Africa, which threaten to cause billions of dollars in crop losses and disrupt regional food security. In 2010, yellow rust devastated wheat fields in Ethiopia, causing losses of up to 80%.

Further, the recommendations for releasing and distributing wheat seed to counter Ug99 echo the proposed framework for building resilient national seed systems to counter or speed recovery from all manner of threats: war, civil unrest, global warming, and the worsening frequency and intensity of drought, storms and pestilence expected from climate change. Screening for Ug99 resistance has run in parallel with screening for yellow rust, leaf rust and local races of stem rust. In Ethiopia, where Ug99 was first observed in 2003, some of the newly released varieties combine resistance to stem rust and yellow rust with a yield advantage of up to 21% over widely grown commercial varieties.

Complete replacement of existing varieties is an enormous task for a crop as widely planted as wheat, requiring the full support and involvement of national stakeholders. The first step is to secure that support. This means building links with ministries of agriculture, agricultural research institutes, agricultural de-



Ethiopia: Off-season seed multiplication at Kulumsa Agricultural Research Center, Ethiopia

velopment and extension services, public and private seed companies, variety-registration and seed-certification agencies, NGOs, and farmer associations — clearly defining each organizations’ roles and responsibilities and providing their staffing requirements and material needs (Figure 4).

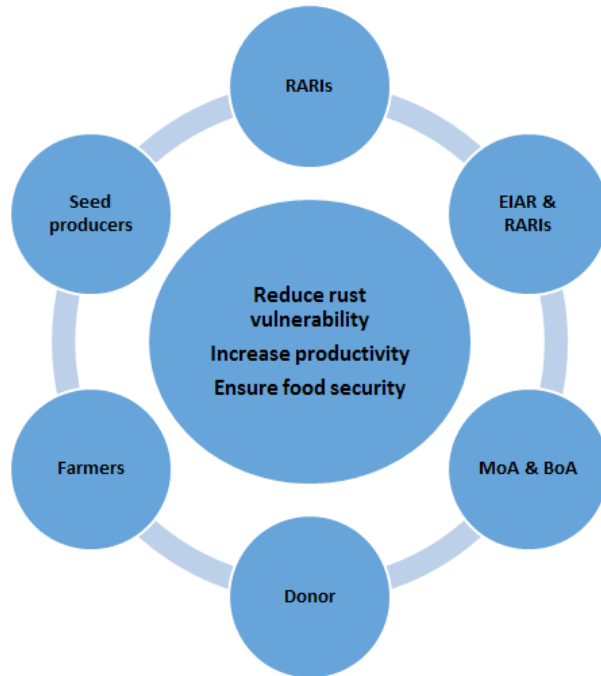


Figure 4. Partners and stakeholders in wheat seed deployment project in Ethiopia

A national technical committee is established to guide project planning and implementation, usually under the leadership of the NARS. Proper stakeholder involvement facilitates allowing test results to be shared and accepted and thereby easing the movement of varieties and seeds across national boundaries. For example, a promising rust-resistant wheat line was released as Misr1 in Egypt and as Moquwam in Afghanistan. This allowed Afghanistan to import 150 tons of Misr1 seed from Egypt to kick-start its own seed multiplication and distribution.



Ethiopia: Off-season irrigated seed multiplication at Werer Agricultural Research Center, Ethiopia

Project implementation is consultative, involving key stakeholders as work plans are prepared at the beginning of each season, activities are monitored during the season, and results are reviewed at the end of the season to inform planning for the next cycle. Stakeholder involvement helps overcome policy and regulatory constraints that would otherwise hinder fast-track variety release and accelerated seed multiplication (Box 4).

Box 4: Lessons from the front lines in the battle against wheat rust

The successful implementation of a project supported by USAID depends on the following conditions and activities:

- A mechanism for international collaborative variety testing was established under the Borlaug Global Rust Initiative, through which participating international agricultural research centers and NARS evaluate their materials for resistance to Ug99 and to its variants in Kenya and Ethiopia.
- Fast-track variety release was achieved through a crash program in which elite germplasm from international agricultural research centers were selected for accelerated release following a single year of adaptation testing at multiple locations by NARS, notably in Ethiopia.
- Newly released varieties and promising lines were popularized through demonstrations to create awareness among farmers and other stakeholders to facilitate their adoption and diffusion.
- Promising lines received accelerated pre-release seed multiplication to produce sufficient amounts of basic (foundation) seed before release. Pre-release seed multiplication occurred during the off-season, notably in Ethiopia, and, in Pakistan, involved the private sector under the Foundation Seed Cell Program.
- Partnerships engaging multiple stakeholders brought on board policy makers and regulatory agencies to facilitate flexible approaches to fast-tracking variety release and accelerated pre-release seed multiplication, to achieve a more timely response to rust threats.
- Availability of funds were sufficient to support national and international efforts to address the global threat of stem rust both in developing new resistant varieties and their rapid seed multiplication.
- A global network of variety testing and sharing data among advanced research institutes, IARCs and NARS accelerated the release and delivery of improved varieties to farmers in the region.
- Partnerships with private seed companies proved to be the quickest and most cost-effective strategy for multiplying and delivering seed of rust resistant in some countries.
- Senior leaders oversaw the planning and coordination of rapid seed multiplication in partnership with other stakeholders.

ICARDA implemented one regional project entitled 'Accelerated seed multiplication to counter the threat of stem rust in wheat' (Egypt, Ethiopia and Pakistan) completed in March 2012; and follow-up bilateral projects in Ethiopia (Rapid deployment of rust resistant varieties supported by USAID) completed in December 2014 and in Pakistan (Wheat Productivity Enhancement Program supported by USDA), the experiences which are highlighted below.

3.5.1 Accelerated seed multiplication to counter threat of stem rust in wheat

A geographically broader project jointly developed by ICARDA and CIMMYT and funded by USAID International Disaster and Famine Assistance it was implemented from 2008/09 to March 2012. It aimed at accelerating seed multiplication to counter the threat of the Ug99 stem rust disease of wheat in six African and Asian countries that lie on the path of potential threat from Ug99. ICARDA implemented the project in Egypt, Ethiopia and Pakistan, and CIMMYT in Afghanistan, Bangladesh and Nepal.

The project started with eight promising lines (three in each country) having Ug99 resistance and a maximum of 50-100 kg seed each for further testing and release by NARS in 2008/09 crop season. In Ethiopia the 'crash' program led to the immediate release of two varieties in 2009/10 from original five promising lines and followed with other six varieties with stem and/or yellow rust resistance from ICARDA and CIMMYT origin. The same holds true for Egypt which released one variety each in 2009 and 2010 from original three combining registration and performance trials together for the first time which used to be

conducted in subsequent years. In Pakistan, among the three promising lines, one with ug99 resistance was released along with other four varieties with confirmed resistance to local stem rust and other rusts. Several wheat varieties resistant to stem and/or yellow rust were released during the project and follow-up projects over the subsequent years (Table 16).

Table 16. Wheat stem rust and yellow resistant varieties released in target countries

Country	No of varieties released	Source	Release period	Agricultural Research center
Egypt	2	CIMMYT	2009-10	ARC
Ethiopia	8	ICARDA, CIMMYT	2010-12	EIAR-KARC & Werer
Pakistan	10	National cross, CIMMYT	2010-13	AAARI, BARI, CCRI, NARC, NIFA & RARI
Total	20			

Note: Most varieties in Pakistan were resistant to local strain stem rust and/or yellow and leaf rust; All varieties released went through pre-release seed multiplication

The project played a catalytic role in supporting early generation seed production and linking that to large-scale seed production by existing public seed enterprise and/or private seed companies. In Ethiopia, both main season and off-season (irrigation for the first time) and low seed rates were used for pre/post-release accelerated seed multiplication of promising lines/varieties in early generation seed multiplication. In Pakistan, NARS and the private sector undertook pre-release and pre-basic seed multiplication under the Foundation Seed Cell program. This enabled to bulk-up sufficient amount of basic (foundation in Egypt) to enter large-scale certified seed production and marketing by the existing public and private sector. The support by the project enabled for the new varieties to capture over 10% of wheat area envisaged at the end of the project (Table 17).

In Egypt, an estimated 19,840 tons of certified seed of new rust-resistant varieties was produced by public and private sector entities and distributed during the three years of the project. This amount of seed had the potential to plant close to 11% of Egypt's wheat area, generating a substantial increase in wheat grain production in that country. Rust-resistant popular varieties enjoyed a yield advantage in demonstration plots of 1.51 t/ha, or 21%, in case of Misr1 over nonresistant, and of 1.41 t/ha, or 19.8%, in case of Misr2 over nonresistant varieties, enabling them to significantly increase production throughout the country. Moreover, farmers planting new rust-resistant varieties achieved a benefit-cost ratio of 2.32 for Misr1 and 2.23 for Misr2.

In Ethiopia, the production of over 33,423 tons seed of two new rust resistant varieties by public sector enterprises will be enough to plant over 12% of its total wheat area during the project period. There was substantial increase on the amount of certified seed of rust resistant wheat varieties distributed during the project period increasing wheat production and productivity in the country.

In Pakistan, a total of 89,306 tons seed of five rust-resistant bread wheat varieties were multiplied by private and public sector entities in quantities sufficient to plant close to 10% of the wheat area. This substantial area covered by rust

resistant varieties improved wheat production and productivity, enhancing food security in target countries.

Table 17. Amount of certified seed of new rust resistant varieties produced in target countries 2010/11 to 2012/13 crop seasons

Country	New rust resistant varieties (year released)	Amount of seed distributed (tons)		
		2010/11	2011/12	2012/13
Egypt	Misr 1 (2009) and Misr 2 (2010)	566	7,947	10,760
	Total wheat certified seed distributed (17 varieties)	39,622	51,365	53,376
	% certified seed of new varieties	1.4	16	20
Ethiopia	Danda'a and Kakaba (2010)	758	5,622	27,043
	Total wheat certified seed distributed (33-41 varieties)	36,785	38,736	71,078
	% certified of new varieties	2.1	15	38
Pakistan*	AARI11, Millat 11, Punjab 11, NARC11 and Dharabi11 (2011)	2,287	42,750	44,269
	Total wheat certified seed distributed (16-20 varieties)	311,805	251,908	171,915
	% certified of new varieties	0.73	17	26

Note: *In Pakistan, only NARC2011 is Ug99 resistance and NARS focus on local stem rust, yellow and leaf rust resistance; number of varieties of certified seed varies from year to year

Pakistan initiated VBSEs (described in section 3.2 above) in rainfed areas where the formal seed system has limited penetration and farmers may not have direct access to the seed of newly released rust-resistant varieties because neither the public sector nor the private sector interested in seed production of these varieties in rainfed areas. As a result farmer-based seed multiplication were initiated with three NARS partners in rainfed areas of Punjab and Khyber Pakhtoonkewa provinces. Preliminary analysis of on-farm seed production and marketing showed on average a net profit of US\$348 per ha which shows better profitability in seed business than grain production.

Under the project ICARDA initiated a case study on variety release mechanism in Egypt, Ethiopia and Pakistan (see section 3.1.2). The main purpose is to analyze the issues that arise in variety release and to make recommendations for 'good practice' that may be useful to those who manage the variety release system.

Moreover, case studies on wheat seed marketing were also initiated and final reports are prepared in Ethiopia and Pakistan (Section 3.1.3 and 3.1.4).

3.5.2 Rapid deployment of yellow rust resistant varieties in Ethiopia

In 2010, the yellow rust epidemic's created havoc to wheat producers where close to 600,000 ha was affected and up to 80% of wheat production was lost in some seriously infected areas of Ethiopia. A joint project launched in Ethiopia by the Ethiopian Institute of Agricultural Research and ICARDA (2011-December 2014), built on the experiences of USAID Famine Fund, to rapidly

deploy high-yielding and rust-resistant wheat varieties. The USAID seed project broadened its scope of operation to include both stem and yellow rust resistant varieties and focused on four thematic areas which include strengthening the national wheat breeding program's capacity to develop rust-resistant varieties and fast-track their testing and release; popularization and demonstration of rust resistant varieties and associated technologies; accelerated seed multiplication (pre-release, post-release and certified seed production) during the main and off-seasons by existing public and private sector; on-farm seed production and marketing directly working with farmers in target districts of Agricultural Growth Program; and strengthening the infrastructure and human resources capacity of stakeholders.

The project has established a functional platform of broad range of partners and stakeholders which include federal (EIAR) and regional (AARI, OARI, TARI) agricultural research institutes; federal (ESE) and regional (ASE, OSE, SSE) public seed enterprises and private seed companies; public and private state farms involved in seed production; federal (MoA) and regional extension and input directorates; farmer seed associations and Farmer's Cooperatives Union; and farmers/seed users.

Supporting research and fast-tracking release: The project provided substantial support to the National Wheat Research Program, at Kulumsa ARC in fast-track testing and releasing of new rust-resistant varieties. The main activities include introduction and evaluating international nurseries, crossing and evaluating segregating population from national breeding program and conducting variety yield trials and verification trials of candidate varieties for release. In 2014, four candidate varieties were presented by Kulumsa ARC, among which ETBW5879 (for high rainfall areas) and ETBW6095 (for dry areas) were released by the National Variety Release Committee. The seed of these two new varieties was multiplied during the off-season and the main season and become available to public/private seed producers for large-scale multiplication by 2015/16 crop season.

Early generation seed production: The project linked NARS with commercial seed producers and supported the accelerated seed multiplication of recently released and existing rust resistant varieties during the main and off-season and 7,013 tons basic seed produced and provided to public seed enterprises and private sector (private seed companies, cooperatives and farmer seed producer associations) from 2011/12 to 2014/15 crop season to produce certified seed for distribution to farmers. Eight farmer seed associations, one federal and three regional public seed enterprises and public and private seed producing farms and new emerging private sector were provided with seed.

Large-scale certified seed production: Availability and access to basic seed regularly is enabled large-scale certified seed production. A significant achievement has been made where certified seed of rust resistant wheat varieties were produced and distributed through partnerships of the public and private sector. For example, about 31,074 tons (73% new varieties) and 66,775 tons (86% new varieties) certified seed of rust resistant wheat varieties were distributed in 2013/14 and 2014/15, respectively. This is sufficient to plant an estimated bread wheat area of 207,160 ha and 445,166 ha during the two seasons. This enabled quick and rapid deployment of new rust resistant varieties on farmers' fields.

On-farm seed production: Apart from direct support to formal sector operations of NARS and partnership with public seed enterprises, the project aimed to bring seed directly to 45 target Agricultural Growth Program districts working with farmers and district agricultural office. A select group of 100 farmers were identified in each district, clustered in adjoining fields, provided with seed of rust resistant varieties sufficient to plant 0.25 ha. Farmers, and development and extension agents were trained on technical aspects of seed production and linked to regional seed inspection services to ensure seed quality. Farmers returned the seed as a revolving fund, kept some for own use and sold excess seed to other farmers through informal channels or formally through cooperatives and public seed enterprises. The revolving seed fund was used to reach more farmers through similar approach by the Bureau of Agriculture (BoA).

During the last four seasons the project directly distributed 919 tons seed through on-farm seed production and technology scaling-out which was planted on 7,164 ha producing 24,785 tons seed/grain potentially sufficient to plant 165,233 ha. The project directly reached 21722 farmers (out of which 7.3% women) benefiting 130,332 household members in four major wheat production regions (Figure 5). In some target districts about 80% of wheat area is planted with yellow rust resistant varieties. The multiplier effect will be considerably higher as part of the produce was used as seed for planting purpose in subsequent years. This would lead to substantial area coverage with Ug99 and yellow rust resistant varieties.



Ethiopia: A woman farmer multiplying seed of rust resistant variety, Wonberima district, Amhara Region

Average yields over two seasons were 3.5 tons with range from the lowest of 2.5 tons to the highest of 4.9 tons on farmer's fields. The average estimated net income from rust resistant varieties varies from US\$50 to US\$200 depending on area planted by wheat. Given that the total land area covered with new stripe rust-resistant wheat varieties is around 400,000 ha, net returns from these improved varieties will be in the range of US\$20 million-80 million.

Durum wheat value chain: In Ethiopia, bread wheat production dominated the landscape, but it is highly vulnerable to periodic epidemics of rust diseases. Durum wheat appeared to be less vulnerable to stem rust and yellow rust. The project aimed at reviving durum wheat production to tackle the rust problems and diversify wheat production and at the same time create the producer-market linkage with the agro-industry. A workshop was organized and attended by 80 participants drawn from relevant wheat value chain actors including representatives of flour, pasta and macaroni factories.

Eight pilot districts were identified to initiate both seed and grain production of two durum wheat varieties. Member farmers of primary cooperatives (208 farmers of which 18 were female) were identified, organized and trained as durum wheat seed producers or grain producers. The seed was produced, collected and marketed collectively or through farmer cooperative unions to their members for grain production in 2015/16 crop season. Furthermore certified seed was distributed to grain producers (712 farmers of which 65 were female farmers) for durum wheat grain production. An estimated 1592.2 tons of durum wheat grain was produced in 2014/15 crop season. The farmers produced durum grain as per the requirements of the industry and aggregated

(minimum of 40 tons), tested for quality (protein, gluten content, moisture content and hectoliter weight) to determine the price based on the quality and sold through unions to the different factories based on contractual agreement. It is envisaged to expand the activities in the coming years including more farmers cooperatives and unions across the country.

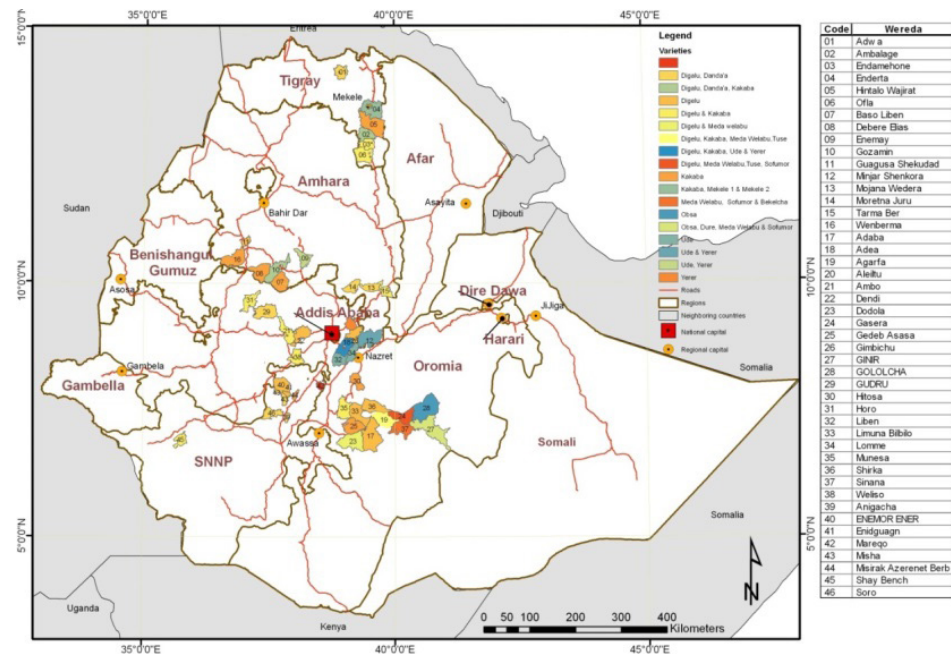


Figure 5. Target districts for on-farm seed multiplication and dissemination of rust resistant wheat varieties

Variety popularization: The project also supported EIAR's pre-extension demonstration and pre-scaling out of technology as well as emergency seed distribution in yellow rust and stem rust affected areas in 2011 and 2014, respectively. In pre-scaling activities 115 tons of seed was distributed and 795 ha was planted producing 2626 tons of seed/grain sufficient to plant 17,506 ha (Table 19). A total of 3,110 farmers (8.2% women) had direct access to seed of rust resistant wheat varieties benefitting 18,660 household members. Likewise, for emergency relief a total of 120 tons were distributed and 813 ha was planted producing 2317 tons of seed/grain sufficient to plant 15,525 ha (Table 19). About 3799 farmers have direct access to seed benefitting 22794 household members.



Ethiopia: Variety popularization cum demonstration using seed production fields, Wonberima

Field days organized at district level using FTCs, demonstration plots and seed multiplication fields to create awareness and demand for seed of new rust resistant varieties. In these events farmers from participating and neighboring districts, development agents, extension workers, researchers and regional, zonal and district level administrators and policy makers participated. At least four field days were directly supported each year where 3,895 participants attended of which nearly 10.1% were female participants. Moreover, the district administration organized field days in all target districts using their own resources. In 2014/15, the activity is extended to 51 districts reaching more farmers in irrigated lowland areas.

Table 19. On-farm seed production with farmer groups

Items	On-farm seed production	Pre-scaling	Emergency seed	Value chain	Total
Seed distributed (t)	919	115	120	72	1,226
Area planted (ha)	7,164	795	813	577	9,349
Estimated production (t)	24,785	2,626	2,317	2,139	31,867
Total Farmers reached	21,722	3,110	3,799	920	29,551
% female farmers	7	8	2	9	7
Beneficiary HHs	130,332	18,660	22,794	5,520	177,306

Strengthening capacity of partners and stakeholders: To strengthen capacity of stakeholders, farm machinery (tractors and implements such as planters, ridgers, levelers, etc. and spare parts) and field vehicles were provided to NARS and three mobile seed cleaners to farmer seed associations engaged in local seed business. Moreover, regional and in-country courses on wheat rusts, wheat production and seed technology were organized and attended by technical staff from agricultural research, extension services and development agencies and farmers. From 430 staff who attended the courses 10% were female participants.

Project impact on adoption and food security: The contribution of the collaborative project was assessed in term of (1) enhancing the adoption of rust resistance bread wheat varieties, (2) the impact on the productivity and food security of adopting rust resistant wheat varieties among smallholder farmers, and (3) the impact on institutional innovations to respond to rust epidemics. Data were collected from a household survey using structured questionnaire, discussions with various stakeholders and review of project documents.

The project has made considerable contribution to increased adoption especially for the two rust resistant varieties (Kakaba and Digelu). The results show that use of improved wheat varieties across the study locations are generally high including those of recently released rust resistant varieties. The econometric results revealed that households with better resource endowment (owned oxen) and that have better access to agricultural extension information and institutional credit are more likely to adopt improved rust resistant varieties. The propensity score matching (PSM) results indicated that households adopting rust resistant varieties obtain 351 to 455 kg/ha more wheat yields than non-adopters. The results therefore unequivocally suggest that adoption of rust resistant varieties has a significant and positive effect on wheat productivity and welfare of farm households. From the institutional point of view the project innovations in terms of establishing systems of fast-track testing and release of rust resistant wheat varieties, accelerated seed multiplication, alignment of the wheat seed system actors, and rust epidemic early warning system are key factors for sustained impact.

3.5.3 Wheat productivity enhancement program in Pakistan

In Pakistan, the wheat seed system appears diversified with involvement of both the public and private sector in the Punjab except other provinces and dryland areas. However, availability of early generation seed remains a constraint in commercialization of new varieties. Within the project framework which focuses on Ug99, greater effort was made in accelerated seed multiplication of early generation seed (pre- and post-release) and linked to large-scale certified seed production by public and private sector.

The following were achieved during the two years of implementation (2011/12-12/13):

- 436 MT seed of promising lines were produced under pre-release seed multiplication (44 MT of exclusively 20 Ug99 resistant promisingly lines); one variety was released in 2013 and seed become available both to public and private sector
- 2170 MT seed of early generation produced by NARS, public and private sector for further multiplication and distribution (104.4 MT exclusively Ug99 resistant varieties)
- 494 MT seed produced from popularization and demonstration of new rust resistant (164.8 MT exclusively Ug99 resistant varieties).
- From yield data, the estimated net return of US\$227/ha could be achieved if seed of new varieties is sold as seed instead of grain.

In dryland areas most of the varieties released were not multiplied by the formal sector due to weaker demand and expected low yields. Neither the public nor the private sector was interested in producing and marketing the seed in the dryland areas. The project initiated on-farm seed production with farmers through a support provided by NARS partners. About 284 MT seed of new and existing commercial varieties was produced with farmers in dryland areas of Punjab, Baluchistan and Khyber Pakhtunkhwa. The preliminary result showed that average net returns from seed sales was US\$337/ha in Barani areas of Punjab.

After 2012/13, under the ICARDA-CIMMYT agreement, efforts are underway to multiply and promote Ug99 resistant bread wheat varieties i.e. NARC 2011 and Pak 2013. For example, in 2014/15 crop season, the seed was distributed to various federal and provincial agricultural research institutes (11 institutes sufficient to plant 12.55 ha), public and private sector companies (40 companies on 31.97 ha) and farmers (102 farmers on 41.28 ha) to expand the seed production and distribution Ug99 resistant wheat varieties.

3.5.4 Support to wheat seed sector in Iraq

Within the Harmonized Support for Agricultural Development (HSAD), increasing the availability and improving the quality of wheat seed was one of the major technical interventions. The project, funded by USAID, aimed at fast replacement of existing commercial varieties with new high yielding varieties through accelerated seed multiplication and dissemination working with NARS,

Seed Companies and farmers. Rapid seed multiplication of elite promising lines (pre-release) and breeder, foundation, registered and certified seed was undertaken by the project where technical support was provided to NARS, public seed companies, farmers and the seed certification agency to ensure quality seed production. During the project, a total of 17,400 tons of seed of different classes was produced increasing the availability of quality seed in Iraq (Table 20).

In Iraq Kurdistan, 40 tons of certified seed of wheat variety Adana 99 was imported from Turkey upon the request of MoAWR (Ministry of Agriculture, and Water Resources) to initiate certified seed production and ensure the availability of high quality seed to the farmers. About 300 ha was planted with 40 farmers and an estimated production of 1000 tons of seed for further distribution next season. This approach would enable fast track introduction and rapid multiplication of new varieties from neighboring countries of similar agro-ecological conditions. The approach found important to kick start large-scale seed multiplication by introducing well adapted varieties from neighboring countries if harmonized systems of regulatory framework are operational at a regional level.

Table 20: Amount of wheat seed produced during HSAD project in 2012/13-2013/14 crop seasons

Class of seed	Seed produced (tons)		Total production (tons)
	2012/13	2013/14	
Pre-release multiplication	1.5	3.97	5.5
Breeder seed	224	330	554
Foundation	1,976	2,985	4,961
Registered	3,381	7,042	10,423
Certified	323	1,136	1,459
Total	5,905	11,497	17,402

Under HSAD project an assessment for seed processing facilities for public seed producers, farm machinery for NARS and seed testing laboratory for seed certification agency were conducted. Following the assessment of seed plants, research stations, and seed laboratories recommendations were made for upgrading these facilities where the list of machinery (plot planters, seed cleaners, etc.) and laboratory equipment (five sets for seed testing stations) have been identified, purchased and provided to stakeholders; and training courses were conducted in operating and managing these facilities.

HSAD also conducted several in-country training courses to upgrade the knowledge and skill of national staff in plant breeding, seed production, seed processing and seed quality control. A total of 11 courses were conducted and 332 staff was trained including women (16%) participants from Ministry of Agriculture and MoAWR (IKR). Moreover, manuals for seed production and seed processing were prepared to strengthen the human resources of the seed sector.



Technical support for quality seed production for wheat (left) and assessment of seed processing facilities (right) in Iraq

The project also provided technical support in formulating seed regulation to implement national seed policy and Seed Act. A broad outline and the formulation of seed regulations was finalized to support the implementation of the National Seed Policy and the Seed Law (Law number 50 of 2012).

The development of rust-resistant wheat varieties cannot be a one-off or short-term effort. International and national breeding programs must produce a range of rust-resistant wheat varieties over time, as any single mode of resistance is expected to be short-lived. Durable resistance depends on maintaining diversity in the resistant varieties deployed.

3.6 Fostering regional cooperation to promote seed trade

3.6.1 Regional seed network

ICARDA initiated the West Asia and North Africa Regional Seed Network, a consultative forum that brings together national seed programs, to promote regional cooperation and information exchange, and ultimately integrates national seed systems to facilitate regional seed trade. To leverage others' expertise and experience, the network was linked to international seed sector development partners such as the Food and Agriculture Organization of the United Nations, Organization for Economic Co-operation and Development, International Seed Testing Association, International Union for the Protection of New Varieties of Plants, and others. The network has made significant achievements in collecting, assembling and disseminating information on the status of the seed sector in member countries. Several catalogs and directories are among the documents prepared and shared over the network's website. The regional newsletter *Seed Info* and its supplement, *Focus on Seed Programs*, were launched to inform the regional and global audience on seed-related news from the region and beyond.

3.6.2 Harmonization of seed sector in ECO region

ICARDA, the Economic Cooperation Organization (ECO) and the Food and Agriculture Organization of the United Nations put into action a regional Technical

Cooperation Program project: Strengthening the seed supply in the ECO region with special emphasis on Central Asia. The project involved 10 ECO member countries: Afghanistan, Azerbaijan, Iran, Kazakhstan, the Kyrgyz Republic, Pakistan, Tajikistan, Turkey, Turkmenistan and Uzbekistan. As part of this work, a number of country reports were prepared to provide background and chart steps toward a harmonized approach to developing the seed sector across the region.

This cooperation has laid the foundation for harmonizing variety release mechanisms, plant variety protection, seed certification schemes and phyto-sanitary measures, which received ministerial endorsement from partner countries. Further effort is underway by FAO to complete the initiative by establishing a regional mechanism within the ECO. This will enable better movement of varieties and seeds across borders and create a regional seed market.

3.6.3 Establishing ECO seed association

History was made on July 2008 in Istanbul, with the formation and official endorsement of the new regional seed association by senior representatives of 10 Economic Cooperation Organization member countries (ECO), ICARDA and the FAO. The ECO Seed Association (ECOSA) held its founding congress and organized the first ECOSA International Seed Trade Conference 2-4 December 2009 in Antalya, Turkey. Since then, ECOSA has served as a forum for fostering regional seed trade and partnership within the region and beyond, organizing annual conferences in which ICARDA and FAO are members and partners of the regional seed association. This is a significant achievement in fostering regional integrating and promoting seed trade.



ECOSA 2009: The first international seed trade conference organized in Antalya, Turkey

3.7 Human resource development for the seed sector

Seed technology is a relatively new discipline and has emerged as an integrated subject on its right during the last three decades or so. In contrast to other disciplines in agricultural sciences there are very limited number of institutes which are active in training the manpower requirement in seed science and technology and offer diverse courses for various levels of studies. As a result most seed specialists are experienced in the art not trained in the field, a discipline which blends science, business and management. Strengthening the human resources is one of key objectives of Seed Unit since its establishment.

A broad range of courses were designed for capacity development from creating awareness for policy makers to capacity development for technical staff which include: (i) train-the-train courses for technical managers and technical staff on various topics of seed science and technology; and (ii) workshops and seminars on topical policy and regulatory issues for policy makers and senior managers. The short courses range from general seed technology to specialized topics, from introductory (to increase basic skills) to advanced level, and the duration from 2 weeks to 4 months. Moreover, workshops and seminars were organized for high-level officials and leaders of the seed programs to increase awareness of seed industry development and identify constraints at national and regional level.

The international or regional conferences, to mention a few, include privatization of the seed sector, plant variety protection, alternative strategies for small holder seed supply, finance and management of small-scale seed enterprises, community seed production, etc. ICARDA also participated and contributed to expert consultations to development of frameworks to Quality Declared Seed, seed security, national seed policy and community seed production organized and coordinated by the FAO.

The Seed Unit also supports and supervises post-graduate studies in regional universities focusing on practical problems of seed technology. This high-level academic study will make it possible to train staff for the leadership of national seed programs. ICARDA carried out an extensive capacity development program in the region and developed several reference books and manuals for those involved in the seed sector, and as such recognized as one of the centers of excellence in the field.

Box 5. Selected technical publications on seed science and technology at ICARDA

Books

Thijssen MH., Bishaw Z, Beshir A, de Boef WS (eds.) 2008). Farmers, seeds and varieties: supporting informal seed supply in Ethiopia, Wageningen International, Wageningen, the Netherlands. 348 pp

Kugbei S. 2000. Seed Economics-Commercial Considerations for Enterprise Management in Developing Countries. ICARDA, Aleppo, Syria. viii + 182 pp. ISBN 92-9127-102-0

Proceedings

Kugbei S, Turner M, Witthout P (eds.). 2000. Finance and Management of Small-scale Seed Enterprises. Proceedings of a Workshop on Finance and Management of Small-scale Seed Enterprises, 26-30 October 1998, Addis Ababa, Ethiopia. ICARDA, Aleppo, Syria. iv + 191 pp. ISBN 92-9127-106-3

Grass, L. and M. Turner (eds.). 1998. Forage Seed Production in Africa and West Asia. Proceedings of the Forage Seed Production Workshop, 27-31 October 1997, Addis Ababa, Ethiopia. ICARDA, Aleppo, Syria. vii + 203 pp. ISBN: 92-9217-079-2

Rohrbach DD., Bishaw Z, van Gastel AJG (eds.). 1997. Alternative Strategies for Smallholder Seed Supply. Proceedings of an International Conference on Options for Strengthening National and Regional Seed Systems in Africa and West Asia, 10-14 March 1997, Harare, Zimbabwe. ICRISAT, Andra Pradesh, India. 288 pp. ISBN: 92-9066-380-4

van Gastel AJG, Manners GR, Wadsack J (eds.). 1997. Privatization of the Seed Industry in West Asia and North Africa Region. Proceedings of the Privatization of the Seed Industry in West Asia and North Africa Workshop, 16-20 November 1995, Tunis, Tunisia. GTZ, Eschborn, Germany. vii + 133 pp.

Manuals

Niane AA, Bishaw Z, Kugbei S, Aria AZ, Wahed A, Sherzad F, Ahmad G, Zadda ZA. 2011. National Catalogue of Wheat Varieties in Afghanistan. Rome, Italy: FAO; and Aleppo, Syria: ICARDA vi+ 82 pp.

Bishaw Z, van Gastel AJG. 2007. Seed Production of Cool Season Food Legumes: Faba bean, Chickpea and Lentil. ICARDA, Aleppo, Syria. vi+ 84 pp

Bishaw Z, Niane AA, van Gastel AJG. 2006. Technical Guidelines for Quality Seed Production. ICARDA, Aleppo, Syria. 23 pp

van Gastel AJG, Pagnotta MA, Porceddu E (eds.). 1996. Seed Science and Technology. Proceedings of the 'Train-the-Trainer' course Sponsored by Med-campus Program (EEC), 24 April to 9 May 1993, Amman, Jordan. ICARDA, Aleppo, Syria. vii + 311 pp.



A regional course on variety maintenance and quality seed production (left); Training manuals developed by ICARDA (middle); and Regional seed policy workshop for ECO member countries (right)

Appendix

Reading list and additional resources

- Africa Rice/FAO. 2011. Atelier Régional sur la Politique Semencière en Afrique de L'ouest Rapport General. Cotonou, Benin (unpublished)
- Almekinders CJM, Louwaars NP. 2002. The Importance of the Farmers' Seed Systems in a Functional National Seed Sector, *Journal of New Seeds*, 4:1-2, 15-33
- Bishaw Z, van Gastel, AJG. 2009. Variety release and policy options. In: Plant Breeding and Farmer Participation, (Ceccarelli, S., Guimaraes EP, Weltzien E (eds.)). FAO, Rome, Italy. 671 pp
- Bishaw Z, van Gastel AJG.. 2008. ICARDA's approach in seed delivery for less favorable areas through village-based seed enterprises: conceptual and organizational issues. *Journal of New Seeds* 9 (1) 68-88
- Bishaw Z, Turner M. 2008. Linking participatory plant breeding to the seed supply system. *Euphytica* 163: 31-44
- Bishaw Z. 2004. Wheat and Barley Seed Systems in Ethiopia and Syria. PhD Thesis, Wageningen University, Wageningen, The Netherlands (with English and Dutch summaries). 383 pp
- Bishaw Z, Turner M. 1998. A Regional Perspective on Seed Security. In: Proceedings of International Workshop on Seed Security for Food Security, Contributions for the Development of Seed Security Strategies in Disaster -prone Regions. pp 23-41, Florence, Italy, 30 November - 1 December 1997. FAO, Rome Italy
- Brennan, J.P. and D. Byerlee. 1991. The rate of crop varietal replacement on farms: measures and empirical results of wheat. *Plant Varieties and Seeds* 4: 99-106
- FAO. 2013. Draft guide for national seed policy formulation (www.fao.org/docrep/meeting/027/mg191e.pdf)
- FAO. 2011. Report of the Expert Consultation Workshop on Seed Policy Formulation, Milan, Italy
- FAO. 2006. Plant Production and Protection Paper, No.185. ISSN 0259-2517
- ICARDA/FAO. 2011. Report on Workshop on Seed Policy in the ECO Region. ICARDA, Aleppo, Syria (unpublished)
- ICARDA. 1997. Seed Security Assessment in the Drought-prone Areas of the West Asia and North Africa (WANA). Consultancy Mission Report. ICARDA, Aleppo, Syria. vii + 58 pp
- ICARDA. 1995. Regional Cooperation in Seed Security in the West Asia North Africa Region. Consultancy Mission Report. ICARDA, Aleppo, Syria. 19 pp
- Heisey, P.W. and J.P. Brennan. 1991. An analytical model of farmers' demand for replacement seed. *American Journal of Agricultural Economics*. 73: 1044-1052
- Joshi, AK, Azab, M, Mosaad, M, Moselhy, M, Osmanzai, M, Gelalcha, S, Girma, B., Bhatta, , Hakim, A. Malaker, PK, Haque, ME, Tiwari, , Majid, A., Kamali, , Bishaw, Z. Singh, RP, Payne, T., Braun, HJ . 2011. Delivering rust resistant wheat to farmers: A step towards increased food security. *Euphytica* 179:187-196
- Kugbei S. 2007. Small- scale seed enterprise start-up and management. Ministry of Agriculture, Irrigation and Livestock & Food and Agriculture Organization of the United Nations, Kabul, Afghanistan (<ftp://ftp.fao.org/docrep/fao/010/a1516e/a1516e01.pdf>)

- Kugbei S. 2000. Seed Economics-Commercial Considerations for Enterprise Management in Developing Countries. ICARDA, Aleppo, Syria. viii + 182 pp. ISBN 92-9127-102-0
- Kugbei S, Turner M, Witthaut P (eds). 2000. Finance and Management of Small-scale Seed Enterprises. Proceedings of a Workshop on Finance and Management of Small-scale Seed Enterprises, 26-30 October 1998, Addis Ababa, Ethiopia. ICARDA, Aleppo, Syria. iv + 191 pp.
- Kugbei S, Bishaw Z. 2002. Policy measures for stimulating indigenous seed enterprises. *Journal of New Seeds*. 4(1/2) 47-63
- Louwaars N, de Boef WS. 2012. Integrated seed sector development in Africa: a conceptual framework for creating coherence between practices, programs and policies. *Journal of Crop Improvement*, 26:39–59,
- Minot N, Smale M, Eicher C, Jayne T, Kling J, Horna D, and Myers R. 2007. Seed development programs in sub-Saharan Africa: A review of experiences. Rockefeller Foundation, Nairobi, Kenya
- MAIL (Ministry of Agriculture, Irrigation and Livestock). 2012. National Seed Policy. Kabul, Afghanistan
- MAIL (Ministry of Agriculture, Irrigation and Livestock). 2009. Seed Law. Kabul, Afghanistan
- Morris M, Singh RP, and Pal S, 1998. India's maize seed industry in transition: changing roles for the public and private sectors. *Food Policy*: 23(1): 55–71, 1998
- Neate PJH, and Guei RG. 2010. Promoting the Growth and Development of Smallholder Seed Enterprises for Food Security Crops. FAO, Rome Italy
- Niane AA, Bishaw Z, Kugbei S, Aria AZ, Wahed A, Sherzad F, Ahmad G, Zadda, ZA. 2011. National Catalogue of Wheat Varieties in Afghanistan. Rome, Italy: FAO and Aleppo, Syria: ICARDA vi+ 82 pp
- Osborn T, Bishaw Z. 2009. Principles for rapid variety release, seed multiplication and distribution in developing countries to counter the threat of wheat rust. In: McIntosh R (ed.). Proceedings of oral papers and posters in the 2009 Technical Workshop, Borlaug Global Rust Initiative, held at Cd. Obregon, Sonora, Mexico, on 17-20 March 2009
- Pray C, Ramaswami B. 1991. A Framework for Seed Policy Analysis in Developing Countries. IFPRI. 1776 Massachusetts Avenue, N.W. Washington, D.C. 20036 U.S.A
- Rohrbach DD, Bishaw Z, van Gastel, AJG (eds.). 1997. Alternative Strategies for Smallholder Seed Supply. Proceedings of an International Conference on Options for Strengthening National and Regional Seed Systems in Africa and West Asia, 10-14 March 1997, Harare, Zimbabwe. ICRISAT, Andhra Pradesh, India. 288 pp. ISBN: 92-9066-380-4
- Sall S, Norman D, Featherstone AM. 2000. Qualitative assessment of improved rice variety adoption: Farmers' perspective. *Agricultural Systems* 66:129 - 144.
- Srinivas T., Bishaw Z, Rizvi, J., Niane AA, Manan ARR, Amegbeto K. 2010. ICARDA's Approach in Seed Delivery: Technical Performance and Sustainability of Village-Based Seed Enterprises in Afghanistan. *Journal of New Seeds*: 11 (2): 138-163
- Strasberg PJ, Jayne TS, Yamano T, Nyoro J, Karanja D, Strauss J. 1999. Effects of agricultural commercialization on food crop input use and productivity in Kenya. MSU International Department of Agricultural Economics Development Department of Economics Working Paper No. 71
- Thijssen MH, Bishaw Z, Beshir A, de Boef WS (eds.). 2008. Farmers, seeds and variet-

ies: supporting informal seed supply in Ethiopia, Wageningen International, Wageningen, the Netherlands. 348 pp

Tripp R. 2001. Seed provision and agricultural development: the institutions of rural change. ODI, London, UK. 174 pp

Tripp R. 2000. Strategies for seed system development in Sub-Saharan Africa: a study of Kenya, Malawi, Zambia and Zimbabwe. Working Paper Series No. 2., Socioeconomic and Policy Program, ICRISAT, Bulawayo, Zimbabwe. 56 pp

Tripp R (ed.). 1997. New Seed and Old Laws. Regulatory Reform and Diversification of National Seed Systems. ODI, London, UK. 259 pp

Tripp R. 1995. Seed regulatory frameworks and resource poor farmers: a literature review. Agricultural Administration (Research and Extension) Network Paper No. 51. ODI, London, UK. 53 pp

Turner M, Kugbei S, Bishaw Z. 2000. Privatization of the Seed Sector in the Near East and North Africa. pp 125-136. In Seed Policy and Programs in the Near East and North Africa. Proceedings of the Regional Technical Meeting on Policy and Programs in the Near East and North Africa. Larnaca, Cyprus, 27 June – 2 July 1999. FAO, Rome, Italy.

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van Gastel, AJG, Manners GR, Wadsack J (eds.). 1997. Privatization of the Seed Industry in West Asia and North Africa Region. Proceedings of the Privatization of the Seed Industry in West Asia and North Africa Workshop, 16-20 November 1995, Tunis, Tunisia. GTZ, Eschborn, Germany. vii + 133 pp.

Varma S, Winslow M. 2005. Healing wounds: how the international centers of the CGIAR help rebuild agriculture in countries affected by conflicts and natural disasters. Consultative Group on International Agricultural Research, Washington, DC

Von Braun J, Bouis H, Kennedy E. 1994. Conceptual framework. In Von Braun J and Kennedy E. (eds). 1994. Agricultural commercialization, Economic Development and Nutrition. International Food Policy research Institute. 441 pp.

Components and sub-components of seed policy

Source: Adapted from FAO, 2011. Report of the Expert Consultation Workshop on Seed Policy Formulation, Milan, Italy.

Variety development	<ul style="list-style-type: none"> - Plant breeding - Multi-location trials - Conservation of plant genetic resources - Identification of priority crops
Seed production	<ul style="list-style-type: none"> - Early generation seed production - Certified seed production - Farmer based seed production
Agricultural extension	<ul style="list-style-type: none"> - Variety awareness - Sustainable crop production - Linkage to seed consumer markets - Research-extension-farmer linkages
Seed marketing	<ul style="list-style-type: none"> - Input trade and seed distribution networks - Seed distribution subsidy - Subsidized seed prices
Seed enterprise development	<ul style="list-style-type: none"> - Business environment and regulations - Investment incentives (tax credit, duty free exemptions, promotions) - Private sector development
Value chain	<ul style="list-style-type: none"> - Agro-industry (driving seed demand) - Crop production - food industry collaboration
Seed security	<ul style="list-style-type: none"> - Seed buffer stocks - Use of seeds in emergencies - Early warning systems - Disaster risk management
Seed regulatory framework	<ul style="list-style-type: none"> - Seed laws and regulations - Government and institutional arrangements for implementation - Intellectual property rights - Phytosanitary regulations (IPPC) - Bio-safety protocol - Harmonization, business regulations, international standards

About ICARDA and the CGIAR



Established in 1977, ICARDA is one of the 15 centers supported by the CGIAR. ICARDA's mission is to improve the livelihoods of the resource-poor in dry areas through research and partnerships dedicated to achieving sustainable increases in agricultural productivity and income, while ensuring efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small ruminant production. In Central Asia, West Asia, South Asia, and North Africa regions, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.



CGIAR is a global agriculture research partnership dedicated to reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring more sustainable management of natural resources. It is carried out by the 15 centers who are members of the CGIAR Consortium in close collaboration with hundreds of partner organizations and the private sector. www.cgiar.org