Original Study Article……….

International Journal of Agricultural Invention

(online available at www.agriinventionjournal.com)

***International Journal of Agricultural Invention* 9(1): 244-253: June, 2024**

ISSN: 2456 – 1797 (P)

Study on the seed technologies policy

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ARTICLE INFO

Original Study Article
Received on April 26, 2024
Revised on April 30, 2024
Accepted on May 29, 2024
Published on June 01, 2024

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PUBLICATION INFO
International Journal of Agricultural Invention (IJAI)
RNI: UPENG/2016/70091
ISSN: 2456-1797 (P)
Vol.: 9, **Issue:** 1, **Pages:** 244-253
Journal Homepage URL
http://agriinventionjournal.com/
DOI: 10.46492/IJAI/2024.9.1.30

ABSTRACT

Seed performs various functions in agriculture and as such plays a strategic role in a range of debates, in particular those concerned with rural development and food security, biodiversity, business development, knowledge and technology, and culture. The term ‘seed’ has several meanings, but it is used here only in the biological sense and restricted to crop plants and is used here to include any type of planting material that is intended for use in producing a new plant, i.e. either generative or vegetative, such as roots, tubers, bulbs, cuttings, rhizomes and apomictic seed. The use of the word ‘intended’ implies that human intervention in handling seed is explicitly considered. Only when biodiversity issues are being considered also are other types of seeds are included, i.e. seeds of wild relatives of crop plants. There is a need to bridge the different sciences, not so much as part of a search for a holistic view or ‘cosmovision’ on seeds and their contribution to human wellbeing, but rather to contribute to building a good foundation for policy making that can steer the flow and use of seed. Such policy making is influenced by various international agreements that do not necessarily focus primarily on seed systems themselves. Often, they are concerned with other issues like biodiversity, trade and culture, and these may have a marked impact on seed systems when implemented through national law. Seed is an important vehicle for improving agricultural output, and major development goals such as food security, sustainable rural development and poverty reduction as well as the effective management of agro-biodiversity can only be achieved if the right types of seed are used. The sustainable availability of good quality seed for farmers is thus an important development issue. Conventional approaches to seed system development are based on a linear approach in which policies should be directed at developing seed systems by guiding them through a number of fixed stages from traditional to commercial. Seed policies in developing countries have long concentrated on this approach which aims at transforming farmers’ seed systems into commercial, formal seed systems. This research stems from a concern that such influences may affect access to good seed by farmers and smallholders in particular.

KEYWORDS

Rural Development, Food Security, Biodiversity, Business Development, Knowledge Technology, Culture

HOW TO CITE THIS ARTICLE

Gayar, A. El. (2024) Study on the seed technologies policy, *International Journal of Agricultural Invention,* 9(1): 244-253. DOI: 10.46492/IJAI/2024.9.1.30

The Roles of Seed

Seed for Food and Agriculture

Seed is a crucial input in any form of crop production and one of the most precious resources in farming. The genetic makeup of the seed determines to a large extent the yield potential and yield stability of the crop and also the use qualities of the product. The germination percentage and seedling vigor determine the primary plant population in the field, one of the main factors for reaching this yield potential. The seed health status can be a key element in determining the development and severity of a disease epidemic.

The choice and handling of the seed thus determine the chances for success of the crop to a significant extent. In this context, for every farmer the two key issues as far as seed is concerned are availability and quality.

Availability and Access

Seed has to be available for every crop production cycle. It has to be there at the right time, in the right quantities, with the right qualities and at the right price so farmers can access the seed they need.

Seed is in principle readily available in crops where the seed is the same plant part as the consumed product. This is the case in cereals, pulses, and some vegetative propagated crops such as potato. Botanical seed can also be a ‘by-product’ with little value other than the fact that it can be used as seed or planting material. This is the case with root crops, fiber crops and vegetables such as cassava, sweet potato, jute, cotton and tomato. This ‘by-product’ is either readily available, for example, cassava or cotton or the production of seed is a separate operation which is the case with leafy vegetables. Biennials like onion, sugar beet, radish and cabbages, and many leafy vegetables are harvested before flowering, and several fruit vegetables such as cucurbits and okra, have to be harvested for consumption well before the seed matures. In these crops seed production becomes a more specialized operation. Some plants have to be left in the field to mature or special seed production plots have to be laid out. Even where consumption grain can be used as seed, availability can be a problem. Severe drought, for example, can wipe out a crop’s production and thus challenge next season’s seed availability.

Communities that regularly face such conditions commonly develop coping strategies such as the long-term storage of carry over seed. Also civil strife is known to disrupt seed supply. Even temporary displacement of farming communities can leave a whole region without seed to plant when normal conditions return. Availability can also be challenged when farmers depend on purchased seed. This can happen when a seed provider is unable to supply seed at the right time, when logistics are poorly organized or when the least profitable (remote) markets are supplied last or not at all. Even when seed is available, price could hinder poor farmers accessing good seed. Dependence on purchased seed is greatest when acceptable alternatives are not available, for example, when on-farm seed production is difficult to realize due to disease or germination problems, or becomes impossible if the varietal characters' are to be maintained (hybrids).

Quality

Four basic seed quality aspects can be distinguished as:

- Physiological quality (germination, vigor)
- Sanitary quality (seed-borne disease status)
- Analytical quality (amount of good seed in a particular lot)
- Genetic quality (varietal adaptation, varietal purity)

The first basic requirement of seed is that it has to germinate at the right time. Secondly, the seedling has to be strong enough to withstand the environmental conditions that it faces when emerging (seedling vigour). The use of seed of low physiological quality is likely to result in poor crop development and depressed yield potential, especially in non-tailoring crops like legumes and many vegetables. Physiological seed quality depends to a large extent on the health and nutrition status of the mother plant, and on storage conditions and length of storage from the moment of physiological maturity.

The incidence of seed-borne diseases determines the sanitary seed quality. A number of plant-diseases can be carried in or on the seed creating a source of infection and a threat for the new crop. This can affect the severity of an epidemic of a plant disease that may be common in a particular area. Moreover, when seeds are transported over longer distances, they may introduce new and potentially much more damaging epidemics. For clients of the commercial seed trade, analytical seed quality is often more important than it is in farmer-produced seed. The amounts of trash, weed seed, and broken seed in a seed lot constitute a net loss for the buyer when purchasing seed per unit weight. Like disease, the presence of weed seeds can either add to the seed bank in the soil loaded with the same weed species, or add new and potentially very harmful species to a farming system. There are few cases where analytical seed quality is a limiting factor in farmers’ seed systems.

To a large extent genetic seed quality including varietal identity and purity determines the success of a crop. Since it determines aspects like yield potential, yield stability and product quality, the seed has to be adapted to prevailing ecological conditions and produce a crop that meets the consumption and market preferences. These may differ considerably from location to location and between farmer groups of different backgrounds, cultures and levels of wealth (World Bank, 2006).

Seeds of Change

Discussions about agriculture and agricultural change inevitably lead to the subject of seed. Since seed is the carrier of the genetic makeup of the plant, it is a key tool for technology transfer. Seed in a wider sense agro-biodiversity together with soil and water management are central to the sustainability of traditional farming systems. Seed is one of the key tools capable of changing complete farming systems. This can be seen, for example, by the effect a new crops such as maize has had on farming in northwestern Europe after adaptation to a shorter growing seasons or in situations where changes have been made to existing crops, such as, for example, vegetables that can thrive in soil-less greenhouse horticultural conditions (UPOV, 2005).
The genetic basis also contributes to increased yield stability through tolerance to abiotic stresses or resistances to pests and diseases, or to increased product value through qualities that are either important for a good price in the market, such as the grain color of legumes, or that have direct nutritional benefits for home processing and consumption. As a result, seed is a key tool for technology transfer and technology driven development strategies and is widely considered a focal point in agricultural progress.

The ability of seed to change agricultural production systems became particularly clear during the Green Revolution. The introduction of short straw wheat and rice varieties that increased yields by increasing the harvest index was a breakthrough of enormous importance in parts of Asia and Latin America. The short growth habit made it possible to reduce plant spacing, the time needed for the crop to reach maturity and most importantly it made possible the effective application of chemical fertilizers because of the greatly reduced susceptibility to lodging. The Green Revolution had important institutional effects, as the value of international agricultural research was readily acknowledged by stakeholders, including donors. National agricultural research organizations in developing countries that had concentrated on export crops in the colonial period increasingly focus on food crops and rural extension services were either developed or strengthened in order to transfer the technologies to farmers.

In this way technologies were effectively transferred initially through seeds from international centers being passed to farmers through national public institutions. As a result several countries were able to reduce their dependence on imported food grain. Yet, the changes were not all positive. There was a difference in adoption rates between better-off and poorer farmers, which led in many cases to the latter losing their land before they could benefit from the new opportunities. In various locations, excessive use of pesticides and irrigation water, and insufficient attention to soil fertility led to a large-scale soil degradation and water pollution. A reduction in crop genetic diversity in the field and in the diversity of foods in the diet of the poor lead to hectic debates about the role of “modern varieties” (MVs) or “high yielding varieties” (HYVs) in development.

Seeds of Harmony

Seed is such a vital element of farming that seeds and characteristics of the plants that grows from them is inextricably linked with the culture of the people that developed, selected, maintain and use them. The concept of ‘cosmovision’ developed in Latin America, which placed agriculture in a holistic world perspective, conceptualizing it as a continuous interaction between the indigenous culture, the environment and technologies. In this vision, people are seen as part of that world and not as outside managers and users of the environment. They need to protect the harmonious coexistence of the spiritual and material world also in the agricultural methods they use. Living organisms such as seeds play an important bridging role. This vision puts emphasis on the linkage between the seed and people’s culture and leads to claims that this linkage needs to be protected from outside pressures and that the seed should be protected from replacement by other varieties if culture is to be maintained. It also leads to demands to protect the seeds from exploitation by others without the consent of the community to which it belongs and it rejects property claims because it is believed that the special character of the seed is given by spiritual powers (Tatenhove and Leroy, 2003).

Seeds of Concern

Interest in the genetic value of seeds has created worries about the availability of sufficient genetic diversity for future use. This has been lead to initiatives to conserve genetic resources in gene banks, on-farm and in situ. Genetic resource policies are part of the over-all biodiversity policy arena, covering biodiversity at the landscape, ecosystem, species and genetic levels. Ecosystems are important for genetic resource conservation since the wild relatives of our crops are repositories of crop genetic diversity. Current developments in reproductive and more recently molecular sciences allow the transfer of potentially valuable genes from a much wider array of species to crops than was hitherto possible. Conserving agro-ecosystems is important for managing the genetic resources of crop species in the wild. In addition, on-farm conservation strategies allow for the conservation and further development of crop genetic diversity through a combination of farmer-led and natural selection.

Seeds of Profit

The value of seed for crop production and the investment needed to overcome seed production limitations is reflected in the commercial value of the seed itself. The self-replicating nature of seed characterizes it strongly as a public good. Seed as a tangible asset may not be non-rivalries but the information embedded in its genetics could be used by one without reducing its utilization by others. However, seed is also a high value commodity. High quality seed may be bartered in local exchange systems against consumption grain at rates of one to two. The value of seed in commercial systems can exceed a factor 50 compared to food grain for some crops. Such prices reflect the actual value of high quality seed for farmers, and may be much higher that the production costs of the seed itself, leaving opportunities to extract significant funds for research investments and shareholder rent. The commercial potential of seed provision is an important driver of current thoughts about seed system development in developing countries. Seed provision has long been regarded as primarily serving rural development and food security, and seed supply was thus considered primarily a public task where the benefits of the spread of quality seed would accrue to farmers and countries as a whole through increased agricultural output and food security. Current policies in many countries, however, concentrate on supporting private investment in seed production and supply.

This means that public seed production and distribution services are being dismantled or privatized. The emergence of local seed enterprises has been stimulated through tax benefits and intellectual property rights regimes, which also supported the emergence of multinational seed companies on the seed markets of developing countries.

A Crucial Input for Crop Production

Seeds are a basic requirement for crop production and one of the most precious resources in farming. The choice and handling of the seed determines to a large extent the success of the crop. For every farmer the two key issues as far as seeds are concerned are availability and quality. The importance of seed in crop production and food security and its ability to play an important role in technology transfer and improving farming systems has led to government interest in the organization of seed supply. In industrialized countries this has led to public investment in research and quality control institutions that help guide sector seed production. From the late 1950's development policies in developing countries placed the entire formal seed system from genetic resource management and breeding to seed distribution under public control. After initial investments in breeding and seed in the 1960s and 70s, many developing country governments, often with donor support, developed seed policies and regulations to guide the further evolution of the seed sector. The approach required associated interventions such as targeted investments in infrastructure, support through tax benefits and the granting of intellectual property rights to emerging local seed enterprises and the foreign seed companies involved in developing country seed markets.

Farmers' and Formal Seed Systems

Seed supply systems are analyzed by identifying two major types:

- Farmers' seed supply systems, covering methods of local seed selection, production and diffusion.
- Formal seed supply systems, covering seed production and supply mechanisms operated by public or private sector specialists in different aspects of seed supply and ruled by well-defined methodologies, controlled (stages of) multiplication, and in most cases regulated by

national legislation and International standardization of methodologies. Such systems are introduced, organized, operated in most cases at (inter) national level, and generally involve cash transactions and large uniform quantities. This corresponds with the terms 'conventional seed sector' and the 'organized seed sector'.

Farmers' Seed Systems

Farmers' seed supply systems are based on the recurrent production and selection of seeds alongside or as part of crop production. Historically, the use of seed marks the transition from human food collection to agriculture and the transition from early nomadic to the first sedentary civilizations. Characteristics of plants that are not optimal for the prevailing methods of crop production are selected against and other characteristics, such as larger grains, non-shattering of seed and erect plant architecture are selected for. In this process, plants have changed considerably and new types have developed, some even having biological crossing barriers with their ancestors and thus developing into new crop species, for example maize, triticale, and triploid bananas.

These processes continue to generate new diversity. Many farmers today continue to select good plants, panicles or grains from their crop in order to obtain a source of the seed for their next plantings. The resulting diversity is based on the diversity of ecosystems in which the selected takes place, the diversity of farmers and their selection methods and the diversity of selection objectives that they use (for example,. grain and straw yield, cooking and consumption qualities, storage characteristics, etc.). Some farmers take an interest in seeds and develop into local seed specialists, whereas others may be better at optimizing land preparation and soil fertility or some other skill. Uncertainties about seed saving due to natural disasters or other sources of seed insecurity, plus the fact that the crops of the local seed specialists may germinate better due to additional care and may gradually improve genetically are the major reasons for traditional seed exchange or trade at the local level. The value of seed is recognized in local (barter) trade, but handfuls of seed are commonly shared among farmers and communities because there are many farmers who are always looking for new types of seeds as 'things to try'.

Next to seed selection as part of crop production and the selection of seed for each crop planting, there is a sharing, a diffusion of seed among farmers and farming communities (Arts. & van Tatenhove, 2005). Even though the genetic quality of the seed is recognized and valued in farming communities, there are no reports of such values being monopolized. The farmers' seed system can be depicted as a rather closed system of production and selection that is open for occasional out and influx of materials through diffusion. Seed materials and the knowledge associated with them are closely linked and embedded in the community and are often closely associated with the community's identity.

Formal Seed Systems

Commercial seed systems emerged in industrialized countries in the second half of the 19th century and rapidly developed further after the re-invention of Mendel's laws on heredity in the early 20th century. The development of a commercial breeding and seed sector in the USA was especially enhanced by the discovery of the phenomenon of heterocyst and the subsequent introduction of hybrid varieties of maize. This trend separated crop improvement and seed production from other regular farm operations, creating different specialized actors, including breeders, seed producers and seed conditioners. In industrialized countries this development was associated in the early 20th century with an increased use of farm inputs like chemical fertilizers and mechanization followed by chemical crop protection. Such formal systems have been refined over time and specialized procedures and institutions have evolved, namely:

- Breeding research and practical crop improvement (breeding)
- Continuous variety maintenance procedures
- Regulation of a generation system in seed production from breeder's to certified seed; certification systems are then harmonized internationally through the OECD seed schemes
- Tested seed quality systems for which all procedures and techniques have been harmonized internationally.

Different countries developed different levels of formal (state) regulation and control for the different links in the chain.

The formal seed system aims at securing a trusted supply of seed to farmers who can thus access the results of plant breeding and obtain seed of a relatively constant and trusted quality.

The Roles of Seeds and Seed Systems

The formal seed system is considered a chain. This chain represents a one-directional flow of seeds from gene banks and breeders' working collections to breeding programmers, and further through seed production and marketing and distribution programmers to farmers' fields where they are used as an external input. Next to genetic resources, breeders also use a range of technologies which may originate outside the field of breeding, such as modern statistical and genomic tools, which are made applicable in practical breeding by 'breeding research'. There is a small feedback mechanism in this material chain since new varieties finally also end up in gene banks as inputs for further use in crop improvement.

The formal seed sector is mainly organized in one direction. It forms a pyramid with small quantities of breeder's materials at the top and large quantities of commercial seed in the marketing channels. As far as genetic diversity is concerned it is a funnel with a wide variation in the gene banks at the top and a very small number of varieties that actually reach the farmer. This chain is a closed system of materials except for the very small quantities of seed from local varieties or wild relatives that may be taken up in the gene bank collection (and turning the chain in a loop). At the marketing end of the chain seed leaves the system when it is used by farmers, and in some cases is reused and distributed further in the farmers' seed system. The main feedback mechanisms consists of information flows that make sure that breeders develop varieties that the customers need and that the seed production planners can use to make sure that sufficient seed of the required qualities is available on the market (Matthews, & Giblin, 2006). Formal seed systems have developed very effectively for most crops in industrialized countries. The introduction of hybrid varieties in maize in the USA triggered a fully commercial seed sector for that crop from the 1920s onwards, whereas for other crops (notably cereals and pulses) components of the system such as plant breeding still depend heavily on public investments.

In other countries, such as The Netherlands, the public sector has withdrawn completely from breeding except for some perennial fruit crops. The government does, however, invest heavily in upstream breeding research, particularly in genomics and its application in breeding. The large-scale scientific plant breeding of food crops for developing countries to increase national and global food security started in the 1950s. This was followed in the 1960s and 1970s by significant investments aimed at establishing formal seed production systems. The main emphasis of these seed initiatives was to spread the "high-yielding varieties" of the Green Revolution as quickly as possible with a development and food security focus. Seed production was thus considered primarily a public task. Between 1958 and 1987 the United States Agency for International Development (USAID) supported the development of the seed sector in 57 countries.

The FAO Seed Improvement and Development Programmer covered 60 countries, whereas the International Bank for Reconstruction and Development (World Bank) funded 13 national seed programmers and at least one hundred other seed related projects in the decade following 1975. These programmers were geared to developing the capacity to multiply quality seed of modern varieties and distributing it to farmers in order to modernize agriculture and contribute to national and global food security. Seed was considered a tool for technology transfer.

The programmer included the establishment of contract growing schemes within the public sector, the erection of large-scale seed processing facilities and basic seed quality control infrastructure and the development of the human resources needed to implement these plans. Large numbers of seed technologists were trained in these programmers, notably at Mississippi State University in the USA where significant expertise in supporting developing countries in seed technology had been developed. Distribution was commonly organized through the public agricultural extension services. From 1985 onwards, many of these seed production programmers included aspects of commercialization, i.e. privatization of public sector entities and promoting private investments in the seed sector.

The privatization trend in seed system development became part of a more general shift from conventional formal seed supply to a modern seed industry framed to look like the successful commercial seed industry in industrialized countries. The shift requires the primary focus on seed production to gradually change to seed demand (Lemonius, 2003). Seed policies that followed the general economic policies of structural adjustment led to the transformation of public seed units into viable seed enterprises. This proved much more difficult than expected largely because of the shift in 'driver' needed for such a transition. In development-oriented seed chains it is the breeding component that drives the chain: seed production and marketing are necessary to take new varieties to as many farmers as possible. In commercial seed systems it is primarily the marketing component that takes the lead. Even though the basic components are the same (breeding, seed production, marketing), developmental and commercial formal seed systems are fundamentally different. Insufficient appreciation of this difference is an important reason for the fact that many attempts to commercialize the public seed production infrastructure failed.

Linkages between Farmers' and Formal Seed Systems

Conventionally, the formal and farmers' seed systems remain separate except for two major points where they meet:

- Genetic resource conservation activities extract the diversity from the farmers' seed systems, where locally selected landraces evolve, and
- Seed marketing brings new varieties into the farmers' seed system where they can be multiplied as new varieties or mixed and hybridized with local materials.

In most countries, this separation is clearly visible and seed policies concentrate on developing an efficient formal seed system. In conventional seed system development strategies, this separation is confirmed. Farmers' seed systems are considered traditional and backward systems providing untested and thus poor quality seed and not warranting major support or investments. The formal system is regarded as a modern organizational form and one that is essential if agricultural development is to take place.

Interaction at Different Points

Integration of knowledge and materials from the formal and farmers' systems can be stimulated within different components of these systems.

Genetic Resources

The conventional link is the extraction of genetic resources from the farmers' seed systems for the purpose of conservation and broader use. Gene banks and breeder's collections of genetic resources commonly contain a wide array of farmers' varieties and landraces. Linking local knowledge with formal knowledge greatly facilitates conventional (ex situ) operations for the conservation of genetic resources. Local knowledge adds to the efficient collection and characterization of materials. Using formal knowledge to assist the local system has led to a range of on-farm strategies for the management of genetic diversity in crops. Gene banks have not only obtained materials from the local system, they have also played a central role in the re-introduction of appropriate genetic diversity of crops after disasters. The 'seed of hope' programmer that followed the civil unrest in Rwanda in 1994 was an excellent example of the reciprocal role of gene banks. Initiatives for the on-farm management of genetic resources can also support farmers' seed systems in their objective to stimulate the use of local varieties and landraces by farmers. A recent addition to this strategy is to include the effective development of markets for diversity based products in such initiatives, either in the country itself or in export markets.

Plant Breeding

The linkage of local and formal knowledge in plant breeding has resulted in novel strategies for breeding both for benign and more diverse ecological conditions. Participatory Variety Selection has greatly increased the understanding of farmers' preferences by scientific plant breeders. It has also created an initial recognition of the ability of local communities to select materials for their own conditions. The concept of participatory plant breeding has introduced farmers' knowledge into many more aspects of plant breeding: setting objectives, creating variation, selection and finishing of a new variety.

The complexity and variation of marginal environmental conditions that creates great difficulties for breeding programmers to overcome genotype x environment interaction can in some cases be tackled effectively by breeding for diversity in participatory settings (Esquinas Alcázar, 2005). Overview of different experiences, practices, analysis of a variety of methods and impacts of number of ongoing initiatives. These show that, from a scientific point of view, participatory plant breeding connects scientific plant breeding with social sciences and that there are initiatives started by social scientists and by ‘hard core’ plant breeders alike and that there are many instances where these specialists have found each other in an effective cooperation. Farmer-participation is also likely to lead to an increased use of local genetic resources in breeding programmers that would otherwise be largely dependent on materials from international programmers. This could potentially lead to an increase in genetic diversity.

Seed Multiplication

Farmers’ seed systems can be substantially improved through the introduction of scientific knowledge developed within formal seed systems. This includes knowledge about agronomic practices and ways in which farmers can improve the way they handle and store seed. Knowledge of seed transmitted diseases which is rather poor in many local communities is also a critical element here. Secondly, improving seed storage conditions can significantly improve the sustainability of supply. The identification of diseases is the key to avoiding them. Furthermore, understanding local methods of handling seed, such as storage in the chimney, the use of leaves with insecticidal properties ash or vegetable oils when storing seed or even local methods of seed priming can contribute to formal knowledge.

Marketing

Finally, farmers’ seed systems can benefit from a linkage with the marketing aspects of formal systems. One strategy is to decentralize and diversify seed supply by the promotion of local seed producers and merchants. Farmers who are known in their community for the quality of their seed may be assisted to develop into small-scale seeds men, thus filling the gaps that the larger formal seed units leave in remote areas or in the market for particular seeds. Some basic knowledge of accounting and planning is essential to the success of such strategies.

Challenges for Integration at Policy Levels Policies

The changes in seed sector development from the linear approach to the notion of integrated and diversified seed systems creates a range of challenges for various stakeholders. National seed policies that observe the need for diversified seed systems design particular roles for the public, private and civil sectors. They need to create appropriate support for the various actors involved each of whom may have contradicting needs and objectives. This may create challenges for the regulatory framework surrounding the seed sectors and the institutional implementation of policies supportive of diversification. The linear approach has the beauty of simplicity but the complex reality normally does not fit the theory.

Regulatory Frameworks

Governments are faced with the notion that regulatory frameworks have to serve the different needs of various types of breeders, seed producers and farmers:

- The emerging private sector may need protection to develop financial stimuli, and a certain level of freedom to operate; and the government may want to check on the products of the private sector for consumer (farmer) protection;
- The public seed sector has to adapt to changing conditions and objectives, making room for the private sector, and its role in poverty reduction and food security may include leaving the conventional top-down approaches to breeding and seed supply in favor of participatory methods;
- The valuable aspects of the farmers’ seed systems have to be nurtured and supported, and government and civil society organizations are to be guided to do so.

The promotion of formal seed production in many countries has led to the introduction of a regulatory framework that was to guide the developments in this part of the seed sector. These laws do not take into account the role of farmers’ seed systems, and in many cases they criminalize farmers who sell or barter locally produced (noncertified) seed of non-released varieties. Integrating the local and formal seed systems cannot be stimulated without the support of appropriate regulations.

While policy makers may be struggling with guiding and regulating their diversified seed sectors, international developments have created additional challenges for national governments and other actors. The introduction of intellectual property rights and national sovereignty over natural resources into the field of agriculture, and the subsequent discussions in various forums on the concept of farmers rights have raised new questions for national policy makers about how these issues should be dealt with at national and local levels.

Institutional Change

At the institutional level, the creation of linkages between formal and farmers' seed systems requires fundamental changes, especially in the way that formal institutions and actors operate. Technical scientists such as geneticists, breeders and seed technologists have to co-operate closely with social scientists and new working procedures need to be designed. The standard evaluation processes of researchers may have to be abandoned. For example, the range of genetic resources conserved in diverse farming systems has to be assessed differently from the way in which resources stored in a gene bank are assessed. The number of varieties that are formally released is commonly used as a yardstick for the success of formal breeding and in reviewing the performance of breeders, but it cannot be used to measure advances in participatory plant breeding because in most cases - new varieties developed in such programmers are not officially released. In addition, the issue of ownership of inventions may lead to discussions among the partners, especially when participatory research uses both formal and local knowledge (Engels and Visser, 2003).

International and National Policies

The importance of seed in agriculture has made seed an issue in national and international policies. Its multiple roles, moreover, makes it vulnerable to policies that may not be directed at seed itself or even at agriculture. It is, therefore, necessary to assess a number of such policies and their implementation in exploring how developing countries can maximize the role of seeds in rural development. These include international policies that focus on agriculture, development, sustainability and trade.

In an increasingly globalized world, issues are debated at the international level. Often this leads to jointly agreed objectives, such as the Millennium Development Goals or rules laid down in conventions and treaties. In the environmental sector in particular, many such treaties have been concluded over the last 25 years in response to the growing recognition that many environmental issues are trans boundary and go beyond short term national interest. The Millennium Development Goals (MDGs) currently play a strong normative role in the development arena and form a good example of jointly agreed objectives that have not been worked out in binding treaty. The MDGs illustrate that in agricultural development strategies poverty alleviation now has priority over production-oriented goals.

Agriculture is seen as a tool that can be used to achieve a number of goals. This shift is a reflection of the widely held view that the world produces enough food to feed its population and that food insecurity is mainly the result of poverty. However, recent evidence indicates a process of gradually shrinking global food stocks a phenomena exacerbated by policies to stimulate the production of biofuels and the consequences of climate change. Global, regional and national food insecurity has in an absolute sense returned to regional and international agendas, and agriculture itself is receiving increasing political attention in the development arena. Sustainable development has dominated the development policy arena as a cross-cutting theme ever since the preparations for the 1992 United Nations Conference on the Environment and Development in Rio de Janeiro and the 2002 World Conference on Sustainable Development in Johannesburg. Even though the concepts are derived from the environment agenda, it is clear that the social and economic implications will impact on other policy fields, including agriculture. For example, the Convention on Biological Diversity has a significant influence on the management of agricultural and horticultural seeds. These agreements have to fit into a dominant global strategy in the trade sector, which concentrates on promoting global markets. This trend has been strengthened by the reconstruction of the General Agreement on Tariffs and Trade into the World Trade Organization (WTO), the many and wide ranging bilateral and regional developments that aim to facilitate international trade and national initiatives that focus on reducing public spending and promoting private enterprise. A good illustration is the Agreement on Trade Related Aspects of Intellectual Property Rights, one of three basic agreements that form the foundation of the WTO which has had a significant impact on agricultural and horticultural seeds (Stannard *et al*., 2004). Many major policies have their roots in international debates. Others reach international for an early stage and during formal discussions country representatives or stakeholders from civil society organizations or private sector associations identify the challenges of a changing world, and formulate a joint response. Most of these global responses are implemented through government interventions based on national regulations, and some through private initiatives based on the “People, Planet, Profit” concept in business strategies. Most international policies and institutions do not focus exclusively on agriculture, but they do have a marked effect on crop production and more particularly on seed. These global trends can, therefore, be translated into different views about the development of agricultural production.

Conclusion and Recommendations

Gene banks are important for the conservation of genetic resources, and for making these available through their evaluation, documentation and seed management systems. Genetic diversity does not, however, evolve any further in gene banks. Given their different strengths and limitations, these three strategies should be considered complementary rather than exclusive. The management and use of genetic resources with the aim to broaden the genetic base of crops contributes to ‘cashing in’ on the option value of genetic resources. For this thesis, it is important to note that the diversity of seeds in farming systems is important in the context of global biodiversity policies. Worries also extend to trends emerging in the commercial seed industry. Since then, the industry has gone through several phases of concentration and is now strongly integrated into the pharmaceutical and chemical industries in so called life-science companies that have interests in the application of genomic (proprietary) knowledge in different fields, including plant breeding.

The concern is that this will result in corporate power to control seed markets and genetic resources particularly but not exclusively through genetically modified seeds. Seeds have, therefore, also become an issue in the various debates on equity, including in the context of the north-south divide the definition of the right to seed-related farmers’ knowledge.

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