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Ensuring Seed Quality in Ethiopian Seed System

Status and Challenges

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Ethiopian Institute of Agricultural Research

Ensuring Seed Quality

in

Ethiopian Seen System

Status and challenges

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Contents

Preface

The Ethiopian Seed system has been evolving in attempt to ensure the availability of required type of seed in the required quality and quality at affordable price. The key milestones in the process are the decentralization of the system emergence of regional seed enterprises, participation of private seed companies, and emergence of regional agricultural research institute and agricultural universities, and above all the tremendous trust and recognition given to the use of seeds of improved crop varieties to achieve the targets set in the Growth and Transformation Plan. However, the system still faces multiple challenges mainly related to the limited capacity and lack of role clarity of the different actors, the focus of the system on very few crops and varieties, mismatch between supply and demand resulting in shortage and excess inventory, and degradation of seed quality because of inappropriate production practices, storage and transport facilities.

Recognizing the importance of ensuring quality of seed in the system a one-day workshop was organized by the project on Enhancing Development and Dissemination of Agricultural Innovation through Farmer Research Groups (FRG II Project) of the Ethiopian Institute of Agricultural Research (EIAR) in collaboration with Quality Seed Promotion for Smallholder Farmers Project (QSPP) of the Ministry of Agriculture (MoA) on 18 March 2011 at EIAR to discuss about the status and challenges of the Ethiopian seed system to ensure seed quality. This publication presents the proceedings of the mentioned workshop.

We believe that the information contained in this publication is a good reflection of on-going efforts to inspire all actors in the seed system in ensuring the supply of quality/good seed to farmers, and we trust that this work, together with other studies, will provide a sound base for future efforts.

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Good Quality Seeds and Linking Formal Seed System with Farmers' Own Perspectives and Initiatives: A Japanese Experience

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Introduction

Soil, water, and genetic resources constitute the foundation upon which agriculture and world food security is based. Of these, the least understood and most under-valued are crop genetic resources. They are also the resources most dependent upon our care and safeguarding. And, they are perhaps the most threatened (FAO1996).

It is well recognized that seeds are most important input for agricultural production and they carry important genetic information of which the desirable types can be expressed under good technical production know-how. However, the benefits of good crop varieties cannot be realized without the availability of seed to farmers. Furthermore, good varieties for farmers need to be maintained under specific conditions to produce good seeds for farmer use.

What are good seeds?

The question "what are good quality seeds?" can be answered in many ways. Simple ideas will be based on genetic and/or physical purity, health, and high germination rate. Among these, externally evaluated qualities are purity in terms of lack of contamination of weeds, other crop seeds, and non-biological contaminants such as stones, and appropriate size and weight, and so on. Bigger seeds usually have better yield, and the seed weight is also important for good seedling plant vigor upon planting. For example, good quality wheat seeds weigh about 30-55 g/1000 seeds and that for rice is about 30-35 g/1000 seeds. Color and smell can also be seen as quality parameters since each crop/variety has normally got its own typical color, and healthy seeds have normally got no smell.

Germination rate is another important attribute of seed quality. However, for field practice, emergence rate is more important. Pieper (1952), as cited by Kaoru Ehara (1971), showed that minor deterioration in seed germination rate can affect the germination vigor and rate of emergence. For instance, seeds of rye with 98%, 91%, and 80% germination rate had 97%, 82% and 58% germination vigor and 96%, 47% and 48% emergence rates, respectively.

In addition, internal or invisible qualities of seeds include the value of seeds that are usually recognized as quality of the variety coupled with the quality of the seeds themselves. While proper varieties are usually not replaced every year, good quality seeds need to be produced every year. In this aspect, the importance of farmers' role comes in.

Seed Certification and Replacement

Seed certification is one of the important mechanisms in order to provide farmers with good quality seeds. For staple crops of a nation, government or its designated agencies have the responsibility of this role. In Japan, seeds of rice, wheat and soya beans are certified by agencies designated by prefectural governments. Vegetable seeds are often certified by producing companies themselves based on ISTA rules.

Seed certification and distribution system in case of rice and other main staple crops in Japan is briefly explained below. First of all, required characters for formal seed certification agencies are:

- The membership consists of seed growers, companies, and others interested in producing pure seeds;
- They are governed by board of directors elected by members;
- They have legal status under state or national legislation with the authority to set standards for certification; and
- They have close working relations with seed growers and agricultural research, extension, and regulatory agencies.

Inspections are carried out at three stages: field designation, field inspection, and product inspection.

- The first step involves field designation along with growers' registration with government and indication of location of seed fields;
- Field inspections are done twice at different maturity stages. The first field inspection is done for checking proper management, variety character, contamination, and pest/disease; and the second inspection is carried out at seed maturity stage. The inspectors are researchers, subject matter specialists, and development agents helped by assistants from agronomic advisors of cooperatives; and
- Products inspection is also required under seed law. This is done in order to confirm adequacy of germination rate, purity of crop and variety, freedom from weeds, acceptable or little disease infection or pest infestation, color and also requirement under products standard. The acceptable seed moisture content is normally 14.5%.

In order for seeds to be certified, the first step is a decision made on seed production fields. They need to be isolated chronologically, i.e. fields should have not been planted for specified period to other varieties of the same crop or other similar crops. Fields need to be isolated from other varieties of the same crop with appropriate distance. Freedom from noxious weeds is also important. In this sense, existing cooperative type of farmers' groups are not necessarily suitable for seed growers because members of such general purpose or crop production purpose do not necessarily hold and/or have access to fields suitable for seed production.

Seed distribution mechanism in Japan is shown in Fig 1. Aichi Prefecture, one of the agriculturally important areas in Japan, has eight seed growers associations, and the characters of these associations are summarized on Table 1. There are different types of associations either within or independent from cooperatives. It can generally be said that seed growers tend to establish their own associations with loose cooperation with existing general purpose cooperatives. In order to coordinate the balance between demand and supply, the prefectural government bodies monitor these activities.

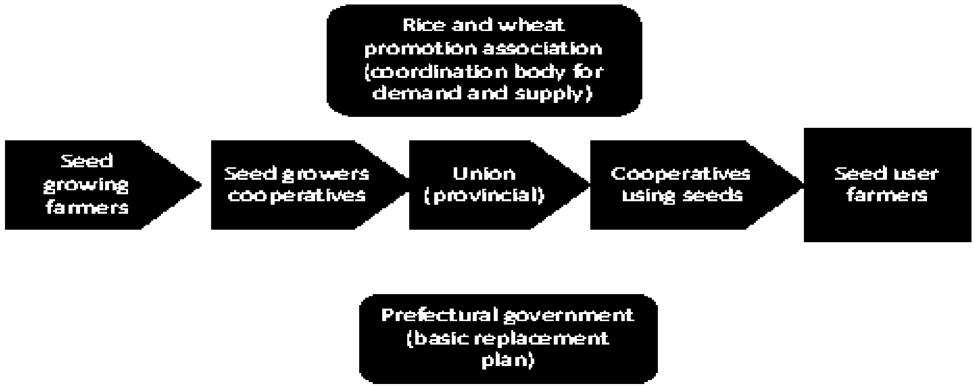

Fig.1. An example of seed distribution mechanism on staple food at prefectural level in Japan

Table 1. Diversity of formal seed growers in Aichi Prefecture, Japan

Name of cooperative	Location (Woreda)	Character	Number of farmers		
			Rice	Wheat	Soybean
A	I	Association of seed growers	27		
B	II	Seed growers group within cooperative	69	47	32
C	III	Association of seed growers	15	2	2
D	IV	Section of seed growers group within cooperative	15	4	
D	V	Section of seed growers group within cooperative	17		
E	VI	Kabare production association (judicial person)	1	1	1
E	VII	Association of Seed growers organized within cooperative	11		
F	VIII	Seed growers group within cooperative	12		

In Aichi Prefecture, replacement rates for seeds of major crops are shown in Fig. 2. In the cases of rice and wheat, around 60% of seeds are replaced every year, and these rates are in steadily increasing trend but not drastically. For soy beans, less than 40% of the seeds were replaced in 2005, and this may gradually increase in future to reach the 50% target set by prefectural government.

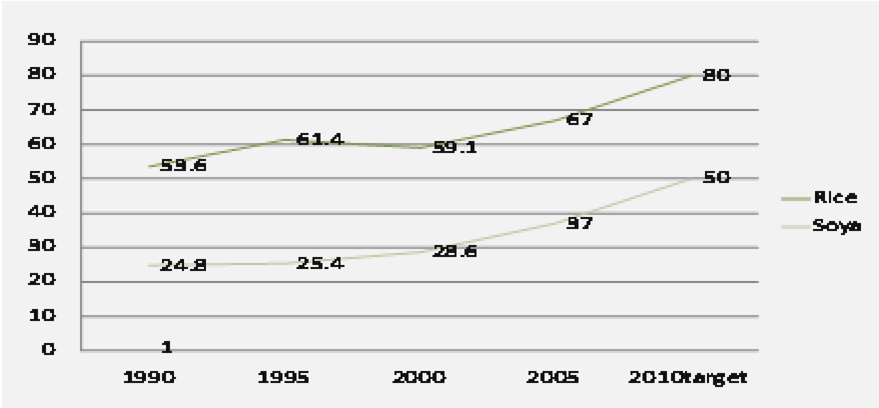

Fig. 2. Replacement rate for major crops grown in Aichi-Prefecture

In the case of rice, the most important crop in Japan, varieties grown in different prefectures have different tendencies (Fig. 3). In Miyagi and Niigata, more than 80% of fields are sown to one variety, but in Gifu and Okayama, relatively small portion of fields are sown to major varieties, which are different from those of Miyagi or Niigata. This suggests that farmers under different conditions, both naturally and socially, take different strategies for variety choice, and each prefecture provides the necessary seeds based on the demands.

Yield loss after self seed production by farmers is not serious up to certain generations such that the yield reductions amount to about 98% after one year, 96% after two years, 90% after three years and 83% after nine years. These data support the judgment of farmers who use their own seeds for certain generations.

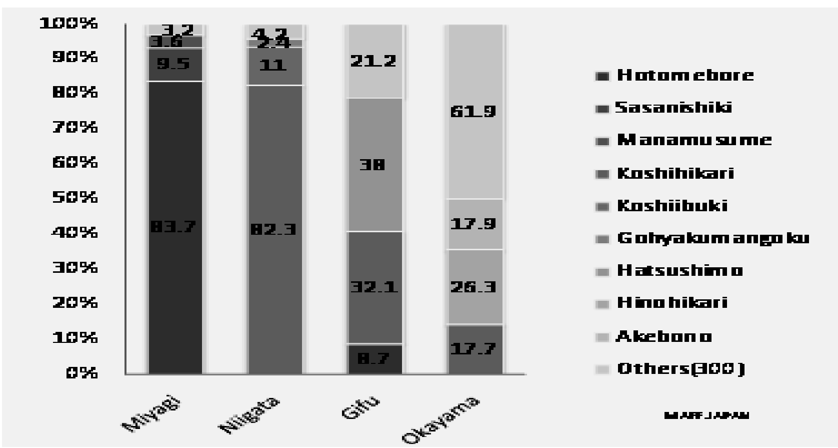

Fig. 3. Share of different rice varieties grown in different regions in Japan

Promotion of Seed Production by Farmers

Hiroshima Gene Bank promotes farmers own seed production in order to distribute and/or re-introduce crop varieties in rural areas. There minimum recommendations for beginner seed producers are:

- Protection from rain and proper drainage for higher fertilization and less disease infection;
- Selection of mother plants in which case limited amount of diversity is necessary as strength of local varieties, but there is a need to exclude off-types;
- Mitigation of possibility of contamination based on the breeding behavior of each crop;
- Proper timing of harvest;
- Drying under shade;
- Germination test; and
- Storage (cool, dark and dry storage, and in Japan, domestic fridge is best choice)

In addition to the common characters as good quality seeds such as purity, vigor, and health, farmers who produce seeds by themselves have other criteria for their own good quality seeds. Examples are:

- Intentionally keeping variations within the limitation of practically recognizable identity;
- Having deep insight on harvesting time and storage conditions; and
- Carefully choosing mother plants.

With such small additional technical considerations, some farmers in Japan enjoy self harvesting of their seeds based on their own choice of characters and suited to their environment. Although natural and social conditions are different between Japan and Ethiopia, many of the criteria for choosing and saving good quality seeds by farmers in Japan are shared by farmers in Africa such as Ethiopia and Burkina Faso under their own saving seeds traditions. This may confirm the importance and possibility of inclusion of farmers in production and distribution of good quality seeds in the Ethiopian context.

Conclusions and Recommendation

Access to 'good seeds' is certainly vital for farmers' livelihood. Characters of good seeds are universal in many aspects and should be realized for better production. However, good varieties mean different things for different stakeholders/farmers, and they are very much location, timing and market specific. Therefore, promotion of good (improved) varieties is a different issue from promoting and securing good quality seeds. Integration between the two is necessary, but they need to be clearly understood as separate matter.

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The Ethiopian Seed Quality Control System

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Introduction

In Ethiopia the formal seed sector has not developed as expected due to multiple reasons. Lack of proper organizational set up, inadequacy in trained manpower and limited private participation are some of the main drawbacks. All of the components and segments of activities are seriously affected with the overall weakness.

Seed quality control/assurance which is vital at every segment of the activity is almost neglected by most of the stakeholders in the sector. It was well known that the seed quality control was among the first considerations in the Ethiopian seed system. Some records show that the seed quality concept and rudimentary activities in seed quality aspects were introduced to the seed system even before the present formal seed production and distribution got its current shape some 30 years ago. Since then, especially after the enforcement of the Ethiopian seed law No. 206/2000, seed quality control showed some progress but it gradually got weakened to its current alarming status.

This paper attempts to briefly review the system and identify points of intervention to rehabilitate the seed quality aspect so as to serve the seed system in the best way possible.

Historical Background

The formal seed quality system was partially exercised in a much disorganized manner in some parts of the country as early as 1942. According to Bishaw *et al.* (2008), the Ethiopian formal seed system was introduced five decades ago with the activities of crop improvement research by the existing research and higher learning institutes. The activities were ad hoc in their nature that they did not serve the farming communities in a sustainable way. Later on, however, the seed production showed a better organized fashion under the Chillalo Agricultural Development Unit (CADU). Seed quality testing was recorded to be conducted as early as 1972 by the CADU at its laboratory in Kulumsa. It was also recorded to have been started in other agricultural research centers like Debre Zeit, Holeta, Bako, Alemaya, and Awassa. Nevertheless, the CADU activities were the pioneer in the introduction of partial seed quality control in Ethiopia (FAO, 1972).

Seed quality testing which was introduced by CADU is only one of the several activities in seed quality system. Other seed quality control/ assurance activities especially field quality inspections and the applications of pre-and post-control methods were absent for longer period of time after the introduction of seed testing. Before the introduction of the seed law, the major seed producers conducted lab seed tests just to know and let their clients know the planting values of the seed produced and distributed. There were no seed certification standard norms, written procedures and a coordinating body. These activities have been continued with the introduction of some other field quality inspections even after the establishment of the Ethiopian Seed Enterprise (ESE). Immediately after its establishment, ESE had introduced a department for its seed quality assurance which kept its intended purpose till now. The first organized seed testing lab was established and field and seed standard norms were introduced by the department. The standard norms and the field inspection procedures were used only internally at the ESE until the seed system was legally enforced in 2000 through the seed law. However, the ESE was the first to introduce field and seed standards and the system field quality inspections to the formal seed system in the country.

Early Activities

As discussed above, the early seed quality assurance activities of the ESE included seed testing and field quality inspections that are both used for internal purposes. Besides, in order to disseminate the concept and knowledge of seed quality to other stakeholders, the ESE coordinated and conducted several seed quality trainings to the staffs of the then Ministry of State Farms Development, Ministry of Agriculture, Institute of Biodiversity Conservation and many others. Most of the in-country trainings were sponsored by international organizations like ICARDA, FAO and UNDP. In addition, some of the seed quality inspectors of the ESE were trained outside the country. The Swedish International Development Agency (SIDA) had remarkably contributed to such undertakings in addition to its vital advisory roles in the introduction of seed quality system in Ethiopia. The trained seed quality inspectors were assigned at each of the seed multiplication state farms where they shared their knowledge thereby enabling the spread of the concept of seed quality throughout the state farms in a very short period of time. Seed samples were collected and were sent to the only lab at the head office of the Ministry of State Farms while the field inspections were performed at the level of the various branches after the erection of big seed processing plants at different locations nearby the grain producing state farms.

The ESE adopted the seed standard norms from other countries while seed sampling intensities, procedures and many of the technical quality assurance applications were adopted from the International Seed Testing Association (ISTA). These technical applications were also adopted by the current seed regulatory system, though Ethiopia either did not have any ISTA accredited lab or did not join the ISTA. The ESE remained as a sole seed producer in the country for longer period of time while having an internal seed quality assurance system without any legal backing.

Legalization of Seed Quality in Ethiopia

As with many of the other seed related activities in the formal system, legal enforcement came at later scenario of development in Ethiopia. The issuance of the draft Ethiopian Seed Policy was the prelude to the first Ethiopian Seed Law which came into picture in 2000. The Ethiopian Seed law (proclamation 206/2000) is a comprehensive legal document in that it covers most of the seed related activities and actors. Seed production processing and distribution have got legal grounds through this proclamation. Variety release and seed quality control were also legalized. The Ethiopian Field and Seed Quality Standards which were formulated under the coordination of the then Ethiopian Quality and Standards Authority (EQSA) were enforced following the seed proclamation. Besides, with the financial support of the World Bank, one central and several satellite seed testing labs were established at different locations of the country to serve the seed regulation. All these labs were meant for seed certification purposes and operated under the National Seed Industry Agency (NSIA) for years. The NSIA, which was born after the seed proclamation, was the legal body to execute the seed quality control and certification. NSIA was also given the mandate to regulate all other seed related activities and implement the Farmers-Based Seed Production and Marketing Scheme Project. The agency employed seed quality inspectors and lab technicians who were engaged in the seed quality control works.

The scope of activities of the NSIA in seed quality control were limited to the then existing seed companies – the ESE and Pioneer Hi-bred International- and to crop seeds of maize and bread wheat. The field and seed quality standards were deficient and contain very high and compelling seed standards for some crops and parameters. Although their testing procedures were standardized in the document, the field quality lack standards for some diseases which if neglected may cause devastating consequences.. The results were that such diseases were not considered in the official field quality inspection, and hence their potential danger was overlooked. Besides, the high standards set for some parameters limited the production of "certified" seeds of some crops like sorghum, tef, and many of the beans and oil crop species which suffered unattainable germination and isolation standards. The ESE reflected its concerns on many of the standards especially in the early generations. It was attempted several times to revisit and revise the deficiencies in the standard setting, but this has not yet materialized. This is one of the most important concerns in the current seed quality system in the country. The introduction of the independent seed quality tests was also limited to crude field inspection and seed tests of moisture, physical purity, and germination capacities. This might have been due to priority setting in light of the limited resources and shortage of manpower. In spite of these, the activities of the NSIA, nevertheless, marked the beginning of an independent seed quality control system in the country.

The World Bank project supported several in-country seed quality control trainings, and also assisted the ESE in establishing satellite labs in all its seed processing and distribution branches. To-date, the ESE owns five small and one main seed testing labs used for internal seed quality assurance purposes (Table 1). These labs are the only seed labs used for internal quality assurance available hitherto. All the seed companies other than ESE depend upon the seed regulatory labs for their internal seed quality assurance purposes.

In addition to the labs of the ESE, the MoA has one seed laboratory, and regional bureaus of Agriculture have got ten laboratories at ten different locations in various parts of the country (Table 1).

Table 1. Seed Testing Laboratory Facilities in Ethiopia

Institution/location	Seed testing laboratory Annual Capacity (samples)
A. Ethiopian Seed Enterprise	
Addis Ababa	5,000
Asela	2,500
Koffele	2,500
Awassa	2,500
Nekempte	2,500
Bahir Dar	2,500
Sub-total	17,500
B. Regional Bureaus of Agriculture	
10 locations*	25,000
C. Federal Ministry of Agriculture	
Addis Ababa	5,000
Total	30,000

** Ambo, Assela, Axum, Dessie, Durame, Durbete, Gondar, Markos, Mekelle, and Wolaita*

Reorganization of the executive body (NSIA)

In an attempt to coordinate the solitary activities of agricultural inputs, the Government of Ethiopia took a major step towards the establishment of the National Agricultural Inputs Authority (NAIA) in 2002. The rights and responsibilities of the NSIA and the National Fertilizer Industry Agency (NFIA) which was established in 1994 (Proc. 106/1994) were transferred to the NAIA. This new development diminished the importance of the young seed quality control and certification undertaking while the seed sector continued its development.

While the situation continued further, a restructuring took place in 2004 when the Ministry of Agriculture and Rural Development (MoARD) was formed to coordinate all the agricultural regulatory activities. The rights and obligations of the NAIA were then transferred to MoARD. The seed regulatory tasks were further shared among the different departments of the MoARD. Seed quality control and certification were further diminished in manpower and activities. Later on, the responsibility was given to the bureaus of agriculture and rural development of the various regions. This made the well-equipped central seed testing lab idle. The regions, on the other hand, have to depend upon the ill-equipped small labs scattered in different parts of the country to test the seeds produced in their areas of domain. Besides, almost all of the regions lack adequate trained manpower, field vehicles and other facilities to handle the ever-expanding seed production plots in their respective regions.

Status of Seed Quality and Certification

The current situation of the formal seed sector could be characterized with the prolificacy of both private and public seed companies whose interests are on the production and sales of hybrid maize seed associated with very weak seed quality control setup. Seed quality is the most neglected matter in the seed industry. Though remarkable progress was recorded on the production of hybrid maize seed in the past cropping season, it was achieved through a compromise in quality. Regional seed quality control bodies are striving to reach the production premises of several private and public seed production farms. The regional seed quality control bodies are also expected to inspect and verify the seed production plots of their regional seed enterprises. Since both the regional seed enterprises and the seed regulatory bodies are mostly affiliated to the regional bureaus of agriculture, compromise in quality would not be unexpected under these situations. The year 2000 seed law has now turned out obsolete in many respects such that it could not match with the current development scenario in the sector especially in the area of seed quality. The organizational set-up and the trans-regional seed movements are becoming areas of controversy. While all of the regional seed quality control bodies remained weak, some of them demand certificates for any seed lot coming from other regions. This will seriously affect the seed availability of varieties which are not produced by the certificate-demanding region.

The other area of problem is the aggravated fraudulent crimes which have the potential damage on the seed system. Both small farmers and the seed companies are negatively affected by fake seed. Though fake seed is a phenomenon in most developing countries, the strength of the seed regulatory limits its danger. Hence, under the present circumstances, those people who are engaged in this crime may find themselves in a very favorable environment.

Conclusions

It seems that the seed quality control assurance system of Ethiopia has not performed steadily since its inception some 30 years back. It has reached its highest performance peak in the years following its legal recognition. Soon after, it descended when its activities were denied proper organization set-up. At present, seed quality has become the most important concern in the formal seed industry. It is also highly affected by serious capacity limitations. Structurally, the system lacks appropriate guidelines and updated quality standards. The field and seed standards need revision.

Immediate rehabilitation of the system is deemed necessary in the following areas.

- The system should be organized in a sound manner both at the federal and regional levels;
- Proper attention should be given to capacity building. It is very much necessary to rehabilitate the seed testing labs which are managed under the regional agricultural bureaus. Lab equipments and proper manpower and vehicles are of immediate need;
- The current field and seed quality standards need revision. The deficiencies and the unattainable standards should be revisited and amended accordingly; and
- In the short term, the application of “quality declared system” may be another option. Seed certification may go side by side with the quality declared system provided that appropriate field and seed standards are availed.

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Source Seed Quality Assurance Mechanisms in Ethiopia

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Introduction

Seed is one of the most important sources of innovation, particularly in resource-constrained small farm environments. It carries the genetic potential of the crops, determining the upper limit on yield and, therefore, the ultimate productivity of other inputs (Jaffee and Srivastava 1992). The responses of all other inputs depend to a large extent upon the quality of seeds used. The direct contribution of quality seed alone to the total production is estimated at 15 – 20% depending upon the crop and it can be further raised up to 45% with efficient management of the other inputs. In addition, new roles of seeds are rapidly recognized all over the world for the delivery systems of many innovative biotechnological products, and as carriers of plant protection chemicals, and biological and growth regulators.

In order to better understand what a seed system is, we need to look into its three components-technological, economic, and legal. The technological component has to do with variety selection; the economic one involves production and marketing; and the legal component has to do with the rules and regulations governing the previous two aspects. Over the centuries, selectors of improved varieties and seed growers have become increasingly specialized.

The availability of quality seeds of a wide range of crop varieties is the key to attain food security. Some of the direct benefits of quality seeds to farmers include enhanced productivity, higher harvest index, reduced risks from pests and other biotic factors and higher profits. Therefore, improving access to good quality seed of improved and adapted cultivars is a critical requirement for sustainable agricultural growth and food security. This paper presents a review of machanisms of quality assurance for source seeds, i.e., breeder, pre-basic, and basic seeds.

Source Seed Quality

The demand for seed in Ethiopia increased from time to time as farmers became convinced of the role of quality seed in realizing the full potential of modern high-yielding varieties. In the early years of Ethiopia's seed supply system, the Ethiopian Seed Enterprise (ESE) was the sole entity engaged in production and supply of quality seed to farmers. Subsequently, additional three regional state seed enterprises, namely: Oromia Seed Enterprise (OSE), Southern Seed Enterprise (SSE), and Amhara Seed Enterprise (ASE) were set up to cater for their own respective regions. Currently, 33 private seed growers are involved mainly in hybrid maize multiplication and distribution. Despite these efforts, substantial gap still exists in satisfying the quality seed demand by farmers particularly for food grain crops. At present, mainly EIAR and higher learning institutions (HLIs) are responsible for multiplication of source seeds.

The impact of investments on agricultural research can be realized only if farmers have better access to high quality seed of new crop varieties. The seed production process consists of a sequence of stages in which seed of a new variety is multiplied to obtain sufficient quantities of commercial seed. Source seeds include breeder, pre-basic and basic seed classes. In the case of breeder and pre-basic seed classes, strong and comprehensive seed multiplication program must be developed and interlocked with all other activities that can assure seed quality standards. Source seed production is confronted with series of bottlenecks in the national seed systems. Amongst these bottlenecks, seed quality is the major one. The quality of the seed determines to a large extent the success of the crop in terms of yield and product quality, and thereby in terms of contribution to food security and the value of crop products in the market.

Seed quality is defined as standard of excellence in certain characteristics and/or attributes that will determine the performance of the seed when sown or stored (Hampton, 2002). Production of genetically pure and good quality nucleus seed is a demanding task that requires high technical skills and comparatively huge financial investment. During seed production, strict attention must be given to the maintenance of genetic purity and other quality parameters in order to fully exploit the genetic potential of the variety under production. Seed quality is a total sum of different aspects of a seed including genetic and physical purity, physiological quality and health quality (Cromwell, 1990).

Genetic quality

The genetic purity (trueness to type) of a variety can be deteriorating due to several factors during production cycles. The important factors are the inherent genetic information contained in the seed which provides the potential for higher yield, better grain quality, and greater tolerance to biotic or abiotic stresses; and varietal identity, specifically the transfer of seed of desired variety from the breeder to the farmer through successive generations of seed multiplications.

Physiological quality

This refers to the viability, germination, and vigor of seed which determines the germination and subsequent seedling emergence and crop establishment in the field as well as the storage potential of the seed lot.

Physical quality

This refers to the analytical purity, freedom from contamination of other crop/weed seeds, size and weight of seeds, and seed lot uniformity

Health quality

This refers to the absence of infection with seed-borne pests (fungi, bacteria, virus, etc.) or contamination with noxious weeds. Seed quality can be affected by environmental conditions under which the crop is grown and the cultural practices employed (Agrawal, 1986).

Components of Quality Attributes

In Ethiopian seed system, field standard developed for certifying different crop varieties considered are rotation, isolation distance, off-types and other cultivars, and diseases and noxious weeds. At the same time for laboratory standard, germination percent, moisture content, pure seed, weed seed, inert matter and other crop seed. Rule for seed testing like seed sampling, determination of moisture content, germination test, and biochemical tests are also considered. However, in our condition most of the standards are not yet tested due to limited capacities and experiences. Probably, hybrid maize is fully certified with all labels and tags.

In Ethiopian research system, the production of quality source seed is subjected to several crop production requirements. The broad steps of seed production in the field are as follows:-

Field standard

Field selection and land preparation

Selection of appropriate field is the key to success of a seed production program. The seed production must preferably be planted in the area of adaptability where the soil and environmental conditions are most conducive. It will help prevent gene shifts and excessive losses from environmental hazards like frost and drought etc. Excess moisture or prolonged drought adversely affects germination and frequently results in poor crop stands. Therefore, the land in which the variety grown should have to get enough amount of rainfall during the growing period. In addition, irrigation can be important at planting for seed crops on dry soils to ensure good uniform germination and adequate crop stands. Good land preparation helps in improved germination, good stand establishment and destruction of potential weeds. It also aids in water management and good uniform irrigation.

Previous cropping

The field should not have grown the same crop for the previous year unless the variety was the same variety and met inspection requirements for varietal purity the crop should be planted on a field with a known history to avoid contamination from volunteer plants, noxious weeds, and soil-borne diseases that are potentially seed transmitted. If the seed is grown through supplement of irrigation, it must be irrigated 3 weeks before planting in order to pre-germinate the probable seed from last season.

Isolations

Isolation means keeping the seed production plots distant from other fields of the same crop. Seed production plots should be located in a distance that there is no risk of contamination through cross fertilization by the pollen from the neighboring plant. The distance for isolation is decided by the mode of pollination and on the velocity and direction of weed. Isolation between seed plots can be achieved by distance (spatial isolation) or time (temporal isolation). When both time and space isolation are not possible, mechanical barriers may be implemented. If the crop is self-pollinated often 2-3 meters around the edges of the field are adequate to prevent taking in any plants from the neighboring field during harvest. If the crop is cross-pollinated, the field should be either located far enough from fields or volunteer plants of other varieties of the same crop; or the field is planted at a different time, so that it will not cross-pollinate with adjoining fields of other varieties of the same crop. The recommended isolation distance for maize is 400-500 meters. If it is not possible to get the required isolation distance, it would be advisable to plant the seed crop at a different time, so that the seed crop will not be flowering when other fields of the same crop are shedding pollen

Roguing

Roguing is the removal of off – types and diseased plants from the seed field before or after flowering. It is used to avoid genetic contamination, out-crossing, and transmission of seed borne diseases. In self pollinated crops rouging should be continuous, while in cross pollinated crops roguing should be done before anthesis and it should be done in both seed parent and pollinator rows. Rouging may be done at many of the following crop growing stages as per needs of the seed crop.

Following recommended agronomy

Seed production must be done following the recommended agronomic package of the given crop. Beginning from the recommended method of sowing through appropriate fertilizer application, timely tinning, usage of appropriate seed rate, the right depth of sowing, the right amount and frequency of irrigation , timely de-tasseling, weed and pest control and till harvest the field condition must be maintained around optimum.

Field inspection

The primary objective of field inspection is to ensure that the seed production pertains to the designated variety and has not been contaminated genetically and physically beyond minimum seed standards. Field inspection is done by a team of researchers from respective research project. The number and the stage of inspections may vary from crop to crop depending upon crop duration, mode of pollination, nature of contaminating factors, susceptibility to contamination and the stage of disease susceptibility. In general field inspections may be done during vegetative or pre-flowering stage, flowering, post-flowering stage, pre-harvest stage, and harvest stage.

Seed harvesting

It should be completed as soon as the moisture content decreases to an appropriate level. Although germination potential and vigor are at their highest when the seed reaches physiological maturity, the moisture level present at that point makes it impractical to harvest and process the seed. After maturity, germination potential and vigour begin to deteriorate, thus making the timeliness of harvest fundamental to the quality of seed. Manual / Mechanical harvest is essential in order to avoid damage to seed. Care is taken while threshing to avoid mixing of off-types. Threshing can be done on a cement floor or clean land.

Biotechnology

Recently in EIAR, rapid multiplication systems have been developed in potato seed tuber production to provide large quantities of plantlets, micro-tubers and mini-tubers of high quality. Micro-tubers, plantlets and mini-tubers are high quality starting materials that can be produced year round in vitro conditions (micro-tubers, plantlets) or ex vivo conditions (mini-tubers) at a high density. Rapid multiplication is very flexible and gives a high rate of multiplication. It also provides seed potato tubers free from seed borne diseases. In addition, other stimulant and fruit crops like coffee, pine apple and grapes are also multiplying through tissue culture. Currently, most of the coffee seedlings are multiplied and distributed to farmers and other users through tissue culture.

Processing and quality control

In order to maintain varietal purity almost all research centers in EIAR lacks mechanical drying equipment after harvest and are relying on the weather to dry (commonly the sun), where unexpected rainfall can lead to seed spoilage and low germination. In addition, most of the research centers lack cold storage if needed to store source seed for more than a year.

Seed packaging and labeling is another area of weakness, as bags are only in 50 and 100 kg sizes, irrespective of farm size or seed rate. In almost all research centres, seed packaging equipments are not available and seeds are not bagged properly. Sometimes tags are not found on the sacks that lacks proper morphological descriptions; therefore, producers are sometimes confused in distinguishing which type of variety and what generation of seeds they acquire from the respective research centre.

Contemporary ideas on seed supply emphasize labeling as a way to build farmers' confidence in formal seed, and to help them identify which types of seed are likely to have physical and genetic value. There are concerns with the quality of source seeds both at seed growers as well as farmers' level and users are confusing on which stage of seeds and from which seed source they received.

Seed testing

Since the inception of research programs in the Ethiopian agricultural research system (NARS), considerable efforts have been made to supply source seed to seed producers. However, most of the seed supplied by the NARS lacks the standard quality. This is mainly attributed to shortage of qualified personnel in seed technology; lack of adequate facilities for internal quality control and short term storage; lack of appropriate breeder seed maintenance storage facilities to keep the quality standard; and inadequate budget for source seed multiplication.

The purpose of seed inspection is to maintain and make available to producers, high quality, and genetically pure seeds of superior cultivars. Only those cultivars that are of superior genetic make-up ought to be multiplied to maintain purity and identity of the variety and are normally eligible for internal certification. Both the germination capacity and the status of the physical purity of the raw seed affect the seed quality. Seed lots with lower physical purity increased expenses through the resulted lower volume of cleaned seed and time consuming and inefficient seed cleaning and processing operations. Thus, raw seed tests shall be conducted for germination and physical purity before they were paid for. Therefore, seed samples must be collected and submitted for laboratory analysis after drying and processing. Laboratory tests to be conducted include varietal purity, weed and other crop seed, inert material, other varieties, germination capacity and moisture content of the seed. Seed testing include seed sampling, purity analysis, germination test, moisture test, test for seed health, and others.

To date in EIAR, there are no full pledge quality laboratories with required equipment and furniture. The availability of these facilities varies from one center to the other. Some centers may have some of these facilities, but none has a complete set of facilities indicated above. However, seed testing laboratories are essential organization in seed certification and seed quality control program, Therefore, research centers responsible in the production of source seed are required to establish certain certification authorities' facilities and procedures for sustainable supply of improved varieties

Trends in source seed production

The Ethiopian government has put in place favorable policy setup for agricultural research and it supports the research system by allocating appropriate resources. As a result, the country's agricultural research system has developed and released more than 664 varieties of 50 different crop types (MoA, 2010). However, due to many reasons, use of high yielding varieties has not widely disseminated to the farmers at the desired extent.

In the formal seed production system, seed multiplication passes through several generations to avoid building-up of physical or genetic contamination over time in the same lot of seed. Seed production follows a generation system to ensure all seeds provided to farmers originate from a known source (breeder seed). As soon as a variety is officially released, the small amount of breeder seed received from the breeder is multiplied through a number of generations before it becomes available to farmers in larger quantities as certified seed. Each generation is produced under strict supervision and must meet the required seed quality standards. The number of generations that are allowed after breeder seed depends on the mode of reproduction of the crop, risk of contamination, multiplication ratio, and quantity of seed required (Fig. 1). Ethiopia uses the nomenclature of the Organization for Economic Cooperation and Development (OECD) for each generation, and these are breeder, pre-basic, basic and certified seed classes (Table. 1). The purpose of such seed classes is to maintain purity and quality by ensuring the purity of early generation material, particularly breeder seed, which is usually maintained in smaller amounts. To increase crop productivity, farmers ought to have access to improved seeds of the right type, at the right time, at the right place, at a reasonable price, and packed at the right size and type of packages. Though this is the proper way of promoting agriculture through the provision of the vital input, the seed, the practice in the country varies from farmer to farmers.

Table 1 Seed classification based on OECD scheme (Ethiopian system)

Seed class	Color of certification tag
Breeder Seed	White, violet mark
Pre-basic Seed	White violet mark
Basic Seed	White
Certified Seed 1st generation	White, Blue mark
Certified Seed 2^{nd}-4^{th} generation	White, Red mark

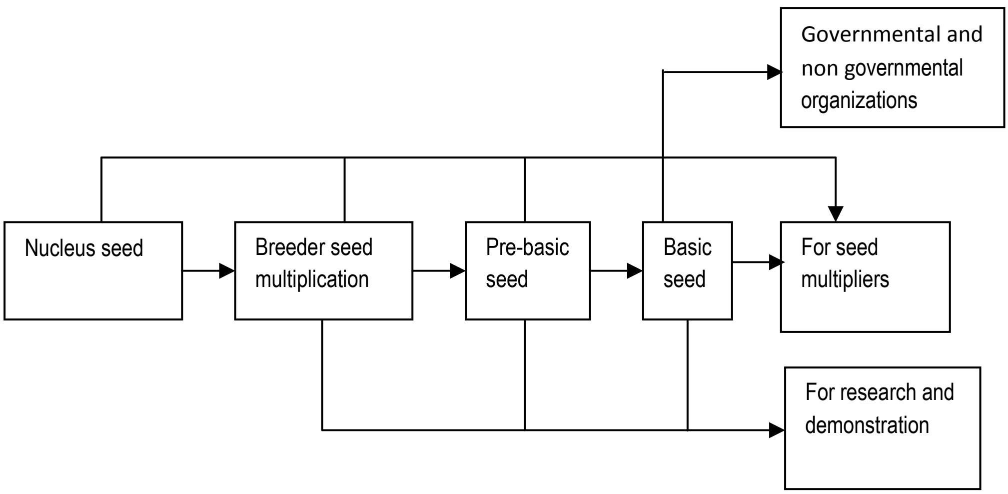

Fig 1. Schematic diagram indicating the role of research systems in seed multiplication

For the last 10 years, EIAR through its research centers has been producing breeder, pre-basic and basic seeds of cereals, pulses, oil crops, vegetables, fruits, spices, coffee and cotton. Due to lack of systematic demand and proper coordination, the seed production has been fluctuating year after year. However, starting from 2008/09 cropping season, the production was increasing as some research centers began to produce twice per year using irrigation.

At national level, assessment of the demand for certified seed is carried out by the Ministry of Agriculture (MoA) through the Regional Bureaus of Agriculture. The assessment is made on the basis of the area sown under different crop varieties, area covered by hybrid and self-pollinated varieties as well as the seed replacement rate achieved. The availability of seed is also ascertained by the same ministry on the basis of production of seed in public and private seed growers. MoA's Input Supply and Marketing Directorate facilitate arrangements with seed producing agencies to ensure whether the requirement of seeds is met to the maximum extent possible.

In Ethiopia, supplies of source seeds fail to fulfill the demand of seed producers. However, as a result of a shift in seed multiplication strategy, the production of improved seeds especially that of hybrid maize and wheat has been considerably improved since the last two years. The gap between demand and supply of basic seeds for both hybrids (Fig. 2) and non-hybrid (Fig. 3) maize has in recent years been considerably narrowed down. However, the supply of basic seed was greater than the demand in both cases. If the efforts in recent years were continued, it would be possible to satisfy the demand of source seeds in a sustainable manner.

Based on the country's certified seed demand, the actual need for source seed to be multiplied by different research centers is planned and communicated to EIAR by the National Seed Multiplication and Distribution Committee (NSMDC). The allocation of responsibility for production of breeder seed is discussed in the annual planning workshop through the facilitation of Technology Multiplication and Center Development (TMCD) Coordination unit of EIAR. The allocation with respect to particular crops is made to various centers as per the facilities and capabilities of the centers and the availability of nucleus seeds of the particular variety to be multiplied. After the seeds are multiplied by each research center, the quantity and type of seed is communicated and compiled by TMCD coordination office of EIAR, then reported to NSMDC. Based on the information from NSMDC, the available source seed is fairly allocated to all producers in an equitable manner. The breeder and pre-basic seed classes produced are mainly allocated for seed enterprises (ESE, RSEs) and/ or private basic seed growers.

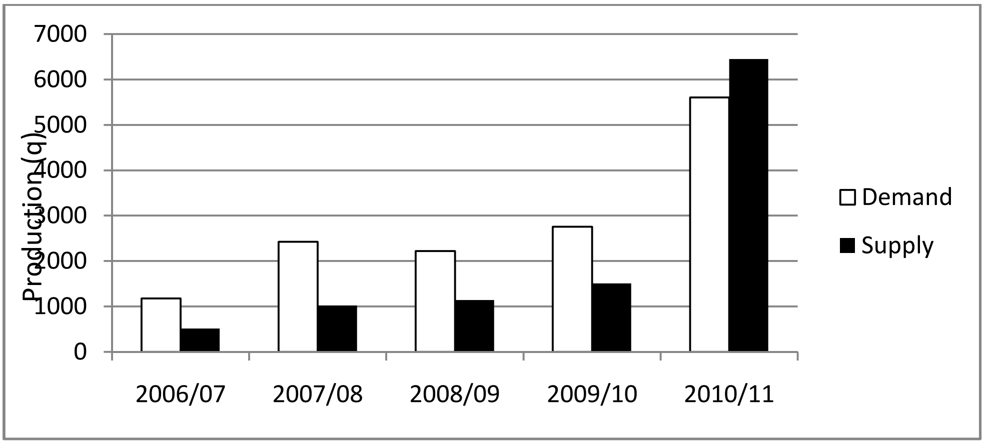

Fig 2. Demand and supply of hybrid maize basic seed (2005/06-2009/10)

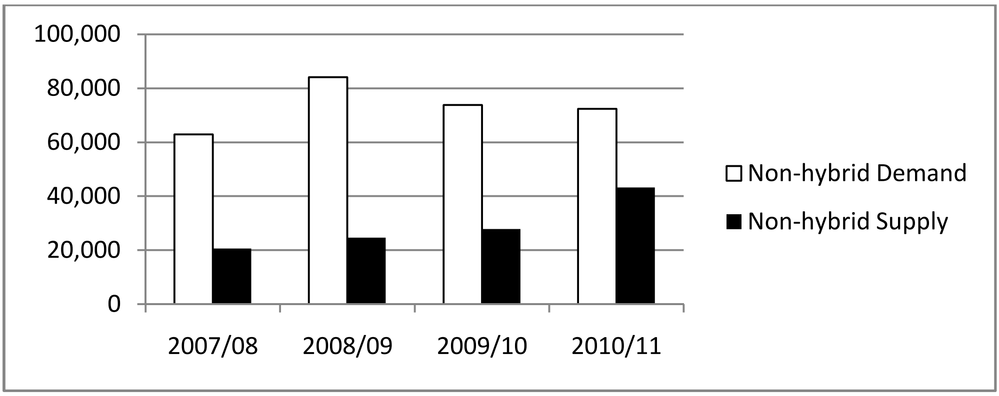

Fig 3. Demand and supply of non -hybrid basic seed (2005/06-2009/10)

Procedures of Variety Release and Source Seed Quality Assurance

Seed producers should be aware of the technical and regulatory requirements for growing a crop for seed, and ensure that all operations are carried out strictly under specific guidelines and timely. The quality of seed can be ensured by following a combination of key technical procedures and regulatory measures. By establishing administrative guidelines and technical procedures, the quality control assurance system plays a supervisory role for smooth operation and implementation of the program and for enforcing the regulatory measures so as to maintain the quality of seed produced.

The lack of trained workforce, shortage of farm machineries, and high seed production costs are some of the major constraints hindering the availability of source seeds in the EIAR seed system in terms of quantity and quality.

Variety release mechanism and its challenges

In Ethiopia, a crop variety evaluation and release system has been in use for more than 25 years. Since the start of the national variety registration and release system, 664 varieties have been officially released, but only about 18% of these varieties have been under production at the moment. This may be as a result of either some varieties in use become obsolete or the newly released ones were not popularised This limited use of improved seed is detrimental to agricultural development in general, and the situation has to be changed to bring about agricultural productivity and production at the desired level.

The variety release system in the country was initially established and managed by the National Crop Improvement Conference that involved stakeholders in the recommendation and release of different crop technologies. The system was institutionalized following the National Seed Improvement Program and Seed Proclamation 206/2000. The release procedure has been revised at different times to accommodate the demand of users (MoARD, 2008).

Since 2004, the variety release and registration task has become the responsibility of the Animal and Plant Health Regulatory Directorate of the MoA. Varieties need to have been tested in extensive multi-environment (location and season) trials before they are proposed for release at regional or national level. Breeders carry out a minimum of two to three years' national (NVTs) or regional variety trials (RVT) in at least three to five locations or different agro-ecological zones (a minimum of six environments) before submitting an application to the National Variety Release Committee (NVRC). The variety should be tested for yield, tolerance to pests, and other important agronomic characters in comparison with a standard varieties and/or local check. Superiority in yield, grain quality, and acceptable level of distinctness, uniformity, and stability are some of the required attributes to grant a release.

Improved varieties are the backbone of the formal seed industry. The national agricultural research system (NARS) is responsible for variety development and generation of appropriate technologies that can maximize the yield potential of new varieties. Basically, two types of tests are carried out in the evaluation of varieties for release/registrationdistinctness, uniformity, and stability (DUS) test; and value for cultivation and use (VCU) test.

A DUS test is a descriptive assessment that establishes the identity of the new variety by using morphological characters along with its uniformity and stability. It is a useful tool for the purposes of seed production, certification, and plant variety protection. The DUS tests are usually run for two years. The new variety is compared with the existing best variety to establish its distinctness. A variety description is prepared and differences from other varieties clearly noted.

The Ethiopian variety release system contributed to improved crop production, improved export earnings of the country and life of farmers, created high demand for improved crop varieties, and developed national experience in the evaluation, release and registration of varieties (MoARD, 2008).

As indicated in the aforementioned sessions, in Ethiopia several varieties were released but only few are available in the production system mainly due to loss of the original positive merits of some of the varieties. The main reason of loosing performance is that these varieties were released without proper DUS and VCU tests. Other indirect influencing factors include: i) lack of incentives to breeders for the developed variety; ii) inadequate office facilities and shortage of personnel; iii) limited participation of other stakeholders than researchers in the development of varieties; iv) release additional new varieties every year without checking the status or the impact of the previously released ones; v) poor institutional linkages among federal and regional research centers in the varietal development and evaluation processes that created overlap of varieties; vi) lack of standard naming procedures to be strictly followed in the registration processes; vii) lack of detailed description of morphological characteristics of released varieties, and viii) lack of standardized procedures for variety maintenance (MoARD, 2008). On the other hand, it is also normal for some varieties to turn obsolete and get out of production due amongst others to pest resistance break, dwindling productivity, and release of better performing new varieties.

Variety maintenance and breeder seed multiplication and quality

Maintenance and breeder seed production of public-owned varieties at national level is the responsibility of the federal and regional research centers, higher learning institutions and other institutions/organizations; while for private-owened producers Pioneer Hi-bred PLC, Red Specled Ethiopia Trading, and Syngenta Agro services that developed the variety. However, this responsibility is not properly met due to lack of systematic provisions and clear ownership of tasks for varietal maintenance both during initial breeder seed multiplication and later on during re-multiplication of the same variety for renewal of stocks.

EIAR, through its research centers, has moderate seed production farms to produce early generations to maintain seed quality and availability. Most of the produced breeder seed is supplied to seed producers and partly to research centers for demonstration and popularization purposes. Since 2008, the amount of breeder seed multiplied by EIAR has considerably increased especially for cereals and in some extent for pulse crops (Table 1). However, for oil and vegetable crops, the breeder seed production still remains low.

In general, breeder seed production in the EIAR seed system remains to be a challenge. Some problems have been encountered in maintaining the genetic, physical, and physiological quality of source seed distinguishing characters. This is particularly manifested by complaints coming from seed growers, who insist that this problem limits their ability to obtain optimal production of basic and certified Seed, (Getinet, 2000; Yemane and Lee-Smith, 1984). Furthermore, many seed producers and farmers have complained about the quality and the high prices of seeds distributed to them.

Pre-basic seed multiplication and quality

Pre-basic seed is the progeny of breeder seed, and it is usually produced under the supervision of a breeder or his designated agency. However, recently, inaddition to pre-basic seed by NARS, ESE, regional seed enterprises (RSEs) and private seed companies are involved in pre-basic seed multiplication with assistance from the breeder responsible for maintaining the purity of the variety. In EIAR, pre-basic seed is multiplied in order to supply adequate seed for seed producer, for demonstration and popularization and for further basic seed production in the research centers. Concerning ESE, and other seed producers, pre-basic seed is produced for certified seed multiplication and demonstration purposes. This generation of seed is commonly used for crops that have low multiplication ratios and where large quantities of certified seed are required. For the last two to three years, the amount of pre-basic produced both by EIAR and ESE has been increased (Table 2) due to the increase multiplication of breeder seeds.

Pre-basic seed should be produced in plots away from any source of pollen contamination. Up to 10-15% of the off-type plants can be rouged-off before flowering. Rouging-off for ear and seed traits is done at or after harvest. The personnel responsible should ensure maintenance of genetic and morphological purity of the variety through careful supervision.

Table 1. Breeder seed production of EIAR during the last ten years (2000/01-2010/11)

Crops	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Cereals	237.4	164	217.49	266.75	145.37	198.49	313.9	270.18	53.71	1040.15
Pulses	13.69	0	92.46	75.08	36.91	33.555	113.59	121.63	12	211.85
Oil crops	16.64	13.99	15.31	5.02	17.94	22.05	13.99	19.92	15	2.5
Vegetables	0.1345	0.1725	14.175	17.375	25.066	41.903	57.9	6.4	11.9	0
Total	267.8645	178.1625	339.435	364.225	225.286	295.998	499.38	418.13	92.61	1254.5

Table 2.. Pre-basic seed production of EIAR over the last ten years (2000/01-2010/11)

Crops	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Cereals	0	294.02	123.35	697.62	304.91	1213	1212.14	1483.7	770.52	2330.19
Pulses	23.57	84.54	9.81	106.08	278.5	169.84	827.71	561.06	248.58	186.69
Oil crops	9.66	18.25	20.7	246.69	241.37	101.06	396.23	112.81	215.78	411.97
Vegetables	1.0201	1.4919	2.272	2.3	3.45	520.106	50	81	75	0
Total	34.2501	398.3019	156.132	1052.69	828.23	2004.006	2486.08	2238.57	1309.88	2928.85

In EIAR, multiplication of pre-basic seed is solely done by a farm management division with minimal participation of the respective breeders. In addition, the quality control of improved varieties is done by the producers of pre-basic seed themselves and sometimes there is lack accountability.

Basic seed production and quality

Basic seed is the progeny of breeder or pre-basic seed, and it is usually produced under the supervision of a breeder or his designated agency and seed quality control is done internally. However, the quality control should have normally been addressed by external institutions.

In Ethiopia, the responsibility of basic seed production has been entrusted upon ESE, RSEs, Regional Bureaus of Agriculture (BoA), and licenced private seed producers having the necessary infrastructural facilities. In principle, EIAR should have minimal involvement in the production of basic seed; however, the institute is forced to multiply this class of seed due to severe shortage of seeds in the country (Table 3). The basic seed of improved varieties of most crops produced by ESE is distributed to regional agricultural offices and other non-governmental organizations. For the last many years, it was challenging to fulfill the national demand for basic seeds. On the other hand, in the last two seasons, the demand for hybrid maize appeared to have been met through a crush seed multiplication program (Tables 3 and 4. In EIAR, the increase in basic seed production was observed on both cereals and pulses (Table 3), while in ESE an increase in basic seed production was seen only for cereals with the production of basic seeds for pulses and oil crops either remain the same or decreased.

Table 3. Basic seed production of (Q) major crops in EIAR over the last ten years (2000/01-2010/11)

Crops	**2000/01**	**2001/02**	**2002/03**	**2003/04**	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**
Cereals	6042.71	4438.95	3416.94	9443.39	9964.07	7117.4	6547.5	5663.64	5693.71	5977.6
Pulses	361.2	225.31	93.12	688.05	800.85	537.71	1082.59	1756.99	1191.73	1764.82
Oil crops	649.9	519.27	307.8	1046.85	735	848.17	491.49	1110.82	550	169.07
Total	7053.81	5183.53	3817.86	11178.29	11499.92	8503.28	8121.58	8531.45	7435.44	7911.49

Table 4. Basic seed production of major crops in the ESE over the last five years (2005/06-2009/10)

Crops	2005/06	2006/07	2007/08	2008/09	2009/10
Cereals	13900.18	12788.17	17979.35	22095.9	36690.53
Pulses	2223.76	1650.82	1399.42	2089.27	1718.26
oil crops	178.59	156	134.93	255.09	353.97
Horticultural crops	1.18	12.5	3.46	38.45	55.93
Total	16303.71	14607.49	19517.16	24478.71	38818.69

Human Resources and Physical Capacity

Human resources

Availability of qualified experts is key to ensure quality source seeds. In terms of qualified human resources, EIAR does not have trained professionals specialized in seed science and technology. In all the 14 federal research centers under EIAR there currently are about 220 employees involved in Technology Multiplication and Center Development (TMCD) program, and most of these are below diploma level (Table 5). Besides, there is little or no formal seed technology related research in the country due mainly to lack of seed technologists. This situation is not surprising since little attention was given to seed technology in the past. The current situation is likely to change such that at least one seed technologist would expected to be recruited for each research center. Based on the new draft TMCD study, about 870 personnel of various educational levels are needed in order to produce the standard quality seed. Moreover, the situations may change in the near future because Haramaya University has already introduced post-graduate program in seed science and technology, and some graduates are being employed.

Table 5. The current status of human power resources in the technology multiplication and center development program of EIAR

Research Center	Education level				
	PhD	MSc	BSc	Diploma	Others
Debre Zeit	1	1	1	1	16
Kulumsa	0	0	1	1	18
Melkassa	0	0	0	2	23
Holleta	0	0	0	2	7
Ambo	0	0	0	1	8
Jimma	0	0	1	4	29
Werer	0	0	0	1	34
Pawe	0	0	1	0	12
Assosa	0	0	0	1	5
Bako (Maize)	0	0	0	1	4
Forestry	0	2	2	4	100
Hawassa	0	0	0	1	1
Sebeta Fishery	0	0	0	1	1
Wendo Genet	0	0	0	1	1
Tepi	0	0	0	1	2
Total	1	3	6	22	261

Landholding capacity

Almost all research centers under EIAR have moderate size of land for both research and source seed production under rain- fed and irrigated conditions (Table 6). In the future, if the research centers are going to produce basic seeds of different crops the situation will not allow proper isolation distances. For instance, for the production of self-pollinated crops an isolation distance of 3 to 10 meters, while for cross pollinated crops 400-500m of isolation distance is necessary. In addition, in order to meet the current source seed demanded by growers, existing facilities for irrigation are insufficient and should be strengthen in shortest period of time. Therefore, to cope with the current demand of source seed, the available land size in each research center will not be enough until otherwise EIAR limit itself on the production of breeder and pre-basic seeds or avail additional land for the production of source seeds.

Table 6. Landholdings (ha) of research centers of EIAR

Center	Cultivated landholding (ha)				Total
	Rain-fed		Irrigated		
	Research	Seed multiplication	Research	Seed multiplication	
Holetta□	113.67	86.00	0.00	0.00	199.67
Debre Zeit	47.42	132.62	20.00	50.00	250.04
Melkassa	77.21	133.32	0.00	48.00	258.53
Kulumsa	76.00	347.00	10.00	20.00	453.00
Jimma	182.00	75.00	20.00	20.00	297.00
Werer	0.00	0.00	43.00	130.00	173.00
Wendo Genet	10.37	5.00	12.50	9.52	37.39
Bako	17.00	8.00	1.00	4.00	30.00
Ambo	-	-	-	-	0.00
Pawe	33.35	60.00	0.00	0.00	93.35
Assosa	20.00	203.00	0.00	0.00	223.00
Tepi	24.50	5.00	-	-	29.50
Sebeta	-	-	-	-	0.00
Forestry	111.50	244.30	16.00	0.00	371.80

Physical facility capacity

Seed processing facilities are instrumental for a better quality seed source production. The source seed processing involves drying, shelling, cleaning, grading, treating, packaging, and storage. Facilities related to seed production, processing and storage include combiners, shellers, seed processing machines, storage structures and packaging facilities. Other vital aspect of the seed industry is conditioning and storage, which must be adequate to preserve the physical characteristics of the seed specified by regulatory standards.

In EIAR, there are no full-pledged quality laboratories with required equipments and other facilities. The availability of these facilities varies from one center to the other. Some centers may have some of these facilities, but none have the complete set of facilities indicated above.

Overall, in order to be able to supply quality source seed sustainably all research centers should be strengthened with necessary facilities. These include seed cleaning machines of high standard suitable for processing small seed lots in all research centers designated to produce and supply source seed, seed storage facilities for short term (up to 18 months) and medium terms, farm machinery implements for proper seed bed preparation, crop management and harvesting. Provision of facilities such as tractors, implements, threshers, cleaning and grading machines, and seed treatment and dressing facilities is very important for all the centers. Seed packaging and labeling is another area of weakness, as bags at present are only in 50 and 100 kg sizes irrespective of farm size or seed rate. The bags are also unlabelled having no indication of physical quality or germination rate. Contemporary ideas on seed supply emphasize labeling as a way to build farmers' confidence on the formal seed supply and to help them identify which types of seed are likely to have physical and genetic value

Almost all research centers in EIAR lack mechanical post-harvest drying equipments and they rely on sun and/or air drying, and as such unexpected rains may lead to seed spoilage and low germination. Another vital aspect of the seed production is cold conditioning of storages, which must be adequate to preserve the physical characteristics of the seed specified by regulatory standards. Research centers sometimes need to store source seed for more than a year, and storage conditions need to be carefully maintained particularly keeping temperature and humidity at low levels. Unless these conditions are regulated, the viability of the seeds in storage can drop quickly, especially if the seeds are to be stored additional one or more seasons. Loss of viability is a major problem with particularly with maize, sorghum, wheat and pulse crops since the germination rates of seeds of these crops after some 6 months storage are often below 50%. As a result, the seed quality can be quite poor sometimes lowering the yield potential of the improved varieties to levels below the standards. This, in turn, increases uncertainty for seed producers about the quality of seeds from research.

Challenges of Quality Assurance

According to the next five years' growth and transformation plan of the Ethiopian government, availability of certified seed should be increased by 15% every year. To produce such amount of seeds, accessibility of quality source seeds is of paramount importance. However, with the resources and facilities currently available it will be difficult to attain the goal. Considering available land for source seed production by NARS, and the required isolation distance, i.e., 3-5 m for self pollinated and 400-500 m for cross polinated crops, it could be difficult to prodcue quality source seeds for more than 664 released crop varieties.

Despite EIAR's efforts to enhance source seed multiplication, quality maintenance, and distribution, the following limitations have been identified:

- Lack of proper planning and implementation of source seed multiplication;
- Standard varietal maintenance system is not fully in place;
- Inadequate demonstration and popularization of newly released varieties;
- Shortage of qualified personnel in seed technology for quality source seed multiplication;
- Lack of adequate facilities for internal quality control;
- Lack of adequate short- and long-term (cold storage) storage facilities;
- Lack of adequate irrigation facilities for the production of source seeds of improved varieties twice a year;
- Absence of seed research in the research system; and
- Lack of emphasis to train and produce professional seed technologists.

Conclusions and Recommendations

In Ethiopia, the present huge volume and the rapid growth in production and demand offers a unique opportunity for the development of the seed sector and trade in varieties and planting materials. Unlike grain production, seed production requires great care, more precision in procedures and more technical skill. In order to have access to quality seed, it is important to follow plant breeding rules and regulations; undertake systematic increase of the limited quantity of breeder seed to obtain larger quantity of seed to be distributed to seed growers; and introduce internal quality control procedures within NARs to ensure genetic and physiological quality of seed during the process of multiplication, post-harvest management, storage, and labeling until the time for subsequent sowing.

There is favorable policy framework with respect to variety release and registration mechanisms, but guidelines emanated from these regulations are not adequate. It would be essential to update and revise policy guidelines considering all crops and commodities and to standardize and improve seed laboratories to ensure dependable DUS and VCU tests in the release process.

Both the germination capacity and the status of the physical purity of the raw seed are important aspects of seed source quality. Seed lots with lower physical purity increase expenses through resulting in low volume of cleaned seed obtained and time consuming and inefficient seed cleaning and processing operations. Thus, raw seed tests need to be conducted for germination and physical purity as one measure to ensure source seed quality.

Quality seed production involves temporary storage and raw seed sampling, sample transportation to the labs and testing. The currently existing problems in this respect are serious since the subsequent operations are related to both quality of the seed and cost of production.

The institutions involved in the source seed production are EIAR, RARIs, HLIs, licenced private growers and MoA with the latter involved in the variety release system. For these institutions the main barrier is that there is lack of coordination both between and within federal and regional institutions. This barrier could be mitigated by defining responsibilities and by capacity building of staff in terms of both skills and facilities. In addition, some of the source seeds produced by research centers are either deficit or surplus due to inadequate planning. Therefore, there is a need to prioritize crops and varieties to be multiplied on the basis of national need.

Due to the lack of capacity to produce and supply source seed for all improved varieties, it is recommended that federal and regional research institutes should have to limit themselves on the production of breeder and pre-basic seeds while the responsibility of basic seed production ought to have fully been transferred to ESE, RSEs and private seed companies.

The last three years experience showed that the shift of reliance of source seed multiplication from rain-fed to irrigation cultivation can immensely fasten and increas seed production. Therefore, equipping and strengthening research centers with necessary irrigation facilities will have paramount importance.

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Forage Seed Production and Quality in Ethiopia

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Introduction

The potential of livestock to reduce poverty is enormous. Livestock contribute significantly to food production directly *via* the provision of high value animal products, and indirectly by supporting crop production through draught power and manure. Moreover, they are important sources of income and store of wealth for smallholder farmers, thereby providing access to food. In spite of the importance of livestock to the country's economy, the productivity is very low due mainly to feed shortage. Traditionally, livestock feed supply mainly depends upon natural pasture and crop residues, which have low crude protein and voluntary intake. However, there is tremendous potential to alleviate feed shortage using improved forage crops.

Cultivation of improved forage crops is not a traditional practice in the Ethiopian agriculture for the last many years. This was due to availability of large grazing areas and better carrying capacity. Over time, however, both the area and productivity of grazing lands have greatly declined due to expansion of cropping, disappearance of valuable species, spread of unpalatable species such as *Pennisetum shemperi* and land degradation which are associated with overstocking and overgrazing (Lulseged, 1995). These and the increasing demand for livestock products are the basic reasons for the start of cultivation of forage crops by smallholder dairy farmers in order to mitigate the feed shortage problem. Currently, farmers perceived improved forage production as feasible option for improving feed supply. This requires adequate supply of quality forage seeds, but unavailability of forage seeds associated with unaffordable price is one of the major constraints for fodder production. Therefore, forage seed production systems have to be stimulated for mitigating feed shortage in the country.

Various survey results indicated an increasing demand of forage seeds by smallholder farmers; however, to cater for the increasing demand forage seed production has not been adequately addressed by formal institutions like the Ethiopian Seed Enterprise. Moreover, forage seed aspect has not been adequately addressed by research. Consequently, lack of quality seeds of improved forage varieties has remained to be one of the limiting factors for improved forage production in Ethiopia. Very limited works have been done in the areas of seed production and seed quality aspects for some recommended forage crops. This paper provides highlights of the major forage crops recommended for the country and the status of seed production and seed quality aspects for selected forage species.

Recommended Forage Crops

Ethiopia has a wide ecological diversity and a huge wealth of biological resources. The complex topography coupled with environmental heterogeneity offers suitable environments for a wide range of life forms. The country is known to be the center of origin and diversity for a number of domesticated crops. During the last five decades considerable research effort has been made with main emphasis on introduction, evaluation, and selection of forage crops in different agro-ecological zones of the country. A wide range of annual and perennial forage species were evaluated in areas ranging in altitude from 600-3000 meters above sea level, and many promising species have been selected for high, medium, and low altitudes. The selected forage crops are generally well-adapted to the different agro-ecologies and high yielding, and have better quality compared to natural pasture. In addition to the forage germplasm evaluation, numerous agronomic and management studies on establishment methods, fertilizer and seed rates, sowing date and methods, harvesting date for forage and seed, frequency of harvesting, forage and seed yields were carried out, and appropriate cultural practices have been identified for these selected forage crops.

Most of the forage species are well-adapted and productive in the mid altitude areas followed by high and low altitudes. In the highlands, water logging, low temperatures and frost, soil acidity and poor fertility are some of the major reasons for poor performance compared to the mid-altitude areas. In the low altitude areas, few forage crops are adapted due to the harsh environmental and drought conditions. Some forage crops like *Chloris gayana*, *Panicum coloratum*, *Panicum maximum* and *Pennisetum purpureum* have wider area of adaptations in the different agro-ecologies. Generally, more than 44 forage species and varieties have been recommended for different agro-ecologies of the country (Table 1). Most of these forage crops are propagated by seed and few of them are propagated by vegetative means.

Many forage species and their varieties have not been officially released, but some of the recommended forage species have been cultivated by users in the different agro-ecologies. Out of the 44 forage species, only few species were registered (Table 2). Currently forage crops variety releasing procedures are drafted and official releasing is started, but this should be strengthened from different perspectives.

Table 1. Number of recommended forage crops in different agro-ecological zones in Ethiopia

Species	High altitude	Mid-altitude	Low altitude	Total
Grasses	>7	>12 (1*)	>3 (2**)	>19
Herbaceous Legumes	>5	>12 (1*)	>5 (5**)	>16
Browse Trees	1	>6	>3(2**)	>8
Root crops	1	-	-	1
Total	>14	>30 (2*)	>11 (9**)	>44

** Can also grow in high altitude areas; ** Can also grow in mid-altitude areas*

Table 2. Forage species and varieties registered

Forage species	Variety	Common name
Grasses		
Avena sativa	CI-8237	Oats
Phalaris aquatic	Sirossa	Phalaris grass
Pennisetum purpureum	ILCA 16984	Elephant/ napier grass
Chloris gayana	Massaba	Rhodes grass
Panicum coloratum		Colored guinea grass
Legumes		
Trifolium quartinianum		Clover
Vicia dasycarpa	Lana	Vetch
Lablab purpureus		Dolichos
Browse trees		
Chamaecytisus palmensis		Tagasaste

Forage Seed Production and Productivity

Production Technologies

Forage seed production technologies are very essential for the production of high quantity of quality seed. But, the technologies are not yet well developed for most of the forage crops under the Ethiopian conditions.

Identification of suitable forage production sites and land preparation are the bases for successful establishment of forage crops. Due to diverse agro-ecologies, some of the forage crops like lotus and fodder beet cannot produce seeds across locations, and identification of their proper niches for seed production is very crucial. Types of seed, soil, and weather conditions are some of the factors that should be considered during land preparation for forage seed production. Observations and long-term research experiences showed that forage crops which were established from seeds require fine, weed-free and leveled seed beds than the case of small seeded cereals like barley and wheat.

Seeding rates and sowing dates can affect the establishment performance, and they vary according to soil and environmental conditions, and the type of seeds. Increasing seeding rates secure better establishment but lower seeding rates may help to economize the scarcely available forage seeds. Most large-seeded annual forage crops require higher seeding rates compared to the small-seeded perennial forage species. For better establishment and productivity napier grass, tagasaste and fodder beet should be planted at 40-50 cm intra-row spacing in rows 75 cm apart, 50 cm within row spacing in rows 1 m apart and 20-30 cm intra-row spacing in rows 50 cm apart, respectively. Planting materials for vegetatively propagated species like Napier grass are stem cuttings, root splits and shoot tips which vary across agro-ecologies. Stem cuttings are suitable in warmer areas, whereas root splits and shoot tips are suitable for cold and wet conditions.

Forage crops are virtually sensitive when the sowing is too late due to high rainfall, and low soil and air temperatures in the highlands. Most small-seeded annual and perennial forage crops exhibited consistent yield reduction when sown late. This was also found to affect the subsequent yield performance of perennial forage species. Though early sowing at the onset of the main rainy season (June) is advisable, late planting of napier grass, oats and browse trees up to early July did not markedly affect establishment and yield in the highlands. Therefore, specific sowing date should be established for each forage species under different agro-ecologies to improve the establishment, and forage and seed yields.

Research results indicated that application of urea and diammonium phosphate (DAP) fertilizer support better establishment and herbage yield as compared to unfertilized treatment plots. Hence, a blanket application of 100 kg/ha DAP at planting of perennial grasses and legumes and 23 kg/ha nitrogen annually for only perennial grasses after the establishment year is the recommended practice in the highlands. On station trials at Holetta showed that application of backyard manure at the rate of 10-15 t/ha improved establishment and seed yield comparable to nitrogen application at the rate of 46 – 92 kg/ha. Small-seeded forage grasses and legumes should be sown shallow while larger seeded species such as vetch and oats could be covered in conventional ways similar to cereal crops such as wheat and barley. Studies in the highlands indicated that weed control has tremendous effect on the productivity of forage crops. For instance, hand weeding for annual forage grasses and legumes like oats and vetch or application of herbicides like 2,4-D for only grass species and scything (cutting both weeds and the forage seedlings together) for perennial grasses like rhodes and panicum in the establishment year could be used for weed control. After good establishment of perennial grasses, weed development is highly suppressed, and it only requires rouging out of major perennial weeds in the subsequent production years. For perennial forage crops like tagasaste and napier grass, hand weeding once a year during the main rainy season helps to obtain comparatively better yield in the production year.

Forage crops for herbage should be harvested at the proper stage in which one can obtain higher biomass yield and better herbage quality, and for most forage species this is normally at the early stages of blooming. Determination of proper harvesting stage for forage seeds is more complex compared to food crops due to unsynchronized seed maturity and seed shattering problems caused mainly by growth habit like indeterminate flowering conditions of some forage crops. Under Ethiopian conditions, post-harvest processing including threshing and winnowing are done manually due to lack of appropriate facilities. This not only makes the process difficult, but in turn it has also got its own effect on the total productivity and seed quality, and its subsequent utilization.

Assessing the estimated demand and supply of forage seeds at national and at different levels is an important aspect in designing the forage seed production schemes in a given locality. However, there is no much information on this regard. But the general trend showed that the demand for forage seed is increasing nationally while on the other hand the supply and distribution systems are very week, and the prices are very high. Therefore, encouraging both the formal and informal seed production system by providing the available necessary seed production technologies will assist create better market opportunities and awareness, and ensure sustainable seed supply systems in the country.

Seed Production and Productivity

Most forage crops in Ethiopia are cultivated for herbage/fodder purpose with very limited attention to seed production. Some of the problems associated with forage seed production are low seed yield performance, unsynchronized seed maturity, seed shattering and difficulty in threshing that consequently result in high cost of production. This in turn leads to high price of forage seeds which will encourage producers. Currently, very limited organizations including research centers, higher learning institutions, private seed enterprises, some smallholder farmers, and NGOs are involved in forage seed production. However, the production from the above organizations is far below the increasing demand for seed. Hence, it is high time to strengthen forage seed production and supply systems at all levels to tackle seed shortage and thereby enhance the production and utilization of the promising forage species.

Most annual forages produce higher seed yields and are easier to process and mange compared to most small-seeded perennials and browse trees. Research results indicated that annual forages such as oats, vetch, cowpea, and lablab can produce between 300 - 3500 kg/ha of seed depending on the location and agronomic practice employed. Management practices such as harvesting and post-harvest processing like threshing and cleaning are relatively difficult in small-seeded perennial grasses and forage legumes. These species have unsynchronized maturity and seed shattering problems. As a result, their annual seed yields are very low ranging from 50 – 400 kg/ha for species like Rhodes, panicum, phalaris and alfalfa. Hence, keen follow-up and collecting seeds at the optimum harvesting stage are essential to avoid seed loss. Browse trees such as tagasaste, sesbania, and leucaena are normally good seed yielders but have problems of hard seed coats and dormancy. Research results at Holetta showed that tagasaste yielded up to 300 g of seed per plant per year. Effects of methods of clearing re-growths of perennial grasses such as Rhodes and panicum on stubble and seed yields were also evaluated at Holetta (Table 3). Generally, both the grasses produced higher seed yields when stubbles were cleared by burning compared to cutting. Though burning has its own merits and demerits in pasture management practices, clearing by controlled burning could result in better re-growth and seed yield than cutting. It was also observed that early clearing before the start of the main rainy season is beneficial for vigorous juvenile regrowths and higher seed yields.

In view of the long-term efforts made by different research centers, recommended forage species have been cultivated, and small quantities of their seeds/planting materials have been maintained in the different federal and regional research centers. Forage species most comonly produced in different parts of the country and whose seeds are maintained in small quantities include oats, rhodes, phalaris, napier, panicum, cenchrus, andropogon, sudan grass, setaria, tall fescue, vetches, clovers, lablab, medics, cowpea, alfalfa, lotus, desmodium, stylosanthes, pigeon pea, leucaena, tagasaste and fodder beet (EARO, 2000)

Table 3. Effect of stubble clearing method on seed and stubble productivity of rhodes and panicum grasses (Getnet *et al*., 2004)

Clearing method	Stubble (DM t ha^{-1})		Seed (kg ha^{-1})	
	Rhodes	Panicum	Rhodes	Panicum
Burning	8.28	7.79	227.56[a]	145.15[a]
Cutting	8.20	7.62	204.10[b]	116.97[b]
Mean	8.24	7.71	215.83	131.06

Forage Seed Quality

There are a lot of quality parameters in forage seeds. Purity (physical and genetic) and viability (germination) are primarily important seed quality parameters, but other factors like moisture content, health, homogeneity and density could also be considered in seed quality measurements. Physical or analytical impurity is common especially in perennial grasses and legumes seeds mainly due to threshing and shattering problems. Difficulties in separating the seeds of rhodes, stylosanthes, alfalfa, and similar other from chaff, pod, and broken seeds due to unavailability of seed threshing and cleaning facilities may result in physical impurity in the seeds. In addition, weed seeds or other crop seeds can cause serious economic losses and diminish seed quality in most forage crops. Most of the forage crops are recommended at species level so that genetic purity is less important, but for cross pollinating forage crops such as alfalfa, and some browse trees like tagasaste and species which have many varieties like oats, the genetic purity is crucially important. Genetic purity or trueness to variety is established and maintained by special purification and seed increase programs in the field, seed inspections and pedigree records. Growers should realize that purchasing seed of unknown variety often leads to low yields, reduced stand life, and increased cost. Some of the reasons for genetic impurity are: 1) lack of skills and awareness on varietal differences and on management of pure seed production especially at smallholder farmers' level; 2) lack of seed quality control system including official variety release, control of genetic purity at field level, seed certification; and 3) absence of enough seed producing enterprises.

Viability (germination) is very important factor affecting forage establishment. Many forage seeds have seed dormancy, which means that mature and viable seeds do not germinate. Establishment performance of perennial forage crops is usually low due to poor seed germination and lack of proper seed treatment to improve germination. However, forage seeds have some desirable qualities as compared to seeds of food crops. These include the ability to be stored for longer period, and less problem of diseases and storage pests. Laboratory results indicated that loss of viability of seeds of different forage crops after five years of storage is very minimal for some selected forage crops (Table 4). Mean germination percentage of different forage seeds showed a decreasing trend over years but the rate is very low indicating that they have longer storage life. Alfalfa and vetch can be stored for more than ten years under cool room temperature conditions. On the other hand, small-seeded forage crops and seeds of some browse trees have generally low germination percentage due to problems associated with production management and seed dormancy. Each forage species has its own optimum seed harvesting stage, and early or late harvesting has a negative effect on seed germination. Lack of proper skills on post-harvest handling like threshing and cleaning can also result in low seed germination. Some forage crops have indeterminate growth habit which has a negative effect on seed quality unless the seeds are harvested at optimum harvesting stage. Environmental stresses such as frost, high temperature, and extreme moisture can also affect the germination potential of most forage seeds. The most important aspect of seed quality in relation to harvesting stage and post-harvest cleaning is experience and very keen management.

Some forage seeds such as phalaris, rhodes, panicum, setaria, clovers and browse trees have got dormancy problem due to inherent (mechanical and physiological) dormancy, chemical dormancy and enforced dormancy. Mechanical dormancy is caused by impermeable characteristics of the seed coat or mechanical restriction to air or water exchange. Physiological dormancy can result from incomplete differentiation of the embryo or embryo growth restriction due to after-ripening processes. Chemical dormancy is caused by inhibitory substances such as ammonia, hydrogen cyanide, alkaloids, ethylene and other compounds that prevent germination. Enforced dormancy (also known as environmental dormancy) describes the condition in which viable seeds do not germinate because of some limitation in the environment.

Several physical procedures are used to break seed dormancy by improving seed coat permeability. Mechanical treatments are used to scarify or physically break the hard seed coat of clovers such that water would be able to enter into the seed and the seed dormancy terminated. Soaking the seed of tagasaste in boiling water for 9-11 minutes is used to decrease the hardness of seed coat, and thereby increase the germination percentage from 3% (untreated seed) to 75%. Alteration of temperature from cold to warm or warm to cold initiates the enzyme activities of the embryo, and terminates dormancy leading to and hastened germination. Several chemicals treatments are also effective in promoting germination. Inorganic treatments such as acid, alkali or salt and organic chemicals such as dichloromethane, acetone, formaldehyde, and malic acid can disrupt the seed coat and improve germination. Soaking of the seeds in chemicals can be used to induce seed hormones and facilitate germination of forage crops. Several plant hormones can break dormancy. Giberellin is able to promote seed germination and kinin is able to terminate seed dormancy that is caused by abscisic acid.

Table 4. Germination (%) of seeds of different forage crops at different storage durations under room temperature and humidity conditions in the highlands of Ethiopia (HRC,1994)

Forage species	Germination over years of storage (%)				
	1st year	2nd year	3rd year	4th year	5th year
Phalaris tuberosa	64	51	34	39	31
Lolium perenee	46	33	14	20	21
Festuca arundinacea	68	43	51	26	36
Setaria anceps	7	4	2	2	3
Chloris gayana	28	23	19	17	17
Panicum coloratum	61	45	26	18	19
Panicum antidotale	20	9	11	7	9
Avena sativa	93	77	73	-	-
Medicago sativa	95	87	86	89	72
Vicia species	89	91	91	93	93
Mean	**57**	46	41	35	33

Conclusions

Production and maintenance of adequate seeds of well-adapted and recommended/released or officially registered forage species is fundamental to a progressive national forage development program. However, very less emphasis has been given to the forage seed aspect in the overall agricultural development activities of the nation. Growing, harvesting, and processing seeds of grasses and legumes require special knowledge and skills so that research activities with regard to these aspects should be initiated at national level to generate suitable and feasible technologies.

There is also a need to promote and disseminate the technologies to different stakeholders engaged in forage seed production. Currently, the demand for forage seed is increasing at an alarming rate, but the supply does not match the demand. Therefore, due concerns required in future forage seed research and production are development of suitable forage seed production technologies primarily in the areas of identification of suitable seed production sites for selected recommended forage crops; optimum seed harvesting stages; and adequate post-harvest seed processing and handling technologies. There is also a need for assessment of the national demand and supply for forage seeds, promotion of quality forage seed production for both domestic and export markets, and development of both human power and physical facilities in the area of forage seed research and development.

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Rice Seed Production in Cambodia

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Introduction

The most important crop in Cambodia is rice as it accounts for three-quarters of the cropping area and the annual paddy production is about 7 million tons. Cambodia-IRRI-AusAID Project (CIAP) assisted by International Rice Research Institute (IRRI) and Australian Agency for International Development (AusAID) has been trying to improve both the formal and informal rice seed production system in Cambodia since 1990. Before CIAP, farmers have been retaining their own seeds from their produce for a long time. But the private sector has significantly been involved in seed production since the implementation of Agricultural Quality Improvement Project (AQIP) by AusAID. In Addition, some community based seed production is emerging in several provinces.

This paper gives an overview of the status of rice seed production in Cambodia, and highlights the importance of linkage among stakeholders in the seed sector from the aspects of securing food supply and sustainable agricultural growth.

It also focuses on local initiative in seed production and distribution including prospects of community based seed producer groups. An example of productivity improvement project in Battambang is introduced to discuss the seed production and distributions system. Then, it discusses the public sector and donor-led interventions that enabled preferable environment to promote quality seed use among Cambodian farmers.

After pointing out some important issues in the rice seed sector in Cambodia, implications of the Cambodian experience to Ethiopian seed sector are discussed. One of the important discussion points is promoting quality seed user groups in the informal seed production and distribution system.

Cambodian Rice at a Glance

Cambodian economy is led by industrial and service sectors, although the rural economy is dominated by the agricultural sector specifically rice industry. According to Ministry of Economy and Finance (2009), the share of the agriculture sector in the total GDP was estimated at 33.5% in 2009. The share decreased from 34.3% down to 29.7% in 2007, but it recovered again over the last 2 years due to decreased gross value added in industry and services, and increased sales of agricultural commodities. The growth rate for the agriculture sector has been increasing at an annual average of 5.4% since 2006. It recorded 15.7% in 2005, but it experienced a diminishing growth rate of -1.9% in 2004 because of the decrease in wet rice production, which is subject to natural seasonal condition, contributes about 80% of total production. The country has been rice self-sufficient since the 1990's after the ending of the long domestic conflicts. The white rice surplus is estimated over 2.2 million tons in 2009 (Table 1). The average yield was 2.836 t/ha, and 2.620 t/ha for wet season rice and 4.126 t/ha for dry season rice. The reasons of continuous high output are the expansion of cultivated area including irrigated area, improved management of farmers including the use of quality seeds and fertilizer application, and good climatic conditions. There is a potential to increase rice exports if the general trade quality standard requirements are met by improving processing capacity and quality.

Table 1. Rice production in Cambodia from 2005-2009 (MAFF, 2010)

Parameters	2005	2006	2007	2008	2009
Cultivated area (× 10^3 ha)	2,443.530	2,541.443	2,585.905	2,615.741	2,719.080
Harvested area (× 10^3 ha)	2,414.405	2,516.415	2,566.952	2,613.363	2,674.603
Production (× 10^3 t)	5,986.179	6,264.123	6,727.127	7,175.473	7,586.870
Rice Yield (t/ha)	2.479	2.489	2.621	2.746	2.836
Rice surplus (× 10^3 t)	1,319.571	1,433.880	1,649.640	202.503	2,244.598

Seed Control Regulatory System

Legal Framework

Before the Seed Law, the existing legislations concerning variety and seed were Sub-decree on Standard and Agricultural Materials Management of 1998 and Law on Bio-safety of 2006. The Seed Law was passed by the national assembly in 2008. The first drafts were prepared in 2001 by Agricultural Productivity Improvement Project of World Bank (WB) in the Ministry of Agriculture, Forestry and Fisheries (MAFF), and it was revised and augmented by an Asian Development Bank (ADB) project in 2004/05. The law emphasised on plant variety protection (PVP) in considering membership of Cambodia in the Union for the Protection of New Variety of Plants (UPOV). The Industrial Property Department of the Ministry of Industry, Mines and Energy (MIME) was responsible for registering new variety under the plant breeder's right (PBR).

The process was unclear and the implementation was complicated due to two responsible ministries. In addition, the subsequent regulations under the Seed Law have not been put in place for the implementation of the Law. The Department of Agricultural Legislation is responsible for preparing laws and regulations. Regulations relating to more than one ministry must be signed by the Prime Minister, and it requires substantial efforts to get them done.

Organizational Set-up

Under MAFF, the General Directorate of Agriculture (GDA) has the overall responsibility for seeds and planting materials, and three crop related departments under the GDA are charged with the responsibility of preparing regulations to implement the Seed Law. The Department of Plant Protection, Sanitary and Phytosanitary is responsible for quarantine and plant material health. The National Laboratory of Agriculture (NLA) is involved in the testing of seed quality.

Seed certification is also a part of seed management and the responsibility is given to GDA. The seed testing can be done at the NLA, but the field inspection should be conducted at provincial level if efficiency for field visit is considered. Currently, Cambodia Agricultural Research and Development Institute (CARDI) and Super Seed Company are conducting internal tests for rice seed quality using their own standards.

Research and Development Organization

CARDI was established in 1999 and became operational in 2000 as a semi-autonomous body under MAFF after a long support of AusAID from 1988 to 2000 through the Cambodia-IRRI-Australia Project (CIAP). Additional assistance was provided by the Asian Development Bank (ADB) in terms of management and further facility development. CARDI is responsible not only for rice but also vegetable seeds and other crops including maize, legumes, and fruit crops such as mango. For vegetables, CARDI has a technical linkage with the Asian Vegetable Research and Development Center (AVRDC) in Taiwan.

Royal University of Agriculture in Cambodia is an educational institute considered as the leading university in the agriculture sector, but it is not necessarily mandated purely for research activities.

Rice Seed Production System

Seed for Cultivation

In Cambodia, open-pollinated varieties (OPV) of rice are dominantly used, and hybrid seeds are available only for some vegetables and maize. There is no seed production of genetically modified organisms (GMO) in Cambodia.

It is said that more than 90% of the rice seed is from informal sources, mainly self-retained seed or exchanged seed in the community. Farmers are keen to get better seed, but these informal seeds are without any treatment apart from simple drying. Consequently, the quality of the seeds is uncertain. In addition to the varieties released by CARDI, a Vietnamese rice variety is widely cultivated in the Mekong delta area of Cambodia for export to Vietnam.

Seed System

The existing rice seed system is not exactly ideal type (Fig. 1). As described above, the seed management including testing and certification is the sole responsibility of the GDA. Seed certification is another important responsibility of the government. In Cambodia, seed test is currently conducted by each seed producing organization as internal inspection. Some projects have supported improvement of the capacity of provincial departments of agriculture in terms of inspection of seed farms and testing for seed quality. Even for the seeds produced in the government institutions, the certification is not widely conducted as a formal process. Therefore, there is no formal seed quality assurance, and the terminology ‘certified seed’ is not appropriate to use.

Rice seed propagation is the responsibility of CARDI and national seed farms. As the national institute with breeding capacity, CARDI is mandated to reserve and maintain seed gene resources. However, CARDI provides not only foundation seed and registered seed but also certified seed and graded seed. MAFF has some national seed farms and they also provide certified seed. In Fig. 1, the “light” lines show the existing but not the preferable flow of seed to rice producers because the system is not working for seed propagation as its primary function.

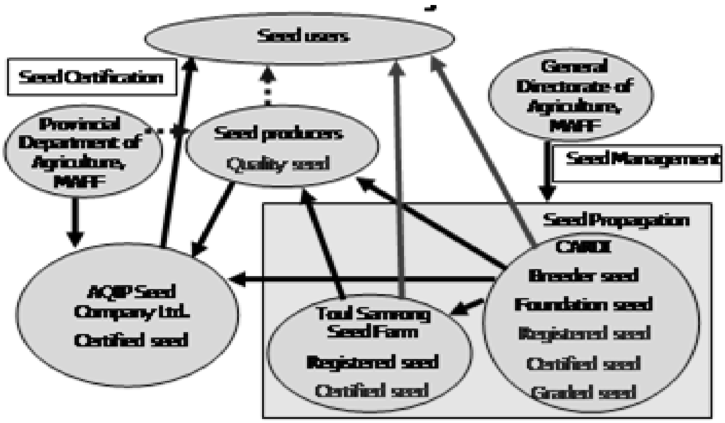

Fig. 1 Rice seed system in Cambodia

Seed production is being done formally and informally by three clusters, namely: government, private and community based. Formal seed production is done by CARDI and state seed farms such as Toul Samrong Seed Farm in Battambang province. The leading private seed company is Super Seed Company established by AQIP. Community-based seed production is basically done by farmer groups to provide seed to neighbouring farmers in several provinces. The blue dotted lines show existing informal interventions to be promoted if the access of certified and graded seeds to rice farmers is aimed to be improved.

Cambodia Agricultural Research and Development Institute (CARDI)

After CARDI started its research activities as a semi-autonomous body, the capacity of research could not be maintained. During the CIAP (1988-2000), 34 varieties were released while CARDI released only four rice varieties since 2000 and until 2010. On the other hand, all the four varieties were among the 10 recommended ones in 2010 as shown in Table 2, and the four varieties were appropriately emphase quality rather than quantity of varieties under current circumstances.

CARDI is also responsible for seed propagation for wide use of recommended varieties. CARDI provides foundation seed not only to government farms and stations but also to NGOs and other organizations to multiply seed for farmers. To operate the multiplication system, it needs to concentrate producing foundation seed and additionally registered seed to service providers. However, CARDI is currently producing certified seed and graded seed in order to generate revenue from their sales. In fact, CARDI is selling milled rice too.

The price for 1 kg of foundation seed and graded seed in the 2004 wet season were USD 2.5 and 0.4, respectively, while the price per kg of foundation seed, certified seed and graded seeds in 2010 were 3.5, 1.9 and 0.6 USD, respectively. CARDI does not consider variety and quality when pricing seed.

Government Seed Production

According to MAFF 2010, two governmental organizations, Toul Samrong National Seed Farm and Prey Phdao Research Station are involved in rice seed production, and their production areas in 2009 were 40 ha and 7 ha, respectively. Due to labor shortage, Toul Samrong produced rice seed using foundation seed from CARDI by trust direct seeding in 2005. The products were not suitable for registered seed production and most products were classified as certified seed. In addition, it seems that substantial areas were used for paddy production to generate revenue. If the government promotes more rice farmers to use certified seed, these government organizations should concentrate on seed propagation to supply registered seed for seed producers.

Table 2. Rice seed available at CARDI, January – July 2010 (MAFF, 2010)

Variety released	Seed class			
	Foundation seed (kg)	Registered seed (kg)	Certified seed (kg)	Graded seed (kg)
Sen Pidao (2002)*	0	0	176	1240
IR66 (1990)*	1000	0	530	4285
IRKesar (1993)	469	0	160	0
Chul'sa (1999)*	355	0	302	737
Rumpe (1999)	470	0	216	0
Phka Rumduol (1999)*	655	0	135	0
Phka Rumdeng (2006)*	411	0	130	608
Phka Rumchek (1999)	595	0	299	2243
Phka Rumchang (1999)	623	0	286	13
Phka Romeat (2006)*	1	0	60	127
CAR1 (1995)	292	0	0	1902
CAR3 (1995)	383	0	267	2488
Riang Chey (1999)*	276	0	223	0
Phka Chan Sen Sar (2009)*	13	0	0	0
CAR4 (1995)*	150	0	148	0
CAR6 (1995)*	207	0	44	0
CAR8 (1996)	200	0	0	0
Grand total	6100	0	2976	13642

**10 recommended varieties for wide use in Cambodia in 2010*

Seed Company

To improve rice seed supply, AusAid supported MAFF by establishing four private companies under Agricultural Quality Improvement Project (AQIP) in 1997. These companies were equipped with basic processing facilities such as dryers, seed cleaning machines, storage, and laboratory equipment. It was ideal to supply seed on a commercial basis in a competitive seed market, but seed demand was not as much as it was expected. They were forced to merge into a company with three operational sites to reduce administrative and management costs. The merged company is Super Seed Company (SSC) and its largest share holder is MAFF with 49% share, and others shareholders are seed growers' associations, company staff and trustees. It deals only with rice seed, and its current capacity of seed production and sale is about 3000tons per year.

Super Seed Company (SSC) has its own rice seed quality standards as shown in Table 3. The standard is similar to the one mostly adopted in Asian countries. The company is equipped with a modern seed cleaning machine; therefore, the inert matters are likely within the limitations of the standard if the machine is correctly adjusted and operated. The critical ones are contamination with other varieties, and that can be reduced by using CARDI foundation seed and by frequent off-type rouging-of operations in the field. The company sells out its product after moisture control usually within a year, and the germination rate is maintained at high level when sold to dealers, but the quality may not be maintained until sown in the paddy fields by farmers.

Table3. SSC's quality seed standard (%)

Factor	Commercial Seed quality (%)
Pure Seed (minimum)	98.00
Inert (maximum)	2.00
Weed Seed (maximum)	0.10
Total Other Crop Seeds (maximum)	0.10
Other Varieties (maximum)	0.20
Germination (minimum)	80.00
Moisture (maximum)	13.00

Source: Super Seed Company website

FAO/EU Food Facility Project (2010) reported SSC's management comment that expansion of the business was severely constrained due to inability to access credit. The report also mentioned that it provided only 2-3% of the seed requirement in the country, but it may be widely diffused if it is multiplied once more under some control. The strategy to increase seed sales of SSC are:

- recruit sales and marketing staff and train them to improve their skills;
- recruitment and strengthening of seed dealers network;
- increasing sales to NGOs and other institutions;
- sell in promotion (buy 10 get 1 free at the end of the season)
- sell with provision of incentives to dealers, farmers, agents and SSC staff;
- continue sales to the best clients; and
- sell other products (e.g. paddy and milled rice).

Recruitment and strengthening of seed dealers network is considered most important because the seed quality should be maintained until the end-users sow the seed in the field. By providing training to seed dealers and further training to farmers through seed dealers, the network would be maintained sustainably.

Another seed supply organization is Apiwat Bandanh Kasekar (ABK). It is an NGO established in 2007 aiming at positioning farmers, farmer groups and small and medium enterprises in the supply chain to create demand and deliver quality products by enhancing the competencies of all stakeholders in the supply chain (FAO/EU, 2010). ABK is focusing on market- oriented approach to purchase premium aromatic rice as paddy and export it as milled rice. The client farmers are required to buy seed for its production to maintain the quality with apparent benefits from the contract.

Community-Based Seed Production

Rice seed production associations and seed producer groups have been established in many rice producing provinces. Some of the groups in northwest provinces are listed and described on Table 4.

Table 4. Seed production by farmers'groups in Battambang and Pursat provinces

District	Province	Membership	Area or seeded amount	Production (t)	Year	Support
Bovel	Battambang	30	8 ha	28	2009	PDA**
Moung Russei	Battambang	21	120 kg		2010	EU
Banan	Battambang	10	7.5 ha	22.5	2010	JICA
Bakan	Pursat	584*	200 kg			CIDA

The group is for rice production but not necessarily all members are involved in seed production;
***PDA = provincial department of agriculture*
Source: Interview and personal communication

Most of these seed production farmers'groups are established by project activities. Some of them sustain their activities after completion of the projects. If the seed is traded within the community, there is no need for seed certification or ravelling. The producer groups usually use foundation seed from CARDI and the cost incurred is high, but users of the produced seed expect to pay less than commercially traded seed. The contribution of the community-based seed production to supply low cost seed is quite high.

JICA's Experience in Cambodian Agriculture

Battambang Agricultural Productivity Enhancement Project (BAPEP)

BAPEP started in April 2003 and ended in March 2006. It had four major activities, namely: (1) Capacity building of government personnel and strengthening the network of related organizations; (2) Improvement of rice production technology; (3) Diversification crops and improvement of farm management; and (4) Strengthening farmer organizations. The activities from (2) to (4) are undertaken directly with the target farmers aiming synergy among the different group activities.

Farmers have produced rice for centuries and the practice is considered sustainable. It is, however, necessary to adjust rice production to meet the recent demands under World Trade Organization (WTO). The quality of the rice produced in Cambodia is not so high due to the use of seeds with mixed varieties. Consequently, rice quality improvementis one of the most important issues to add value. It is necessary to show farmers how new or improved methods of rice production are technically feasible and profitable. Kamping Puoy Agriculture Development Center (KADC) has been strengthened in terms of capacity during the project to conduct experiments on management aspects such as plant density, planting period, fertilizer application and so on. Farmers can select the most suitable rice varieties for production by evaluating rice varieties grown in the demonstration fields of KADC. More than 20 varieties having technical data based on experimental results at KADC were provided to farmers in the target area for practical comparison. In addition, farmers examined the taste of cooked rice of several popular varieties in the area to evaluate commercial values. After the farmers' decisions, KADC produced registered rice seeds for seed growers and initial graded seeds for neighbouring farmers as quality seed users.

BAPEP conducted Farmers Field School (FFS) on rice production for the group members during a whole cropping season. In the 2004 wet season, the average yield of the group members reached 4.2 t/ha while it was only 2.8 t/ha in 2003. The major reasons for achieving this result were the use of high quality seed, pre-screening of seed by gravity, efficient irrigation, and better crop management including transplanting young seedlings, timely fertilizer application and timely harvesting.

BAPEP's Seed Production and Distribution System

BAPEP took a group approach to improve rice cultivation techniques based on the village community and sub-groups of Farmers Water Users Association (FWUA). Among the group members who had better cultivation skills, each group selected some members as seed growers. This was important for the members such that the quality of seed produced by the selected seed growers is assured.

The project provided registered class seed propagated at KADC to the community seed producers at low prices. BAPEP conducted a season-long training for seed growers amounting to 4 persons in 2004 and 6 persons in 2005. They produced 1890 kg in 2004 and 2520 kg in 2005. Quality seed users' groups were formed to establish a micro-system of seed production and distribution among neighbouring farmers. The produced seed was used for renewal by 14 persons in 2004 and 69 persons in 2005. BAPEP also invited rice millers to provide market information to the farmers on field days organized. The group visited a rice miller to know the importance of rice quality improvement and they examined how rice quality is determined by using some test procedures. The most important criterion of the produced rice for the rice miller was moisture content that influences performance of milling machines. The advantage of quality seed is to assure purity of produce, but the rice millers would not pay much attention to contamination of other varieties unless that contamination is with red rice. Therefore, it is not highly promotional to use certified seed for farmers if the seed price is expensive. The produced quality seed was traded with two bags of paddy for one bag of quality seed. The rice miller could provide price incentive to farmers for the produced rice that meets evaluation criteria when using quality seed. Then, they could make a contract with the rice miller to sell the produced rice at a higher price than the ordinary market price, and more than 10 members benefitted from the contract sale. Other members also benefitted by getting bargaining power with quality production assured from the quality seed. The seed producers sustained their activities and increased their seed production in Banan district.

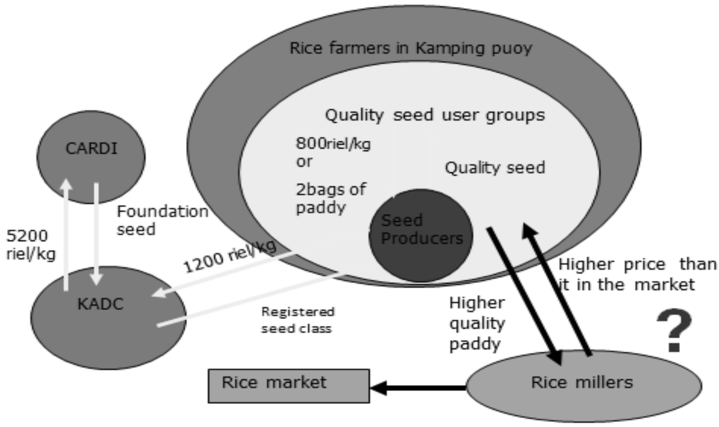

Fig. 2 Seed production and distributions system in BAPEP

Battambang Rural Area Nurture and Development Project (BRAND)

During BAPEP, agricultural extension officers were not directly involved in the project because no extension officer was assigned for the area. Therefore, the second phase of the project, aimed at strengthening the extension capacity in order to disseminate the rice technology developed by BAPEP to other areas. The purpose of the project was ‘enhancing agricultural service delivery to farmers in the target communes’ and the overall goal was “improved farming system of farmers in the target districts in Battambang Province.” In addition, ‘collaboration among parties involved in agricultural production, marketing, and policies’ comprised one of the project outputs. BRAND and PDA led the province to establish Battambang Rice Promotion Committee (BRPC) to start Battambang Brand rice, and it was approved by the governor. Some members of the rice miller association belong to BRPC, and they shipped Battambang Brand rice to the market through an antenna shop in Phnom Penh. BRPC must have a clear mission statement that expresses the committee’s aim to promote regional economies based on sustainable and pro-poor growth as a fundamental principle. Upon recommendation, BPRC invited representatives of seed growers and farmers as members of the committee to establish the relationship described in Fig.3.

The diagram shows the roles of public sector in the promotion of branded rice. More attention should be paid to the future direction of Battambang brand rice marketing through BRPC's activities. This is because the activities might create some negative impacts if they accelerate increasing economic gaps between traders and producers. It should give the right direction to the concerned organizations by authorizing standards and certification as well as protecting farmers by providing informative guidance at the early stage of value chain formation.

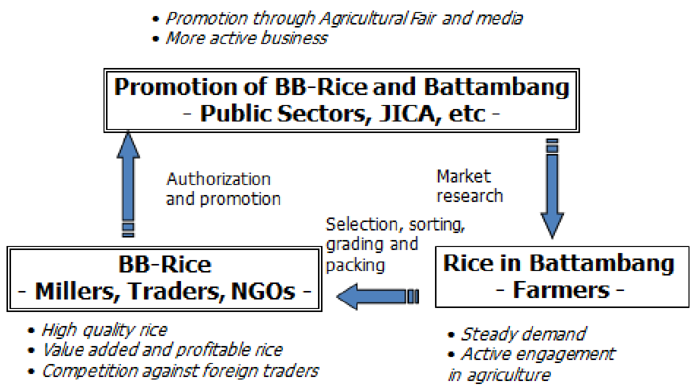

Fig. 3. System diagram to promote Battambang Brand rice

Issues on Seed Production

Official Seed Quality Standard

Preparation of regulations is needed to implement the Seed Law in Cambodia. One of the most critical issues is to officially standardize seed quality under the law such that it will be used among all concerned organizations. This is the basis of fair commercial trade of seeds. Seed certification is vital to sustain quality products. To maintain the quality of seed, it is necessary to establish laboratory testing based on the quality standard such as germination and purity, and to implement field inspection systems at least in the major rice producing provinces.

Seed Production and Distribution

Seed production and marketing should be conducted on a commercial basis by private companies, seed growers, seed traders and rice millers. These stakeholders should actively promote quality seed of recommended varieties together with improved crop production technology and market linkages for the produced paddy. The system would be maintained by diversified seed supply channels to farmers at minimum cost and subject to maintaining seed quality.

It is easy to widen the use of quality seed if the market is assured similar to that for the imported Vietnamese variety. The farmers produce paddy with seed provided by traders or rice millers. The farmers are assured to sell their paddy to traders at an agreed price, but it is sometimes lower than the farm-gate price in the same area. They are forced to sell particularly if they had borrowed money for obtaining fertilizers. Assuring sale of produce is important for farmers when they produce paddy.

To increase supply of rice seed and improve access of farmers to quality seed, CARDI needs to continue providing foundation seed and registered seed until some organizations start to produce registered seed for seed producers. Since CARDI is expected to concentrate on research and development as defied in its original terms of reference, its present seed business may sooner or later be transferred to private sectors or NGOs.

It is profitable for seed growers if they produce high value seed at low cost. When seed is distributed to end-users, it is critical for paddy and seed to be distinguished. The government sometimes supplies seed as emergency measure to farmers at a lower price than the market price, if not free of charge. This distorts market system of certified seed, and it should be avoided by providing seed to the market and milled rice to farmers for emergency food.

Community-Based Seed Production

To promote quality paddy production, it is necessary to increase the number of quality seed users. The approach is to create quality seed users before quality seed producers. When quality seed users are formed as a group, it assures the use of seed among the group members. It is desirable to capacitate seed producers on private business-bases to sustain the system.

Local seed producers with limited capacity usually provide low quality seed at low price, and farmers outside of the community are not confident in the quality of seed produced locally even if the quality is at satisfactory level. Therefore, it is necessary to have in place a system of authorization or certification of quality seed produced in the community by an independent organization so as to be able to sell the seed to external persons.

Implications for Ethiopian Seed Sector

Food Security *versus* Plant Variety Protection

Plant variety protection is an international issue, but it is relatively less important in Ethiopia because commercial seed development is less active at this moment. Ethiopia is seeking for food self-sufficiency; therefore, the seed related issues should be emphasized from the aspects of food security. This means that varietal development by the government institutions should be relatively focused on grain commodities rather than vegetable and other industrial crops. It is also noted that most of grain crops are not considered as cash crops so that private seed companies usually do not work on grain crop variety development. Some of the important factors for seed development are productivity and stability in grain production if the majority of farmers are subsistence farmers. When more farmers are seeking trading, consumers' preference should be examined as one of the key factors of variety development for ensuring marketing. The private sector will be interested in variety development considering consumers' preference, if the market is commercially matured. That is the time when private sector takes part in. Rice is one of the growing potential crops for cash income in Ethiopia, and rice seed development will be potentially privatized considering market preference in the future.

Formal *versus* Informal system

At present, the quality of farmer-retained seed is uncertain. However, community-based seed production is a relatively good low-cost system that can maintain quality of the seed to a level satisfactory to neighbouring farmers. The informal system is able to supply quality seed to a wide range of customers such as neighbouring farmers as well as unknown customers, if certification is provided by an independent organization. There must be a simple local seed certification system that assures the buyers in the local markets. It is important to recognize the fact that the informal system can play a better role if there is support from the government. This can be done by providing quality assured propagated seed from the formal system to informal system. This is the government intervene to upper stream of quality seed production. In addition, seed distribution is another issue to have wide dissemination of quality seed. Formal system can cover nationwide market while informal system can serve for limited locality.

Seed Producers *versus* Seed Users

There are seed growers who can supply quality seed, but it is difficult to find end-users who demand quality seed through the informal system. In Cambodia, there is a strong demand from farmers for quality seed, but the community-based seed producers cannot sell all the seed they produce. There is a market matching problem in Ethiopia too. The experience of quality seed users group may be applicable for expansion of the seed markets especially for grain crops such as rice and tef.

Farmers' Response to Variety or Quality

Unlike subsistence farming, where the producers and consumers are identical, commercial farming needs to understand the demand of consumers. Consumers are conscious about food quality but not about seed quality. How can consumers identify the food quality if it is grain? Consumers are often interested in visible images such as grain damage, colour and size.

Farmers are keen about variety if it gives different visual images that attract consumers. In fact, it is critical for farmers, if consumers are willing to pay extra-money for better quality products or not. Unless farmers find tangible benefits by using quality seed, they are conservative and use their own retained seeds. The value chain approach should be extended back to the seed by assuring quality of seed which is the initial point for engaging purity and traceability from the field to the market.

Conclusions

Research on seed is sometimes translated among researchers simply to mean variety development. Government research organizations are not supposed to continue vegetable breeding activities once it can be done by private sector as a part of the commercial seed business. In Ethiopia, the private sector for vegetable seed is yet to take off. Besides, EIAR together with regional research organizations must maintain the lead responsibility for variety development trials taking into account the diverse needs of the Ethiopian farmers for food security.

To reach the farmers' needs, the seed propagation, seed production and seed distribution systems should be realigned. Government should support and strengthen existing players in the seed sector to encourage and utilize informal seed production and distribution system. Considering the large part of seed supply by informal system at the farmer and community levels, training should be provided to improve the management for informal seed producers. To have a more sustainable seed supply system, it is vital to have a commercial system for some crops. It is also important that the government should give focus on improving access to market information for seed securing market matching. The coordination is essential to ensure the activities that all stakeholders contribute to the overall goal of building an effective and efficient seed industry for the country.

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About FRG II

THE PROJECT FOR Enhancing Development and Dissemination of Agricultural Innovations through Farmer Research Groups (FRG II Project) is to enhance the capacity of researchers to take part in innovations through farmer research group approach (FRG approach). Implemented by a technical cooperation between Ethiopian Institute of Agricultural Research (EIAR) and Japan International Cooperation Agency (JICA), the FRG II covers all the agricultural research institutions in the country through training on the approach, financing FRG based research projects in selected priority research areas and filling gaps and enhance linkages between research and extension through delivery of technical information. For more information, visit

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