Seed Trade Liberalization and Agro-Biodiversity in Sub-Saharan Africa

MICHIGAN STATE UNIVERSITY

Michigan State University
International Crops Research Institute for the Semi-Arid Tropics

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Abstract

This publication examines seed trade liberalization in Africa, identifies lessons learnt during earlier liberalization efforts, and discusses the impacts of liberalization on agro-biodiversity. ICRISAT and Michigan State University collaborated on an FAO-funded project to study these issues, with a view to strengthening ongoing government efforts to reform and harmonize seed policy and seed trade regulations in various regions in Africa. These are the proceedings of the end-of-project workshop held at Matopos, Zimbabwe, during 5-6 Dec 2002.

The proceedings review the status of seed policy reform in West Africa, East Africa and Southern Africa; discuss lessons learned through an analysis of the reform process; and identify and prioritize follow-up activities. An economic model is also presented, as a framework for analyzing the costs and benefits associated with various reforms, for example regional registration of new varieties, harmonization of phytosanitary laws; and appropriate strategies for national and regional plant breeding programs.

The reform and harmonization process is relatively advanced in East Africa, and could provide a model for other regions. But key issues still remain to be addressed. In East Africa, technical agreements established during earlier discussions need to be implemented, and the reform process extended beyond the three countries currently involved. In Southern Africa, such technical agreements are yet to be established. In West Africa a coordinating agency must be identified, to guide the reform process, and governments must strengthen the almost non-existent private seed sector. Capacity building will be needed in all regions, in order to effectively implement reforms.

Seed Trade Liberalization in Sub-Saharan Africa

Proceedings of a workshop

5-6 Dec 2002

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Editors
David Rohrbach and Julie Howard

ICRISAT
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PO Box 776, Bulawayo, Zimbabwe

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Conference Report

David Rohrbach[1] and Julie Howard[2]

1. Principal Scientist (Economics), ICRISAT, PO Box 776, Bulawayo, Zimbabwe. 2. Asst Professor of International Development, Michigan State University, MI 48824, USA

ICRISAT and Michigan State University collaborated on an FAO-funded project to investigate the impacts of seed trade liberalization on access to and exchange of agro-biodiversity. The project also focused on ways to strengthen ongoing government efforts to reform and harmonize seed policy and seed trade regulations in various regions in Africa. These workshop proceedings review the status of seed policy reform in each region, discuss lessons learned through an analysis of the reform process, and identify and prioritize follow-up activities.

The proceedings contain (i) a conference report summarizing project results and the key issues raised at the end-of-project workshop, (ii) papers presented at the workshop, on various aspects of seed policy reform in East, West, and Southern Africa.

Background

This report summarizes the proceedings of an end-of-project workshop on seed market liberalization in Africa, held 5-6 Dec 2002 at the Matopos Research Station just south of Bulawayo, Zimbabwe. The meeting brought together project team members and a few key African stakeholders, to review project results, confirm some of the lessons drawn, and prioritize follow-up activities.

The project to investigate the *Impacts of seed trade liberalization on access to and exchange of agro-biodiversity* was funded though FAO under a Letter of Agreement with ICRISAT signed in March 2002. The main aim was to strengthen the discussions on seed regulatory harmonization in Africa by analyzing the policy changes designed to harmonize and liberalize regional seed markets. This involved four main activities:

- Comparative review of discussions and agreements on harmonization of seed laws and regulations in East, West, and Southern Africa
- Case study of the perceived costs and benefits to more liberalized seed trade in Southern Africa

- Case study review of justifications for and potential impacts of regional variety registration in Southern Africa
- End-of-project workshop to discuss implications for seed trade policy.

This report briefly reviews the results of the end-of-project workshop and summarizes results from project studies, highlighting the major issues raised. Some of the analytical findings are discussed; more detailed results are presented in the papers in later sections of these proceedings.

Harmonization of Seed Laws and Regulations in East, West, and Southern Africa – Comparative Review

During the last few years, regional discussions have been held in East Africa, West Africa, and Southern Africa regarding the harmonization of national seed regulations. These discussions, still ongoing, have made variable progress towards achieving harmonization.

West Africa

A presentation on West Africa (pages 148-166) discusses progress on different aspects of harmonization of seed regulations in the region; efforts to develop a regional variety catalog, common phytosanitary standards, common field inspection and seed quality standards; as well as interest in trade agreements facilitating seed flows.

These agreements have been complicated by the multiplicity of institutions involved in discussions, often independently of one another – the West African Economic and Monetary Union, the West Africa Seed Network, the West and Central African Council for Agricultural Research and Development, and the Institut du Sahel of the Comite Inter-Lutte Contre la Secheresse au Sahel. These efforts involve different groups of countries and issues. Currently, there appears to be no coordinating body or central repository for information about these diverse efforts.

Progress in regulatory reform has also been affected by the lack of seed policies and seed legislation in a number of West African countries. Even where legislation is in place, it is not consistently enforced.

Suggestions were made to create a central forum to improve coordination and information sharing. Concerns were also raised about the need to move quickly from agreements (in principle) to actual implementation of regulatory reforms in each participating country. This may require capacity building investments as much as policy analysis.

East Africa

The presentation on East Africa (pages 104-123) reviewed the history and progress of harmonization discussions, and highlighted some of the apparent explanations for the gains achieved to date. Specific agreements are already being implemented on variety release, phytosanitary controls, seed certification, seed trade, and plant variety protection. Regulations and seed laws are in the process of being redrafted in Kenya, Uganda and Tanzania. A 'second tier' of East African countries is being encouraged to adopt similar reforms.

The speed and level of gains achieved to date are related to:

- the fact that only three countries and a few crops were initially targeted
- the free trade agreement of the East African Community
- strong preparatory work (eg, appointment of national resource persons) and support for national technical committees
- strong private sector involvement
- the articulation and monitoring of specific technical agreements, rather than simply agreements in principle for reform
- leadership from regional organizations such as ASARECA.

Nonetheless, several challenges remain. Drafting of new legislation and some regulatory reforms has been slower than expected. This has raised fears about backsliding on commitments to liberalize national seed sectors. Continuing external funding will be necessary to support ongoing national and regional negotiations, to monitor the process, and to expand these agreements to cover countries outside the East African community. Another concern is that broader issues of seed sector development still need to be tackled. Regulatory harmonization and liberalized trade may primarily benefit commercial markets for maize seed. Additional investments will still be necessary to develop seed markets for other crops.

Southern Africa

In Southern Africa (see pages 124-147), efforts to promote seed sector reform have a longer history of a broader range of discussions. Issues of seed security and seed sector development have attracted as much, if not more attention, as regulatory harmonization per se. There is agreement in principle on the value of regulatory harmonization, but this has not yet been translated into specific technical agreements. The SADC Seed Security Network plans a series of technical meetings on regionalized release, phytosanitary controls and seed quality control in early 2003.

Several possible justifications were discussed for the more limited progress to date in Southern Africa. These include the lack of consistency in funding for national and regional negotiations, and the lower priority for regulatory changes, as opposed to improving regional seed security and broadening national seed markets. Many of the regional meetings have spent as much time discussing strategies for community seed supply, local seed systems and seed security, as on regulatory changes per se.

The workshop discussed the possible value of placing future harmonization discussions within the context of seed security rather than simply as an effort to facilitate commercial trade. Regulatory changes must also take account of the substantial investments made in many SADC countries in developing informal seed sectors or local community seed systems. In this context, government seed services will likely need to shift from an emphasis on regulatory controls, aiming instead to facilitate the production and trade of adequate quality seed of a wider range of crops. To do so, they will need to encourage truth-in-labeling and provide training, rather than simply provide legal coordination.

Lessons Learned

Ten major lessons were derived from these regional reviews.

Lesson 1. Seed regulatory harmonization is more likely if based on clear agreements on strategic priorities for national and regional seed trade, security and sectoral development. These priorities may differ across regions. For example regional commitments to free trade may be a priority in East Africa, while Southern Africa may primarily target seed security.

Lesson 2. Policy harmonization is necessary but not sufficient for national and regional seed sector development. Initial benefits may accrue to a few commercialized seed crops. Broader public and private investments will be needed to improve seed security and seed access in rural communities.

Lesson 3. Lack of coordination among seed policy discussions is retarding progress. This appears more a problem in West Africa, and perhaps Southern Africa, than East Africa. Agendas change from meeting to meeting, making sustained progress difficult. This may result partly from the lack of sustained donor funding for a multi-year process of negotiations and legislative/ regulatory reform within each region.

Lesson 4. Progress in harmonization is facilitated by starting small, and focusing on achieving specific technical agreements. Agreements among a sub-set of countries for a sub-set of crops can provide a strong foundation from which to build. Agreement is more likely if these countries have similar regulatory frameworks to start with. They should also have a commitment to liberalizing their trade. Similarly, regulatory changes are more likely if the discussions are led by local institutions, and focus on achieving specific technical reforms within a limited time period.

Lesson 5. Policy harmonization does not necessarily lead to trade liberalization. For example, the UEMOA harmonization agreement in West Africa established a common tariff barrier to seed trade.

Lesson 6. Harmonization discussions can stimulate quick gains through rationalization of national regulatory procedures. Commitments to harmonization and trade liberalization have led to the establishment of simplified trade documentation and one-stop trade shops in East Africa. These are already encouraging expansion of seed trade.

Lesson 7. Agreements to harmonize only constitute a first step toward reform. They must be backed by legal assistance, training, and monitoring of the implementation process. Many national seed authorities lack the resources needed to draft new seed laws. External support, and a study of legal frameworks in neighboring countries, can speed this process. Implementing new regulatory and legal frameworks also requires long-term commitment to re-training of seed personnel. Continuous monitoring of this process can highlight problem areas and resolve questions about the reliability of efforts in neighboring countries.

Lesson 8. Larger benefits may be achieved from regulatory harmonization if the contributions to seed security and expanded seed trade are explicitly targeted. Components of regulatory agreements can help expand trade and improve seed security. These components – regional variety lists, standardization of trade documentation and procedures, reduction of phytosanitary barriers – should be highlighted.

Lesson 9. Dialog between scientists and policy makers is essential for harmonization and regulatory change. This dialog can be facilitated by documenting the gains to liberalized or harmonized trade, quantifying the economic costs and gains, through policy briefs, and through purposeful

engagement in policy dialog. Priorities for analysis should be jointly determined with policy makers.

Lesson 10. The role of government needs to change from the current focus on regulatory control to a focus on facilitating market development. National seed services need to invest more in sharing information about seed supply and demand, promoting and monitoring truth-in-labeling, and training to improve the quality of seed production. Public-private partnerships should target the expansion of retail seed trade of a wider range of crops and varieties.

Costs and Benefits of Liberalized Seed Trade

The limited timeframe and resources of this project did not allow for a detailed analysis of the costs and benefits of liberalized seed trade. A paper was presented outlining a framework for such an analysis (pages 37-65). This highlighted linkages between the liberalization of national seed markets and regional seed markets. It also noted the complexity inherent in making a discrete set of decisions relating to a diverse agenda – regulations on variety release, sale, property rights, quality control, and trade. As a result, there are no examples of published studies measuring the impacts of regional regulatory harmonization. A few studies have sought to measure the impact of liberalizing national markets, but even these draw broad inferences from the correlation between liberalized rules and the evolving patterns of seed trade.

Ultimately we face a decision whether to pursue a more quantitative analysis of the impacts of harmonization, or a more qualitative assessment of the likely gains and losses. This decision is complicated by the fact that harmonization has not been comprehensive enough, or implemented for long enough in any region, to measure ex post impacts. Consequently, we would still have to assess the likely impacts on an ex ante basis. Further, it may be difficult to disaggregate the impacts of domestic market liberalization from the impacts of regional harmonization per se.

Given these complications, the meeting suggested the value of first pursuing a more detailed qualitative analysis of the costs and benefits of harmonized and liberalized seed trade and to assess the order of magnitude of these costs and returns. The results could inform efforts to monitor the reform process.

The meeting also noted that this analysis could be conducted either for individual reforms or for a large group of reforms. For example, separate analyses might focus on the likely impacts of regional variety lists, or

harmonization and liberalization of phytosanitary controls, or standardization of trade documentation.

However, uncertainty persisted about the relative value of this sort of analysis. There was not unanimous support for the original suggestion (proposed at the beginning of the project) that more information on costs and benefits could strengthen political support for harmonization. Hence the need to clarify (through dialog with policy makers and others) what information and analysis is most sought by policy makers.

Justification for and Potential Impacts of Regional Variety Registration

A third component of the project examined the case for regional registration of varieties. Regional registration is expected to contribute as much as any regulatory change to the development of more regionalized seed markets. Efforts have been initiated in both East and West Africa to establish regional lists of varieties released for sale in more than one country. This has been accompanied, in East Africa, by an agreement to reduce the period of pre-release testing to one year if a variety has already been released in a neighboring country. In Southern Africa, an agreement has been fashioned to consider the value of regionalized variety registration on its own.

Two presentations discussed the regionalized breeding efforts of international research centers and seed companies in Southern Africa. An economic model was also presented, for assessing the contributions of regionalized variety registration.

There is broad agreement that wide adaptation is feasible and practical in internationally oriented crop breeding programs. While individual breeders argue that their target zones are distinctive, there is only limited evidence of larger yield gains derived from pursuing narrower adaptation. Instead, substantial evidence exists for multi-country releases. The performance of many of these varieties is highly competitive with varieties bred by national crop breeding programs.

The discussion noted, however, that such gains may be partly because international programs have more resources and access to a wider range of germplasm. If similar resources were allocated to location-specific breeding, larger gains might be available here. This may also depend on the crop considered.

The two presentations also suggested that pursuit of wide adaptation is economically efficient, allowing faster productivity gains across a larger number

of farmers. The larger target population may also encourage greater private sector investment in the development and dissemination of new varieties.

Two constraints to more regionalized breeding and seed markets were noted. First, narrower adaptation may result from the limited distribution of pests and diseases. However, breeding targeted by agro-ecological zone can still be complemented by efforts to incorporate resistance to location-specific pests.

A larger concern is that large breeding programs or seed companies could dominate weak ones. The question was raised – how can regionalized breeding and variety registration be sold to smaller national agricultural research systems (NARS)? Regional coordinating bodies may need to pursue a deliberate strategy of strengthening smaller NARS and facilitating their access to regional germplasm. Greater investments in networking across national breeding programs may be necessary to build trust and allay fears of domination by a few entities.

Ultimately countries need to choose between strengthening links between a number of national seed markets, versus developing a single regional seed market. The group agreed that the latter is likely to be more productive than the former. However, this will require a significant shift in the orientation of most NARS programs. This shift may be easier, initially, with crops of secondary importance.

Seed Supply and Agro-Biodiversity

In general, regulatory harmonization and expansion of seed trade is expected to have a favorable impact on agro-biodiversity, at least in the short to medium term. Expansion of seed trade will improve farmers' access to a wider array of varieties. This could change if the seed industry becomes substantially concentrated. However, available data at national level show that seed market liberalization has led to more companies offering seed of more crops and varieties.

One presentation considered the more immediate effects of emergency seed distribution on agro-biodiversity using data collected from areas of Mozambique that had been affected by flooding. Seed had been widely distributed to flood-affected households to enable them to re-establish farming. This analysis is still underway, but the initial results of interviews with farmers suggest little if any loss of crop and varietal diversity. Farmers quickly gained access to varieties from neighbors unaffected by flooding (eg those in upland areas) and seed traders from more distant communities. Seed fairs were identified as a means to facilitate this trade.

Larger concerns were raised with the ad hoc nature of emergency seed delivery systems commonly employed following droughts. Since countries rarely plan ahead for emergency seed needs, government and NGOs often respond by simply dumping seed. This disrupts efforts to build rural seed markets, and encourages the distribution of a narrow range of more commercialized crops and varieties. Liberalization of regional seed markets and harmonization of regulations may speed the flow of varieties to farmers. However, better planning to improve seed security per se could also facilitate the distribution of new varieties of a wider range of crops.

The meeting also briefly debated the financial incentives for genetic diversity. Greater gains may be made by strengthening regional genetic resource centers as repositories of a wide range of germplasm, and encouraging broader use of this germplasm in crop breeding programs. As farmers become increasingly commercialized, individual incentives to maintain a wide range of crops and varieties may decline.

Future Agenda for Policy Advocacy, Research, and Development Activities

Representatives from East, West, and Southern Africa were then asked to summarize some of the implications of these analyses for their regional deliberations on seed policy reform.

East Africa

Isaac Minde from ECAPAPA suggested these analyses had reaffirmed the regional decisions to promote national consultations followed by regional consultations linking technical analysis with policy discussions among a wide range of public and private stakeholders. Further capacity building is needed at technical, legislative and policy making levels. Questions remain about the breadth of impacts of harmonization – whether impact will be limited to a few crops such as maize, or whether larger markets will encourage investment in seed sales for secondary crops as well. This implies the need to re-examine the relationship between the formal and informal seed sectors. Interest was expressed in examining how regionalized registration of varieties may complement recent efforts to establish regional variety lists. Interest was also expressed in more economic analysis of the gainers and losers from the liberalization of regional seed trade.

The challenge is to complete the implementation of technical agreements established during the first round of East African discussions. This will consume much of the resources available for this process. However, efforts have also been initiated to encourage 'second tier' countries to adopt some of the agreements already established between the three East African countries. ECAPAPA also plans to strengthen its monitoring of this process both to ensure continuing progress and to begin measuring impacts.

West Africa

Boubakar Diallo of INSAH/CILSS and Mariam Sow acknowledged that West Africa is further behind in its harmonization efforts than the other two regions. They suggested the need for a single regional coordinating body to facilitate the process. This could initially encompass the CILSS countries. But questions were also raised about the potential roles of REPA and CORAF.[1] It was eventually proposed to first focus on a small number of countries in order to create a foundation to build upon (following the East Africa model).

Another challenge is that the private seed sector in West Africa is weak. Thus, better coordination across NARS may be the appropriate goal in the first phases. Simultaneously, governments must encourage expanded investment in private seed trade.

It was suggested that indicators of the likely impacts of harmonization and liberalization be identified in order to facilitate monitoring.

Southern Africa

Edward Zulu of the SADC Seed Security Network summarized the next steps planned by his organization. Three technical meetings have been proposed for early 2003 to discuss regionalized registration, certification systems and phytosanitary standards. These may offer similar bases for technical agreements as achieved in East Africa. In contrast, however, all countries in the Southern African Development Community (SADC) are targeted. It is politically unacceptable to move ahead with only a few countries. The results of these meetings will be presented to the SADC Council of Ministers for endorsement.

1. INSAH = Institut du Sahel, CILSS = Comite Inter-Lutte Contre la Secheresse au Sahel, CORAF = West and Central African Council for Agricultural Research and Development

Questions were raised about the technical preparation for these meetings and the breadth of crop coverage. The discussions must remain focused, yet responsive to a wide range stakeholders. This is why three separate meetings have been planned.

Cross-regional

A review of strategic stakeholders was followed by a discussion of possible sources of information and coordination across the three regions. The group agreed that the Africa Seed Network was never a viable entity. The African Seed Trade Association (AFSTA) has cited regulatory harmonization as a priority, but appears to have done little on this issue to date. AFSTA could play a greater role in the future, if it becomes stronger. But it remains unclear how its efforts will relate to the many countries without significant private seed sectors. This includes most countries in Central and West Africa.

In general there was agreement on the need to maintain strong communication among a wider range of stakeholders, including NGOs and farmer associations involved in seed production or distribution. This implies the need for greater consideration of policy and regulatory constraints to the development of smaller or less commercialized seed markets.

Next stage of project activity

The discussions at this meeting highlighted the value of comparing experiences and drawing lessons across the three African regions. Despite the limited participation in this meeting, these also highlighted the value of involving participants with diverse experiences from the three regions. In particular, lessons from East Africa are expected to benefit future efforts in Southern and West Africa.

Participants identified four areas meriting further cross-regional collaboration. It was suggested that a follow-up project be drafted to support this continuing initiative. The four areas are:

1. Facilitating policy dialogue

A follow-on project will stimulate more policy dialog by funding a series of policy briefs on key issues. An effort might be made to review priorities for policy analysis and briefs among key decision makers.

There was also strong interest in obtaining support for meetings between key stakeholders to discuss policy targets and agreements. These could

include discussions between seed companies, farmer associations, regulators and policy makers, on specific reforms. These meetings could be organized under the auspices of regional institutions like ECAPAPA, FANRPAN and INSAH.

The emphasis would be on facilitating inter-regional dialogue. For example, those involved in reducing the phytosanitary list from 33 to 3 pests in East Africa could review this progress with stakeholders in West or Southern Africa.

2. Capacity building

There was general agreement that regulatory harmonization is difficult as long as national regulators do not trust the capabilities of their neighbors. Concerns were raised about the need to improve the capabilities of policy analysts.

It was suggested that a technical steering committee could administer a grant program to support capacity building for the development of common legislative or regulatory frameworks. This could include grants to facilitate drafting of common generic frameworks for biosafety regulations or plant property protection that could be then modified to meet national and regional requirements. In addition, training would be provided in techniques of seed market analysis and strategies for assessing the impacts of policy reform.

3. Coordinating body or clearing house for information

This project seems to have provided a focal point for sharing experiences across regions, sharing documentation, and monitoring progress. The group wants to maintain this, but is unsure where it is best housed.

It was suggested that a follow-on project could maintain this role while identifying a local institution to take it over. For example, ICRISAT could run a clearing house for information on seed policy reform for 2-3 years and then pass on the responsibility to AFSTA. Or this clearing house could be jointly managed with identified regional bodies.

4. Research

It was agreed that we remain at an early stage of the reform process. It is impossible to know where this will lead. Therefore, it is important to maintain a monitoring system to track agreements as well as impacts. Further research was needed on how trade harmonization will contribute to seed security; on alternative strategies for regionalized release of new varieties; on promoting regionalized seed supply for less commercialized crops; and on the impacts of

seed market reforms on agro-biodiversity. A common research project could monitor the impacts of seed policy reform across the three regions.

Ultimately, we agreed that a committee of six (with people from each region) would draft a formal proposal. It is anticipated that this concept note would be drafted by 15 Jan 2003. It was suggested that to make this a truly continent wide project, the funding would need to be significant – ideally at least US$300,000 per year over a 3-year period.

Looking Beyond National Policies: Regional Harmonization of Seed Markets

David Rohrbach,[1] Isaac Minde,[2] and Julie Howard[3]

1. Principal Scientist (Economics), ICRISAT, PO Box 776, Bulawayo, Zimbabwe. 2. ECAPAPA Coordinator, PO Box 765, Entebbe, Uganda 3. Asst Professor of International Development, Michigan State University, MI 48824, USA

Harmonization of seed laws and regulations has been a primary focus of seed system development efforts in sub-Saharan Africa during the past 5 to 10 years. Harmonization was first proposed in a 1987 consultant's study in Southern Africa (Danagro 1987). Since then, the issue has been considered in over 20 regional meetings and many more national discussions. Regional harmonization has been declared to be one of six main project areas of the African Seed Network (FAO 1998b), and one of seven main objectives of the African Seed Trade Association (AFSTA 2002).

This priority reflects the evolution of Africa's seed industry. Liberalization of national seed markets has stimulated private investment in seed production and sale. National seed parastatals are being replaced by a range of national and international seed companies and small-scale entrepreneurs. Competition is growing. Yet seed industry development in Africa remains highly skewed. Many countries still do not have private seed companies; a few crops account for the majority of seed sales; and much of the seed trade is financed by publicly funded relief and development programs.

While Africa's harmonization discussions have ostensibly focused on establishing common, internationally accepted standards for seed sector regulation, a broader set of outcomes appears likely. International standards are being adapted to suit local market conditions. More liberal strategies for variety release, seed quality, and trade are being considered. Correspondingly, regulatory authorities are being encouraged to play a more proactive role in facilitating market development.

Regardless of the outcome of harmonization discussions, policy makers must make strategic decisions regarding the evolution of national seed industries. Questions remain about how to fill the large gap left by the narrow focus of private sector investment (eg on hybrid maize or horticultural crops).

Also, the level of national commitment to regional market integration still needs to be determined.

These debates about seed standards and regionalization are likely to continue as harmonization policies are implemented. This paper reviews the status of harmonization discussions in East, West and Southern Africa; summarizes the major questions of liberalization and seed sector development; and concludes with a comment on the continuing need for public investment in seed market development.

Why Pursue Harmonization?

There are many justifications for harmonizing seed laws and regulations in Africa (Danagro 1987, Commonwealth Secretariat 1994, FAO 1998a). Most specifically, adoption of a common set of internationally accepted market regulations is expected to facilitate the flow of seed between countries. Seed trade will be quicker and less costly. At the broadest level, harmonization can promote the expansion of national and regional seed industries by stimulating private sector investment.

Seed sector growth

Africa's commercial seed sector is small by global standards. Less than US$500 m of seed is traded on national and regional markets in sub-Saharan Africa (FAO 1998b). This is less than 2% of the international seed trade. Approximately half of this is traded in southern Africa. South Africa alone accounts for US$170 million; Zimbabwe for another US$40 million (FAO 1998b).

Less than 10% of the seed planted by Africa's farmers is purchased on the commercial market (Commonwealth Secretariat 1994). Most farmers plant seed saved from the previous harvest, and adoption of new varieties developed by public and private breeding programs remain low.

Furthermore, only a few seed crops are traded (FAO 1995, 1998a). The most important is maize. The majority of maize seed traded in southern Africa is of hybrids, but trade of open-pollinated varieties is also widespread. In larger markets, retail seed trade exists for cash crops such as wheat, cotton, sunflower, soybean, and vegetables. But in most countries, there is very limited seed trade for many staple food crops including sorghum, pearl millet, groundnut, pigeonpea, cowpea, beans, and rice.

The lack of private investment in seed production and marketing results partly from government controls on the market (Rusike and Eicher 1997). Throughout sub-Saharan Africa, seed multiplication and distribution was historically organized under government auspices. The public sector either took direct responsibility for seed provision, or held a commercial interest in a national seed company. Little competition was allowed. As markets were liberalized during the 1980s, private investment expanded. But the pace of expansion varied widely across national and regional markets. Most countries in Africa still do not have private seed companies – especially those willing to invest in domestic seed multiplication.

Three aspects of harmonization are particularly important for stimulating private investment. Protection of plant variety rights will encourage the development of new varieties for sale. Easier and more transparent procedures for variety release and registration will increase the range of varieties available. And common phytosanitary regulations and quality standards and simplification of trade procedures will reduce trading costs and increase the quantities of seed sold.

Conformity with international trade rules

Harmonization discussions in Africa have generally started with a review of seed laws and regulations in a few key countries. While a few countries have well defined policies, many have only rudimentary seed laws and regulations (FAO 1998b, Lemonius 2001). This was sufficient as long as the government took primary responsibility for seed multiplication and distribution. But as markets were liberalized and trade expanded, stricter legal and regulatory standards were sought.

Internationally accepted seed standards applied in Europe and the USA have been offered as a point of departure for regulatory reform (Condon 1997). African countries have been called upon to join the International Union for the Protection of New Varieties of Plants (UPOV); adopt plant variety protection consistent with UPOV conventions; and amend national legislation to conform to the TRIPS agreement.[1] They are being encouraged to join the OECD Scheme for the Movement of Seed in International Trade (OECD Seed Scheme), the International Seed Testing Association (ISTA) certification programs, and the International Plant Protection Convention

1. Trade-Related Aspects of Intellectual Property Rights agreement proposed under the auspices of the World Trade Organization.

(IPPC). Countries would correspondingly be expected to adopt internationally accepted phytosanitary standards and plant quarantine procedures.

Most observers agree with the objectives of establishing clear plant property rights, phytosanitary standards, and seed quality standards. UPOV, ISTA and IPPC standards are viewed as appropriate guidelines for trade on the formal, commercial market. The problem is that much of the seed trade in Africa is not strictly commercial. The main question then becomes, what standards are practical to implement.

Market efficiency

The problem of practical standards is most evident in the market for relief seed, which accounts for the largest proportion of seed trade across much of Africa. The relief market constantly tests the limits of seed regulation. Since demand for emergency seed generally outstrips available supplies, buyers and regulatory authorities must choose between having no seed for distribution, or supplying seed of uncertain type and origin. Time constraints limit phytosanitary assessments. At best, seed may be certified for physical purity and germination.

Relief efforts have exposed key differences in variety registration lists and regulatory frameworks, even between neighboring countries. Strict adherence to national registration lists would allow very little seed trade, because many countries have deliberately pursued a policy of registering only specific, locally suited varieties. Countries have different phytosanitary lists of pests and diseases subject to quarantine; different seed nomenclature, quality standards, export and import procedures.

When seed shortfalls are severe, these regulations are commonly relaxed; but may be strictly applied the following season. The problem is, companies are then uncertain about when a given regulation will be enforced. Or a regulation may exist in theory but never be implemented in practice. Smaller companies complain that seed regulations are applied differently to different companies.

Yet regulatory authorities face an almost impossible task. The profitability of the relief market, and open pursuit of tenders, has led to the establishment of many small-scale seed traders, few of whom invest in research and market development. They may purchase grain and clean it to a minimum seed specification, enabling them to offer competitive prices in

government and NGO tenders. In the process, however, these companies also rely on lax enforcement of regulatory standards.

Frequent demand for emergency seed has also encouraged many NGOs to establish community seed projects (Rohrbach et al. 2002) where farmers are provided training to become small-scale seed entrepreneurs. When seed sales are between neighboring farmers, regulatory authorities are relatively unconcerned. But a significant share of this seed may get bulked and traded to more distant communities. Some national authorities (eg Tanzania and Zambia) have sought to enforce the less rigorous standard of quality declared seed. But in practice, even this relaxed standard is difficult and costly to enforce.

Thus, the recent evolution of seed trade in many parts of Africa has strengthened interest in the establishment of common regulations. But it has also raised many questions about what standards are practical.

Harmonization Discussions

Harmonization discussions in East, Southern, and West Africa had different starting points, and evolved in different directions. In East Africa, the discussions were heavily influenced by the re-establishment of the East African Community (EAC), with an underlying commitment to free trade. In Southern Africa, they were influenced by the diversity of stakeholders in the seed sector, and the dominance of emergency seed. In West Africa, with little private seed trade, the harmonization discussions were associated with public interest in promoting wider sharing of germplasm. Partly because of these differences, efforts to link the three regional initiatives (African Seed Network 2001) were unsuccessful. Nonetheless, each region faced similar difficulties in defining a set of harmonization agreements.

East Africa

In 1996, members of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) expressed concern about the difficulty of transferring germplasm across national borders. Such transfers are essential to successfully implement regional commodity research networks. ASARECA applied for a USAID grant to support a series of meetings aiming to harmonize seed policies and regulations in the region.

It chose to first concentrate on harmonization in Kenya, Tanzania and Uganda, because these countries were in the process of re-establishing the East African Community (EAC 1999). Harmonization of seed regulations was a natural corollary of efforts to implement an EAC free trade agreement.

The three countries also had the advantage of a common starting point for their discussions. A common set of seed laws and regulations had been established in the original EAC before it broke apart in 1977. More than half the officials responsible for implementing these seed regulations in 1977 were still in place in 1999. Dialog between these countries was relatively easy because of their common language and cultural traditions.

ASARECA organized two sets of meetings: national meetings to review local seed policies and discuss negotiating positions; followed by two major regional meetings to work out specific agreements. All meetings had participation from the public and private sectors. Because of the preparatory work, key participants were mandated by their national governments to negotiate a regional agreement.

Roughly half the time at the national meetings was spent discussing problems of national seed sector development: eg, the need to clarify national policies on plant property rights, seed quality control, and trade regulations. In the process, national authorities were encouraged to improve the efficiency of their procedures. For example in one country, a seed import consignment had to be inspected by three different government offices upon arrival at the airport. After the meetings, only one officer was required.

The regional meetings concentrated on working out technical agreements on specific regulatory procedures and standards. These included agreements on variety release, plant property rights, certification standards, phytosanitary standards, and trade documentation. A number of these are already being implemented.

ASARECA encouraged other countries in East Africa to send representatives to the regional seed meetings. These ‘second tier’ countries are now being asked to consider accepting one or more of the agreements negotiated among the EAC countries. Similarly, ASARECA has encouraged countries needing to draft new seed legislation to first consider the models offered by their neighbors. Broader harmonization of seed regulations may then be achieved over time.

Southern Africa

Harmonization discussions in southern Africa have had a longer history and broader focus. Harmonization was first proposed in a regional review of seed system development strategies implemented under the auspices of the Food Security Technical and Administrative Unit (FSTAU) of the SADCC[2] in 1987 (Danagro 1987). Over the next 15 years, harmonization issues were considered in at least 11 regional meetings and five national workshops (Table 1). Workshop debates were wide-ranging, often placing greater emphasis on seed production and distribution strategies rather than regulatory

Table 1. Seed policy conferences and workshops in southern Africa, 1987-2002

1987	SADCC commissions DANAGRO study of national seed systems in member countries; regional seed project for harmonization of seed laws recommended
1988	SADCC technical experts meeting on regional seed production and supply (Harare, Zimbabwe) proposes 11 regional seed projects including one titled *Harmonization of seed laws in the SADCC region*
1993	Regional workshop on improved on-farm seed production for SADC countries (22-26 Nov 1993, Mbabane, Swaziland) – recommends harmonization of seed laws and extension of regulations to support on-farm seed production
1994	Regional workshop to discuss a study on harmonization of seed laws (4-6 Oct 1994, Harare) – 17 recommendations for seed sector development
1997	Enhancing research impact through improved seed supply: options for strengthening national and regional seed supply systems (10-14 March 1997, Harare)
	Regional technical meeting on promotion of regional network for on-farm seed production and seed security in SADC countries (23-26 Sep 1997, Maseru, Lesotho) – recommends establishment of SADC Seed Security Network
1999	Planning workshop for the seed sub-committee (22-24 Nov 1999, Kadoma, Zimbabwe)
2000	Round table discussion on *sui generis* protection of plant varieties under Article 27.3(b) of TRIPS (27-28 Jan 2000, Harare) – recommends development and implementation of laws on *sui generis* protection
	Sub-Saharan Africa seed initiative stakeholders workshop (10-11 Feb 2000, Lusaka, Zambia)
2001	Sub-Saharan Africa seed initiative stakeholders workshop (26-28 Sep 2001, Kadoma)
2002	Strategic planning workshop for the seed sub-committee (28-30 Jan 2002, Nyanga, Zimbabwe)

2. Southern African Development Coordination Conference, which in 1992 became the Southern African Development Community (SADC)

frameworks. One working group might consider regulatory issues of seed certification, phytosanitary standards, or property rights, while others considered problems of seed security and community seed production.

Between 2000 and 2001, these efforts were coordinated under the World Bank's Sub-Saharan Africa Seed Initiative (SSASI). In a strategy similar to East Africa's, SSASI aimed to first target harmonization in four countries – Malawi, Mozambique, Zambia, and Zimbabwe. A review of national seed policies would be followed by a discussion of regional seed strategies. Efforts would gradually be expanded to the remaining SADC countries (Zulu and Lemonius 2000).

As a result of the SSASI project and the groundwork laid by previous regional discussions, agreements in principle were reached on over 30 recommendations for regulatory reform (Lemonius 2001). These included variety release procedures, variety registration, seed certification, phytosanitary regulations, and trade documentation. Stakeholders from both the public and private sectors endorsed the need for a pluralistic seed system involving both community and commercial entities. However, while there is substantial agreement on a framework for harmonization, the strategy for implementation remains uncertain, and few specific changes have been made in national seed regulations.

Despite the prominence of the harmonization debate, the main priority in southern Africa is seed security. In June 2001, representatives from the southern African countries chose to concentrate on establishing a regional SADC Seed Security Network. The main aim of the network is to share information about seed production and availability in order to improve access to seed in case of droughts and floods. Seed Focal Points have been identified in each country to facilitate sharing of information – but regulatory structures remain unchanged.

West Africa

In West Africa, the harmonization debate is more recent. Interest was stimulated by a 1998 FAO-sponsored conference in Abidjan targeting a generic review of seed policies and programs for sub-Saharan Africa. The meeting recommended the establishment of an African Seed Network to coordinate efforts to strengthen seed systems in the region (FAO 1998b); and also the establishment of a Working Group on Harmonization on Seed Rules and Regulations. Both were continent-wide initiatives, not specifically for

West Africa. The seed network is not yet functional, and the working group never met.

Issues of West African seed policy and harmonization were next discussed in a March 2001 meeting organized by INSAH/CILSS. Again, this meeting was a general review of seed issues, and included a technical working group on regulatory harmonization. CILSS was particularly interested in encouraging easier movement of new varieties across borders, for testing. Correspondingly, the main result of these discussions was an agreement to establish a regional catalog of West African varieties and develop common criteria for variety registration across the nine CILSS countries (FAO 2002). CILSS has also agreed to pursue harmonization of phytosanitary standards. These efforts are still underway.

Another FAO meeting was held in March 2002 (FAO 2002). Prior to this meeting, FAO hired a lawyer to summarize the status of seed laws and regulations in nine West African countries. He noted that only four of the nine countries had enacted seed laws, though some of the others had seed regulations. The meeting ultimately agreed to organize an analysis of the prospects for harmonizing seed regulations across three countries: Senegal, Nigeria, and Cameroon.

Harmonization of national regulations has been specifically proposed between Senegal and Mauritania, to facilitate trade of rice seed. Little quality seed is available in Mauritania, whose farmers depend on seed multiplied in Senegal. In the past, single seed lots have been subject to overlapping inspection in both countries. A joint association of seed professionals was created in 2001 to try to harmonize quality control regulations. Negotiations are still underway.

Harmonization Issues[3]

While international standards offer a baseline for harmonization discussions, the specific agreements being negotiated reflect local interests and operational procedures. In practice, international standards are being adapted to meet the contingencies of national and regional markets.

Table 2 summarizes the main regulatory changes recommended to date. In Southern Africa, most of these adjustments have been agreed in principle. In East Africa, they are at early stages of implementation.

3. This section draws heavily from papers by Ngugi, Sow, and Rohrbach et al. elsewhere in these proceedings.

Table 2. Summary of recommended changes in seed regulations in East, Southern, and West Africa, 2002

East Africa	Southern Africa	West Africa
Variety release		
Release committee should consider only one additional year of national data for release of a variety already released in a neighboring country Establish standardized procedures for variety trials	Compulsory registration only for grain crops Clear guidelines on data requirements Consider variety information from any source Establish technical committee to develop guidelines for harmonized system of variety registration Data from another country should be considered for release	Not considered
Variety registration and plant property rights		
Develop regional variety catalog All countries should have PBR legislation Farmers rights to be considered	All countries should have PBR legislation Farmers' rights may be considered	Develop regional variety catalog
GMOs		
Establish harmonized biosafety regulations	Develop guidelines and biosafety regulations for introduction of GMOs	Not considered

...Continued

Table 2. ***Continued***

East Africa	Southern Africa	West Africa
Phytosanitary standards		
Adopt FAO pest risk analysis procedures, complete assessments in all countries Establish common regional list of quarantinable pests Reduce the number of quarantinable pests for regional seed movement from 33 to 3 All countries should join IPPC	Harmonize and simplify plant quarantine regulations Participate in IPPC Conduct proper pest assessments in each country	Harmonize and simplify phytosanitary procedures and regulations
Seed certification		
Accredit private agencies and institutions to carry out certification on behalf of national certification agencies Identify limited set of crops for compulsory certification Establish common field and lab standards Establish three seed classes Establish common accreditation procedures and criteria	Seed certification should be recommended for most crops but mandatory only for a few Maintain minimum quality and labeling standards Further develop and recognize non-certified seed class Introduce common terminology, procedures and standards for various classes of certified and non-certified seed All countries should join ISTA and participate in relevant OECD seed schemes	Not considered

...Continued

Table 2. ***Continued***

East Africa	Southern Africa	West Africa
Import and export procedures		
Standardize documentation required in accordance with IPPC model	Simplify import procedures, establish one-stop shop for clearances	Not considered
Develop common documentation to govern import and experimentation with GMOs	Rationalize trade procedures to speed the process	
Streamline processing and issuing of trade documentation including import permits, phytosanitary permits	Establish common quality criteria for traded seed	
Market entry for seed companies		
Not considered a barrier	Not a significant problem, but NGOs should report their activities to national seed service	Not considered
Other regulatory issues		
Establish uniform tariff as per EAC treaty	National seed center should concentrate on monitoring seed trade rather than restricting it	
	Strengthen databases	
	Public sector should multiply varieties of limited interest to private sector	

Material contained in this table was derived from Ngugi 2002 (East Africa), Lemonius 2001 (Southern Africa), and Sow 2002 (West Africa)

Variety release

In most African countries, new varieties must be tested by national authorities in a series of trials before they can be released, and registered for distribution in the country. Trial results must be submitted to a national Variety Release Committee in a formal proposal requesting release. This process worked reasonably well when all varieties were derived from national breeders or a single national seed company. The expansion in sources of new varieties has brought questions about the fairness and efficiency of this process.

The most common complaints relate to slowness and lack of transparency. A variety may be developed for sale across a wide agro-ecology spanning different countries; but must be separately evaluated and released in each country. This could require two to five additional years of multi-location trials. Even then, release might be delayed, or even prevented, by the objections of one or more members of a Release Committee. Concerns have been raised about the transparency of this process, and possible bias of committee members.

Options to simplify release procedures have been discussed in both East and Southern Africa. The East Africans agreed to implement new testing procedures to speed the process in second or third countries; and to consider trial data from both public and private sources. Seed companies have responded by sharply increasing their submissions of varieties for release – and national authorities are finding it difficult to cope with this load.

In Southern Africa, a technical committee will be established, to develop guidelines for a harmonized system of variety registration. The primary objective is to improve the transparency of the release process. Local stakeholders have also agreed to consider the option of multi-country release.

Variety registration and plant breeders' rights

In most countries, varieties can be sold only if they are on a national variety registration list. In order to be registered, the origins of a variety must be identified, and the distinctiveness, uniformity and stability (DUS) must be confirmed. In the few countries with plant property rights legislation, this process also establishes legal ownership of the variety. But most countries have yet to establish plant breeders' rights (PBR).

Most stakeholders agree on the need to establish a legal framework for PBR. The WTO requires this sort of protection, and UPOV standards on PBR

are well recognized. The main uncertainty is how to recognize farmers' rights to varieties. The Model Law of the Organization of African Unity has been widely discussed as a framework for recognizing farmers' rights. But uncertainty about the boundaries for such rights limits their codification and application. The strongest proponents of farmers' rights seem to be the NGOs.

Another question is whether African countries will accept the concept of regionalized variety registration. The regional variety lists being developed in East and West Africa would simply identify varieties that have been released in more than one country. Internationally oriented seed companies would prefer a more integrated, regional release and registration process. Policy makers in southern Africa have agreed to consider this, but national crop breeders may be less supportive.

Genetically modified organisms

Regional discussions on harmonization have not debated the advantages and disadvantages of GMOs in any detail. Most scientists seem to accept GMOs as inevitable – discussions have been more concerned to ensure that common sets of biosafety regulations are in place. Few countries in Africa currently have biosafety regulations, but most recognize the need to establish them. The regionalization discussions have probably speeded the sharing of information about regulatory frameworks being established in neighboring countries.

Phytosanitary standards

Participants in these discussions in both East and Southern Africa have commonly complained about the need for more practical phytosanitary standards. National pest and disease lists are said to be out-dated; they include pests and diseases that are either endemic throughout the region or of little economic significance. Large differences in the lists of neighboring countries are difficult to explain. To complicate the problem further, national capacities to enforce these standards are limited.

Agreements have been reached in all three regions to harmonize phytosanitary standards, with common lists of quarantinable pests and diseases, and harmonized inspection and quarantine procedures. This will require new pest risk assessments in each country – which is expensive and time consuming.

In East Africa, the number of quarantinable pests has been reduced from 33, to 3 pests on a common regional list. In southern Africa, South Africa agreed to review the phytosanitary facilities and procedures of neighboring countries, and initiate inter-laboratory reference tests.

Seed certification

A major concern in all regions is how to protect farmers (especially smallholders) from the distribution of poor quality seed. Regulatory authorities see this as their main mission. Stricter certification regulations are one way to achieve this. But certification is difficult and expensive to implement, particularly if seed is produced by many companies and contract farmers. Enforcement becomes more difficult with the expansion of community seed projects and widespread demand for relief seed.

The main international standards for seed certification are defined under ISTA. Countries have been encouraged to join this association to ensure agreement on standards for seed entering the international trade. However, in many countries ISTA membership is considered too expensive, and the necessity for maintaining such strict certification standards continues to be debated. While membership in ISTA is still being encouraged, most countries are adopting a more flexible regulatory position.

More liberal quality regulations are initially being adopted in national regulations. In order to facilitate seed production and trade by small-scale farmers, particularly for crops of lesser interest to large commercial seed companies, regulatory authorities have defined standards for two new seed classes, namely quality declared seed (FAO 1993) and common grade seed. Certification regulations are not being applied to seed traded between farmers within and across neighboring communities.

The first steps towards harmonization of quality standards are agreement on nomenclature and the definitions of seed classes, and identification of common field and laboratory standards for inspection. The next issue is what crops must still be subject to compulsory, as opposed to voluntary, certification. Seed companies commonly accept the value of compulsory certification and may even use this as a means to limit new competition. However, the broadening of seed classes to include common or quality declared seed implies a de facto agreement to pursue truth-in-labeling. These discussions are still underway.

Import and export procedures

Seed companies commonly complain about the complexity of documentation required for seed exports and imports. Phytosanitary inspections may be required by both the exporting and the importing country. Some countries require export permits. Most also require import permits. Bank documents confirming the transaction value and payments need to be linked with customs paperwork and certification papers. Collecting all this documentation can take substantial time and effort; a transaction may take up to six months to complete.

Many traders complain more about the apparent inefficiency of regulatory and customs authorities, rather than the procedures per se. This has led to calls for 'one-stop shops' to facilitate trade paperwork. To achieve common procedures and standards governing seed trade, national procedures must first be rationalized or simplified.

The explicit agreement to liberalize trade in East Africa, in conjunction with the re-establishment of the East African Community, stimulated a quick agreement to standardize paperwork for seed trade. Each of the three countries has already started using the same documentation for import or export permits, quality certification, and phytosanitary certification. The only differences in these forms are the country name and logo. The three countries have also agreed to streamline the processing of trade documentation. Kenya and Tanzania now have a 'one-stop' source of these permits.

In contrast, in Southern Africa, Zimbabwe continues to restrict seed trade with government controls on seed exports. These are viewed as being necessary to ensure national seed security. Further progress in these negotiations may first require agreement in principle on liberalized, regional seed trade.

In both East and Southern Africa, tariff barriers are not an issue. Seed is traded with little or no tariff under the terms of the SADC Free Trade Agreement, the COMESA agreement, and the East African Community treaty.

Market entry for seed companies

In both East and Southern Africa, the number of seed companies operating has increased sharply during the past 10-15 years. Most major international firms are operating in the region, and many small local companies have been formed

in response to the liberalization of domestic markets during the 1980s, and the high demand for relief seed.

Correspondingly, market entry has not been discussed in the regional harmonization discussions. Establishment and registration of a seed company is considered relatively simple in most countries. The main exception is uncertainty about the status of community seed projects established by NGOs.

Nonetheless, concerns remain about the dominance of international seed companies. National authorities have maintained investments in national seed companies in order to ensure that local seed production capability is maintained. This is viewed necessary for national seed security, and to provide a channel for the multiplication of varieties developed by national crop breeders.

Harmonization Versus Liberalization

Regional discussions of harmonization in Africa have two levels of focus. The first level is to define the extent of the regulatory framework needed in each country. Countries without seed policies, or with limited seed laws, are being called upon to adopt an internationally accepted set of seed laws and regulations, including legal protection for plant property rights. They are being encouraged to adopt common standards and procedures for seed certification, phytosanitary control, and biosafety. Regional working groups are considering common procedures for variety release and registration, as well as common documentation governing seed trade.

There are no major disagreements about the need to harmonize procedures. Rather, the main concern is to improve national regulatory capabilities in order to implement these agreements. Regulatory authorities in different countries need to trust each other's capacity to correctly and consistently implement common standards. This has led to calls for capacity building among national regulatory authorities.

The second level of focus is on what levels of standards to adopt. This is more contentious. While international standards (ISTA, IPPC, UPOV) are widely accepted as a basis for opening discussion, most local authorities recognize the need to adapt these requirements to the needs of local markets. International standards are viewed as being too strict for local conditions, and costly to implement.

Ultimately, regulatory authorities need to define standards suitable for three inter-related markets – the formal commercial market, the 'common

grade' seed market, and informal sales by farmers. Commercial sales by formal seed companies are the easiest to regulate, but also the least likely to need strict controls, because the companies face a strong incentive to maintain quality in order to maintain their reputations. 'Common grade' seed is traded to offset supply shortfalls in the event of emergency. Since commercial retail sales are limited, commercial seed stocks tend to be small. When the demand for relief seed rises sharply, due to drought or floods, grain must be purchased from the grain market and physically cleaned. In some cases, seed of an unknown or unreleased variety may be purchased from a neighboring country. In either case, regulatory authorities cannot maintain the standards normally expected of the commercial seed trade.

The third market encompasses local seed production by farmers for sale to their neighbors and to neighboring communities. Frequently, some of this seed is assembled and distributed by NGOs in more distant communities. These programs produce many varieties of limited interest to commercial seed companies. Strict quality control is difficult. Some regulatory authorities have tried to mandate the adoption of quality declared seed standards, but even this standard is difficult and expensive to implement.

One option is to set one level of standards for trade within the country, and a second stricter level for trade across borders. The problem is that these seed lots are not always distinct, particularly when relief seed is urgently needed. Alternatively, seed standards may be strictly set for a few commercial crops such as hybrid maize, but relaxed for most open and self-pollinated varieties. But the distinction between commercial and non-commercial crops is similarly subject to change.

If harmonization agreements ultimately conform to the dictates of common practice, regulatory frameworks are likely to support more truthful labeling. Common rules and nomenclature will facilitate trade of seed with identified characteristics. Efforts to prevent the production and sale of low quality seed, may be replaced by efforts to educate both seed producer and buyer about quality options. More liberalized markets then represent a practical consequence of the need to rely on a diverse array of seed sources and marketing channels.

National versus regional markets

Most discussions on harmonization aim to improve linkages between national markets. However, national seed markets will remain at least somewhat

distinct. Countries will maintain their own variety release and registration lists. Phytosanitary standards may be common, but plant quarantine will still target a subset of pests within each country. Quality control will involve common nomenclature, standards and testing procedures governing trade between countries. But trade within countries may still be subject to unique standards.

Most public officials consider development of the national seed sector to be their first priority. They argue that if a company wants to sell seed in a country, it should produce seed in that country. While imports are readily accepted in periods of emergency, the common perception is that the best way to ensure seed security (availability and quality) is to expand domestic production.

In contrast, international seed companies are already pursuing a regional vision. They prefer to produce seed in one or two countries for sale throughout the region. The country of production would be chosen on the basis of cost, productivity, and disease incidence. Thus, until recently, Zimbabwe has been a preferred source of production for sale in neighboring countries.

Regionally oriented production also reduces the risks of holding large stocks of different types of seed crops. Seed can be shifted between countries depending on local market conditions and the incidence and severity of emergency situations.

In each of the three regions in Africa, efforts have been initiated to develop a regional variety list. This is a step toward regionalized release of varieties. However, it is still expected that varieties will be separately released in each country. In southern Africa, SADC has agreed to consider the concept of regionalized release. But at this stage, seed stakeholders are simply considering the significance of regional data highlighting the wide adaptation of sorghum and maize varieties. Considering a policy change usurping national authority to regulate varieties that can be sold, would be a major new initiative.

In effect, harmonization of seed standards is an important step to facilitate seed trade, but will not necessarily ensure that a regional market develops. Compiling a regional variety list is another step towards regionalization, but regionalized trade will still be restricted by the enforcement of national variety lists.

Two policy questions remain to be considered. First, will national authorities encourage more open and competitive markets for variety

development and sale? While national registration lists are justified in terms of the need to protect farmers from poorly adapted varieties, they also restrict the flow of varieties developed for similar agro-ecologies in neighboring countries. National breeders and national release committees prefer to promote domestically developed varieties. The question remains whether national crop breeders or regulatory authorities will allow open competition across regional markets.

Dependence on regional seed trade also raises the question of seed security. Countries must be willing to rely on their neighbors for seed stocks. They must allow export of seed even when domestic shortfalls loom. Both decisions are politically difficult. The liberal trade agreement established by the East African Community may be a prerequisite to the development of a truly regionalized seed market. But in addition, policy makers probably need to confront the question of how best to ensure regional seed security.

Harmonization and Seed System Development

The pursuit of regulatory harmonization has offered an easy point of focus for seed system development efforts in Africa. But the impacts of harmonization are likely to be limited. Establishing plant property rights and easing release procedures may help expand private investment. But the economics of market development will still favor a limited range of commercial seed crops and a limited depth of market investment.

Agreements on regulatory harmonization may reduce the cost of seed being traded between countries, facilitate germplasm flows, and ultimately encourage more multi-country releases of a few favored varieties. Flows of relief seed may be hastened. Clarity of standards and 'one-stop shops' for trade documentation may also speed the delivery of seed to established markets. But regulatory harmonization is unlikely to expand seed sales in regions without formal seed markets. This includes much of rural Africa.

Policy makers will still need to confront the question of why seed markets are so limited in Africa. Few farmers are able to purchase commercial seed within their village. Availability is restricted to a few commercialized crops, and to cities and some peri-urban markets. Seed companies complain that market size is small and seed demand uncertain. Meanwhile, farmers complain about their lack of access to improved seed. Re-aligning market regulations is unlikely to bridge this gap.

Public investments in seed system development are still required in order to exploit the productivity gains that new varieties offer. Major questions remain about how this is best accomplished. Public investments in community seed projects commonly target the distribution of new varieties in outlying communities. Yet most of these investments are ad hoc in design and unsustainable in funding (Tripp and Rohrbach 2001, Rohrbach et al. 2001). The adoption of new varieties in Africa is commonly supported through subsidized seed delivery through relief and development programs. But these are similarly inefficient and unsustainable. Rather than encouraging the development of retail trade, they encourage seed companies to target bulk sales to public distribution programs.

Larger gains may be made by targeting public support towards developing retail trading networks for a wider range of new varieties. This includes ensuring foundation seed stocks for newly released varieties. Extension programs could run variety demonstrations in collaboration with seed companies. Information about farmer preferences for alternative grain and plant traits could be fed back to the seed sector. The common practice of free seed distribution in the event of drought or flood could be replaced with distribution of vouchers redeemable at organized seed markets or local retail outlets. Of course it is easier simply to hand the seed directly to farmers. But rural retailers then face no incentive to stock and sell seed on their own.

In sum, regulatory reforms should be considered as one component of a larger program of seed systems development. This view was evident in the discussions in southern Africa, where seed security and strategies for developing community seed systems were as often discussed as harmonization of regulations per se. But this also made it harder to reach agreement on policy reforms.

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Assessing the Costs and Benefits of Seed Policy Liberalization and Harmonization: Concepts, Evidence, and Methods

Mywish Maredia

Associate Professor, Dept of Agric Economics, Michigan State University, MI 48824-1039, USA

Introduction

For over three decades sub-Saharan African countries have had an interest in regional integration to promote agriculture and accelerate economic growth. The potential benefits of regional integration include: (i) *lower transactions costs* due to the removal of barriers to cross-border movement of goods and production factors, (ii) *efficiency gains* from repositioning of firms away from small national markets to production for the larger regional market, (iii) *long run welfare gains* as a result of lowering external protection, and allowing market signals to work in determining production location.

The areas of integration include liberalization and harmonization of seed policies and regulatory frameworks across countries. Important steps have already been taken toward standardizing seed regulations and procedures in East Africa.[1] However, progress has been slower in other regions. Proper assessment of the likely impact of liberalized seed trade requires a thorough analysis of the costs and benefits, which has generally been lacking. One common argument against liberalization is the perceived risk of increased disease transmission if standards are harmonized to facilitate trade. However, little attention is being given to the real costs and potential benefits. There is therefore a need for a balanced analysis of the potential impacts of liberalized regional seed markets, based on reality rather than perceptions.

1. For example, in East Africa, a regional working group has been constituted and meets regularly to work on harmonization of variety evaluation, release and registration, seed certification, and plant sanitation standards (ECAPAPA 2001). Uganda, Kenya and Tanzania have agreed to abandon a mandatory 3-year requirement for testing new varieties. A variety can now be released after one year of breeder's data and one additional season of testing.

The purpose of this paper is to add an economic perspective to discussions on the impacts of seed policy harmonization and liberalization in sub-Saharan Africa. A literature search was carried out and appropriate resource persons contacted; we examined impact studies conducted in regions that have undergone significant policy changes over the last decade (eg the EU, MERCOSUR and ASEAN regions). The goal was to summarize the known economic impacts of seed policy liberalization and harmonization, and compare the models and methods used in ex-post studies. However, the literature is scanty; clearly, more studies are needed to strengthen discussions on harmonization of policies and regionalization of seed markets. As a step towards this goal, this paper:

- Develops a decision framework for public policy on seeds
- Outlines the potential economic costs and benefits of seed policy liberalization and regional harmonization
- Presents evidence and approaches found in the literature to assess net economic benefits of seed policy reforms
- Suggests methods and specific data needed to assess ex ante impact of potential gains.

With the advent of biotechnology tools, there have been many discussions on intellectual property rights (IPR), biosafety policy for GMO seeds, and the need for regional and international harmonization of biosafety protocols and plant variety protection laws (as stipulated by WTO under the TRIPS agreement) to promote international transfer of seed technology. Although issues pertaining to GMO seed are not specifically discussed in this paper, the general framework developed and arguments laid out for and against liberalization and regional harmonization hold true for all types of seeds and planting materials, irrespective of what method was used to develop them.

The paper begins with a public policy decision-making framework and a description of a liberalized seed input market. It then summarizes the potential costs and benefits of a liberal and regionally harmonized seed market, approaches used to assess these costs and benefits, and evidence from past studies. The concluding section outlines the model and specific data needs to carry out ex ante impact assessment of potential gains from seed policy liberalization and harmonization.

Decision Framework for Public Policy on Seeds

Seed policy decisions to be made by the government can be analyzed based on the criterion of whether a policy change will generate social benefits large enough to justify the change. To determine the appropriate seed policy regime for a country we can apply (at least conceptually) the framework commonly used in the economics literature to determine the 'efficient level of research investment'. To assess the 'efficient level' we estimate a research production function relating investments to outputs. Similarly, the concept of production function can be applied to conceptualize a *policy production function* that relates policies to outputs or outcomes. Such a policy production function can be conceived as a meta-function made up of discrete policy environments or regimes as public policy moves from a closed seed market towards an open and regional seed market. This transition will typically involve changes to various components of the seed policy, eg variety testing and release procedures, introduction of new varieties in the market, variety protection, seed trade, etc.

To reflect the practical decision-making problem of policy makers, discrete policy decisions for reform can be conceptualized in terms of three policy regimes – restrictive, liberalization of domestic seed sector, and liberalization of seed trade (Table 1). These are comprised of regulatory options affecting the 'rules of the game' of different components of a seed system – from germplasm research and testing to commercial seed trade. These different policy regimes are described below.

1. Restrictive. This regime has 'closed economy' policies in the form of government control in all aspects of the seed system: seed inspection, compulsory release of all varieties, limited access by private sector to public germplasm, and non-tariff trade barriers (eg, import and export permits, unrealistic phytosanitary regulations). These policies aim to restrict the introduction of varieties from foreign sources, in the interest of promoting national food security and reducing the potential risk of seed-transmitted diseases.

2. Liberalized domestic seed sector. This regime has seed policies and regulations at country level to promote both public and private sector involvement in the seed system (ie reduce barriers to entry). It involves improving seed policies that encourage research and variety introduction by private companies, NGOs, international agricultural research centers (IARCs) and universities, and facilitates safe international seed trade.

Table 1. Seed system components and impacts under three policy regimes

Regime 1 Restrictive	Regime 2 Liberalized domestic seed sector	Regime 3 Liberalized seed trade
Components of the seed system		
Germplasm research and exchange		
Private sector access to public and IARC germplasm restricted	Private sector allowed access to public sector germplasm free or at a cost	As in regime 2
Variety testing and release		
Strict standards of variety performance; many years of testing required for release	Testing standards and data requirements relaxed	Testing standards and data requirements standardized across countries in a region
Plant variety protection		
Not necessary	Organizations and breeders allowed to register ownership of varieties	Protection criteria and requirements conform to international standards; harmonized across countries in a region
Variety registration		
Compulsory registration for all varieties – varieties have to be tested and approved by govts before sale	Compulsory variety registration limited to a few major crops. For other crops, voluntary registration (to protect property right)	Registration may be done regionally — registration in one country recognized by other countries
Seed certification		
Compulsory certification to ensure seed quality and accuracy of information. Done by govt seed service	Official seed certification available but voluntary; govt promotes truth-in-labeling	Seed certification requirements harmonized across countries; common seed class definitions; inspection results in one country used in other countries
Phytosanitary rules		
Unrealistic phytosanitary rules requiring seed testing and import/export certification	Rules focus on realistic pests and disease threats; transparent procedures	Phytosanitary seed tests standardized across countries. Countries cooperate to study regional seed-borne pests and diseases

...Continued

Table 1. *Continued*

Regime 1 Restrictive	Regime 2 Liberalized domestic seed sector	Regime 3 Liberalized seed trade
Market indicators		
Introduction of varieties from local private and foreign sources		
Difficult to impossible — controlled by govt	Incentives in place (channeled through private sector)	Promoted and facilitated (more varieties may enter from a larger number of sources)
Number of varieties available in the market		
Limited	Increased	Substantially increased
Commercial seed trade (imports and exports)		
None or based on a quota system	Allowed, subject to national policies and trade regulations	Expanded
Seed market size		
National	National for some crops; international/ regional for others	Regional for all
Private sector involvement in breeding research and seed distribution		
Discouraged	Incentives in place	Potential to expand
Role of NGOs and small-scale seed entrepreneurs		
Not allowed	Allowed and encouraged	May either continue in niche markets or disappear as companies expand their markets
Seed industry structure		
Public sector monopoly	Seed industry more competitive	Industry concentration may increase

3. Liberalized seed trade. This policy regime has seed policies and regulations that promote seed trade (both imports and exports) within a regional or an international context. This policy regime will involve harmonization of seed policies with international regulatory structures (UPOV, ISTA, etc). It could also involve common regulatory agreements (harmonization) within a trade

community (eg, regional registration of varieties) to facilitate a more liberal trading environment and is based on the principle of maximizing mutual benefits and sharing the costs.[2]

Some caveats to this 'three-regime' framework are worth noting. First, in practice, it will be difficult to classify a country exactly in one of these three policy regimes. For example, a country may evolve from a restrictive to a partially liberalized regime before fully liberalizing its seed policies. Depending on the legal, political and social framework under which public policy-makers function, a country may reform certain components of its seed system more drastically (for example, making variety registration voluntary) than others (seed certification may remain compulsory). Also, a country may reform seed systems of certain crops (eg, vegetable seeds) more easily than others (eg, staple crops important for food security). Thus there will be a continuum of policy regimes that countries fall under at any given time. The three regimes described here are, however, a useful way to conceptualize the outcomes and direction of change as a national seed system evolves from a restrictive regime to different levels of liberalized seed system (Box 1).

Second, the evolution of seed policy regimes from restrictive to liberalized seed trade may not necessarily be linear. In practice, a country may partially liberalize some policies to conform to regional/international standards and agreements but may retain restrictions on other components to safeguard national interest. Thus, harmonization of seed policies can occur with different degrees of restrictive or liberalized national seed systems. In our conceptual framework, 'harmonization' under the third policy regime represents the efforts that policy makers make to facilitate a liberal trading environment. This will necessitate at least partial (if not full) liberalization of national seed policy.

Third, the transition from restrictive to liberalized policies is often not smooth and occurs in discrete stages. This results in discontinuities in the *policy production function.* For example, the transition from regime 2 to regime 3 involves additional efforts on the part of governments to organize themselves, learn about the existing regimes in different countries, participate

2. 'Harmonization' can occur in a restrictive policy regime also, whereby countries in a region 'harmonize' policies that reinforce regional trade barriers. In policy regime 3, 'harmonization' per se is not the goal. 'Regionally harmonized polices' as used in this paper refers to policies adopted at country and regional levels that facilitate liberal trade and movement of seeds and planting materials. This goal is pursued after a regional agreement is reached on some degree of 'liberalization' of national seed systems.

Box 1. Expected outcomes of a liberalized seed system

There is no one set way of moving from a restrictive to a fully liberalized seed system. Liberalization will occur in steps and will differ in degree and scope across countries. Thus there is no one definition of a liberalized seed market – but it is helpful to describe the expected direction of change in a country's seed market features as it liberalizes. Similarly, it is useful to characterize a hypothetical seed market as a country takes additional steps to harmonize its policies with neighboring countries with the goal of increasing seed trade.

Market competition

With liberalization, the seed industry will attract a variety of companies, including subsidiaries and joint ventures of research-intensive multinationals (for maize hybrids, vegetables, etc) as well as small and medium local companies for non-hybrid seeds of wheat, cassava, etc. Seed growers and traders in the informal sector may eventually join the formal sector by starting new companies or contracting with other companies.

Seed market linkages

With liberalization, domestic markets will be linked to the international seed industry to ensure that farmers have access to modem technology. Public research in national institutes and international centers will remain important and complement private technology transfer and research. The informal seed sector will be enriched by a steady and expanded supply of new varieties for local and informal multiplication. The contribution by NGOs to sustainable seed supply initiatives will increase.

Geographical operations of seed firms

As seed industry moves towards a regionally liberalized/harmonized policy regime, harmonization will allow companies to operate in two or more countries, selling seed in markets defined by agro-climatic zones and cropping practices, not political boundaries. Public varieties (from NARS and IARCs) from one country will be more easily available in other countries in the region. Countries will be able to better respond to regional disasters as relief seed becomes cheaper and of higher quality.

in a regional planning process, and coordinate the harmonization efforts. All this is considerably more time-intensive than liberalizing seed policies at a country level independent of others (regime 2).

The basic decision variable in this framework is a policy regime that affects the 'rules of the game' of different components of a seed system. These rules impact the market indicators of a seed system – number of varieties available to farmers, number of seed firms, market size, volume of commercial seed trade, etc (Table 1), which in turn affect the costs and benefits for governments, seed firms, and farmers. Seed policy decisions should be based on the criterion of whether a change from one policy regime to another generates economic surplus large enough to justify.

Abstracting from differences in timing of costs and benefits associated with a policy change, and the specific crops affected, the net benefits of a change in public policy accruing to a country can be conceptualized as:

$$(1) \qquad \text{Net benefit} = P\,Q\,K_r(R) - C_r(R) \qquad \text{for } r = 1,2,3$$

where PQK is a measure of the change in the economic surplus (ΔES) conventionally used for assessing the impacts of research investment assuming perfect elasticity of demand and perfectly inelastic supply. P is the price indicator of an index of output Q affected by the policy change K is the policy production function relating the shift in the supply curve K to a seed policy regime R. Subscripts r = 1, 2, 3 represent policy regimes 1 (restrictive), 2 (liberalized domestic sector) and 3 (liberalized seed trade). C is the total cost of policy change associated with regime R.

Thus in this model, a national policy change will impact two variables: the shift in the supply curve (K) and the costs of policy change (C). A regional policy change will additionally impact the market size (ie, variable Q). The main parameter estimates, therefore, are K, C and Q. The public policy choice among alternative policy regimes will depend on whether the expected present value of net benefits resulting from a change in seed policy is positive.[3] The terms 'cost' and 'benefit' as used here refer to the economic cost and benefit in the broadest sense possible. They include not only the easy-to-quantify benefits and costs such as productivity gains/losses, but also those

3. Public policy decisions in reality are not always based on a cost-benefit analysis. Some components of seed policy will need to be changed to conform to international agreements. For example, WTO members have to adopt stricter plant variety protection laws under TRIPS guidelines. Countries that are part of the UPOV Convention have to adhere to additional PVP guidelines.

that are harder to quantify, eg benefits and costs resulting from changes in seed industry structure and market concentration.

Factors that will influence this choice for moving from regime 1 (restrictive) to regime 2 (liberalized domestic seed system) include: the expected change in supply shift (productivity impacts), impacts on various time lags, the potential for technology spill-ins (ie, the availability of appropriate varieties from other sources), size of the country, and change in costs (including risks and other 'costs' that are harder to quantify, eg seed industry concentration) associated with the policy change. The policy choice to further move from regime 2 to regime 3 will additionally be determined by the expected expansion in the size of the market (relative to the size of domestic market), agro-ecological environments shared by others in the region, and economies of size and scope in seed production and distribution. The first step in this analysis is identifying and assessing the costs and benefits of different policy regimes (or options) from a country's perspective.

Potential Costs and Benefits of Seed Policy Options

Any change in seed policy will generate quantifiable and non-quantifiable benefits (reduced costs or positive gains) and costs (reduced benefits or positive losses) to society. It is useful to conceptualize these societal costs and benefits as a sum of those occurring at the state or government level (seed policy implementers), the seed firm level (seed producers), and the farm level (seed consumers). Costs and benefits that can possibly occur at each of these levels are summarized in Tables 2 to 4. These should be viewed as hypotheses about possible effects of seed policy change rather than firm impacts that will occur in all countries and scenarios.

At the state level liberalization can generate benefits as well as costs. For example, it will likely reduce the cost of regulations in some areas (eg, variety testing, registration, certification) but may increase it in others, eg, plant variety protection, anti-trust law enforcement and prosecution (Table 2).[4] Also likely to increase are the research costs involved in assessing potential

4. For a discussion of costs and benefits specifically associated with changes in IPR and biosafety regulations relating to plant biotechnology, see Van Wijk 1996, Maredia 1998, 2001, and Maredia et al. 1999.

Table 2. Summary of state-level costs and benefits associated with different seed policy regimes

	Regime 1 Restrictive	Regime 2 Liberalized domestic seed sector	Regime 3 Liberalized seed trade
Cost of maintaining variety testing, registration and certification units	High	Lower	Shared by countries in the region
Regulatory enforcement and prosecution costs	Low	High	Same as regime 2
Border patrolling costs to prevent illegal seed trade	High	Low	Low
Research costs to study regional seed-borne pests and diseases	None	May be required	Necessary
Regulatory costs for developing and enforcing PVP	None	Necessary	Shared by countries in the region
Negotiation and transaction costs to standardize regulations across countries	None	None	High
Cost of public sector breeding research	Necessary	Lower as private sector takes over some crops	Same as regime 2
Cost of subsidies to maintain seed multiplication and distribution units	Necessary	Lower	Almost eliminated
Cost of enforcing anti-trust laws	None	May be required	Necessary
Costs to minimize risks for (or encourage) private investment	None	Necessary	Necessary
Risk of depending on one or few foreign firms for national seed security	None	May increase	High

Table 3. Summary of firm-level costs and benefits associated with different seed policy regimes

	Regime 1 Restrictive	Regime 2 Liberalized domestic seed sector	Regime 3 Liberalized seed trade
Time lag between research and variety introduction	Requires long period to release a variety	Time lag will decrease	Time lag will decrease on average
Cost of seed production	Likely to be high due to certification and testing requirements	Will decline	Lowest, since production will be based on comparative advantage and economies of scale
Research efficiency, as indicated by genetic gains in varieties released	Low	Likely to increase due to access to public germplasm	Likely to increase due to access to public germplasm (from local and foreign sources)
Seed market size	Small	Will expand or decline depending on competition	Will expand to the whole region or decline due to competition from other firms in the region
Cost of seed imports and exports	High time and money costs	Costs will reduce	Costs will reduce
Cost of filing and maintaining PVP and other forms of IPR	None	Will increase	Will increase

risks and economic threats of seed-borne pests and diseases.[5] There are also likely to be substantial negotiation and transaction costs involved in standardizing regulations across countries. On the other hand, liberalized seed trade will likely reduce border patrolling costs if seed trade is occurring through unofficial channels.

5. In many countries phytosanitary regulations are established without fully understanding the biophysical and economic implications of a pathogen's presence in the country. This has led to confusing regulations, unnecessary tests or inspection requirements, and unjustified trade barriers. With world trade increasingly governed by WTO, exporting countries will be demanding evidence that quarantine impediments are based on sound scientific principles. Quarantine measures may be challenged if not justified, and may be accused of being used to restrict trade. Quarantine restrictions in a liberalized environment will therefore have to be based on risk assessment studies (Maddox 1998, De Graaf 1994). If regional trade is liberalized, many countries will have to redefine their phytosanitary requirements with the goal of preventing introduction of a devastating pathogen rather than on the principle that all pests and diseases are a threat (Majumdar 1993, Fikre and Navaratnam 1991).

Table 4. Summary of farm-level impacts associated with different seed policy regimes

	Regime 1 Restrictive	Regimes 2 and 3 Liberalized
Adoption of improved varieties of different crops	Low	Increased
Crop productivity	Low	Increased due to increased yield potential and lower seed cost
Cost of seed	May be high because of limited competition and increased production costs associated with restrictive policies	Likely to decline
Risks of pest and disease	May be high or low depending on: implementation and relevance of phytosanitary rules to the real threat; existence of illegal seed trade; frequency of disaster seed relief efforts	Potentially decrease by promoting seed trade through official channels, reducing need for emergency seed relief, and focusing on realistic phytosanitary threats
Losses due to inappropriate varieties, poor seed quality	Uncertain	Uncertain

Figure 1 illustrates the expected participation of the public and private sectors in the seed system with increasing liberalization. The private sector role is expected to progressively increase with policy reforms, at least for commercialized crops. However, profit-oriented firms are unlikely to assume functions that cannot be easily exploited for commercial gain. Thus, the public sector will continue to play an important role in supporting basic research, conducting applied research targeted at subsistence crops and marginal environments, and collecting and disseminating market information even in a nationally liberalized seed system. With increased potential market, regional harmonization (as a policy component of the liberalized seed trade regime) may further attract private sector participation for less commercialized crops. For example, with regional harmonization, it may become attractive for the private sector to provide cassava planting materials or improved varieties of sorghum or beans if the larger regional market guarantees a threshold level of demand for its product every year (not necessarily from the same consumers).

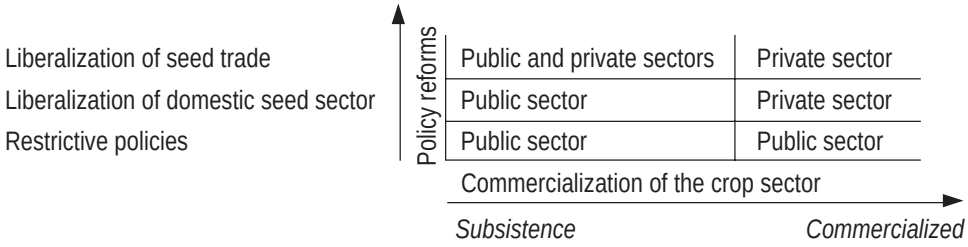

Figure 1. Public and private sector participation in the seed system under different policy regimes, for subsistence versus commercial crops

Thus, national and regional liberalization is expected to reduce the need for governments for seed multiplication and distribution. With the involvement of more private firms, the need to support public research on all crops and ecologies is also likely to be reduced, releasing the pressure on government budgets. [6]

On the other hand, governments may need to invest in business development programs and strengthening regulations that govern the corporate sector, in order to encourage seed entrepreneurs to invest. Special policy measures may be needed to ensure that the benefits of improved seeds are widely shared, such as targeted subsidies to reduce the cost of adopting improved seed and complementary inputs, market infrastructure to reduce risk for seed entrepreneurs, and market development initiatives to provide small-scale producers with access to stable and reliable outlets for their grain. Governments will also have to weigh the potential cost and risk associated with market liberalization – for example, a few foreign seed companies gaining control over the seed supply of nationally important crops, or the possibility of unscrupulous traders selling low quality and disease-prone seeds. Ultimately, all these state-level costs and benefits will be reflected in the magnitude of C in the Net Benefits framework (equation 1).

For an individual firm, a policy change promoting regionalized seed trade may increase or decrease its market size depending on its own size/scale and competition from other firms in the region. However, at the aggregate firm level, liberalization is likely to have a net positive impact, since the goal of policy reform is to promote and expand their involvement in the seed system. These net benefits are not directly reflected in equation 1, which measures

6. For example, Pray (1996) reports that privatization shifted the cost of financing agricultural research from taxpayers to farmers.

social net benefits of a policy change. However, they are passed on to seed consumers (ie, farmers) and reflected in the supply shift (K) at country level and the size of production affected (Q) at regional level.

Table 3 summarizes the expected gains and losses in different aspects of a seed firm's operations. Liberalization is likely to lower the time and money costs involved in complying with seed regulations. It will also reduce the cost of producing, importing and exporting seeds, which will be reflected in lower seed prices for farmers. The only costs likely to increase if plant variety protection laws are enforced as part of liberalization are the costs of protecting the varieties. However, these costs are necessary for firms to stay in business and are likely to be based on an internal cost-benefit analysis, which ensures that their gains from protecting a variety are more than the costs of protection.

At the farm level, the farmers (who are also operating a business with a profit motive) are also expected to gain and lose from liberalization. As indicated in Table 4, gains are expected to occur from increased yields and lower seed costs as seed markets become more competitive and offer a wider range of varieties. Yields are expected to increase as a result of better adaptation, tolerance to environmental stress, higher harvest index, reduced pest and disease losses, and improved grain quality of new varieties compared with the varieties available to farmers before policy reforms. However, it is also hypothesized that with the influx of seeds from other countries, there will be increased risks of crop losses caused by movement of harmful pests and diseases along with seeds.[7] Yet another concern is the losses to farmers due to inappropriate varieties and seed quality as a result of 'relaxed' regulations.

It should be noted that these hypothetical losses, often discussed in the context of seed policy liberalization, are not a function of the policy regime per se. For example, the risks of seed-borne pests and diseases depend on the implementation of phytosanitary rules and how effective they are in detecting the real threat. These risks can be high even in a restrictive policy regime if seed trade occurs illegally across borders without any phytosanitary inspection, or if the phytosanitary regulations are not relevant to the real threat of pests and diseases.

7. Critics of this viewpoint argue that the goal of moving towards policy regimes 2 and 3 is in fact to restrict the spread of pests/diseases across borders. The hypothesis is that liberalization will reduce illegal seed trade by making trade through official channels more attractive. It will streamline (not relax) phytosanitary regulations such that they do not interfere with seed trade more than necessary to detect real threats of seed pests and diseases.

Ultimately, the indicator of individual farmers' gains/losses is the adoption (or disadoption) of improved varieties, which collectively generate social benefits (or losses) in the form of increased (or decreased) supply of food and fiber in the economy. In equation 1, this will be reflected in the value of K.

As a summary, Figure 2 illustrates the expected change in social benefit and cost parameters at the state and farm levels relative to the benchmark policy regime or status quo.[8] Liberalization can increase the potential benefits by increasing crop yields, reducing seed costs, increasing adoption of improved varieties, and reducing R&D lags and regulation costs. But the policy change will also increase the potential costs to society in the form of increased regulatory costs to develop and enforce PVP and anti-trust laws, and prosecute fraudulent practices. Moving from a liberalized domestic seed sector to a liberalized seed trade policy regime will add both benefits and costs as illustrated in Figure 2. The potential benefits include lower costs of border patrolling (against unauthorized seed trade) and increased opportunities for seed exports. The negative impacts of liberalized regional seed trade include the time and resource cost to develop agreement on a standardized/common seed policy system, and research cost to study regional threats of pests and diseases.

The changes in the magnitude of benefit and cost parameters (that ultimately affect variables K and C in equation 1) for different seed policy regimes illustrated in Figure 2 are empirical questions. Estimating these parameters and assessing the net benefits of a policy change requires data on farm-level net benefits and state-level net costs. Effective seed policy decisions, therefore, rest on good estimates of costs and benefits of moving from one policy regime to another, an area in which there has been very little empirical work. Discussions to date on seed policy liberalization and harmonization have focused on perceived risks of open seed markets (eg seed industry concentration and farmer losses due to pests, diseases and poor seed quality). Little attention has been given to assessing these risks and the potential benefits at state and farm levels. In the following section, we present some methods and discuss the data needs to assess ex post and ex ante, the impacts of moving towards a liberalized domestic and regional seed system.

8. The cost and benefit parameters in Fig 2 illustrate the possible effects of a policy change on a national seed system. They are not representative of, and should not be interpreted as, the relative size/ magnitude of different cost/benefit variables in equation 1.

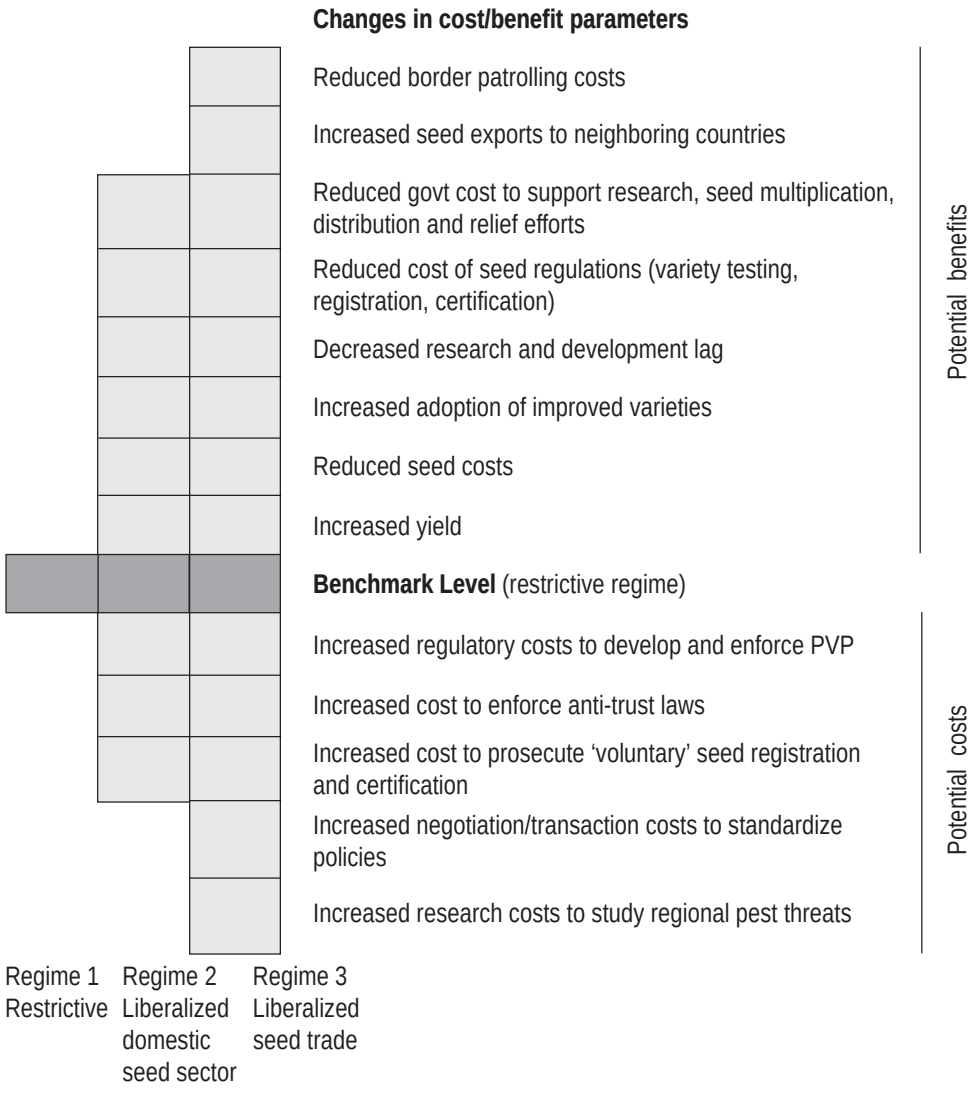

Figure 2. Changes in costs and benefits for seed policy regimes 2 and 3 compared with the benchmark level under a restrictive policy

Assessing the Net Benefits of Seed Policy Change: Evidence, Methods, and Data Needs

It is difficult to capture all the benefit and cost parameters listed in Figure 2 in a comprehensive model such as the one given in equation 1. Since many

factors (eg macroeconomic policies, weather, agricultural pricing policies) affect aggregate crop production, it is difficult to estimate aggregate impacts of changes in seed policy. Moreover, the impacts are uneven across crops – productivity and seed cost may change dramatically in some crops. Hence, the approach best suited for ex post and ex ante analysis is to estimate partial benefits for specific crops. Here we present evidence and methods of ex post assessments of impacts of change in seed policy regimes, and discuss the data needs and methods for ex ante assessments.

Impacts of liberalization

In the past two decades several countries (eg Turkey, India, Peru, Bangladesh) have undergone partial or drastic seed policy reforms promoting private sector involvement and allowing the import and export of seed. The nature and scope of seed reforms were different, but they nonetheless represent an evolution from a restrictive to a more liberalized regime. The limited examples of ex post assessments of these changes suggest the use of two methods of assessing impacts:

- Assess qualitative measures of impact indicators
- Assess quantitative measures of impact indicators

Qualitative measures of impact indicators. The impacts of policy change can be assessed by measuring the change in impact indicators listed in Table 1 (number of private seed companies, volume of seed trade, number of new varieties available to farmers, public sector investment in seed multiplication and distribution, private investment in seed research, etc).

Morris et al. (1998) present evidence of increased private investment in maize research in India as a result of liberalizing seed laws in the late 1980s. Number of maize varieties and hybrids released, seed sales, and number of maize seed companies have increased in the post-reform period. A 1995 survey of 864 maize-growing households in six states in India confirmed that the maize seed industry was rapidly expanding as a result of the reforms (Singh and Morris 1997).

Gisselquist and Pray (1997a,b) provide similar evidence from Turkey, following regulatory reforms in the 1980s. In 1980, prior to reforms, the seed industry was composed of two semi-private companies and a strong public sector managing and controlling most commercial seed production and trade through cooperatives and state-owned enterprises. After reforms, in 1985

there were nine new seed companies, further increasing rapidly as major US and Europe-based multinationals along with companies from Israel, Taiwan, Thailand, Japan, Korea, and other countries established a presence through joint ventures, licenses, or subsidiaries. In 1994 there were at least 29 companies, most of which are private. The number of varieties available increased significantly. Even without variety protection, private investment in testing and introduction of new varieties for non-hybrid crops such as wheat and soybean increased in the post-reform era. Between 1982 and 1987, the number of sunflower varieties available for sale increased from 3 to about 30; soybean varieties from 2 to over 40.

Policy reforms in Peru occurred in the late 1980s. The number of private seed companies increased from 7 in the late 1980s to 61 in 1994. Seed production by the private sector increased from 12,000 t in 1990/91 to 17,500 t in 1991/92 (Cortes 1997).

One concern about liberalization is that the local industry will be overwhelmed by imported seed and dominated by multinational corporations. The evidence, however, is not conclusive. Early analyses indicated that in countries with open seed policies such as Thailand and Mexico, less than 10% of the seed planted by farmers was imported. In Brazil and Argentina in the late 1980s, local companies that were willing to invest in research were able to compete with multinationals in hybrid crops (Pray 1996). However, as a result of globalization of the seed industry, the structure of local seed industries is changing rapidly, at least in large countries. For example in Brazil, up to 1997 two multinationals, Agroceres and Cargill, controlled 57% of the maize seed market, with the remaining 43% being distributed among 60 companies. After mergers and acquisitions in the past few years, four companies between them now have 85% of the market – one company alone has 63% (Garcia and Bahia-Filho 1999).

Thus it is possible – although solid evidence is lacking – that given the economies of size and scale in seed production, for some crops (eg hybrids) the local seed industry in small countries may be completely dominated by one or a few multinationals. The recent trend of mergers and acquisitions in the global seed industry is likely to occur at a regional level when seed markets are liberalized. The impacts on small countries within a region have not been documented.

Quantitative measures of impact indicators. Quantitative measures (crop yields, net farm income, seed prices, etc) can be assessed. Net benefits of a

policy change can then be estimated using an economic model – although no single model may suffice.

There are very few published studies on the economic impacts of seed policy liberalization. The Turkey study by Gisselquist and Pray (1997b) estimates that post-reform maize hybrids boosted annual net farm incomes in 1990-92 by $97 million. Similarly, the seed policy reforms added at least $33 million to annual vegetable exports. Their method estimates the yield response function and calculates the impact of higher yields on farmers' net incomes. It involved:

- Modeling maize yields as a function of hybrids (percent maize area sown to private hybrids, all of which came in after and because of policy reform), fertilizer, and rainfall. They include a trend variable to capture impact of transport improvements, extension, and other missing variables.
- Projecting maize yields using estimated coefficients from model specification – actual values for fertilizer use, rainfall, and trend, but zeros for post reform hybrids.
- Estimating annual gross value of additional production due to post-reform hybrids.
- Estimating the change in net farm income per hectare as a result of post-reform hybrids, accounting for higher production as well as higher seed costs and higher cost of harvesting and drying a bigger harvest.

They used a less rigorous method to assess the impacts of seed reforms on export vegetable crops. This compared the pattern of growth (pre-reform versus post-reform years) in the value of exports of fresh and processed vegetables. The increase in exports was attributed to seed policy reforms and the impact on net incomes of increased exports was calculated based on a 'rule of thumb' attributing one-third of the value of additional exports in the post-reform era (Gisselquist and Pray 1997b). Using the same method, they estimate that net income increased by $ 4 million due to increased seed exports after policy reforms in the 1980s.

Moreover, some of these impacts, especially on the government and the private sector, can be considered as intermediate outputs of seed policy reforms that lead to further social benefits and costs in terms of productivity, incomes, production, and risks of disease transmission.

Evidence on the risks of farmer losses due to pests or poor quality is not well documented. But policy reforms will in fact reduce the potential risks of farmer losses due to harmful pests and diseases. Similarly, the impacts of open

seed markets on farmer losses due to inappropriate varieties or poor quality seed are at best uncertain or positive. The evidence suggests that these risks are more likely in regime 1 when the public sector is the sole agency that decides which varieties to import and distribute (Gisselquist and Pray 1997a,b).

Impacts of regional policy harmonization

In the past few decades, several regions have undergone seed policy harmonization, including the European Union (see Box 2) and MERCOSUR regions. Seed input markets were liberalized and harmonized, but the impacts have not been assessed from a regional perspective. There is lack of empirical evidence on either qualitative or quantitative impact indicators of moving from one policy regime to another.

Harmonization of liberal seed policies leads to regionalization of seed markets, which is expected to mutually benefit all countries in the region. Conceptually, therefore, the unit of impact analysis of harmonization policies should be a region, rather than an individual country. However, policy makers would be more interested in country-specific impacts than regional gains (which will be a net sum of country-specific gains). The qualitative and quantitative impact indicators described above can be also used to assess regional benefits and costs. Due to lack of evidence, here we only attempt to describe the methods that can potentially be used, rather than those that have been used.

1. Assessment of qualitative and quantitative measures of impact indicators. This will include assessing the impacts of policy harmonization in a region by measuring the change in:

- Number of private seed companies operating in more than one country
- Share of private and public sector seed sales in the region
- Volume of seed trade within the region
- Number of new varieties available to farmers that were developed within the region
- Private sector investment in seed research in the region.

These indicators will need to be measured for each country. It is possible that for some indicators, the impacts may be opposite for a smaller versus larger country. For example, seed exports may increase for a large country or

Box 2. Regional harmonization of seed policies in the European Union

Council Directives on regional marketing of seed were first introduced in Europe in 1966 by the EEC, which later became the EU. These Directives originally dealt with cereals, fodder plants, oil and fiber plants, and beet. They were described in terms of marketing rather than certification to emphasize the objectives of supplying high quality seed to the farmer, and encouraging the unrestricted movement of seed between EEC member states. Seed certification provides agreed procedures for production and quality control to achieve minimum quality standards throughout the EEC.

The original Directives allowed member states to restrict the marketing of seed to cultivars on their national lists. This restricted free marketing. In 1970 the Council Directive on the Common Catalogue of Varieties of Agricultural Plant Species was introduced. This laid down uniform rules for the acceptance of cultivars and required member states to compile national lists of cultivars accepted for certification and marketing. Procedures were also devised for producing a Common Catalogue of Varieties comprising all the cultivars on the national lists. This provided a basis to allow certified seed to be freely marketed throughout the Community.

The Directives have been periodically amended in response to technical and political developments, and enlargement of the Community. The recently introduced Council Regulation on Community plant variety rights provides plant breeders with cultivar protection throughout the Community, and is based on the 1991 UPOV Convention.

Some salient features of the regionally harmonized seed system in the EU:

- *Certifying authority*: Responsibility for implementing the directives through statutory provisions lies with each member state. The certification procedure lays down steps to be taken by the certifying authority.
- *Cultivar registration*: To be included in a national list, cultivars must pass the DUS and VCU tests. Registration defines the cultivars accepted for certification and marketing by each member state.
- *Quality control of seed production*: The number of generations of certified seed are limited; maintainer of the cultivar is responsible for producing basic seed and earlier generations; field standards for isolation, purity etc are defined; a minimum number of inspections is required.

...Continued

Box 2. *Continued*

- *Quality control of the seed after harvest*: All member states must comply with ISTA standards for post-harvest operations.
- *Information required at the point of sale*: All certified seed lots must carry an official label. Size and color of the label and the information contained, are prescribed for each category of seed. Once certified, it is the seller's responsibility to ensure that the certification standards are met.
- *Proportion of controlled seed on the market*: Only certified seed or standard seed of vegetable plants may be sold. Farmers may save seed for use on their own farms, but for protected varieties this may require permission from the breeder and payment of royalty.

Source: Adapted from Bould 1998

one with a well-established seed industry, but imports may increase for a smaller country. It is hypothesized, however, that the aggregate impacts of increased seed trade at the regional level will be a sum of positive gains at the country level – as a result of both increased exports and increased imports.

2. Economic impact assessment. This will include assessing the impacts of harmonization on regional crop yields, seed prices, pest/disease risks, and adoption rate. Economic models described above for estimating impacts at a country level can be used to estimate the regional net benefits of seed policy harmonization.

A study of maize yields in 45 countries over 25 years (1960-85) found strong correlation between yield increases and volume of seed imports from USA (in temperate countries) and local private sector research (in tropical countries) (Echeverria and Pray 1991). Though this study did not focus on the impacts of regional policy harmonization, it shows the possibility, at least ex post, to assess quantitative measures of yield impacts of increased seed trade within a region. The method involved estimating a maize response function (regression analysis) relating output per hectare as a function of levels of seed imports, fertilizer use, and research investment with a variety of qualifying variables such as land quality and weather.

Another method is to assess the net benefits of public sector research (including the IARCs) in a with- and without-policy harmonization scenario at a regional level. The change in economic surplus as a result of policy

harmonization will be reflected in higher adoption of improved varieties of public varieties and increased productivity across countries.

Methods and data needs for ex ante assessment of seed policy reforms

At present, policy makers are constrained by the small number of empirical studies on the actual benefits and costs of reforms and the impact on the supply of new seed technology. Without such information, it is difficult to determine what impacts reforms will have on the transfer and availability of new varieties from private and foreign sources. One objective of this paper is to outline a plausible ex ante assessment approach to better inform policy makers on the potential benefits and costs of changing to a policy regime that promotes regional seed trade and introduction of varieties from private and foreign sources.

The simplified economic surplus model (benefit-cost model) illustrated earlier provides a useful framework to assess crop-specific aggregate impacts of a policy change. Assessing, ex ante, the gains from improved seed availability (both quantity and quality) due to liberalization (ie, removing controls on introduction of new varieties) and regionalization (ie, making seed markets regional) is akin to assessing the potential gains from plant breeding research in a world without input policy distortions and input trade restrictions. In this approach we estimate the economic costs and gains due to reduced controls in various components of a seed system (variety research, protection, registration, certification, trade, etc).

To estimate, ex ante, the economic impacts of a policy change, the indicators of interest are the expected impacts on unit cost of crop production from the introduction of new varieties, impact on seed prices, adoption rate, market size, expected change in the size of market, and expected losses due to risks of new pests and diseases, and inferior seed quality.

Given the lack of empirical evidence on the relationship between policy change and several of these indicators, a full-fledged quantitative assessment using the economic surplus model will be beyond the scope of any ex ante analysis. The approach proposed, therefore, is to: (i) first pursue a strong qualitative analysis to define the major costs and benefits expected from a policy change, (ii) assess the probability and order of magnitude of these major costs and benefits in a given context, (iii) then attempt to quantify them using an economic framework.

Ex ante assessments of impacts of seed policy reforms will thus require several steps:

1. Understanding the nature and scope of policy reforms

This will require talking with government officials on what will be the nature of seed policy reforms. What will be the degree of liberalization sought by policy reforms? Which components of the seed system will be affected by the change in policy? What crops?

2. Defining the costs and benefits

A useful strategy in the absence of empirical evidence would be to identify costs and benefits based on stakeholder viewpoints of pros and cons of a policy change. This will require interviewing public sector administrators, researchers, seed entrepreneurs, farmers, representatives of IARCs, NGOs and multinational seed companies, administrators/policy makers, and representatives of regional organizations/networks.

3. Assessing the potential demand and supply of new varieties

Superior varieties will always be in demand by farmers in any country. However, a clear assessment of the potential demand for seed of improved varieties is necessary in order to measure the potential size of the seed market. Data should be collected on technical factors such as seeding rate, and frequency of seed purchase necessary to realize the yield potential (and other benefits) at farm-level. Where applicable, these data need to be collected separately for hybrids and open-pollinated varieties. Secondary data on area and production for major crops need to be collected to estimate the potential demand for seed each season. For a regional estimate, area and production need to be estimated for major agro-ecological zones and/or cropping systems.

Assessing the current and potential supply of formal sector seed will require data on sales, imports and exports. Much of the demand and supply in many developing countries is for seed distributed by NGOs and donors under disaster relief or regular development programs. Interviews with personnel from the public sector, NGOs, and private firms will help gather information from both the formal and relief sectors, and assess their response to policy reforms as they impact on the supply of seed in local and regional markets.

4. Assessing pre-reform indicators of seed system performance

As a first step, one needs to assess the without-policy-reform situation as reflected in market indicators. Qualitative and quantitative data – eg production of source seed, seed multiplication, processing, quality control, marketing (seed sales data), and seed trade (imports, exports, emergency relief supply, seed coming from across borders, etc) – need to be collected in order to identify the key constraints in national and regional seed systems.

5. Assessing the potential impacts of policy reforms on market indicators

The next step is to predict the likely impacts of policy reforms on indicators such as: source and number of varieties available to farmers, their yield potential, risk of seed-borne diseases, price of seed, and the likely adoption of these varieties. Potential impacts on seed industry restructuring and how they relate to the performance indicators should be part of this assessment.

It may be useful to list all the possible impacts on market indicators identified in Tables 2 to 4 (or those defined in step 2 above) and measure/estimate the change in each indicator as a result of changes in specific rules/components of the seed system or full liberalization of seed markets at the regional level.

6. Estimating farm-level impacts

Using the projected impacts of farm-level indicators such as yield and price and estimating a simple farm-level crop budget, one can then assess the per unit (ton or ha) net reduction in costs, or net gains in profits, due to new varieties.

7. Estimating economic impacts at aggregate level

The per unit estimates of cost reduction can be aggregated at a market level by assessing the economic surplus using the framework described in equation 1. This will need data on market size (area, production for each crop); projected adoption rate over a period of time; projected output price over a period of time; projected change in the R&D lags of new varieties; and projection of any crop losses due to risk factors (a probability estimate based on past experience in the region or elsewhere of transferring new pests and diseases).

8. Comparing the estimates of (present value of) net benefits with potential costs of policy reforms

Costs of policy reforms will be the most difficult to assess. Depending on the nature of reforms and degree of liberalization and harmonization, some costs may be obvious – such as elimination or addition of a government department.

However, many costs are difficult to assess. At the country level, these include the time and effort invested by policy makers in debating the issues, reaching consensus, drafting new policies, going through the legislative process and implementing the policies. This process can take several years. Policy harmonization at a regional level may involve further costs in policy makers' time and effort to meet, resolve differences, and reach a consensus with other countries in a region.

A second best approach to take ex ante is to assess the potential benefits and present them along with qualitative and quantitative estimates of expected cost increases or cost savings as a result of policy change. Conceptually, it is difficult to estimate crop-specific costs of seed policy change since reforms will rarely impact only one crop. Because of economies of scope, many of the cost components identified in Figure 2 are national costs across commodities, whereas the benefits to be assessed only account for partial benefits to be realized at a commodity level. Some costs must be apportioned across commodities – perhaps based on the share of the value of the crop in the total value of agricultural production in a country.

Conclusions

Many countries are contemplating reform or are already in the process of reforming seed policies. Many smaller countries, especially in Africa, want to take policy reform one step further and harmonize seed regulations at a regional level. Donors and international organizations such as the World Bank have encouraged and supported these governments to reduce controls on variety introduction, giving farmers immediate access to regional technology, and also creating larger regional markets that will attract private domestic and foreign companies. It is outside the scope of this paper to describe the current status of seed regulations and the recommended or needed changes in the regulatory system. The purpose of this paper was to present concepts, evidence and methods that describe what is involved in assessing the potential impacts of policy change in order to provide an economic perspective to the reform process in Africa.

One limitation for policy makers is that the limited examples found in the literature do not really define the full range of costs and benefits of a seed policy change. None of these studies looks at the impact in the context of Africa. Very few ex post studies look at the benefit of the transfer of new varieties across countries as a result of policy change. Without such

information, it is difficult to determine the impacts policy reforms will have on the transfer and availability of new varieties from private and foreign sources.

More empirical research is required to test the hypothetical costs and benefits discussed in this paper. One approach could be to provide empirical evidence that a policy reform will not cause harm, for example, by looking at the disease risk factor of increased seed trade. But empirical evidence that a policy reform will not cause harm (will not increase the risk of seed-transmitted diseases) may not be sufficient to change a policy. Without evidence of positive gains, policy makers might not push reform.

The economic concepts and (lack of) evidence presented in this paper will hopefully encourage studies on both ex ante and ex post assessments of impacts of liberalized and harmonized seed markets in Africa. The methods outlined for ex ante assessment provide a starting point for such studies, though there is scope for refinement to generate much richer qualitative and quantitative information once the analysis is actually undertaken in a specific country or region.

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Regional Plant Breeding and Variety Registration: A Case Study of Southern Africa

Mary Mgonja,[1] Emmanuel Monyo,[1] David Rohrbach,[1] and Mywish Maredia[2]

1. SMINET Coordinator, Principal Scientist (Breeding), and Principal Scientist (Economics) respectively, ICRISAT, PO Box 776, Bulawayo, Zimbabwe. 2. Associate Professor, Dept of Agric Economics, Michigan State University, MI 48824-1039, USA

Introduction

Other papers in these proceedings discuss various aspects of regionalization, such as plant breeding, seed regulations, and variety registration. This paper examines the case for regionalized variety development and registration in southern Africa. Recent work by ICRISAT and other CGIAR institutions has led to significant research progress in establishing a justification for regionalized breeding and registration. But this has yet to be matched by changes in policy.

Currently, every country in the Southern African Development Community (SADC) seeks to maintain an independent program of variety development for most major crops. Due to resource constraints, many of these breeding programs are under-staffed and under-funded. This slows the development of new varieties, and downstream, the availability of seed of these new varieties to farmers. One solution is greater regional integration of crop breeding programs, moving from a set of relatively isolated national investments towards a coordinated regionalized investment linked with the global research community. The international agricultural research centers (IARCs) of the CGIAR provide national breeders with access to an international germplasm base. The CG Centers could additionally help link national investments into more coordinated regional programs.

This paper reviews the regional breeding strategies pursued by two IARCs (ICRISAT and CIMMYT) and one private seed company, the Seed Company of Zimbabwe, in the SADC region. Based on the review of each program we summarize the justifications for a regionalized breeding and variety registration strategy for the SADC. Technical advances made in

support of regionalization (eg environmental characterization and identification of regional test sites) are described. Finally, ongoing activities and future plans are discussed.

Breeding Strategies Used by CIMMYT

CIMMYT, like other IARCs, has traditionally evaluated its germplasm in collaboration with national agricultural research programs (NARS) and private seed companies. The evaluation is conducted through a large number of multi-location yield trials that test diverse germplasm across a range of environmental conditions.

The maize improvement program in southern Africa was, until 1998, implemented through the Maize and Wheat Improvement Research Network. The network's objectives were to facilitate the exchange of improved maize and wheat varieties, and strengthen NARS research capabilities through human resource development and exchange of information. In 1998, the focus of CIMMYT's breeding program shifted towards improving tolerance to major environmental stresses like drought and low levels of nitrogen. Stress-screening sites were identified in different countries and maize breeders from the public and private sector were invited to submit promising varieties for testing. The objective was to evaluate new varieties from any breeding program under the stresses most commonly experienced by resource poor farmers (Banziger et al. 2000). This regional maize improvement work is currently being implemented through the Southern Africa Drought and Low Fertility project.

Target environments

The CIMMYT program currently targets close to 20 countries in southern and eastern Africa. At the broadest level, CIMMYT targets its breeding efforts at four agro-ecological zones (Hassan et al. 2001): highlands, wet subtropics, dry subtropics, and lowlands. These 'mega-environments' have been demarcated based on daylength, temperature, and rainfall. Each zone has a maize cropped area of over 1 million ha, increasing the probability of payoff to an internationally focused breeding effort. But this classification may be further refined to account for disease and pest incidence.

The maize breeding program in southern Africa emphasizes development of genotypes with broad adaptability in order to increase yield

across a wide area, containing both high-stress (eg drought, disease, acid soils) and favorable environments. This is done by evaluating the performance of breeding materials under managed stress and non-stress conditions. For example, trials are conducted in disease hot-spots, drought-prone areas, or areas with poor soil fertility or acidic soils; as well as high-potential areas. The trials may be grown by CIMMYT, NARS, private seed companies or NGOs.

It is generally understood that productivity gains derived from selection for broad adaptation can be equal to selection for specific adaptation, but never greater (Wright 1976). If genotype-environment (GxE) interaction is large, selection for broad adaptation would be disadvantageous, even with a large number of selection environments. However, CIMMYT sees limited risk in pursuing broad adaptation. Trial results suggest that selection response has been observed to be effective across a range of stress levels for that particular stress, and may have spillover effects to other stress factors (Banziger et al. 1999). The larger source of risk lies in the level of diversity of germplasm being tested – working with a small number of germplasm lines, whether they possess broad or specific adaptation, is undesirable.

Variety releases and adoption

Variety registration and release is done by individual national and private breeding programs. Different national variety release committees have different requirements. Companies that sell maize hybrids developed by CIMMYT keep information on pedigree confidential. Information on hybrids released by these companies does not indicate or distinguish between hybrids that originally came from CIMMYT and hybrids that were developed by the companies themselves. This increases the difficulty of tracking multi-country releases and regional adoption of specific cultivars.

Nonetheless, the existence of regional adaptation is apparent in recent multi-country releases for maize open-pollinated varieties (Table 1). The three varieties are also being used in Angola, Mozambique and Zambia though they have not been formally released in these countries.

Adoption of released varieties derived from CIMMYT has not been formally assessed, but appears to be high.

Table 1. Maize OPVs released in 2001 and 2002

Variety	Country of release	Year
ZM 421	Malawi	2001
	Zimbabwe	2002
	Tanzania (Situka)	2002
ZM 521	Malawi	2001
	Zimbabwe	2002
	Tanzania	2002
	South Africa	2001
ZM 621	Malawi	2001

Breeding Strategies Used by ICRISAT

In 1983, ICRISAT was asked by the SADC Heads of State to set up a regional crop improvement program in southern Africa for sorghum and pearl millet. These crops are important for food security, especially in drought-prone areas where poverty is highest. About 3 million ha is planted to these crops each year, but 75% is accounted for by only four countries: Tanzania, Mozambique, Zimbabwe, and Namibia. All other SADC countries have at least small areas planted to these crops, which remain important for food security (especially in some regions) within each of these countries.

Target environments

When the regional Sorghum and Millet Improvement Program (SMIP) was established, ICRISAT's breeders arimed to develop widely adapted varieties with different maturity periods, but especially varieties with earlier maturity – and thus the capacity to escape late-season drought. In the mid 1990s, an effort was made to more strictly define the agro-ecologies to be targeted. Twenty-six production systems were defined worldwide, based on areas of adaptation of the Institutes' five mandate crops. Two of these 26 production systems were in Southern and East Africa:

- Lowland, rainfed, short season (less than 100 days), sorghum/millet/rangeland
- Semi-arid, intermediate season (100-125 days), sorghum/maize/rangeland.

In recent years, these broad production systems have been further delineated, using geographic information system (GIS) techniques, on the

basis of Length of Growing Period (LGP), ie the period when precipitation exceeds potential evapo-transpiration. The primary focus of current breeding programs is on areas with LGP of 3, 4 and 5 months, where the bulk of sorghum and pearl millet are grown; the secondary focus is on areas with LGP of 6 months, where smaller quantities of sorghum are grown.

ICRISAT's regionally focused crop breeding efforts pursue broad adaptation. However, efforts to involve farmers in variety selection have encouraged the complementary pursuit of location specific priorities. These may be based on differences in pest and disease pressures or farmers' grain and plant trait preferences. Table 2 summarizes priority traits chosen in consultation with farmers in various southern African countries.

The involvement of farmers in variety selection was particularly strong in Namibia (Ipinge et al. 1996). Here farmers, rather than researchers, chose the initial pearl millet varieties to be released. Monyo et al. (2001a) describe the performance of a pearl millet composite population developed in Namibia through selections initially made by farmers. Similar programs have been launched in Tanzania (Letayo et al. 1996) and Malawi (Chintu et al. 1996). Yet farmer participation does not necessarily narrow the zone of adaptation of selected varieties – the pearl millet variety originally selected by farmers in Namibia was later released in three other SADC countries.

Table 2. Trait prioritization for sorghum and pearl millet in Southern Africa

Priority traits	Priority areas/ regions
Sorghum	
Productivity/ hybrid vigor	Zimbabwe, Botswana, South Africa
Early maturity	Zimbabwe, Namibia, Botswana
Grain quality for food, feed and malt	South Africa, Zimbabwe, Namibia
Novel traits for new products	South Africa, Zimbabwe, Namibia
Drought resistance	Zimbabwe, Botswana, Namibia
Pest resistance (stem borer)	Tanzania, Zambia, Malawi, Mozambique
Resistance to leaf and head diseases	Tanzania, Zambia, Malawi, Mozambique
Striga resistance/management	Tanzania, Zimbabwe, Botswana,
Pearl millet	
Grain quality (nutrition)	South Africa, Zimbabwe, Namibia
Drought	Zimbabwe, Botswana, Namibia
Downy mildew	Tanzania, Zambia, Malawi
Grain yield	Zim, Botswana, Namibia, Tanzania, Malawi, Mozambique
Pest resistance (stem borer)	Tanzania, Zambia, Malawi, Mozambique

Release and adoption of varieties

In the 20 years of the SMIP program, 45 varieties of sorghum and pearl millet have been released in eight SADC countries. These varieties are grown on 10-50% of the total area under sorghum and pearl millet in these countries.

A number of these sorghum and pearl millet varieties have been released in multiple countries (Table 3). For example, the sorghum variety Macia has been released in Botswana, Mozambique, Zimbabwe, Namibia, and more recently Tanzania (Obilana 1998, Saadan et al 2000). The variety ICSV 112 has been released in Zimbabwe, Swaziland, Malawi, and Mozambique, under various names (Obilana 1998).

SMIP currently focuses on four 'target' countries, aiming to build on past variety development work by strengthening seed systems to ensure that seed of the new varieties is widely available. As a result of these efforts, adoption has grown rapidly. An adoption survey in Tanzania in 2000/01 revealed that improved sorghum varieties were planted on roughly 36% of the country's national sorghum area – up from 5% three years earlier. In Zimbabwe adoption of improved sorghum varieties had increased to 29%. Pearl millet adoption had doubled to 49% in the past five years (Monyo et al. 2001b).

Breeding Strategies Used by the Seed Company of Zimbabwe

The Seed Company of Zimbabwe (Seed Co) is a private firm based in Zimbabwe, but with production and marketing infrastructure spread across

Table 3. Recent multi-country releases of sorghum and pearl millet varieties developed by ICRISAT

Variety	Country and year of release	Variety	Country and year of release
SDS 3220 (Macia) sorghum	Mozambique, 1989 Botswana, 1994 Zimbabwe, 1998 Namibia, 1998 Tanzania, 1999	SDMV 92040 pearl millet	Zimbabwe, 1998 Namibia, 1998
ICSV 112 (SV 1) sorghum	Zimbabwe, 1987 Swaziland, 1992 Malawi, 1993 Mozambique, 1993	ICMV 88908 (Okashana 1) pearl millet	Namibia, 1990 Malawi, 1996 Zimbabwe, 1996 Botswana, 1999

southern Africa. Seed Co markets seed for a range of food crops including hybrid maize, soybean, sorghum, pearl millet, and groundnut. The company's breeding program targets both national and regional needs. Here we focus on Seed Co's hybrid maize program.

Target environments

Most of Seed Co's maize breeding research is carried out in Zimbabwe, where the company is based. Varieties for export are also tested at specific sites in other countries. Target environments in Zimbabwe follow an established agro-ecological classification used by the government, called Natural Regions (NR). These are based on physical and climatic factors (altitude, daylength, temperature and rainfall).

- NR I: for specialized and diversified farming; over 900mm of rainfall
- NR II: intensive farming, rainfall 750 to 1000mm
- NR III: semi intensive farming, rainfall 650-800mm
- NR IV: semi extensive farming, rainfall 450-600mm, frequent drought
- NR V: Extensive farming, frequent drought

In addition, Seed Co also considers pest and disease incidence, as well as grain yield and other agronomic parameters.

In southern Africa as a whole, Seed Co pursues variety development for four broad target environments similar to those chosen by CIMMYT: Lowland tropical to sub-tropical, Mid altitude dry, Mid altitude moist, and High altitude moist. As with environments in Zimbabwe, regional target environments are defined in terms of environmental factors: altitude, temperature, rainfall, and pest and disease incidence.

In both national and regional programs the objective is to breed for broad adaptation within each target environment. This allows the company to pursue larger regional seed sales for each variety.

Impact and adoption

Adoption of Seed Co maize hybrids is high in Zimbabwe. The company accounts for more than 80% of all maize seed sales in the country, and more than 75% of Zimbabwe's maize area is planted to fresh seed each year. Sales are more variable in other countries because of the greater use of open-pollinated varieties rather than hybrids. Because Seed Co targets broad adaptation, multiple releases of maize hybrids in the region are common – at least 28 hybrids have been released in more than one country. Countries with

the most Seed Co hybrid releases are Zimbabwe, Zambia, South Africa, Malawi, Swaziland, Mozambique, Tanzania and Uganda.

Regionalized Breeding and Variety Registration

For many years, NARS in southern Africa have maintained independent national breeding programs for most crops, often operating in target areas too small for the returns to justify the costs. With resources for both public and private R&D diminishing, issues of efficiency, comparative advantage and economies of size and scale become critical.

Regionalized breeding programs and regional variety registration (as opposed to separate registration in each country) have been proposed as strategies to counteract the challenges of small market size and limited research resources. With this approach, research will be governed less by political boundaries and more by biophysical factors that cut across country borders. This requires a good understanding of recommendation domains where a variety may be suitable. It also requires a scientific basis and economic justification for pursuing regionalized breeding.

Regionalized breeding and variety registration can speed the access of farmers to new varieties in two ways. First, a common set of data may be used to justify release and registration in more than one country. Second, the larger regional market may attract private investment into the seed trade. Scale economies may encourage larger investments in the development and sale of open pollinated varieties as well as hybrids. Correspondingly, seed availability, crop productivity and food security may all increase.

Research in support of a regionalized breeding approach

Plant breeding is usually complicated by the presence of GxE interaction. Southern Africa is characterized by large GxE interactions because of large seasonal fluctuations ranging from severe drought to flooding. The impact of environmental factors is multiplied by the fact that most small-scale farmers use few external inputs. As a result, variations in crop production are the highest in the world (Heisey and Edmeades 1999).

Selection of improved genotypes thus requires a good understanding of the characteristics of various environments – the environment where the research is conducted, the target environment where the new varieties will be grown, and other environments where the varieties may be suitable. Breeding

programs need to characterize environments to interpret GxE interactions and make informed decisions on test sites, germplasm selection, breeding strategies, and potential zones of adaptation for a new variety.

ICRISAT, CIMMYT and other institutions, working with NARS partners in the SADC region, have worked on two sorts of environmental characterization: (i) direct characterization using environmental or climatic variables, eg crop simulation modeling and use of GIS, (ii) indirect characterization using statistical techniques to measure plant responses and provide a bioassay of the influence of environmental conditions on plant performance.

GIS mapping

GIS tools were used to map agro-ecological zones across the region based on length of growing period (Fig 1). Thus, different agro-ecological environments have been clearly delineated, as a prerequisite to further site characterization and identification of target areas for new varieties.

Using GIS tools, the areas of adaptation for each of the multiple released varieties were also mapped (Fig 2). We identified areas – beyond the areas of release – where these varieties might be adapted (Mgonja et al. 2001). Specific varieties are likely to be suitable for important production zones even in countries where intensive testing has not been done. One example of where such maps could be used is in the agricultural recovery program for Angola. The maps show that at least one variety each of sorghum and pearl millet should perform well in southern Angola, and these could be immediately introduced.

Apart from facilitating dissemination of appropriate new varieties to specific areas, this sort of mapping is also useful to relief programs. For example, if a drought or flood occurs in one part of the region, and there is a need for emergency seed relief for planting in the following season, it is easy to identify what varieties are adapted to the afflicted area. It is also easy to identify where else in the region those varieties are grown, and where seed might be sourced. In future, it may also be possible to set up a Regional Seed Security System wherein seed stocks of regionally important varieties could be held as a regional reserve.

Statistical site stratification

The number and location of testing sites are critical factors that affect the efficiency of and potential gains from breeding (Peterson 1992). ICRISAT

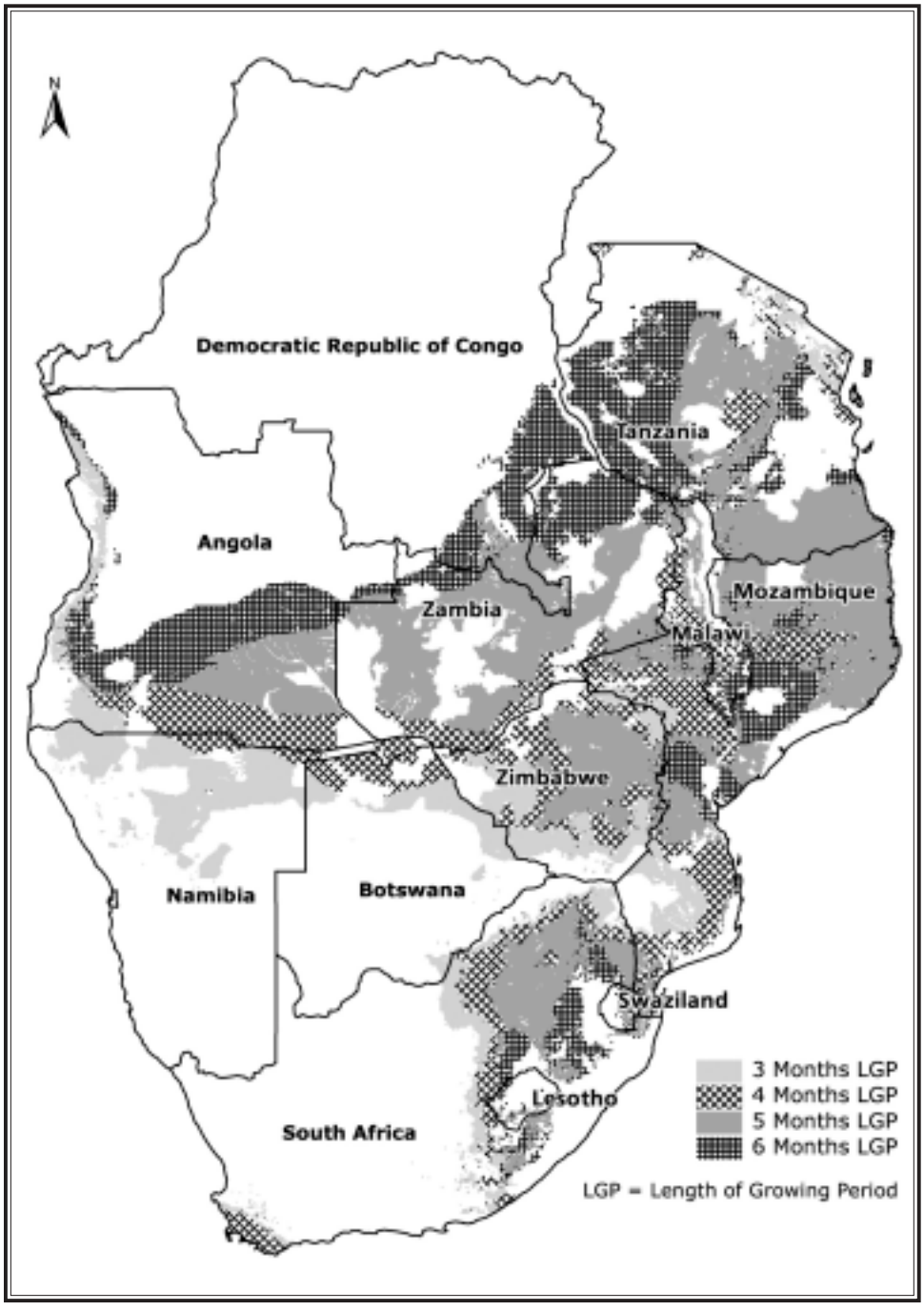

Figure 1. Length of Growing Period (LGP) in the SADC region

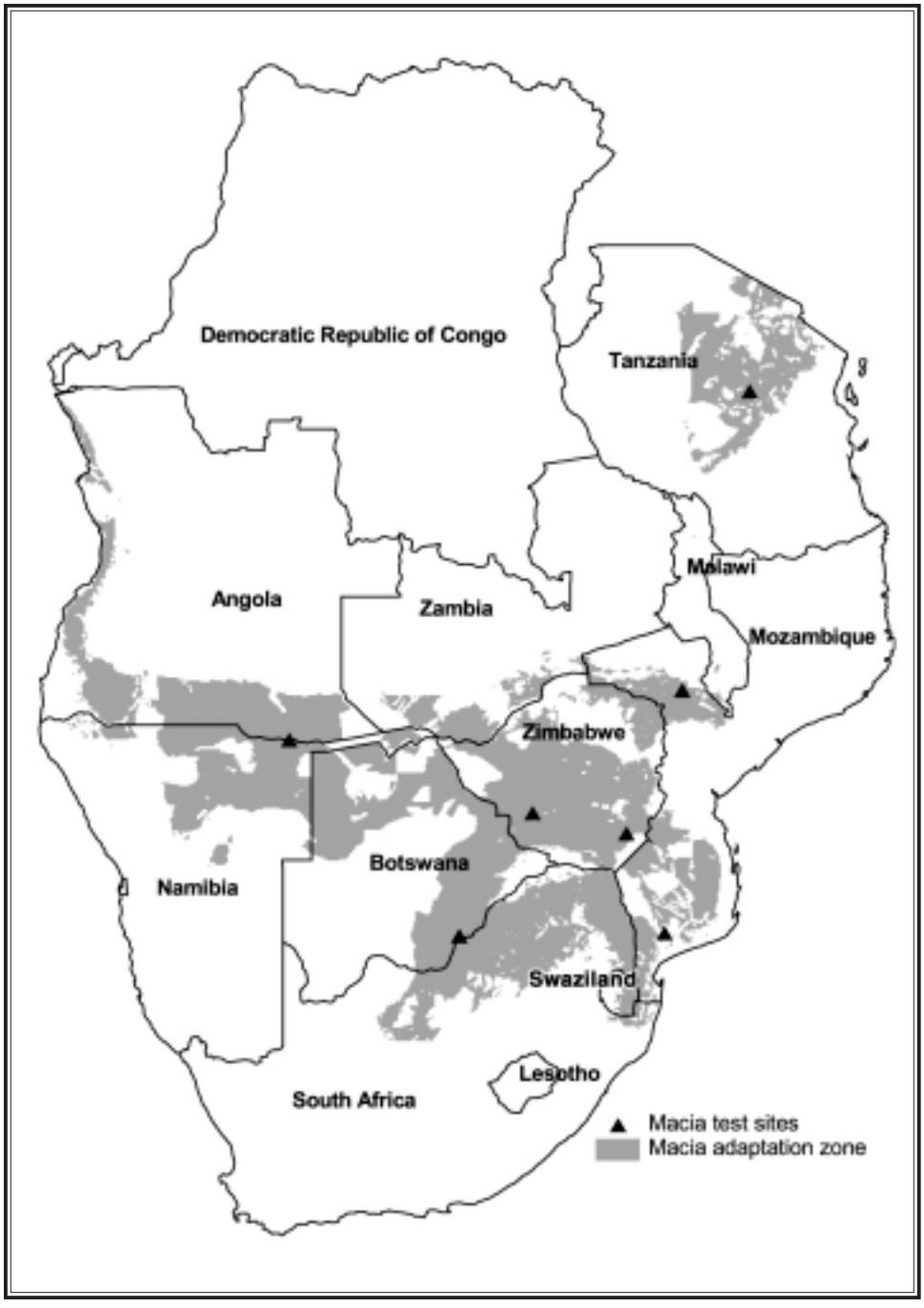

Figure 2. Adaptation areas for sorghum variety Macia

has helped identify a limited number of test sites, where a regional trials program could be implemented, with no loss of statistical validity of results. Historical data from multi-environment sorghum and pearl millet trials conducted in the region over 15 years, were analyzed using Sequential Retrospective (SeqRet) pattern analysis. The sites were then stratified according to their similarity of variety yield differentiation. The pearl millet trials covered 25 sites over nine years (1989/90 to 98/99). The sorghum trials covered 34 sites over seven years (1987/88 to 92/93, and 99/00). The 25 pearl millet sites were clustered into six groups with a model fit of $R^2 = 76\%$ while the 34 sorghum sites clustered into six major groups with $R^2 = 75\%$ (Chandra et al. in press).

Thus, we now have an objective basis to select representative test sites for future testing of varieties and hybrids. Future testing can be restricted to a few sites picked from within each of the identified site-groups.

Initiatives on regionalized variety registration

ICRISAT, in collaboration with NARS, other IARCs and the SADC Seed Security Network, is now seeking to establish a system of regionalized variety registration, as opposed to separate registration in each country. There are several justifications for this approach:

- Each SADC country shares agro-ecological environments (and biotic and abiotic constraints) with its neighbors. Thus, outputs of a breeding program in one country can potentially be adapted and adopted in similar environments in other countries. A growing number of examples of successful multiple variety releases of maize, sorghum and pearl millet have shown stable performance across a wide range of environments, cutting across country borders.
- At the same time, each country has multiple environments – more breeding effort is needed per unit of crop area in a given country. A regional program would help reduce these costs.
- Results of site stratification have identified a few key benchmark test sites; costs can be reduced and efficiency increased by implementing a regional testing program at these sites.
- Regionalized crop breeding will allow NARS to share data, responsibilities, expenses, and breeding materials much more efficiently across the region.

Some progress has been made towards achieving regionalization in the SADC region:

- In 1999 agreement was reached with NARS sorghum and pearl millet breeders to pursue a regionalized breeding program. All partners, including private seed companies, have agreed to contribute human and financial resources as well as germplasm.
- A crop improvement group was convened in 2000 to verify needs and strategies, define agro-ecological zones and specific niches for breeding, and identify research priorities. The group also identified NARS with the capacity to lead specific components of a regional program.
- The 'lead NARS approach' has been accepted and operationalized. In this approach, a particular NARS (or a small group of institutions) leads work on a constraint that is important in several countries, and results are shared across the region.

The 'Lead NARS' concept

In this approach, a national program with a comparative advantage (eg more resources, or availability of disease hot-spots) leads research in a particular area, on behalf of other national programs that share the same problem. The 'Lead NARS' coordinates research, and shares results/breeding materials with other NARS. Instead of each country running its own program, most of the work is done by one program on behalf of the region. This reduces duplication of effort and saves resources. To date, two pilot 'Lead NARS' programs have been established. Tanzania is the Lead NARS for incorporation of *Striga* resistance into sorghum landraces; *Striga* is a major problem regionwide. Zambia is the Lead NARS for developing improved photoperiod-sensitive sorghum landraces suitable for long-season areas, which are important in several countries. National programs are enthusiastic about the approach, and there is considerable opportunity for expansion.

Future Plans

Three IARCs (ICRISAT, CIMMYT, CIAT), the SADC Seed Security Network, and some private seed companies are collaborating to provide a sronger scientific and economic justification for regionalized variety registration. This is being targeted initially at four 'fast track' crops – sorghum and pearl millet, maize and beans. The SADC Food, Agriculture and Natural

Resources Secretariat has endorsed the approach. Eventually, it is hoped that regional variety registration will form part of a broader regionalization, including harmonization of seed regulations across the region, and creation of a large, unified market for seed trade.

Technical committees are being formed to address specific issues related to regionalized plant breeding and variety registration. These committees will help move forward the agenda for regionalized registration and release, seed quality control, plant quarantine control, and seed trade. The objective is to establish a protocol for regional registration and harmonized seed regulations to facilitate regional seed trade; and implement the procedures initially for the 'fast-track' crops.

Future activities on recommendation domains were discussed at the Inter-Center Seed Meeting in June 2002. There is a need to map variety adaptation across the region for other crops, and to compare methodologies and results from each IARC to find what works best and where. CGIAR Centers in Eastern and Southern Africa (CIAT, CIMMYT, ICRAF, ICRISAT, IITA) will work with NARS and private seed companies on this issue.

Another new initiative, suggested at the Inter-Center meeting, is the 'one-stop' source of information, to complement a regional variety registration system. The SADC Seed Security Network is documenting country variety lists for all crops. ICRISAT has collected some information on multi-country releases from IARCs and the private sector. This information will provide a starting point for an information database for the region, containing descriptions of registered varieties and availability of seed of all classes.

Conclusions

Not every country needs its own independent breeding program; breeders should be encouraged to use data (eg results from variety trials) from neighboring countries with similar environments. Countries with a large or very diverse area of a crop may be justified in having a large breeding program. But other countries, with smaller crop areas and ecological similarity to their neighbors, could limit their expenses to confirming results obtained from neighboring countries. Ultimately, countries can concentrate their resources on crops and agro-ecologies for which they have larger or more unique needs.

There is a clear justification for regional, as opposed to national, variety release. Regional releases can help deliver new varieties more quickly to larger numbers of farmers. Multiple rounds of variety testing in individual countries

can be replaced with a single round that covers a wider region. Similarly, there is potential for establishing regional seed markets. For most open and self-pollinated varieties, the commercial incentives for seed producers are limited. National markets are too small to justify large investments; but a regional seed market offers larger, steadier investment returns. The SADC Seed Committee has agreed to examine the case for regionalized registration of sorghum, pearl millet, maize and beans. If this is successful, it would be an important step towards greater efficiency and economies of size and scale in variety development and seed production throughout southern Africa.

In recent years, ICRISAT has sought to promote a more regionalized approach to crop breeding. National breeders have expressed support for this program, and the initiative has been commended in recent SADC meetings on regional seed policy. But national policies remain focused on retaining independent breeding programs. The gains achieved to date still need to be consolidated with policy commitments to such regional scientific collaboration.

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Justification for Regionalized Plant Breeding and Variety Registration

Mywish Maredia,[1] David Rohrbach,[2] and Mary Mgonja[2]

1. Associate Professor, Dept of Agric Economics, Michigan State University, MI 48824-1039, USA. 2. Principal Scientist (Economics) and SMINET Coordinator respectively, ICRISAT, PO Box 776, Bulawayo, Zimbabwe

Introduction

In a climate of stagnating (and often declining) budgets, research managers should be looking for ways to improve the returns to their limited investments in technology development. In so doing, they must inevitably confront questions of priority setting (which research questions should be pursued) and research strategy (how can this research be most efficiently conducted). National research programs cannot be expected to support research for all crop and livestock enterprises in all agro-ecologies. Resources need to be concentrated on a few main enterprises or agro-ecologies. Nor can national entities expect to pursue the full range of strategic, applied and adaptive research for each priority problem. Countries with smaller budgets and fewer scientists likely need to concentrate on applied and adaptive research with a problem solving focus.

In this context, a key strategy for improving the efficiency and impacts of agricultural research investments is to make use of technology spillovers. Agricultural technologies (and methods) may be obtained from scientists and institutes elsewhere, throughout the world. Spill-ins may be actively sought from neighboring countries, or internationally oriented research institutes pursuing similar objectives. Examples of successful technology spillovers are common. A number of recent studies have highlighted spillovers facilitated by international agricultural research centers (IARCs) (Maredia et al. 1996, Evenson and Gollin 2003). Examples are also apparent in the orientation of many international seed companies to breed for wide adaptation.

The paper outlines an economic model useful for evaluating how national research investments can benefit from technology spillovers from neighboring countries. The model refers primarily to crop breeding, but the principles may be applicable to a wider range of agricultural technologies.

The paper argues that many national agricultural research systems (NARS), particularly smaller systems in developing countries, should be pursuing a more regionalized crop breeding program. Focusing on regionalized investment and promoting technology spillovers can improve the efficiency and payoffs to national research investments. The paper starts by laying out the concepts, issues, and challenges of regionalized breeding. It then outlines an economic model for assessing the returns to a complementary set of regional and national research investments. These decisions are brought into focus with a summary of regionalized breeding efforts recently implemented by ICRISAT in southern Africa. Finally, the paper summarizes some of the implications for investment decisions by donors, IARCs, and NARS in sub-Saharan Africa.

Regionalized Breeding and Variety Registration: a Conceptual Framework

Understanding G, E, and G x E

There are two explicit components that define a plant breeding program – the genotypes (G) and the environment (E). Plant breeders basically aim at improving genotypes for a given plant environment (see Box 1 for definitions). The genotype refers to the genetic constitution of a plant. It is this component that a breeder aims to improve. Individual genes or groups of genes govern different traits of a plant. The expression of these genes commonly depends on the circumstances of plant growth. The genetic diversity in a plant population stems from both the variability of its genes and their responses to different circumstances. The success of a breeding program, in part, will depend on the genotypes available to a breeder and the nature of their genetic diversity.

The environment for plant breeding determines the objectives of research. It is most commonly defined in terms of the agro-ecological conditions influencing plant growth – water, temperature, nutrient and pest conditions. However, environment also encompasses the pressures of consumer demand for specific plant traits. Thus, a plant breeder may look for a high yielding variety suited to drought-prone areas, which also stores well or can be efficiently milled.

A third implicit component in a plant breeding program is GxE interaction, which denotes the differential response of genotypes to different

agro-ecological environments. The presence of GxE interactions highlights the existence of distinct plant environments, as well as the existence of different genotypes with differential responses to each agro-ecological environment.

One of the main tasks of plant breeding is to define research domains targeted for crop genetic improvement. A target research domain generally represents a geographical or agro-climatic area where the new varieties are expected to be grown. This is most commonly defined in terms of agro-ecological factors, but may also be defined in terms of political boundaries (eg a country) or market boundaries (eg a targeted area of seed sales).

Target research domains may be defined narrowly or broadly depending on the resources available to the breeder and knowledge of the GxE interaction. Many breeders pursue wide adaptation (large target domains) in order to cover the largest possible geographic area with their limited resources. In the process, however, productivity gains available through the

Box 1. Definitions

Target research domain: The geographical area over which results from the plant breeding program are to be applied. It is a non-homogenous unit made up of a continuum of plant environments.

Genotype (G): Refers individually or collectively to the genes carried by individual varieties.

Environmental factors: The different factors that make up the environment of a plant, eg water and light availability, disease, etc.

Plant environment: The smallest homogenous environmental unit in the target research domain, composed of a set of circumstances that are drawn from the same population distribution.

GxE interaction: The differential response of genotypes to a set of plant environments.

Wide and specific adaptation: Within the context of the target research domain, wide and specific adaptation denotes the number of breeding environments (more or less, respectively) where the varieties can be grown.

Potential impact area: The area over which the variety is commercially released.

Impact area: The area on which the variety is actually grown.

exploitation of narrow adaption may be lost. A key planning question is how to handle this trade-off.

Implications of GxE for design of plant breeding research

Plant breeding research would be immensely simplified were it not for GxE interactions. Because of these interactions, no one variety will excel everywhere, and in all years. There are potential gains from tailoring research to each environmental niche. But in principle, there are infinite environmental niches – even a single field has soils and growing conditions different from neighboring fields. Plant breeders need to decide how many unique enivronments to breed for.

It is expensive to maintain multiple breeding populations targeting many different environments. While the productivity gains may be higher when breeding for specific adaptation to a small environment, the costs of maintaining many such breeding programs is high. Costs (and productivity gains) will be lower if breeders pursue wide adaptation, ie develop varieties that can be grown over a larger and more diverse area. In general, plant breeders face a trade-off between the size of their breeding program and the potential productivity gain that might be achieved. To further complicate this decision, the actual level of GxE interaction, and the level of productivity gain available from pursuing narrower adaptation, are not accurately known.

Figure 1 illustrates these trade-offs. Consider a country with three distinct environments, E1, E2, and E3. If research is targeted towards each environment, the expected yield increments are represented by B, C, and D. If the breeding program aims for wide adaptation, the expected yield increments are represented by curve A. Programs tailored to each environment offer the prospects of larger yield increments, but involve higher costs. Breeding for wide adaptation may offer the prospect of a higher average yield increment over the three environments, with lower costs, because only one large research program is needed.[1]

A breeding program with unlimited resources would use large populations and many testing sites to select every generation in all target environments (curves B, C, D). But no research program has unlimited

1. In theory and practice, if the breeding programs have similar resources, the average yield increment from breeding for wide adaptation will not be higher than the average yield increment obtained from specific adaptation.

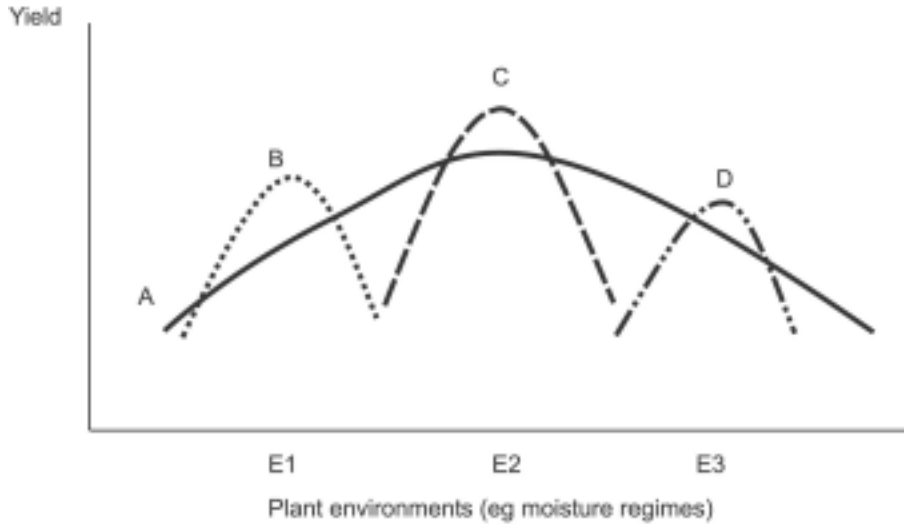

Figure 1. Expected yields in different environments (broad versus targeted adaptation). Source: Evenson et al. (1979)

resources. If resources are spread too thinly over many environments, the critical mass of germplasm and effort necessary to achieve significant productivity gains will not be available. Choices must be made. The plant breeder can purse smaller productivity gains by targeting wide adaptation; or target a sub-set of environments where gains are most likely. Selecting too many environments will strain resources and reduce breeding efficiency; selecting too few environments will either leave a significant farm population under-served or limit the overall productivity gains that can be achieved. The strategic problem is to define these trade-offs between investment allocation and likely return in clear enough terms to make a judgment.

Using the example of Fig 1, a country has four broad options (see Table 1):

- Option 1: Research targeted at specific adaptation in three environments, ie early and late generation testing and selection in all environments, release varieties in each environment (B, C, D)
- Option 2: Research targeted at wide adaptation across the three environments, ie early generation testing and selection in one environment, late generation testing in all the environments, and release of a single variety (the best average cultivar A) for all the environments
- Option 3: Target research in only one (or two) environment, and do nothing in other environment(s)

Table 1. Implications of different options on plant breeding strategies

	Strategy for breeding program			
Option	Crossing	Early generation testing and selection	Late generation testing and selection	Variety release
1	In each environment	In each environment	In each environment	Release varieties for each environment
2	One for all environments	In one environment	In all environments	Release one variety for all environments
3	In 1 or 2 selected environments	In each selected environment	In each selected environment	Release multiple varieties for each environment targeted
4	In 1 or 2 selected environments	In each selected environment	Locally-developed materials: in each selected environment. Imported materials: in other environments	Release multiple varieties for each environment targeted

- Option 4: Target research in only one (or two) environment, and directly import technology from other research programs in the region for other environment(s).[2]

The first three options imply a relatively self-sufficient plant breeding program. Option 4, however, highlights an additional means to pursue research efficiency – accessing varieties from other countries. The feasibility of this strategy depends on the similarity of target research domains across countries and the willingness to share germplasm.

Justification for regionalized breeding and variety registration

National investments in plant breeding encourage the treatment of national agro-ecologies as unique research domains. At best, varieties may be obtained from international plant breeding programs, such as those of the CGIAR, which have a mandate to share germplasm. However, varieties are then tested, selected and released, independently by each national program.

In the absence of political boundaries, there would be a strong case for a few aggregated and specialized breeding programs linked to testing programs

2. There is also a fifth option, pursuing methods other than plant breeding to suppress G x E interactions. For example, altering the environment by increasing or decreasing some inputs (eg, water, chemicals) provides an effective and sometimes economic alternative to meeting the needs of each environment.

at key sites in the major production zones. This is the basic research strategy employed by multinational seed companies.[3] The degree of aggregation of breeding research will, of course, depend on the trade-off between the productivity gains foregone because of the inability to tailor research to a specific circumstance, and the research efficiency gained from pursuing wide adaptation.

Table 2 summarizes the arguments in favor of regionalized breeding and variety registration. One key justification for a regionalized approach is that environments cut across political boundaries, so outputs of a breeding program in one country can potentially be adapted and used in similar environments in other countries. Regionalized variety development and variety sharing in Southern Africa provides good examples. Three quarters of the sorghum and pearl millet varieties released by national governments between 1985 and 2001 were derived from ICRISAT's germplasm. Several of these varieties have been released in more than one country (see pages 68, 70). These varieties account for at least 25% of the area sown to improved varieties in Southern Africa.

Table 2. Scientific and economic justification for regionalized breeding and variety registration

Facts	Implications	Justification for regionalized breeding and variety registration
Presence of G x E interactions	Genotypes respond differently to different environments. This can be exploited to develop cultivars for each environment (specific adaptation)	Increases potential impact area for cultivars with specific adaptation Increases yield per unit of crop area in the region, since breeding effort is targeted to specific environments across the region
Multiple environments exist in each country	More breeding efforts are needed per unit of crop area in a given country Limited seed market for a given market class in a country	Greater economic benefits from higher yields over a wide area Stimulates private sector interest in seed multiplication and distribution
Environments cut across countries	Outputs of a breeding program in one country can potentially be adapted and used in similar environments in other countries	Increases seed trade within the region by reducing institutional barriers

3. For example, Pioneer Hi-Bred International merged their North American and European research operations in view of the basic similarities in environments (Longworth 1993).

CIMMYT's maize breeding program has had similar success. CIAT has even more multi-country releases of bean varieties. While beans are commonly viewed to have specific adaptation, the variety A-286 has been released in eight countries in East and Southern Africa; while A-197 and CAL-143 have been released in three countries each.

Economic Model for Determining Targeting Strategy for a Breeding Program

Countries in Southern Africa can improve their efficiency by taking advantage of variety spillovers either from international organizations with regional breeding programs (eg, CGIAR Centers) or from neighboring countries. Various kinds of regionalized investment strategies are possible. Countries could select breeding materials from the large regional or global germplasm base. Or they could make later-generation selections from varieties developed elsewhere. In all likelihood, some combination of breeding strategies will be needed; but critical judgments must still be made regarding allocation of limited resources between breeding for specific national environments, or selecting widely adapted varieties that have been developed elsewhere. Assessment of the costs and returns of each strategy can inform this decision process.

The model proposed here is based on two assumptions.

- The objective of a research program is to maximize net monetary returns (social returns). No other social or political objectives are considered, ie the model determines the economic criteria for allocating national research resources while taking account of possible spill-ins from breeding programs in neighboring countries.
- Technology is freely transferable from one country to another. There are no political or institutional barriers (eg plant breeders' rights, trade regulations, etc) to technology transfer.

Strategic options at country/regional levels

Four options were described earlier, for a national breeding program (Table 1). These are illustrated in Figure 2 for a region with 3 countries and 3 environments. The number of breeding programs within a country and across the region will depend on the strategy pursued by each country. In this theoretical scenario, countries may invest in many breeding programs

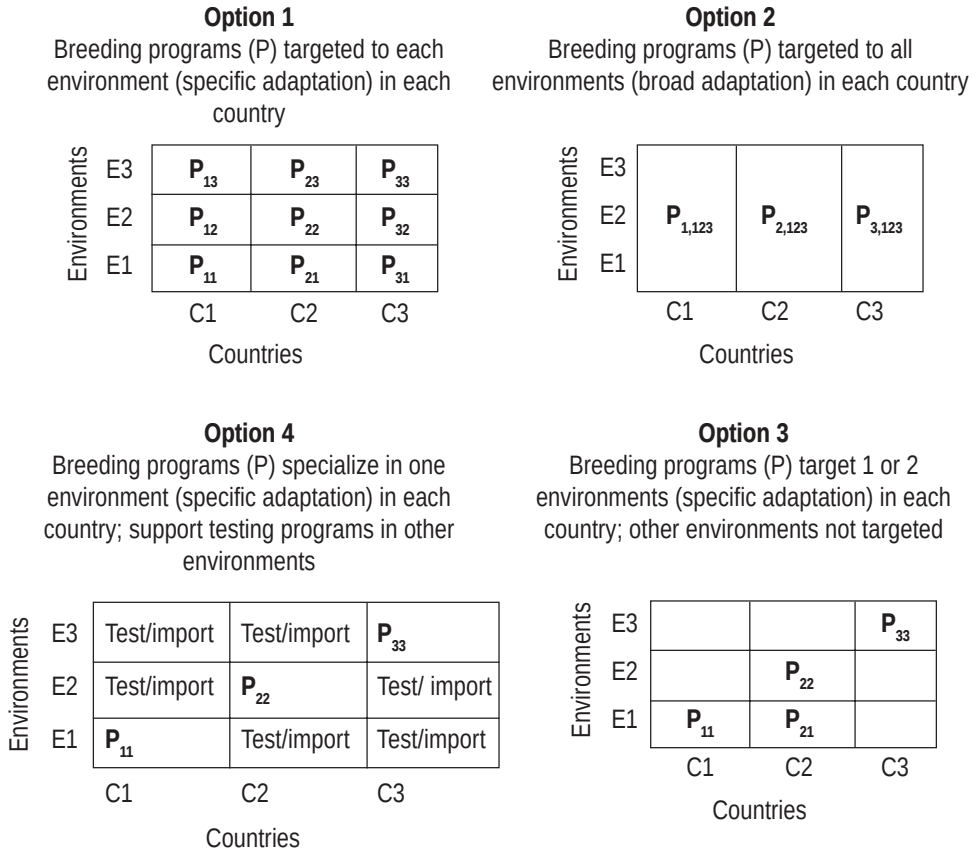

Figure 2. Breeding program strategy options: 3 countries and 3 environments in a region

targeting specific adaptation (eg in each environment in each country, Option 1), or in fewer breeding programs focused on specific adaptation or broad adaptation (Options 2, 3 and 4).

The four options illustrated in Figure 2 can be grouped into two strategic options for designing breeding programs in a given region:

- National strategy: each NARS continues to make investment decisions in plant breeding independent of others, ie pursues Option 1, 2 or 3
- Regional strategy: investment decisions are made taking account of opportunities for variety spill-ins from neighboring countries (Option 4). Information on research targets in neighboring programs may be taken into account in national planning; or investment planning may be more formally coordinated at regional level.

The efficient choice among alternative options will differ greatly across commodities and countries, depending on the size of the commodity sector, physical environment, resource costs, productivity impacts of research, research lags, and economies of size and scope in research.[4] The first step is to identify and estimate the costs and benefits of these two strategic options for plant breeding research in a given region.

Costs and benefits of breeding programs

Research benefit (B) attributed to investment in plant breeding research for a given crop in a given year *t*, in a given environment *i*, is defined as:

$$(1)\quad B_{it} = P_t\, Q_i\, K_t$$

where *P* is unit price of crop output ($/ton), Q_i is total crop production in the environment (a measure of the size of environment *i*), and K is the research-induced rate of shift in the supply curve due to crop improvement research, defined as the sum of research-induced cumulative yield gains due to release of new varieties:

$$(2)\quad K_t = (g_i * T)\, \alpha_{it}$$

where *g* is research-induced production gains per year (kg/ton/year) in environment *i* of varieties developed by the breeding program, T is the number of years since the first release of an improved variety by the research program, α_{it} is the cumulative percentage of Q (adoption) attributed to new varieties in the target environment in year *t*. The model specification is kept simple by ignoring the contribution of research to improvements in grain quality and variety maintenance.

The variables that determine research benefits are *Q* (size of the crop sector), *g* (expected yield growth) and α. (adoption rate). *Q* *α. represents the size of the impact area.

The cost of a breeding program (C) is the sum of costs involved in different stages of varietal development. It includes personnel costs (salaries) and operational costs (facilities, equipment, supplies, transportation, labor, data collection, analysis, etc).

4. Economies of size – unit cost of research decreases with increasing *market size* (measured by impact area) of the research effort on a specific output. Economies of scope – unit cost of research decreases with increasing *outputs* of research (improved varieties as end products, improved germplasm as parent material, new tools/methods of breeding) applied to a specific impact area.

(3) $C = C_1 + C_2 + C_3 + C_4$

where C_1 = costs of crossing (F_1-F_2), C_2 = early generation selection (F_3 to F_5), C_3 = late generation testing/selection (F_6 and above), C_4 = costs associated with variety release (generating test data, variety registration, seed multiplication, certification and distribution)

Each strategic option has different costs associated with it depending on the number of environments targeted for adaptation (wide versus specific), number of locations targeted for early and late generation testing, and variety release procedures (eg plant variety rights, registration procedures, seed trade protocols). For example, C_1 is a function of the number of distinct environments targeted for new varieties. Costs of testing (C_2 and C_3) depend on the number of trial locations and will therefore increase with size of the research domain (Q). C_2 and C_3 also depend on the adaptation strategy of the breeding program, ie the number of environments targeted. The cost of variety release procedures (C_4) will depend on the nature of seed policies and regulations at both national and regional levels. The more harmonized and liberalized these policies are at a regional level the less it will cost to multiply and disseminate new varieties.

Economic criteria for decision making

The costs and benefits generated by research will depend on which of the above plant breeding strategies is used. To judge between a regional breeding strategy (option 4) or any one of the national breeding strategies (options 1-3), an appropriate yardstick is the investment's net present value of the sum of net benefits [$\Sigma NB_t = \Sigma(B_t - C_t)$] over time. For any investment to be acceptable on economic grounds, the expected net present value of the returns must not be negative, and must be higher than or equal to the expected net present value of returns from alternative investments.

An efficient plant breeding program maximizes net benefits by optimizing:

- Genetic gain per dollar invested (g/C)
- Impact area per dollar invested ($Q\alpha/C$)

Figure 3 depicts the relationship between expected yield gains (g), impact area ($Q\alpha$) and research costs (C) for options 1-4 at country level. For example, pursuing broad adaptation (option 2) would lead to the selection of genotypes that can be released in all environments within each country. By implication, option 2 will have a larger impact area for a given budget.

However, gross benefits may be higher under the more targeted breeding pursued under options 1, 3 and 4.

Targeted breeding (narrow adaptation) gives a higher rate of genetic gain, compared to breeding for broad adaptation. However, it also increases human resource and operational costs because all environments in the country are covered (Fig 3).

The lowest cost strategy would be option 3, targeting only one or two environments. Other environments are excluded either because they are too small to justify any research, or because they are 'difficult' environments. This is often the strategy pursued by small NARS with budget constraints.

From a country's perspective, Option 1 requires the highest investment of staff resources and physical infrastructure (Fig 3). Resources may be saved by targeting a sub-set of environments (Option 3) or selecting varieties for a single broadly defined environment within the country (Option 2). The rate of genetic gains from selection will be higher under Option 1 than Option 2. However, targeting varieties for specific environments will have a smaller impact in terms of crop area per unit of resources invested (Fig 3).

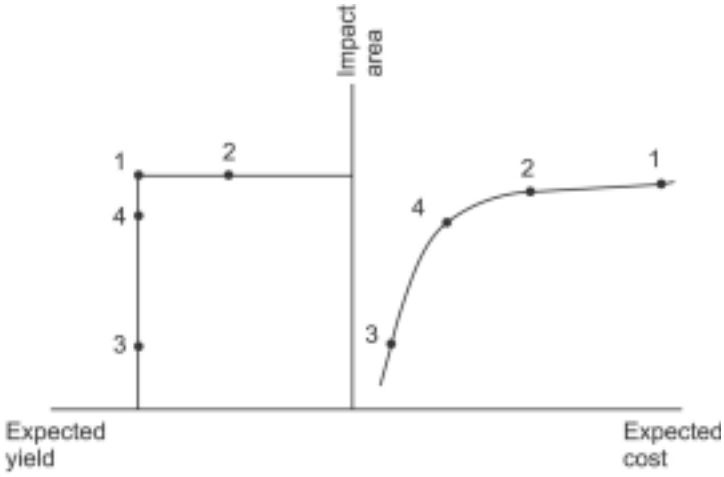

Figure 3. Expected yield, cost and impact area associated with Options 1, 2, 3 and 4. [Data points for each option are hypothetical, shown only for illustration. The actual relationship between expected yields, impact area and cost is an empirical question]

If research resources were unlimited, the optimal choice for a country would be to have a breeding program for each environmental niche (Option 1). This would maximize benefits, measured as yield gain x impact area. However, since research funds are limited, both the opportunity costs (ie the value of research that could have been carried out instead, if that particular research was not funded[5]) and the potential gains of any breeding decision need to be carefully assessed.

At a regional level, if all countries pursue option 4 along with regional variety registration, the aggregate regional benefits can potentially be equal to the sum of national benefits in option 1 – while aggregate costs will be significantly lower than the sum of costs if each country pursued option 1. In Figure 2, this corresponds to the costs of running three breeding programs and six testing programs (option 4), versus the costs of running a total of nine breeding programs (option 1).

Thus, we can postulate that if a group of countries collectively pursue option 4, the aggregate benefits (higher yields over a greater impact area) accruing to the region may be more than the aggregate costs (because of economies of size). However, the true extent of economies of size in research and benefits of specific adaptation (ie, the assessment of where exactly points 1-4 fall on the yield-area and cost-area curves in Fig 3) are empirical questions.

Strategies for Promoting Regionalized Plant Breeding

Regionalized plant breeding is likely to be more efficient than independent national programs. However, it requires coordination among national programs, which could be difficult. Independent national programs are viewed to be more attuned to the needs of each country's farmers and to be able to better develop varieties suited to local agro-ecologies. It is acknowledged that different countries may share similar agro-ecological zones; but there remains an intuitive perception that there are important differences between countries in varietal suitability. This may relate as much to the perception of unique cultural determinants of variety preference as to environmental differences.

These perceptions are reinforced by the historical development of independent national seed systems. In many countries, national seed companies were responsible for multiplying and distributing all varieties developed by publicly funded national breeding programs. National variety registration and

5. This includes the option of investing in crop management research to improve productivity.

release regulations linked NARS breeders with the seed trade, and provided NARS scientists authority to decide what varieties could be produced and distributed in the country. In effect, they could promote the multiplication and distribution of their own varieties – and prevent the release and sale of varieties developed in neighboring countries.

As a result of liberalization of seed markets in much of Africa, NARS breeders now face greater competition. However, regulatory controls over variety release and registration still favor national breeders – particularly insofar as they play an active role on variety release committees. Just as private seed companies promote the sale of their own varieties, NARS scientists naturally tend to promote the registration of their own products.

While there may ultimately be good justification for promoting the distribution of locally developed varieties that are well known, in practice this is impossible for all crops. Even if NARS seek to maintain stricter controls over the breeding programs for a few key crops, resource constraints will force them acknowledge the value of assistance for many secondary crops.

To be fair, most NARS scientists accept the value of variety spillovers. Most look to the international community for access to a wider range of germplasm. ICRISAT annually delivers several hundred lines (early and late generation germplasm) to NARS scientists around the world. Some are almost finished 'varieties' from which NARS scientists can select for local adaptation. Others contain traits otherwise unavailable to national plant breeders. In effect, this represents one way to use research spillovers (Table 3). The success of this approach depends on the capacity of the national breeder to identify and select germplasm of potential value.

Regional crop breeding networks represent a second, more intensive strategy towards regionalized breeding. In many such networks, groups of varieties are distributed to public and private experiment stations and on-farm trial sites distributed across a given zone. These varieties may be selected by one agent (eg a private seed company) or contributed by various public and perhaps private plant breeders participating in the program. Networks offer breeders more information about performance of a variety across multiple environments. They also allow national breeders to compare their varieties with those developed by breeders elsewhere in the region.

Regional crop breeding networks are generally led by an international entity with a regionally oriented mandate; for example, an international agricultural research center. The success of these efforts is apparent in the

Table 3. Alternative models of generating/utilizing research spillovers in plant breeding

Model 1. Assessing internationally available germplasm
- Obtain germplasm and advisory assistance from international research centers
- Test varieties developed elsewhere for local performance

Model 2. Regional plant breeding networks
- Multi-country testing of nationally and internationally developed varieties
- Select varieties performing well in national and international trials

Model 3. Regional research with country specialization
The rate of genetic gains from selection is higher when breeding for specific adaptation; but human resource and operational costs are also higher. The lowest cost strategy would be to breed for specific adaptation in only one or two environments; other environments are excluded from direct research.

From a country's perspective, Option 1 (separate breeding program for each environment) is the most expensive. Option 3 (targeting a sub-set of environments) or Option 2 (selecting for a single broadly defined environment) are less expensive. For Options 2 to 4, it is important to select target environments correctly, to delegate responsibility for breeding to 'lead' NARS for identified multi-country environments, and to distribute responsibility among NARS for breeding for traits of regional importance.

large proportion of varieties being released in Africa that are derived from the efforts of international plant breeders. Questions remain, however, about the sustainability of these networks. Most are publicly funded with money from a shifting array of donors. Most are managed by the CGIAR centers. Yet these international plant breeders are being asked to move upstream towards more strategic research, ie shift focus away from developing finished varieties and encouraging NARS to test them widely, to developing early generation germplasm with traits useful to national breeders.

A third strategy is the development of NARS-led regional plant breeding initiatives. NARS may take over management of the regional research networks built through donor funding; or they may organize based on the explicit pursuit of regional research agendas. In the former, NARS are offering to compare the products of their competing research efforts. In the latter, NARS may divide responsibility for research on regionally significant problems. One country may specialize in breeding for drought-prone environments, another on developing varieties with resistance to common diseases.

These three breeding strategies of generating and utilizing different types of spillovers represent a continuum from relatively independent NARS programs toward more integrated regional programs. These strategies are not

mutually exclusive; they may be pursued in complement to one another. Different strategies may be used for different crops, or for different agro-ecologies. But crucially, all three approaches focus on environments rather than political boundaries.

An example of regionalized breeding in Southern Africa

The SADC/ICRISAT Sorghum and Millet Improvement Program (SMIP) provides an example of the evolution of regionalized breeding in Southern Africa. In 1983, the SADC Council of Ministers asked ICRISAT to establish a regional program to enhance national capabilities to conduct research on drought tolerant crops. This program started by assembling over 30,000 sorghum and pearl millet lines from ICRISAT's global germplasm base for testing in Southern Africa. Meanwhile, most national sorghum and pearl millet breeders were sent to the United States for advanced degree training, after which they were encouraged to make use of ICRISAT's germplasm base as well as start testing varieties that had been developed by the regional program. This process was facilitated by establishing regional sorghum and pearl millet nurseries. In the early stages of the program, ICRISAT breeders selected most of the varieties to be tested in these nurseries. ICRISAT started investing in improving the capacity of key experiment stations in each country in order to facilitate this regional testing program. But over time, NARS scientists were encouraged to contribute their own varieties to the regional trials.

The end results are evident. More than 45 new sorghum and pearl millet varieties have been released by national authorities in Southern Africa. Three-quarters of these varieties were essentially developed by ICRISAT, though with strong support from national scientists. Many from the varieties developed independently by national plant breeders still incorporate germplasm originally provided by ICRISAT. The significance of the regional program is also evident in the fact that more than ten of these varieties – including some of the most widely grown ones in the region – have been released in multiple countries.

This success may be largely attributed to the quality of ICRISAT and NARS breeders, and their determination to increase variety adoption and productivity. However, the program was also based on deliberate strategies for targeting and implementing regionalized research. Early on, ICRISAT breeders defined their main regional mission as the development of early

maturing (hence drought-tolerant) sorghum and pearl millet varieties with bold grains and acceptable levels of disease and pest resistance.

As ICRISAT gained familiarity with the diverse agro-ecologies of Southern Africa, the Institute's scientists identified five major regional production systems, differentiated largely on the basis of rainfall, temperature, and length of growing season. The two largest production systems were targeted for regional attention. In the three smaller zones, support was provided to independent efforts by NARS.

Ultimately, however, ICRISAT faced a challenge. The strength of ICRISAT's regional program had allowed NARS to invest less than they might otherwise have done in their own national sorghum and pearl millet breeding efforts. Yet SMIP was a donor funded project with a limited lifespan. By the mid-point of this project, ICRISAT and its collaborating NARS were challenged to make the regional research network sustainable. ICRISAT agreed to provide continuing backstop assistance to the network, but leadership was to be transferred to the NARS themselves.

Rather than acknowledging the efficiency of the regionalized research network model, NARS have complained that they barely have enough funding for their own programs, much less a regional initiative. NARS managers are reluctant to allocate funding and staff time to a regional agenda. While there is wide recognition of the fact that research environments and production problems cut across national borders, technology spillovers tend to be simply accepted, rather than actively pursued.

ICRISAT has challenged this perspective by re-examining historical data from the network's regional trials in order to establish stricter quantitative evidence of the existence of a few regional breeding environments. This analysis is now being extended, with strong support from NARS breeders, with a more deliberate testing program of GxE interactions. The early results highlight the existence of six major environments for sorghum and six for pearl millet (Mgonja et al. 2002). These environments are defined through a cluster analysis linking the performance of specific sub-sets of varieties with common sets of experimental sites. This analysis suggests that substantially fewer locations are needed to adequately test varieties targeted to specific regional environments. A second consequence is that NARS have expressed willingness to rely more heavily on a regionalized breeding program. Several NARS breeders have even expressed willingness to lead varietal development efforts for key plant traits of regional importance. Thus, a breeder in South

Africa has agreed to lead a regionally oriented program to develop more drought-tolerant sorghums. A breeder in Zambia has agreed to lead a program to develop photoperiod-sensitive sorghum varieties. Scientists in Tanzania will lead the development of sorghum varieties with greater resistance to the plant parasite Striga.

The 'lead NARS' concept is an important step toward developing more regionalized research programs. At the moment, these remain dependent on ICRISAT's leadership and financial support. Questions remain about the extent to which NARS are committed to a formal regional agreement to invest in specialized research programs for the benefit of the region and depend on neighboring countries for other technologies. Uncertainties also remain about the ultimate disposition of property rights to nationally developed varieties of regional importance. Nonetheless, ICRISAT's efforts to verify breeding environments on the basis of cross-sectional measures of varietal performance have stimulated broader interest in re-defining regional environments, and perhaps using these as a basis for justifying the multi-country release of varieties. This has also re-opened the question of resource sharing to tackle regionally significant technology problems.

Emerging Issues of Agricultural Research Policy

The biophysical and economic justifications for pursuing more regionally oriented research are compelling. The main analytical questions relate to investment trade-offs between nationally and regionally oriented plant breeding. When does it make more sense to invest in an independent national program? When are countries better off investing in regional programs? The economic model defined above provides a starting point for this analysis. Plant environments need to be delineated. In each environment, the crop area targeted with new varieties needs to be quantified. The costs, probability of research success, and likely impacts must be estimated for each breeding program. This is a fairly standard model for priority setting. What is unique is the consideration of the prospects for inter-dependent investments across political boundaries. Can one country safely rely on a neighbor for technology support? How can the risks of regionally inter-dependent investments be reduced?

Four issues are critical. First, the most successful regional programs in Africa are led by the CGIAR Centers. These have been so successful that a large share of the varieties now being released (for crops falling within the

CGIAR mandates) are derived from these international programs. Yet the CGIAR Centers are being asked to move upstream – to reduce applied breeding work and concentrate on developing germplasm with useful traits. If the CG Centers shut down their applied breeding work, what will become of the regional variety development networks? Should the CG Centers aim to phase out applied breeding in Southern Africa over a declared number of years, in the expectation that the NARS will take over the regional networks? Are NARS willing to invest their own resources in managing regional programs? This issue merits further consideration by sub-regional organizations such as ASARECA, CORAF and SACCAR.

Donors continue to finance a large share of NARS budgets in many African countries. By investing in independent NARS, donors are reinforcing an inefficient system. Donors – and farmers – can obtain larger gains by investing in a few lead centers of excellence willing to target regionalized breeding. Donor funding may encourage NARS to pursue regional agreements supporting longer term national and international investments on regional breeding. These will need to be backed by managerial strategies to promote broader sharing of research results and accountability to regionally defined technology development objectives.

Greater and more coordinated investment is also needed to delineate target environments for regional breeding programs. Thus far, much of this targeting has been based on broadly defined agro-ecological zones. These boundaries are largely assumed to conform with GxE interactions, but there is little quantitative evidence for the boundaries being used. ICRISAT's recent cross-sectional analysis of trial results represents a start to fashioning a more rigorous basis for identifying regional benchmark testing sites. But substantially more work is needed. This needs to be tested across crops and over a wider range of traditional and improved germplasm. The biophysical analysis needs to be linked with an economic analysis of zoning options. It may be that international seed companies are correct in first pursuing the widest possible levels of adaptation. As plant breeding capabilities expand, the pursuit of narrower adaptation may be justified. A firmer analytical basis, however, is needed for these decisions.

Finally, efforts to promote regionalized breeding need to resolve questions relating to the development of seed markets. Plant variety rights need to be defined with a formula that promotes the dissemination of new seeds. Restrictive variety rights are likely to limit, not promote, dissemination.

National variety release and registration procedures must give way to regionalized variety registration and release. National seed stockholding strategies may need to be replaced with regionalized seed stockholding strategies. Rather than assuming that each country must be self-sufficient in seed, countries would need to accept a dependence on a liberalized regional seed market. Correspondingly, national seed regulations would need to be harmonized across a target region. In general, seed trade regulations would need to be liberalized.

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Harmonization of Seed Policies and Regulations in East Africa

David Ngugi

PO Box 39797, Nairobi, Kenya

Introduction

The seed industry is crucial to the economies of all three countries in the East African Community (EAC). Economic development in these countries is highly dependent on agriculture, which accounts for 60, 40 and 30% of GDP for Tanzania, Uganda, and Kenya respectively. Use of and access to improved varieties by farmers is the key to increasing agricultural development, achieving food security, and improving livelihoods. The seed sector therefore needs a legal framework for it to be efficient. It is important, however, that the legal framework does not impede farmers' access to new varieties at competitive prices, from within or outside the region.

Among the three EAC countries, the seed industry is most developed in Kenya, where it has been growing rapidly both in terms of seed production and area planted using certified seed (Table 1). Growth has been fastest in cereals (maize and barley), potatoes (*Solanum*) and horticultural crops. Seed for cereal crops, in particular maize, is the most widely traded in the region.

Demand for Seed

Agriculture in the EAC is dominated by small-scale, resource-constrained farmers who rely mainly on farm-saved seed. The use of purchased improved seed is very low. For example, adoption of hybrid maize in Kenya, where maize production is big business, is only 50-60%. Adoption of certified potato seed is only about 10%. Although estimated annual demand for certified maize seed

Table 1. Growth of the seed industry in Kenya

Year	Quantity of certified seed (tons)
1963	300
1985	24,000
1995	26,000

in Kenya is 27,000 tons, only 14,000 tons are planted. In Tanzania, less than 4% of farmers use improved maize seed; while adoption for beans, cowpea, pigeonpea, and tuber crops is even lower. The potential demand for seed of various crops in the EAC, estimated on the basis of the area planted annually, is shown in Tables 2 to 4. This highlights a potentially large seed market in all three countries.

Production figures

In all three countries, seed production is dominated by a single company established by the government. Table 5 shows the annual production of seed maize and wheat by the Kenya Seed Company, the largest and oldest company (registered in 1956) in the country. Simlaws Seeds, a subsidiary, was

Table 2. Potential seed demand in Kenya, 1995

Crop	Area, '000 ha	Seed rate, kg/ha	Seed required, tons
Maize	1500	25	37,000
Wheat	150	50	7500
Beans	646	56	36,176
Sorghum	175	4	700
Cowpea	144	30	4320
Pigeonpea	140	20	2800
Irish potato	86	3000	258,000
Barley	25	90	2250
Sunflower	16	10	160

Source: Republic of Kenya 1995

Table 3. Seed requirement estimates ('000 t) in Tanzania

Crop	1986/87	92/93	94/95	96/97	98/99	99/00
Maize	34.5	36.4	37.0	37.7	38.3	38.7
Sorghum/millet	5.2	6.7	7.3	7.9	8.7	9.1
Paddy	23.7	27.8	29.2	30.8	32.5	33.3
Beans	24.8	37.7	43.3	49.8	57.3	61.5
Wheat	4.4	10.4	13.8	18.5	24.7	28.5
Oilseeds	1.3	1.6	1.7	1.8	1.9	1.9
Total	93.9	120.5	132.4	146.5	163.3	172.9

Source: Sibuga 1999

incorporated in Kenya in 1938. The company produces over 90% of Kenya's maize and wheat seed. Currently, annual maize seed production is approximately 30,000 t. In Tanzania, the parastatal Tanseed was originally mandated to produce seed for the whole country. With the onset of liberalization in the early 1990s, other companies have entered the market, although Tanseed remains the biggest player. In Uganda the parastatal is the Uganda Seed Project under the Ministry of Agriculture, Animal Industry and Forestry. For many years it had a virtual monopoly on locally produced seed. It has since been privatized to become Uganda Seed Ltd. Seed production and sales figures by Tanseed and the Uganda Seed Project (Tables 6 and 7) underscore the smallness of the seed industry in these countries.

Table 4. Potential seed use estimates versus actual seed sales in Uganda

		Total seed sold (t)		
Crop	Potential use (t), 1995	1995	1997	1999
Maize	11,880	205.1	828.7	936.2
Sorghum	1590	20.3	17.9	45.3
Finger millet	1680	5.6	16.3	6.4
Beans	345,820	34.6	324.7	1012.8
Groundnut	15,280	3.6	30.8	28.3
Soybean	34,550	32.6	24.4	27.8
Sunflower	74,550	27.5	0.3	1.7
Sesame	1660	1.7	-	-

Source: Annual Progress Reports, 1995, 1996, Uganda Seed Project/Seed Industry Rationalization Project

Table 5. Maize and wheat seed production by the Kenya Seed Company, 1987-96

Year	Maize seed (t)	Wheat seed (t)
1987	23,687	9062
1988	27,581	1686
1990	15,779	6249
1992	14,788	6512
1994	19,537	2793
1996	16,300	1756

Source: Were 1998

Table 6. Seed production and sales by Tanseed

	Maize, hybrid & composite	Wheat	Beans	Sorghum	Paddy	Sunflower	Others	Total
Production								
1991/92	1972	45	73	61	26	15	5	2197
1992/93	1507	26	80	123	24	20	1	1781
1993/94	838	13	72	92	14	12	1	1042
1994/95	799	-	53	112	10	17	1	992
1995/96	707	4	29	40	-	22	-	802
Sales								
1991/92	1404	61	60	128	59	27	1	1740
1992/93	1842	-	3	103	52	22	-	2023
1993/94	1129	-	28	160	-	22	-	1339
1994/95	801	3	21	103	-	24	-	952
1995/96	888	6	55	10	-	35	-	994

Source: Seed Unit, Ministry of Agriculture and Cooperatives, Dar es Salaam

Seed Production and Multiplication

Both private and public sectors are involved in the seed industry. The public sector was dominant until the advent of liberalization in the early 1990s. In Kenya, the publicly funded Kenya Agricultural Research Institute (KARI) has been the sole source of inbred lines for production of maize hybrids, supplying these lines to private seed companies and registered seed growers. More important, KARI is responsible for maintaining basic breeding materials and producing basic and foundation seed, through its Foundation Seed Unit. KARI has developed most of the improved varieties of maize, sorghum and beans grown in Kenya. However, the country has also benefited from direct introduction of improved varieties from outside the country. Most of the potato varieties grown in Kenya were introduced from Europe, notably Holland, Germany, and the United Kingdom.

To a limited extent, universities, notably Nairobi University, have also contributed to the development of improved crop varieties, eg beans, cowpea and pigeonpea. A few private companies have crop breeding programs and have released improved varieties that are commercialized. For example, Kenya Seed Company has released several improved maize varieties; Kenya Breweries, for over two decades, has developed all the barley varieties they use in brewing.

Table 7. Seed sales (tons) by Uganda Seed Project

	1988	1990	1992	1994	1996	1998	1999
Total sales							
Maize	593.6	285.1	763.5	1094.9	395.5	751.1	1003.4
Sorghum	0.4	38.1	145.1	31.5	57.4	65.2	68.4
Finger millet	-	-	15.5	0.5	8.8	7.9	6.4
Beans	170.4	51.9	92.8	559.1	116.1	564.2	1013.2
Groundnut	46.2	106.7	52.2	-	101.2	62.5	28.3
Soybean	25.1	30.8	101.4	19.2	27.0	38.3	28.0
Sunflower	3.2	0.8	16.5	2.8	25.0	10.8	1.7
Sesame	-	-	15.5	0.5	0.9	-	-
Others	-	-	-	-	-	7.4	15.9
Total	838.9	513.4	1202.5	1708.5	724.0	1499.5	2158.9
Export sales							
Maize			500.5	840.0	2.0	21.8	67.2
Sorghum			143.6	20.0	-	0.3	23.1
Beans			33.9	540.0	2.5	-	0.4
Groundnut			5.0	-	64.2	0.3	-
Soybean			15.7	-	-	-	0.2
Sunflower			5.4	-	-	-	-
Sesame			14.6	-	-	-	-
Rice			-	-	-	-	11.4
Total			718.7	1400.0	68.7	22.4	102.3

Source: Kabeere 2001

In Tanzania, plant breeding programs under the Ministry of Agriculture and Cooperatives have been the main source of improved varieties. The Ministry supplies breeder seed of a wide range of crops to Tanseed, which then produces foundation seed on government-owned Foundation Seed Farms. The main crops handled by Tanseed are hybrid/composite maize, paddy, sorghum, beans, groundnut, cowpea, greengram, and sesame. Tanseed produces certified seed on its own farms or through contract farmers, and is responsible for production, processing and marketing its seed.

Like KARI in Kenya and the Ministry of Agriculture and Cooperatives in Tanzania, Uganda's National Agricultural Research Organization (NARO) has been the main source of new varieties in the country. NARO is responsible for maintaining basic breeding materials and providing breeder seed to the Uganda Seed Project (USP) for multiplication on government seed farms.

USP and contract farmers produce certified seed under strict conditions, supervised by the Uganda Seed Inspection Service. Some farmers have formed seed and grain growers associations to produce certified seed on contract. Since the liberalization of the seed industry in Uganda in 1994, both local and foreign seed companies produce, process, and market seed under license by the Ministry of Agriculture. USP now supplies only 10% of total national seed requirements, and only 20% for maize and sorghum.

International agricultural research centers (IARCs) have provided germplasm freely to both public and private research organizations and seed merchants. The main IARCs collaborating with national crop improvement programs in the EAC include CIMMYT (maize, wheat), CIAT (beans), IRRI (rice), IITA (cowpea, cassava), ICRISAT (pigeonpea, groundnut, sorghum, millet) and CIP (potatoes and sweet potatoes).

Quantities and types of seed traded by seed companies

Before liberalization of trade and of the seed industry in particular, there were very few private seed companies, and their impact on seed trade was limited in comparison with the dominant role played by monopolistic parastatals. Since the relaxation of trade regulations, however, the number of registered private seed merchants has increased rapidly. In Kenya, the number of registered seed companies has increased from 27 in 1997 to 38 in 2001. Most private firms produce and market seed mainly for the local market. Only a handful are large enough to undertake research to develop new varieties. Two companies in Kenya (Kenya Seed Company and Oil Crops Development Company) have active plant breeding programs, mainly for maize.

Most private firms in Uganda import seed, mainly vegetables, pastures and wheat. Uganda imports vegetable seeds from Kenya, Tanzania, Denmark, Zimbabwe, the Netherlands, and India. A few companies produce seed (maize and beans) for the local market. For example, Nalweyo produces 15 t of maize and beans annually. Exports are very small, limited to exports of 'commercial seed' mostly through relief agencies and NGOs to Ethiopia, Somalia, southern Sudan, Rwanda, Burundi and the Democratic Republic of Congo. Trade in relief seed has stimulated the incorporation of private companies such as Magric Uganda Ltd and Community Export International. Very little is exported from Uganda to other EAC countries; but Kenya-registered firms such as the Kenya Seed Company and East African Seed Company regularly export seed to Uganda and Tanzania. Kenya

Seed Company officially exports at least 400 t of hybrid maize seed to Uganda annually. A few tons of seed are sold across the border unofficially. Adoption of Kenyan maize hybrids is particularly high in Uganda's Mbale and Kapchorwa districts; farmers in Eastern Uganda are willing to pay 4-5 times the price of 'commercial seed' for hybrid maize seed from Kenya (Kabeere 2001).

Private sector involvement in Tanzania is more recent, a result of trade liberalization since 1990. Tanseed is in the process of being privatized to become Tanzania Seed Ltd. Private companies market their seed individually or through outlets operated by NGOs, farmers associations (eg, Tanganyika Farmers Association), cooperative unions, private merchants and seed stockists. Some locally registered companies grow seed on contract for companies outside the country. The seed is then exported, eg to Kenya, where the contracting company processes (cleaning, grading, conditioning) and sells it. The East African Seed Company, which is registered in Kenya and Tanzania, contracts farmers and companies in Tanzania to grow seed of various crops (vegetables, Pannar maize, sorghum, cowpea, pigeonpea and beans). Processing and packaging are done in Kenya. Tanzania is a net importer of seed from Kenya. Kenya Seed Company was incorporated in Tanzania in 1997. The company regularly exports hybrid seed maize to Tanzania, particularly in the Kilimanjaro area where Kenyan hybrid maize varieties 614 and 625 are well adapted. Kenyan companies export around 250 t per year of maize seed to Tanzania. Sales are projected to increase in future now that Kenya Seed Company has released new maize varieties that are adapted to a wide range of ecological zones – coast, medium, and high altitudes – in Tanzania.

In summary, the seed industry in East African has remained small and generally inefficient due to a number of factors, including government control and a virtual monopoly by parastatals. Other factors have also constrained growth and efficiency and thereby compromised farmers' interests.

- The public sector remains the sole source of breeder seed and new varieties. This has limited the number of new varieties available to farmers. Public sector plant breeders have a poor reward system and limited incentives, resulting in long periods between releases of new varieties. For example, in Kenya no new bean variety has been released by public sector programs since 1984. For sorghum, only one new variety was released by KARI between 1981 and 1994.

- Restrictive seed regulations have prevented the introduction of improved varieties from outside.
- State monopoly in seed inspection and certification has hampered production of certified seed. Seed growers have lost their crops due to late inspection by an over-stretched, under-resourced seed certification service.
- Lack of plant breeders' rights has discouraged investment in variety development programs. Lack of plant protection law in two of the three EAC countries has slowed the introduction of new varieties from outside the region.
- Public monopoly in basic and foundation seed production has led to a shortage of foundation seed. Would-be seed growers in Uganda and Tanzania have been experiencing this problem. The standard of maintenance of basic breeding materials has often been poor, sometimes resulting in contamination of varieties and thus low quality seed to farmers.
- Until liberalization and the promulgation of the EAC Treaty, seed laws and regulations (import duties, phytosanitary requirements, seed standards, etc) were different in each country. This hindered growth of the industry and restricted the flow of technologies across borders. Some regulations that govern variety release and registration have also discouraged entrepreneurs who wish to introduce new varieties from outside. Requirements have also caused long delays before a variety is officially approved and released for commercial use.
- Strong government control of the seed industry and associated inefficiency has contributed to low adoption rates of improved varieties, eg lack of seed retailers in rural areas, lack of competition resulting in poor seed being distributed, or the seed arriving late.

ASARECA/ECAPAPA Initiatives for Regional Harmonization

Harmonization of seed policies and regulations in East Africa is likely to open up and expand the regional seed market. A harmonized EAC market is likely to attract more investment in the industry, creating competition that will likely improve the efficiency of seed markets. The ASARECA/ECAPAPA Project on Harmonization of Seed Policy and Regulations in Eastern Africa was necessitated by the need to:

- Facilitate development of seed markets in the region
- Empower farmers by providing access to quality seed of improved varieties from various sources within and outside the country and region

- Create an enabling environment for development of a competitive and efficient seed industry in the region
- Remove barriers to seed trade among participating countries
- Improve food security in the region.

Intensive discussions at a series of meetings helped identify key issues, and develop consensus on how to resolve them. These meetings eventually led to agreements among EAC countries on areas to be harmonized. The key stages in this process were:

- Identification of National Resource Persons as consultants, one each for Kenya, Tanzania and Uganda. Their terms of reference and the methodology to be followed were discussed at an orientation workshop in Aug-Sep 1999.
- Literature review, consultations and stakeholder interviews, 10 Sep to 30 Oct 1999.
- National Consultative Workshops in the three countries, 2-10 Nov 1999, to develop consensus on the broad issues identified during the orientation workshop.
- Consultative Meeting (2-7 Feb 2000, Entebbe) of NRPs, external resource persons and ASARECA/ECAPAPA Secretariats to review the country reports by NRPs and plan further steps.
- National workshops, Feb-March 2000 (2 days each). Key officials in the public seed regulatory sector, private seed growers, processors, and traders participated. Consensus was reached on areas that required change. Constraints and issues were identified for further debate.
- Regional Workshops (4-8 Apr 2000, Entebbe and 26-30 June 2000, Arusha) to discuss proposals developed at national workshops. Participants reached agreement on a range of issues, including modalities of linkage with EAC (eg see ASARECA 2000, ECAPAPA 2001).
- Meetings of the East African Seed Regional Working Group, 4-6 June and 13-14 Nov 2001.
- First meeting of EAC's Committee of Agriculture and Food Security, 3-7 Sep 2001, Arusha.

Participants at these meetings included representatives of public seed regulatory agencies, government ministries, the private sector (including all three seed trade associations), universities, NGOs, farmer groups, as well as ASARECA, ECAPAPA and USAID.

Reviewing progress on the ASARECA/ECAPAPA initiatives

This study was conducted as part of the FAO-ICRISAT project on seed liberalization. It sought to review progress and achievements under the ASARECA/ECAPAPA initiatives for regional harmonization of seed policies in East Africa. Specifically, the objectives were to:

- Inventory the issues debated to date under the ASARECA/ECAPAPA initiatives, agreements reached, and progress on their implementation
- Assess the evidence used to evaluate laws and regulations for harmonization
- Review the relationships between seed policy/regulations harmonization on one hand, and discussions on trade liberalization on the other
- Prioritize issues and options important for trade liberalization
- Assess possible implications of harmonization of seed polices and regulations on agro-biodiversity.
- Draw lessons from the process followed during the ASARECA/ECAPAPA harmonization exercise.

The study first reviewed the documentation of the various deliberations that culminated in harmonization agreements; as well as local and international literature on seed policies and regulations. Key seed industry stakeholders in all three countries were interviewed. They included representatives of ECAPAPA, national seed trade associations, Ministries of Agriculture, seed companies, and national seed certification agencies.

Expected Impacts of Harmonization Agreements

The following sections discuss the potential impact of the changes in seed policy.

Expected impacts on agro-biodiversity

Shortening the variety testing period. The period of mandatory testing before release has been reduced for both local and foreign varieties. This will broaden the potential sources of new varieties, eg Brazil, and India, with latitudes similar to EAC. It will likely increase the number of varieties grown by farmers. Seed traders, NGOs and scientists strongly supported this change. Some breeders, however, expressed fears of biodiversity loss should plant breeders focus on high yield at the expense of other traits. This problem could be addressed by national genebanks continuing to conserve germplasm for future use. As a result of this change, some entrepreneurs might specialize in

developing varieties adapted to special niches, where local breeding programs have only limited interest.

Harmonized biosafety regulations and introduction of GMOs. The establishment of biosafety regulations will facilitate introduction of and experimentation with GMOs. Introducing GMOs can directly increase biodiversity, but can also threaten it, eg through genetic hybridization or by upsetting biodiversity equilibrium. Seed traders and scientists were unanimous in wanting the region to benefit from biotechnology, but concerned by lack of capacity to control and monitor the use of GMOs. Even before biosafety regulations are enacted, physical facilities as well as human skills will need to be strengthened, to ensure effective enforcement.

Plant variety protection and plant breeders' rights. The introduction of PVP and plant breeder's rights could potentially increase biodiversity by facilitating the introduction of new varieties from other countries. Impact in this respect is clearly evident in the horticulture industry, where several flower and vegetable varieties have been successfully introduced into the region from Europe.

Farmers' rights to plant varieties. Protection of farmers' variety rights is likely to promote conservation of agrobiodiversity. This law was advocated by governments, NGOs, and scientists. India is the only country in the world where this has been implemented – a bill recently passed in parliament confirms farmers' rights to plant varieties concurrently with plant breeders' rights (ECAPAPA 2001). The main problem in implementing this law is that many farmers' varieties, being highly variable, will not pass the DUS test and therefore may not be eligible for rights under the law. In addition, farmers will not be able to afford the tests to establish that their variety does in fact enjoy protection under the proposed law.

Expected impact on seed trade and seed industry structure

One season (instead of 3 years) variety testing and release. The number of varieties available to farmers will increase. More private seed companies will enter the market; competition will increase the number of varieties available and reduce seed prices.

Expanded seed market in East Africa. ASARECA is now facilitating harmonization of seed policies and regulations among the 'second tier' countries, Ethiopia, Sudan, Eritrea, Rwanda and Burundi. The harmonization process will follow and benefit from the new policies and regulations the EAC

countries have endorsed. As the second tier countries come on board, the size of the regional seed market will increase further, attracting more private sector investment.

Government officials and private seed traders expressed concern that liberalization might harm the small and vulnerable local seed industry. Regulatory agencies (KEPHIS and TOSCA) feared that farmers' interests might be compromised by unscrupulous seed traders and hard-selling foreign companies. They suggested the need for stricter legal protection for farmers, and more severe penalties for infringement of the law.

Rationalization of the number of variety release committees. The number of variety release committees has been reduced from two to one (National Variety Release Committee). Its composition has also been rationalized to enhance transparency. This will accelerate the release of new varieties, thus enhancing technology diffusion and increasing the incentive for plant breeding programs.

Accreditation of private persons/institutions to carry out seed certification. Public institutions currently responsible for certification are understaffed and lack resources. Accreditation is likely to lead to a more efficient certification process, and perhaps ultimately lower seed prices. Seed traders and private companies strongly supported accreditation.

Plant variety protection (plant breeders' rights). Enactment of breeder's rights will facilitate farmers' access to new varieties. For example, Kenya's horticulture industry has benefited greatly from PVP laws. Private companies and individuals will have more incentive to invest in developing new varieties, eg Kenya Seed Company has invested heavily in plant breeding since the enactment of plant breeders' rights. With more private investment in variety development, governments could shift their resources to open-pollinated varieties of food crops, where private sector interest is limited. Harmonization in general will strengthen government control and monitoring of seed quality.

Reduction/harmonization of phytosanitary requirements. On the basis of research and survey data, phytosanitary requirements for seed produced in the region have been reduced from 33 to three pests. This will enhance cross-border trading and reduce costs. Seed traders, scientists, and NGOs, in particular, advocated this change. In addition, a harmonized phytosanitary certificate (IPPC model) has been adopted. This will facilitate trade among EAC countries as well as EAC-world trade.

Removal of tariffs on seed. The three countries have abolished all tariffs on seed under the EAC agreement. This is likely to reduce seed prices and therefore increase adoption rates and purchase of improved seed by farmers.

Establishment of regional variety list/catalog. A regional variety catalog will be established. Increased information on new and available varieties in the region is likely to enhance adoption and widen the seed market. Both seed traders and farmers supported the establishment of a regional variety catalog.

Common field and laboratory standards for seed certification. Common field and laboratory standards for seed certification have been adopted, based on international (OECD) standards. Seed traders, seed growers, scientists, and government officials advocated the harmonization of standards. This will allow free movement of certified seed within the region – as well as outside the region, since the standards are internationally recognized.

Common seed classes (reduced from 8 to 4). Seed classes have been harmonized, and reduced from eight to four classes. The new standard will promote faster movement of seed for processing and trading, simplify seed language, and thus benefit seed traders and seed growers.

Rationalization of import/export procedures and certification. Bureaucratic procedures for seed import/export cause great inconvenience to seed traders. The new standardized procedure and documentation under one roof (more or less) has led to big savings on time and cost. Ultimately, it will also reduce seed prices.

Harmonization of seed regulations and general liberalization of seed trade. The number of registered seed companies in Kenya and Uganda has increased in response to trade liberalization and harmonization of seed policies and regulations. The number of registered seed companies in Uganda rose from one to nine. Some seed companies such as the Kenya Seed Company have increased their investment in seed trade. Uganda Seed Traders Association plans to expand into the second tier countries, especially southern Sudan and Rwanda.

Issues of concern

As against the overwhelming gains to be had from harmonization, there are shortcomings in certain areas. For instance, scientists in the public sector have pointed out that lack of scientific capacity to evaluate data (submitted to

justify variety release after one season of testing) might compromise the quality of new varieties. Similarly, the reduction of phytosanitary requirements for regionally produced seed could potentially lead to problems. Facilities and expertise differ between EAC countries, and this might allow the spread of dangerous pathogens in the region. There are over 18 border posts to police in the region. And lack of staff and equipment to diagnose/identify pests and diseases at plant quarantine stations could compromise pest and disease control.

Seed Harmonization and Commodity Trade Discussions

Seed trade and harmonization of policy and regulations are discussed under EAC's Committee on Agriculture and Food Security (AFS). Specifically, matters related to seed trade are handled by two Working Groups – Sanitary and Phytosanitary, and Farm Inputs – under the Committee. The agreements on harmonization were tabled by ASARECA's Seed Regional Working Group to the AFS Committee on 3-7 Sep 2001 where they were endorsed.

This was preceded by several meetings and discussions. An AFS Committee meeting in Arusha, 8-21 Jan 1999, discussed issues of harmonization and strengthening of phytosanitary services, inspection and certification, and seed multiplication and distribution. Seed harmonization and commodity trade were discussed at the East African Cooperation meeting of Experts on Food Production and Security (Arusha, 26-27 Feb 1998). This meeting focused on various issues including harmonization of seed research, promotion of cross-border trade in agriculture and livestock commodities, harmonization of phytosanitary services, inspection and certification, harmonization of legislation on pest and disease control, harmonizing and strengthening regulatory institutions, etc (EAC Secretariat 1998). The issue of PVP laws in Kenya was discussed by the Deregulation Section of the Office of the Vice President and Ministry of Planning and National Development in April 1999 (Kenya Government 1998).

In parallel, discussions on trade liberalization (including the seed industry) took place in all three countries, but more so in Kenya. The Seed Traders Association of Kenya has been an effective voice advocating liberalization.

Plans for Continued Harmonization Discussions and Implementation of Agreements

Plans for the implementation of agreements and continuation of harmonization discussions over the next few years are summarized below.

Period	Activity on Agreement	Remarks
Feb 2002	S-RWG to establish certification standards for other crops (sweet potato, carrots, onions, cabbages, simsim, pigeonpea, greengram, pastures, cowpea) and for informal seed sector.	Tasks are outstanding due to lack of resources for meetings and consultations. Might begin after Oct 2002 since USAID is expected to provide funding to ECAPAPA
	Complete harmonization standards for sorghum, soybean, sunflower, Irish potato, groundnut, tomato, cotton	Outstanding due to lack of resources. Some countries (eg Kenya) having second thoughts about removing compulsory certification for a majority of crops
	Finalize crop species for compulsory and voluntary certification S-RWG to study and design a form for inter-agency certification	On hold due to lack of funding
April-June 2002	Preparation for first regional accreditation workshop	Delayed due to late release of funds expected by STAK
July-Sep 2002	S-RWG to hold regional Seed Accreditation Workshops to develop criteria, quality manuals for seed companies	STAK has obtained funding from USAID for a workshop in Kenya. ECAPAPA will supplement funding to facilitate regional representation. Workshop date not confirmed
April-June 2002	Compile and validate national and regional variety lists	S-RWG has received all 3 national lists, being edited before review by stakeholders. Ownership of some varieties is contested
Sep 2002	Distribute validated national and regional variety lists	On course, lists expected to be ready on time
July-Sep 2002	S-RWG review of quarantine pests	Pest risk analysis in Tanzania completed in 1998, needs to be updated. Kenya – being organized with FAO support. Uganda – not started. Pest surveys are a prerequisite to preparing regional quarantine pest list. Likely to be delayed by lack of resources

Period	Activity on Agreement	Remarks
2002	Draft and finalize Plant Variety Protection legislation	Uganda's draft PVP law is before Cabinet, Tanzania is at an advanced stage. Kenya's amended PVP completed, awaits review by stakeholders before submission to Parliament. However, completion dates not clear
Dec 2002	Indexing farmers' varieties	Outstanding due to lack of enacted PVP laws, also resource and time constraints
Dec 2002	S-RWG to prepare and finalize harmonized biosafety regulations in liaison with national biosafety committee chairmen in respective countries Develop harmonized documents for import of biocontrol agents and LMO products of modern biotechnology	Kenya and Uganda have biosafety legislation ready for enactment into law. Tanzania yet to develop and draft legislation. Tanzania and regional initiatives require substantial funding, likely to be delayed
Nov 2002	Second tier countries to hold consultative meetings in Aug-Sep 2002, followed by national workshops on harmonization	Plans are on course
2002	Training of trainers on pest identification, pest analysis, and inspection procedures	S-RWG responsibility, a budget was prepared. On hold indefinitely due to lack of funds
2002 - 2003	Provision of infrastructure, eg central laboratories – phytosanitary at national level, establish minimum facilities at high risk entry points	Uncertain. Cannot be funded through national budgets, no action plan for seeking resources

Conclusions and Lessons Learnt

How successful is the harmonization initiative?

Tremendous progress has been made within a very short period – it took only 9 months from initiation of the ASARECA/ECAPAPA project to the point where agreements were reached on all major issues. Significant progress has been made in each country in implementing the agreements reached:

- National performance testing of new varieties before official release reduced from 3 years to one season. Agreement adopted and incorporated in national statutes, and fully operational

- Agreement on having one statutory committee for variety release has been adopted and operationalized
- Agreements on standardized field and laboratory standards for certified seed have been adopted
- All countries have adopted the reduction of seed classes from 8 to 4
- Rationalization of import/export procedures and documentation is now operational. Seed traders can now get all the necessary documents from one office
- Tariffs on seed have been abolished (largely under the EAC agreement).

There are still several steps to be completed. These include: incorporation of the agreements in national Seed Acts and creating legal statutes to operationalize the law; establishment of PVP law in all EAC member states; establishment of biosafety laws and regulations to govern use of GMOs; and making seed certification voluntary for all crops. With regard to phytosanitary regulations and accreditation of institutions and/or individuals to undertake seed certification, countries need to allocate resources for training and equipment.

Factors contributing to the success

Detailed planning. ECAPAPA and other stakeholders thought through all the critical steps in a participatory way. Directors of national research institutes (as Directors of ASARECA) were closely involved, from initial conceptualization to implementation. This ensured strong support from their scientists.

National Resource Persons (to spearhead studies in each country) were carefully selected, and thus accepted by government officials, who cooperated closely with them. The criteria for selection of resource persons were: deep knowledge of agriculture and seed matters in the respective countries, scientific reputation, and access to key stakeholders, particularly in government.

An international consultant was hired as a facilitator during planning, and contributed experience from Central America, where similar efforts on harmonization had been successful. A Regional Consultant brought in an additional regional dimension into the discussions. A consultant from Iowa State University, USA, who is an expert on American seed systems, certification and quality control regulations, provided important contributions in discussions on harmonization of seed standards and implications for international seed trade.

Common history under the 'old' EAC. The 'old' EAC (Kenya, Tanzania and Uganda) had many seed laws and regulations in common. Some crop improvement programs (eg sorghum breeding at Serere, Uganda, maize at Kitale and Katumani in Kenya) were done on a regional basis. Crop priorities were also similar – maize, sorghum, wheat, beans, cotton, rice, cassava, sunflower and groundnut. The shared legal and agricultural history made it easier to move rapidly forward and agree on many points.

Iterative collaboration with stakeholders. Strategic stakeholders – institutions as well as individual officers, by name – were identified at the outset. This ensured quality participation in the deliberations. In order to ensure ownership of the process, the institutions or organizations were left free to nominate the individuals from suggested names. The iterative nature of the planning process resulted in systematic, incremental progress at each stage.

Conducive political climate. The project on harmonization came at a time when the three countries were intensely involved in trade liberalization. Improvement and diversification of agriculture with a view to making the industry more competitive and export-oriented in the international market, was the centerpiece of national policies. As a WTO signatory, Kenya had already developed and enacted a PVP in accordance with UPOV 1978. Kenya had to do this to safeguard her horticulture export market, particularly flowers – it could no longer access improved but protected varieties from Europe without having PVP laws in place. It could therefore not compete in the world market for flowers where the most recently released varieties were the most sought after. The Uganda government was also pushing for the enactment of a PVP law to safeguard the interests of its young export-oriented horticulture industry. The launch of the project on harmonization could not have come at a better time – hence the smooth and rapid progress.

Catalytic role of seed trade associations. Seed traders' associations in the three countries played a catalytic role in advocacy and support for harmonization. In particular, the Kenyan association systematically lobbied the Kenyan government on seed issues, eg liberalization of laws and regulations, removal of unfair tariffs, and the need to decentralize some functions such as seed certification. Associations in the three countries have been involved in the harmonization debate from the onset to the present phase when the agreements reached are being implemented. The associations are ready to shoulder the cost and responsibility of preparing and publishing a regional

variety catalog in consultation with national seed certification agencies and research institutes.

Effective leadership. ECAPAPA played a vital role throughout, and was perceived as an honest broker by all stakeholders. The stakeholders first completed the planning phase, then discussed and agreed on the way forward. The seed regional working group was set up to ensure completion of the outstanding agenda. And efficient disbursement of funds ensured timely achievement of the set goals.

Donor support. Financial support for the whole process by USAID has ensured timely achievement of the milestones set in the plan. More importantly, USAID's involvement remained that of an observer – national stakeholders were given the freedom to debate issues without the donor looking over their shoulders.

Constraints to Implementation of Agreements and Completion of Harmonization Process

Implementation of the agreements reached is being handicapped by lack of funding from national governments. Although ECAPAPA might be able to continue supporting the S-RWG with expected new funding by USAID, it is essential to secure government financing in order to complete the process as per the agreements. Plans for government financing should have been built into the project budget from the onset. Resources are needed for developing capacity, eg training and infrastructure for phytosanitary control, accreditation for seed certification. Lack of resources will obviously slow the harmonization process.

National governments are short of money, but fortunately the seed harmonization process has been well integrated into the EAC agenda for agriculture, which emphasizes food security and harmonization of various aspects of agriculture, including removal of tariff and non-tariff trade barriers among the three countries. This might help put pressure on the respective governments to provide funds to support harmonization.

The EAC's Agriculture and Food Security Committee, working closely with the ASARECA/ECAPAPA Seed Regional Working Group, is well placed to help resolve outstanding issues and speed implementation of the agreements reached to date. It is highly unlikely that any country will renege on the agreement reached, now that the EAC Treaty is a reality.

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Harmonization of Seed Laws and Regulations in Southern Africa

David Rohrbach,[1] Julie Howard,[2] and Edward Zulu[3]

1. Principal Scientist (Economics), ICRISAT, PO Box 776, Bulawayo, Zimbabwe. 2. Asst Professor of International Development, Michigan State University, MI 48824-1039, USA. 3. Coordinator, Regional Seed Security Network, PO Box 4046, Harare, Zimbabwe

Harmonization of seed laws and regulations is being pursued in Southern Africa as a means to encourage investment in seed production and expansion of seed trade. Harmonization was first formally recommended in a 1987 study of seed production and supply in the region, conducted by the consulting firm Danagro Advisors at the request of the Food Security Technical and Administrative Unit of the Southern African Development Coordination Conference (SADCC). During the next 15 years, harmonization issues were discussed in at least ten regional workshops. Representatives from Southern Africa also participated in several Africa-wide discussions on harmonization.

These meetings have led to numerous agreements affirming the value of regulatory harmonization. Many recommendations on establishment of common standards and procedures for seed production and trade have been adopted – but few have been implemented in practice. Despite the many meetings, progress toward harmonization of seed laws and regulations has been limited.

This report assesses the progress of recent discussions on harmonization in Southern Africa. It reviews the status of these discussions, the issues arising, agreements achieved, and constraints to progress.

The information contained in this report is primarily derived from a review of documents reporting on the various regional meetings. In addition, we interviewed a cross-section of people who participated in these meetings, as well as representatives of many national and regional seed companies.

Why is Harmonization Needed?

The seed industry in Southern Africa is small by global standards, but substantial in size and scope, compared with the seed sectors in other parts of

Africa. Each year, over US$ 250 million worth of seed is traded on national and regional markets. This includes an estimated US$170 m sold by seed companies in South Africa, and US$40 m by companies in Zimbabwe (FAO 1998). There are no specific data on the quantity or value of seed traded among countries on the regional market. But industry representatives estimate the Southern Africa trade at about 20% of total Africa sales. Most countries in the region import seed. South Africa and Zimbabwe are the largest exporters.

While seed trade in Southern Africa has been growing during the past 15 years, volumes still remain small compared with the potential for seed sales in the region. Adoption rates for new varieties vary widely, but are generally low. More than 75% of farmers in Zimbabwe and South Africa plant hybrid maize. But in most countries, fewer than 30% of farmers plant purchased maize seed (FAO 1998). SADC estimates indicate less than 10% of the region's total cropped area is planted with commercially produced seed. One of the main reasons cited for poor adoption is the lack of quality seed on retail markets. There is a consensus that expansion of national and regional seed markets will depend on harmonization of seed regulations (Danagro 1987, Commonwealth Secretariat 1994, FAO 1998).

Virtually all SADC countries have private seed companies; but most of these are small, national entities with limited trade volume. Only Zimbabwe and South Africa consistently produce large quantities of a diverse array of seed crops for the commercial market. Smaller quantities are consistently produced in Malawi and Zambia. But Tanzania, with one of the largest crop areas in the region, imports most of its commercially traded seed.

High quality maize and vegetable seed are widely traded on national markets. National seed trade is also common for an assortment of cash crops such as soybean, wheat, and sunflower. But commercial trade volumes are more limited for secondary food crops such as sorghum, pearl millet, groundnut, cowpea, and pigeonpea.

Seed of most major food and cash crops is traded regionally. But the largest share of this trade is financed through donor grants for drought/flood relief, resettlement, and special development programs. This market has stimulated the establishment of a number of new seed companies during the past 15 years. By selling seed in bulk to these programs, many seed companies have been able to avoid expensive and risky investments in developing retail trade. But this 'relief' market is highly variable, and depends on the evolving interests of external donors. If demand for relief seed declines, many new seed companies will go out of business.

Due to the limited size of the seed industry in the region, and its heavy dependence on the relief and development market, most small-scale farmers lack access to improved seed on the retail market. Maize or vegetable seed may be available from urban outlets, but rarely from rural retail shops. Access to seed of major crops such as sorghum, pearl millet, rice, groundnut, cowpea, and pigeonpea is even more limited.

The limited supply of seed in rural markets has encouraged NGOs to invest in the establishment of community seed projects. These take many forms ranging from the simple production of seed for sale to neighbors to the development of production contracts linking small-scale farmers with commercial seed companies. Most countries in Southern Africa now have several different sorts of community seed projects, but the sustainability of these projects remains questionable. Most depend on external financial and technical assistance for foundation seed, quality control, and seed marketing.

As more formal and informal entities become involved in seed production and sale, it has become increasingly difficult for national regulators to track and maintain quality standards. New companies, and particularly NGOs, lack basic knowledge of national seed laws and regulations. Yet in many countries it is difficult even to obtain a clear description of these regulations.

Because national regulators have limited training and insufficient resources, regulations are not enforced consistently. When large quantities of seed are suddenly needed in response to flooding or drought, strict trade and quality control regulations are relaxed. But regulations may unexpectedly be enforced under 'normal' conditions.

In the formal seed sector, delays and inconsistent application of regulatory services have led to a growing number of complaints against regulatory authorities. Enforcement decisions are perceived to favor larger, better established seed companies. Smaller seed companies face more questions. Complaints have also multiplied about corrupt practice.

Seed regulatory authorities are also worried about their lack of information about NGO-sponsored community seed projects. But even when the information is known, there is uncertainty about how to apply the regulations. Should seed produced for sale to neighboring farmers be certified? What if this seed is purchased by traders for sale in more distant communities? How can seed regulators even know of this distinction?

These problems have encouraged demands for further liberalization of seed regulations – shifting the onus of responsibility for quality control from

government to the private sector. Many argue, particularly in the private sector, that strict certification of seed crops should be replaced by truth-in labeling. Certification should be voluntary. Inspections in the field should be replaced with more inspections in the retail shop.

But many regulators remain unconvinced. Poor quality seed is sometimes marketed – perhaps not commonly, but it serves as a warning of the risks of deregulation. Seed services commonly use these problems to justify stricter enforcement of existing standards. They demand larger budgets and more staff to better pursue their obligations.

In this context, the many regional meetings on seed issues in Southern Africa have been as much about strategies for developing national and regional seed industries, as about the harmonization of seed regulations per se. Much of the discussion has focused on liberalization of regulations as a means to encourage investment in seed production and trade. There have been debates about what minimum standards are practical and enforceable; and about the complementarity of formal and informal seed systems. The priority has been to identify strategies for improving national and regional seed security.

Harmonization may ultimately be pursued as a by-product of agreements for developing national and regional seed sectors. Much then depends on the level of commitment to developing a regional seed market. If the primary focus is on developing national seed systems, agreements on a common set of regional regulations may be slow in coming. If greater priority is placed on regional cooperation and trade, harmonized regulations should be easier to achieve.

Timeline of Harmonization Discussions

The many regional meetings on seed sector development and regulatory harmonization have covered a wide range of issues. The issues discussed at each meeting are summarized below. Additional details are reported in the proceedings of these meetings (see References), or available from the SADC Seed Security Network.

1. Regional seed production and supply project and technical meeting

In 1987, the Food Security Technical and Administrative Unit (FSTAU) of the SADCC commissioned a study of seed systems in nine member countries.

This recommended 11 projects targeting regional strategies for developing national and regional seed industries (Danagro 1987). In a 1988 regional workshop of technical experts, six of these proposals were approved for development:

- *Harmonization of seed laws in the SADCC region.* This project called for a review of national seed laws, and the drafting of proposals for new, harmonized regulations in each country. The project aimed to consider regulations relating to variety release, seed multiplication, quality control, seed processing and storage, and seed marketing. SADC then commissioned a review of existing seed legislation in the region through the Commonwealth Secretariat (discussed below).
- *Regional seed technology and information network*. A feasibility study and a detailed proposal to donors were completed. The network was to be based in Zambia, but was never funded. The tasks of this network were ultimately subsumed in the SADC Seed Security Network.
- *SADC technical cooperation network for plant quarantine*. A workshop was held in March 1993 to establish the network, but it remains unfunded.
- *Development of production and breeding capabilities for vegetable seed.* This project was organized with SACCAR.
- *Regional seed quality laboratory and national sub-units*. Funding is still being sought for this project.
- *Development of seed production capabilities of small-scale farmers.* Funding was obtained from GTZ. This project focuses on improving seed supply of secondary food crops such as sorghum, pearl millet, and grain legumes.

2. Regional workshop on improved on-farm seed production for SADC countries

In 1993, FAO sponsored a regional workshop to discuss opportunities for improving on-farm seed production by small-scale farmers. After the severe 1991/92 drought, NGOs initiated on-farm seed production projects in Lesotho, Malawi, Mozambique, Tanzania, Zambia, and Zimbabwe. This workshop highlighted the need to support such initiatives in complement to the development of formal, commercial seed systems. In the process, the workshop again recommended the 'urgent need to harmonize the existing region's seed laws' (FAO 1995: 17). The workshop suggested that seed laws should support efforts to improve quality control in on-farm seed production

schemes. The workshop also called for legislation to recognize farmers' rights to varieties.

3. Regional workshop to discuss a study on harmonization of seed laws

In early 1993, the SADC-FSTAU obtained support from the Commonwealth Secretariat for a more in-depth feasibility study on the harmonization of seed laws among its member countries. This study reviewed the seed legislation and practices of each member state and proposed options for harmonization. These proposals were reviewed in a regional workshop organized in Sep 1994 (Commonwealth Secretariat 1994). Ultimately, 17 recommendations were tabled and approved.

- establishment of national seed policies and seed committees
- establishment of statutory variety release committees
- development of a database on regional varieties and reciprocal recognition of new varieties across SADC member states
- adoption of the OECD nomenclature for seed classes
- minimum qualifications for seed inspectors, seed analysts and plant health inspectors
- licensing of certifying agents in the private sector
- establishment of a referee seed testing network
- enactment of laws protecting plant breeder's rights
- membership of all SADC states in the International Seed Testing Association (ISTA)
- enactment of legislation for plant quarantine and phytosanitary services
- formulation of medium term human resource development plans
- enactment of common or harmonized seed laws
- establishment of strategic seed reserves
- establishment of a regional Seed Research and Information Network
- promotion of on-farm seed production in the informal sector with appropriate certification requirements and nomenclature
- establishment of uniform seed certification standards
- establishment of a formal regional association for seed professionals to coordinate training programs and the establishment of common standards.

The consultants provided a model Seed Act, a model set of seed regulations, and a model Plant Breeders Rights Act for consideration by the

workshop participants. Countries were encouraged to use these when drafting or reviewing their own rules and regulations.

4. Enhancing research impact through improved seed supply: options for strengthening national and regional seed systems

In March 1997, ICRISAT, ICARDA, IITA, GTZ and SADC sponsored a continent wide meeting on African seed systems in Harare, Zimbabwe. The conference reviewed strategies for public and private seed multiplication and debated constraints limiting the development of national and regional seed industries (Rohrbach et al. 1997). An action plan was formulated for eastern and southern Africa as a region. This called for the formulation or reformulation of seed policies and laws to promote liberalized seed trade in the region including the establishment of a regional variety list, less restrictive phytosanitary and trade regulations, voluntary registration of varieties, and the enforcement of truth-in-labeling as opposed to strict seed certification. Regulatory harmonization was sought in order to facilitate regional seed trade. Governments were called upon to encourage private sector investment in national seed industries. The conference called for the establishment of a regional or Africa-wide seed trade association. Similar recommendations were provided by groups representing West Africa and North Africa. However, the strategies for following up on these recommendations were left uncertain.

5. Regional technical meeting on promotion of regional network for on-farm seed production and seed security in SADC countries

An FAO sponsored meeting in Maseru, Lesotho in Sep 1997 recommended establishment of the SADC Seed Security Network. The discussions also ranged broadly across issues of seed policy and emergency seed supply, variety release, seed certification, seed marketing, and seed trade. Particular interest was expressed in supporting informal seed sectors in order to ensure seed supplies of secondary crops grown in drought-prone regions. The network was also mandated to 'develop and adopt common seed policies and harmonize rules, procedures, regulations and methodologies to enhance regional cooperation in seed production, processing, storage, marketing and utilization' (FAO 1998: 49). However, a detailed program of implementation was not discussed.

6. Strategic planning workshop for the seed sub-committee

In late 1999, the newly formed SADC Crop Sector Coordinating Unit (CSCU) sponsored a regional meeting to develop action plans for the 'enhancement of seed availability in SADC'. Action plans were to be formulated in four areas – harmonization of seed laws and standards, training in seed technology, information exchange, and improving seed production and distribution systems.

The CSCU was tasked to 'facilitate the development of seed policies and laws, seed testing laboratories and intellectual property rights in member countries where these do not exist' (Crop Sector Coordination Unit 1999). The workshop recommended that (i) member states without seed and variety registration acts should establish these, (ii) inter-laboratory referee tests be established to upgrade and harmonize seed testing procedures and standards, (iii) common seed certification nomenclature be developed based on OECD standards, (iv) mechanisms be created for reciprocal recognition of varieties.

7. Round table discussion on *sui generis* protection of plant varieties under article 27.3(b) of TRIPS

This meeting was organized by UPOV, the World Intellectual Property Organization, and the Organization of African Unity to discuss plant property rights issues. A key issue was how to protect property rights to national germplasm stocks. The meeting recommended the development and implementation of laws on *sui generis* protection of plant varieties.

8. Sub-Saharan Africa Seed Initiative stakeholders workshop – 1

In Feb 2000, the World Bank sponsored a workshop in Lusaka, Zambia, to review and revise an action plan for the Sub-Saharan Africa Seed Initiative (SSASI) regional program for Southern Africa. This initiative examined seed systems in four countries (Malawi, Mozambique, Zambia and Zimbabwe), compiled a listing of seed policies and regulations, developed action plans for seed policy reform in each of the four countries, and formulated proposals for strengthening regional seed supply. Additional countries were to be studied at a later stage. However, representatives of all SADC counties were asked to endorse the initial action plan and final proposals for regional policy reform.

9. Sub-Saharan Africa Seed Initiative stakeholders workshop – 2

A second regional SSASI stakeholders workshop was held in Kadoma, Zimbabwe, in Sep 2001. This summarized the results of the four country studies and sought agreement on a regional strategy document outlining recommendations for seed policy reforms relevant to all SADC countries. Four working groups considered strategies for strengthening national seed systems, and regional collaboration and harmonization. More than 30 recommendations were endorsed on the following issues:

- easing release of food crop varieties
- promotion of public varieties
- organizing seed quality assurance
- supporting private sector development
- coordinating community based seed activities
- the need for better data and reporting
- seed security
- registration and release of varieties
- collaboration in quality assurance and seed certification
- simplifying plant quarantine regulations
- strengthening emergency seed supply.

This workshop also endorsed continuation of the SASSI effort. A new proposal for a second phase of this initiative is being considered by the World Bank.

10. Strategic planning workshop for the SADC seed sub-committee

This meeting primarily considered a draft proposal for longer term external funding of the SADC Seed Security Network (SSSN), including maintaining a central information unit and offices for seed focal points in each SADC country. The proposal was endorsed by the 46 participants representing the public and private sectors in 12 countries. It was proposed that the SSSN should not concentrate only on disaster situations but also focus on seed systems development and seed security more generally. A key proposal endorsed by the meeting was to document the scientific justifications for regionalized variety release or registration for sale.

Problems of Seed Trade

In some of the regional meetings, specific proposals for seed sector development were being presented for review and amendment. In others, the

discussions were more open ended. Working groups were assigned to discuss general categories of seed policy, and recommend reforms or action plans. In either case, similar sets of problems were considered.

The need for regulatory reform was most generally justified on the basis of the importance of agriculture in Southern Africa (accounting for one-quarter of SADC's GDP), and the need to deliver improved seed to farmers in order to increase productivity and food security. In this context, regulatory reform was primarily viewed in terms of liberalization of rules and standards. Liberalized markets are necessary to stimulate investment in national seed systems. In addition, regulatory reforms are necessary to bring national systems into conformity with commonly accepted international practice.

Problems start from the point of variety release. Variety release procedures are long, cumbersome, and sometimes subjective, thus delaying the introduction of new varieties (Danagro 1987, Commonwealth Secretariat 1994, FAO 1998). Several regional discussions noted the 'duplication of variety testing' across member countries. This was said to be unnecessary for varieties suitable for agro-ecological zones cutting across borders. Ultimately, the discussions called for regionalized recognition of varieties (Commonwealth Secretariat 1994, Lemonius 2002).

Investment in the development and trade of new varieties is further constrained by the absence of plant breeders' rights in all countries except South Africa and Zimbabwe. Clarification of plant property rights is also being demanded under the trade rules of the World Trade Organization (WTO). The TRIPS agreement requires countries to have developed national legislation to protect property rights to plant varieties by 2005. This has encouraged more active discussion of variety rights issues.

Once varieties are released, multiplication is constrained by the lack of commercial interest in open and self-pollinated varieties – commercial seed companies are more interested in hybrids. Several meetings discussed the need to strengthen informal seed systems (FAO 1995, 1998, Rohrbach et al. 1997). However, a main theme here was how to strengthen and maintain quality control in local community seed projects.

As national seed markets are liberalized, concerns have increased about the capacity of national seed inspectors to keep track of seed production and trade. The lack of qualified staff was identified as a primary impediment to the maintenance of seed standards and implementation of any harmonization

agreements. Common standards of training for seed regulators were proposed. Several meetings discussed the need to extend responsibility for seed inspection to licensed representatives of the private sector.

Most of the discussions highlighted problems associated with differences in seed standards across countries. Seed certification requirements, nomenclature identifying seed classes, and inspection procedures differ between neighboring countries. Because one country may not recognize another's seed tests, there was duplication of testing and delayed access to imported seed. Seed regulators in different countries do not fully trust the work of their colleagues, and are reluctant to accept different standards. These sorts of problems led to calls for all countries to join the International Seed Testing Association (ISTA) in order to upgrade test facilities and procedures. Agreement was reached that South Africa would provide training and reference testing for other national seed laboratories in the SADC region.

Differences in phytosanitary standards were also commonly identified as a problem limiting seed trade. Each country has its own phytosanitary list of quarantinable pests and diseases. These lists are said to be long, and not scientifically based (FAO 1998), and thus create opportunities for unfair trade practices. Similarly, deficiencies in plant quarantine facilities and phytosanitary regulations are said to increase the risk of entry of new pests and diseases (Commonwealth Secretariat 1994). The various regional discussions agreed on the value of re-assessing pest risks in each country in order to review what pests and diseases are economically appropriate to maintain on the quarantine lists. All countries were also called upon to join the International Plant Protection Convention (IPPC).

One problem with much of this discussion is there was little specific or quantitative evidence documenting these constraints and their impacts. Anecdotal evidence is common. There is little question that the uncertainties of trade restrictions and delays in obtaining export or import clearances reduce the quantities of seed traded, and raise the costs. But it is difficult to determine the actual severity of these constraints, or to estimate their economic cost. Anecdotal evidence also suggests that many of these barriers are reduced in emergency situations. If seed is needed for drought or flood relief, certification requirements are reduced and imports are speeded.

Ultimately, the discussions in Southern Africa revealed substantial agreement about the need for, and appropriate outline of, policy and

regulatory reform. The main difficulty has been how to move from agreements (in principle) about the need for change, to specific policy reforms.

Regulatory Issues

Recommendations from the various national and regional workshops target seed system development as much as harmonization of seed laws and regulations per se. Table 1 summarizes the regulatory issues considered, and the solutions proposed.

Agro-Biodiversity

Amidst all these discussions there has been little direct consideration of the problems of agro-biodiversity. However, the issue has been treated indirectly in several discussions.

Liberalization of seed trade within countries and across the SADC region has likely increased the number of seed companies and the number of varieties available to farmers. Seed companies state that if they have more freedom to operate, a wider range of varieties will become available. Insofar as different seed companies draw their germplasm from different sources, this may be correct. Insofar as companies have the incentive to promote the sale of diverse varieties, farmers may gain access to a wider pool of plant genes. But if the industry becomes consolidated, the germplasm base may narrow.

Observers raised concerns, during interviews conducted during the preparation of this report, regarding the possible impacts of a few seed companies dominating the seed sector in the medium to longer term (5 to 10 years). Consolidation in the international seed industry has raised fears about the narrowing of germplasm sources and supplies in Southern Africa, but there is no evidence that this is currently happening.

Some argue that as seed markets expand, there will remain a significant niche for local seed companies better positioned to use local germplasm, and take advantage of local variety adaptation in smaller markets. This strategy appears possible given that international seed companies tend to prioritize widely adapted varieties targeted at larger markets. However, the larger companies also have the capacity to test thousands of lines in any given location in any given year. The sheer size of this resource may offset the site-specific advantages of small local seed companies.

Table 1. Regulatory issues in seed system reform in South Africa

Law/Regulation	Problems identified	Changes sought	Issues arising
1. Variety registration			
Varieties must be identified on a national variety registration list in order to be sold in each country In some countries a variety must first be released by a national release committee, before it is registered as a saleable variety. Alternatively, registration may precede release in order to first establish a property right to a new variety	Difficult and time-consuming to get varieties registered in some countries Seed companies object to demands for detailed information on variety pedigree, though these have not been enforced	Clear guidelines needed for amount, quality and format of data required for registration (SSASI) Allow registration based on data from any public or private variety owner (SSASI) Allow marketing of varieties after registration and prior to official variety testing for release (SSASI) Companies believe this should be a simple process to establish variety property rights Seed companies prefer regional rather than national registration	Not a major concern in discussions of regulatory harmonization Main argument is over the justification for regional versus national registration of varieties
2. Variety release			
Varieties must be tested by national authorities in most countries, and proven to perform better than other varieties already released Test results are evaluated by a national variety release committee	Testing takes too long – sometimes at least 3 years Criteria for acceptance are not transparent; over-emphasize grain yield Government breeders over-represented on national release committees	All countries should have national release committees with transparent procedures Data from company trials should be considered Variety release should be regional, not national, taking account of agro-ecological zones and related determinants of variety performance	Harmonization per se would require all countries to establish release committees applying similar standards in similar ways Most private companies seek regionalized release or no formal government sanctioned release system

...Continued

Table 1. ***Continued***

Law/Regulation	Problems identified	Changes sought	Issues arising
		Companies argue that release is not necessary for privately bred or sold varieties. Quality control is inherent in the company's reputation	Discussions have endorsed further analysis of regionalized registration or release
3. Plant breeder's rights			
Legally sanctioned property right established for registered varieties	Only Zimbabwe and South Africa have PBR. Lack of rights in other countries limits incentives to trade new varieties – especially self or open pollinated varieties Some NGOs want recognition of farmer's rights to varieties	All countries advised to establish legal basis for PBR	Concerns about theft of varieties, although this practice appears limited. May be a larger problem for horticultural crops, than for grain and legume crops Need for SADC countries to conform with WTO requirements on IPR Debate about whether to follow UPOV standards or OAU model law standard Little discussion on how PBR will be linked to royalties
4. Genetically modified organisms			
Biosafety standards established in Zimbabwe and South Africa, need to be established in most other countries GMOs currently planted in South Africa, under testing in Zimbabwe	GMO varieties unavailable to farmers due to lack of biosafety regulations Fear of GMOs amplified by lack of knowledge about these varieties and lack of biosafety standards	Biosafety regulations need to be established in all SADC countries Common guidelines for introduction of GMOs	GMOs highlighted in some of the later harmonization discussions, but not treated in detail

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Table 1. *Continued*

Law/Regulation	Problems identified	Changes sought	Issues arising
	Movement of GMOs across national borders is probably inevitable, therefore a regional stance may be useful Common standards could facilitate wider sale of GMO varieties		
5. Regional variety list No regional variety lists currently exist	Widely adapted varieties are commonly released and registered in more than one country. Inefficient to test these separately for release in each country Separate release procedure in each country slows farmer access to new varieties	Reciprocal release of varieties in neighboring countries with similar ago-ecological zones Regional release based on a regional program for testing and evaluation Regional registration without release Harmonize regulations for release across countries (SSASI) Technical committee to establish format, information required, and implementation procedure for regional variety list (SSASI)	Reciprocal release was proposed early in the discussions. Now agreement in principle, but modalities still to be worked out

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Table 1. *Continued*

Law/Regulation	Problems identified	Changes sought	Issues arising
6. Phytosanitary standards Each country maintains its own list of restricted pests and diseases for seed certification and trade controls	No clear basis for these lists; pest risk analyses are out of date Lists contain many pests or diseases that are not economically significant or are already endemic, especially for horticultural crops Different lists in different countries limit seed trade. Lists not justified by actual incidence of pests, diseases	Harmonize and simplify plant quarantine regulations (SSASI) Conduct proper pest risk assessments in each country (SSASI) Common regional list of quarantinable pests and diseases to facilitate seed trade Participate in and support IPPC Horticultural sector wants international phytosanitary standards	New pest risk analyses clearly needed, but not clear how it will be funded Need to clarify what constitutes an economically significant pest or disease Possible justification for first attending to horticultural sector
7. Phytosanitary procedures Phytosanitary inspections required for seed certification and export	Inadequate national capacity for inspections – too few inspectors, inadequately trained Inspections difficult or impossible as more small-scale farmers become involved in seed production No clear justification for re-inspection of imported seed. Multiple testing increases seed costs Field checks and testing are time consuming and expensive	Minimum training standards for plant protection specialists Cross-check of inspection results by laboratories in the region All countries to follow IPPC standards	Funding needed to implement these objectives

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Table 1. ***Continued***

Law/Regulation	Problems identified	Changes sought	Issues arising
8. Seed certification Each country has its own criteria for seed certification. Most require certification for some (but not all) crops	Certification criteria different in different countries Seed class definitions different in different countries, creates confusion for cross-border trade Certification criteria too strict, difficult to enforce, particularly with large numbers of small-scale seed producers	Establish common terminology for seed classes (SSASI) Establish common standards for certified and non-certified seed (SSASI) Establish common procedures for certification and labeling (SSASI) Seed certification should be recommended rather than compulsory; if compulsory should only be for a few crops (SSASI) Seed companies want optional certification. Truth in labeling instead of certification requirements Recognize non-certified seed class or quality declared seed with common regional nomenclature and standards Membership in ISTA Participation in relevant OECD scheme, if exporting to OECD countries	Continuing debate on degree of certification required. Certification is necessary to protect farmers… versus… farmers should be given the option to purchase cheaper, non-certified seed General agreement on the value of common nomenclature and standards

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Table 1. ***Continued***

Law/Regulation	Problems identified	Changes sought	Issues arising
9. Export registration Export permits required in some SADC countries. In some countries seed must meet national quality or certification standards before export	Difficult to obtain export permit if domestic seed supplies are perceived to be limited. This disrupts domestic production for the regional market Takes too much time and effort to obtain export permit No need to apply domestic standards to seed destined for export	Remove need for export permits (change sought by seed companies) If required, pre-planting allowances should be made for seed crops planted specifically for export Apply seed standards of destination country, not domestic standards	Not an issue in regional harmonization discussions, but important for some seed companies – particularly those producing seed in Zimbabwe for regional sale Domestic seed shortages lead to government restrictions on exports. Yet regional seed trade is most important in such a situation
10. Import requirements Import certification and phyosanitary certificates required in all countries	Paperwork too complex, clearances take too long in some countries, delays and limits seed imports Not consistent; regulations relaxed in emergency situations Different regulations in different countries create uncertainty about import requirements Clearances needed from many different local authorities	Import clearances should be simplified and obtainable from a single office (SSASI) Regulations should be transparent and well publicized	Not a major issue in harmonization discussions, but important for companies pursing regional seed trade

...Continued

Table 1. ***Continued***

Law/Regulation	Problems identified	Changes sought	Issues arising
11. Tariffs			
Different import tariffs in each country	Seed companies not aware of tariff levels and impacts of COMESA and SADC trade agreements. Not perceived as a major problem, although exporters prefer a common, low or zero tariff level (tariff for seed trade between COMESA countries is zero)	Need to clarify status of seed in SADC trade negotiations	Issue not raised in harmonization discussions
12. Regional seed security			
No specific regulations on minimum levels of national seed stocks. However, larger seed companies seek to maintain significant (≈ 20%) carryover stocks	Seed supplies often limited in drought or flood years. Significant problem for secondary grain and legume crops, less so for maize and vegetables No database for regional seed supply that can be used to help source seed in emergencies	Regional seed stocks should be monitored. Data on potential seed sources should be readily available to buyers in the event of emergency Need stricter agreements on national and regional seed security stocks; but uncertain who will pay the costs of maintaining stocks Regional seed security network proposed and implemented, but funding remains limited	Identified as a priority issue in several regional workshops Regional seed security network has been established, largely as an information sharing group Questions remain about strategies for improving regional seed security per se
13. Market entry for seed companies			
Private seed companies exist in most SADC countries and can be readily licensed	Licensing criteria not clear in some countries	None	Issue apparently not raised in harmonization discussions

Issues of agro-biodiversity, or more specifically, of varietal diversity, have also been reviewed in discussions about plant property rights. One of the main reason for *sui genesis* laws is the concern to maintain varietal diversity in the local seed system. Debate continues, however, regarding the relative advantages and disadvantages of UPOV guidelines for protecting plant breeders' rights versus the African Model Law for the Protection of Rights of Local Communities, Farmers and Breeders, and for the Regulation of Access to Biological Resource. The latter has been proposed as a stronger guideline for protecting farmers' rights to germplasm. This is assumed necessary to protect local germplasm and the underlying varietal diversity. However, the empirical basis for these arguments remains limited.

Finally, concerns have been raised about the impacts of droughts, floods and war on varietal diversity. One of the justifications for establishing the regional SADC Seed Security Network has been the need to protect varietal diversity. It is commonly assumed that farmers lose their germplasm in the event of a disaster. Investments in farmer seed systems, including community seed production, storage and trade, are viewed as means to protect the level and diversity of local germplasm supplies. But the empirical basis for these discussions is limited. A growing range of evidence suggests that seed losses in the event of disaster have been over-estimated. Farmers have maintained traditional varieties through generations of drought, flood, and war. Traditional varieties of most crops are still widely grown.

Ultimately, it is difficult to predict the impacts of harmonization on agro-biodiversity. It seems most likely that harmonization will have a limited impact on varietal diversity in the short run. The longer-term impacts may depend more on the international resolution to property rights issues to germplasm, than on the results of regional harmonization discussions per se. Or they may depend on the decisions of farmers. If SADC farmers have an economic incentive to adopt a narrower selection of germplasm, they will choose to do so. If a wide range of traditional varieties perform better than varieties offered by the seed market, these will continue to be grown.

Impacts, Constraints, and Next Steps

The many regional discussions during the past 15 years have yielded numerous recommendations, but few specific changes in policy or practice. The SADC Seed Security Network has been established, as have seed focal points in each of the SADC countries. But funding for the network

coordinator remains uncertain, and the focal points have limited resources. South Africa's national Department of Agriculture has agreed to help evaluate other national seed laboratories, and manage a ring test of seed samples. But funding constraints have limited the number of laboratories visited, and not all national seed services have participated in the performance trial. Other than this, most of the recommendations agreed to date remain to be implemented.

During the same period, however, most national seed sectors have been liberalized. Many new seed companies have been established, and older parastatal companies have been privatized. The major international seed companies such as Monsanto and Pioneer have expanded their presence in the region. Seed trade has also expanded, though largely in response to NGO and donor demands for seed relief. Numerous community seed projects have been initiated.

The combination of more seed companies, expanded trade, and community seed projects have tested the limits of seed rules and regulation. In some cases, regulations are simply not being enforced. In others, enforcement has been variable. By inference, at least some regulatory liberalization is occurring in practice, if not by law.

Interviews with key stakeholders, particularly those in the private sector, reveal as much unhappiness with the manner with which existing regulations are implemented, as with the content of these regulations. The biggest concern is the slowness of seed trade authorization. As stated in one regional discussion, it can take up to 6 months to complete a trade transaction. This makes seed trade next to impossible. But obviously, not all seed trade takes this long – most transactions seem to take three to six weeks. Regardless, the extensive paperwork adds to seed costs. The situation is worsened by the unpredictability of the process.

Some observers argue that older seed companies have the capacity to work more easily within this system. Newer or smaller companies face more difficulty. They may also face added scrutiny. For example, company X in one country finds it easier to get its varieties on the national registration list than company Y. Company X also has a substantially easier time importing seed. Thus, regulations acceptable to one company may represent barriers to another.

In general, the seed companies interviewed suggested that regulatory harmonization would be a convenience. However, they expressed greater

interest in pursuing a liberalized regional seed market. There was strong interest in regionalized variety registration allowing production in any SADC country for sale in any other. This would allow companies to produce seed in the most favorable agro-ecological environment with low production costs.

In contrast, a number of government observers express concern about the risks of being dominated by a few large international seed companies. Countries prefer to have local companies that are assumed to be more accountable to the needs of local farmers. Some government authorities have correspondingly discussed restricting market access to companies willing to produce seed within the country. But, to date, there is little evidence of market domination by a few multinationals.

National seed authorities remain most uncertain about the value of liberalized trade and regulatory harmonization. The technical staff of national laboratories commonly view their primary mission as protecting the small-scale farmer from poor quality seed. The best way to achieve this is through strict regulations on seed quality and stringent phytosanitary controls. Examples of the trade of poor quality seed are cited to support the argument that rigorous standards need to be maintained. Most observers can offer stories of unscrupulous traders offering grain as seed to take advantage of donor or NGO or government purchases of emergency seed. There is little doubt about that this threat exists; the problem is how to deal with it. A trade-off exists between the need to promote wider participation in seed production and trade, and the need to regulate seed quality. Empirical data necessary to judge these costs and benefits is difficult to obtain.

Ultimately, the evolution toward a more liberal, regional trade regime in SADC appears inevitable. The question then becomes, how to maintain a minimum set of seed standards necessary to protect the consumer, while stimulating more competitive investment in national and regional seed industries.

The regional seed meetings have contributed to this discussion, laying out the outline of an agreement on a common regulatory framework. However, the details of this framework still need to be established. One strategy is to work out technical agreements on nomenclature and standards necessary to harmonize the main set of regulations that most commonly exist. But to avoid raising barriers to seed trade, a common vision of the regional seed market still needs to be established. Will SADC have a set of national seed markets or a

single regional market? Will seed regulations correspondingly be set independently by each country, or on a regional basis? Such questions were implicit in many of the regional meetings, but were never openly considered.

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Annex 1. Timeline of discussions on harmonization

1987	SADCC commissions DANAGRO study of national seed systems in member countries; regional seed project for harmonization of seed laws recommended
1988	SADCC technical experts meeting on regional seed production and supply (Harare, Zimbabwe) – proposes 11 regional seed projects, including *Harmonization of seed laws in the SADCC region*
1993	Regional workshop on improved on-farm seed production for SADC countries (22-26 Nov 1993, Mbabane, Swaziland) – recommends harmonization of seed laws and extension of regulations to support on-farm seed production
1994	Regional workshop to discuss a study on harmonization of seed laws (4-6 Oct 1994, Harare) – 17 recommendations for seed sector development
1997	Enhancing research impact through improved seed supply: options for strengthening national and regional seed supply systems (10-14 March 1997, Harare)
1997	Regional Technical Meeting on promotion of regional network for on-farm seed production and seed security in SADC countries (23-26 Sep 1997, Maseru, Lesotho) – recommends establishment of SADC Seed Security Network
1999	Strategic Planning Workshop for the Seed Sub-Committee (22-24 Nov 1999, Kadoma, Zimbabwe)
2000	Round table Discussion on *sui generis* protection of plant varieties under article 27.3(b) of TRIPS (27-28 Jan 2000, Harare) – recommends development and implementation of laws on *sui generis* protection
2000	Sub-Saharan Africa Seed Initiative stakeholders workshop (10-11 Feb 2000, Lusaka)
2001	Sub-Saharan Africa Seed Initiative stakeholders workshop (26-28 Sep 2001, Kadoma)
2002	Strategic Planning Workshop for the Seed Sub-Committee (28-30 Jan 2002, Nyanga, Zimbabwe)

Liberalization and Harmonization of Seed Legislation and Regulations in West and Central Africa

Mariam Sow Soumare

Economiste agricole, Consultante, BP 9027, Dakar, Senegal

Introduction

Unlike the case in Southern and Eastern Africa, the process of harmonization of seed legislation and regulations in West Africa is in its infancy. National and subregional networks and institutions have collaborated on developing new varieties for decades, but seed legislation and regulations have not yet been the subject of discussions among countries. The low level of private sector involvement in the seed sector in West Africa and the predominance of the informal sector may explain this lack of interest in harmonization. However, some changes may be on the way. This is due to two factors. Governments in the region are withdrawing from the seed sector and are committed to increasing the private sector's role in the supply of agricultural inputs. Also, governments are involved in the international World Trade Organization (WTO) negotiations and in regional negotiations such as those of the Union Economique et Monétaire Ouest-Africaine (Economic and Monetary Union of West Africa, UEMOA). This provides an opportunity to initiate discussions on harmonization, with a view developing a common regional position on seed laws.

This paper summarizes progress made on harmonization, beginning with an FAO-sponsored meeting in 1998; results achieved to date; problems encountered during the harmonization and liberalization process; and prospects for the future.

Information was obtained through interviews with participants at the FAO workshop on harmonization of seed legislation, held in Dakar, Senegal in March 2002. We also contacted informants in Saint Louis (Senegal), Nouakchott and Bamako, as well as the WASNET Co-ordinator in Accra, and Sasakawa 2000 in Bamako. Secondary sources were also used, ie reports of workshops and seminars on seed issues, and other available literature.

Background to the Harmonization Process in West and Central Africa

The seed sector is not well developed in West and Central Africa. Despite the importance of agriculture, use of improved varieties is among the lowest in the world: 2 to 5% for the major food crops, ie dryland cereals, legume crops and tubers. However, adoption is 50-60% for irrigated rice and 90% for cotton, a major cash crop that tends to be intensively managed.

For food crops, most farmers use own-saved seed. Alternatively they may access seed from the informal market, which accounts for almost 90% of seed traded in the region. This is partly due to the predominance of self or open-pollinated crops for which there is limited private sector interest.

The formal seed sector is dominated by the public sector and NGOs. The public sector performs most of the functions in the seed sector, particularly for rainfed cereals and legume crops. With the help of donors, or on their own initiative, governments also distribute free seed in response to emergencies or for political reasons.

NGOs and the private sector play a role mainly in marketing and extension. However, the private sector is beginning to show some interest in seed production and very slowly in research, for a few crops of commercial value (maize, cowpea, rice and horticultural crops) that are traded regionally and internationally. But even in the horticultural sector, very little seed is produced in the region; most of it is imported by foreign companies.

Not all countries in West and Central Africa have a legislative and regulatory framework governing the seed sector; most countries that lacked these frameworks have begun to develop them since the 1990s.

The predominance of dryland cereals and legumes is reflected in seed legislation, which was developed based on the specific features of these species, without considering other crops. However, rapid global changes will require appropriate responses by the seed sector in the region.

All countries in the region have undergone major changes in their economies over the last fifteen years, through liberalization and reforms. In the agricultural sector, liberalization has significantly reduced the prerogatives of the ministries of agriculture and rural development. There is now a clear willingness to transfer to the private sector production and marketing functions for agricultural inputs and products – except for cotton, which remains in the hands of largely state-controlled companies.

Harmonization of seed regulations does not seem to be a major concern for governments. But it could become so, at least for three reasons: (i) the desire not to go alone or without prior preparation for international negotiations (although seed issues are not yet the focus of concerns), (ii) pressure from donors who would like to see the process set in motion in Southern and Eastern Africa to be extended to the rest of sub-Saharan Africa, (iii) the (slowly) growing involvement of the private sector in seed production and trade. In reality, the harmonization process is much less advanced than elsewhere in Africa, and the nascent private sector is still not strong enough to influence the process.

Achievements and Progress of Discussions on Harmonization

Discussions on harmonization in West and Central Africa have been very limited to date. The only achievement is UEMOA's common external tariff. At most, meetings were held on the topic at the initiative of FAO, the West African Seed Network (WASNET) and the Inter-state Committee for Drought Control in the Sahel (CILSS). A brief summary of these discussions is provided below. These discussions, through a series of meetings, covered three areas:

- Tariff harmonization in the UEMOA zone
- The African Seed Network and other initiatives by FAO, CORAF, and WASNET
- INSAH initiative on a regional variety catalog.

Common external tariff

The main achievement so far is on customs and fiscal tariff harmonization applied to seed imports in the UEMOA zone. This harmonization only involves member countries of this organization, ie most Francophone countries in West Africa (except Guinea) and Guinea Bissau. Under the Common External Tariff, import duty in the UEMOA zone was raised from zero to 23%. Seeds were previously in the same category as staple agricultural inputs and were therefore exempted from duty. Under the new regulations imported seed will be liable for duty – far from promoting trade liberalization! However, involving the main actors concerned in the UEMOA negotiation process could help reach regional consensus on appropriate levels of import duty on seed.

The African Seed Network

At the initiative of FAO, a series of meetings were held from 1998 onwards, to start discussions on harmonization. The meetings were coordinated largely by the Research and Development Council in West and Central Africa (CORAF) network. CORAF in turn linked WASNET into the process.

Abidjan, 1998. A technical regional meeting was held in Abidjan in Nov 1998, with participation from 40 sub-Saharan African countries (not only West Africa). The aim of the workshop was to promote food security and sustainable development by improving farmers' access to quality seed of a wide range of varieties. One of the main challenges recognized at this meeting was the need to invest significant resources in capacity building in order to improve seed availability and thus improve productivity and food security.

The meeting recommended the establishment of the African Seed Network which would aim to coordinate policies and programs to strengthen production and marketing systems in Africa. Network activities related to seeds and genetic resources were to be implemented by five technical working groups dealing with:

- information systems to manage agro-ecological and socio-economic data
- harmonization of seed legislation and regulations
- demand-driven seed supply systems
- preparation of responses to emergency situations
- information dissemination and training.

The working group on harmonization of seed legislation and regulation had the following agenda: review legislation and regulations in member countries; undertake surveys with private and public organizations in the seed sector in order to identify regulations that foster or hinder the movement of seed within and beyond the region; assess regulations that provide a conducive environment for (or hamper the development of) seed production and marketing. France in cooperation with FAO has set up a fund to support this working group.

Rome, 2001. A subsequent meeting was held in Rome in July 2001 to discuss the prospects for the FAO/France cooperation program (proposed during the 1998 Abidjan meeting), specifically to address the need for assistance on legal matters relating to harmonization. The discussions drew on experiences from East and Southern Africa in harmonization of legislation and regulation.

CORAF was to lead the African Seed Network in the region because of its the links with a large number of Francophone and Anglophone countries, and with international research institutions. Recommendations and action plans were developed for each region in Africa. It was decided to hold national workshops to collect basic information and identify specific areas for discussion. But funding issues were not settled, which explains why the network is still not functional.

Dakar, 2001. Harmonization of seed legislation was discussed at a March 2001 workshop in Dakar. The workshop noted that although there was cooperation among researchers (eg through networks such as the West African and Central African millet network ROCAFREMI, and West and Central African research network on sorghum, ROCARS and through international research institutes) and between governments (eg negotiations on intellectual property rights through organisations such as UEMAO and the Organization for African Unity, OAU), there was no such forum for cooperation among private operators in the region. Participants sought greater private sector involvement in negotiations on harmonization.

Dakar, 2002. The purpose was to sensitize government representatives on the importance of harmonization; adopt a common methodology for harmonization of regulations in the region; select a sample of countries and themes to be studied; and develop an action plan for the project in West and Central Africa. The first phase will focus on phytosanitary standards, certification standards, and variety release procedures. Three countries will be studied: Cameroon, Nigeria, and Senegal. CORAF will coordinate the program, while France/FAO will cover the consultancy costs and hiring of expertise at the national and regional level. Comparative analysis of the three countries will help develop a strategy for harmonization, to be endorsed at subsequent regional meetings.

WASNET meeting, Banjul, Dec 2001. The West African Seed Network (WASNET) based in Accra was created by GTZ and IITA. Its purpose is to facilitate regional cooperation, harmonization of seed regulations, standardization of production, marketing and quality control, and promotion of regional trade.

Work on harmonization focused on nine themes including certification, review of seed policies, regulation of imports and exports, inventory of seed stocks and seed industries in the region, assessment of seed demand and

production capacity, and development of a variety catalog. This was to be implemented through national focal points. With this ambitious agenda and very limited resources, little progress was made. However, some preparatory work has been done, eg a coordination committee has been established, and specific activities to be undertaken have been identified.

WASNET has reviewed seed certification procedures, seed policies and laws, and import/export regulations in the region, and prepared a catalog of field standards. The long term objectives are to (i) establish a standard certification procedure for West Africa with harmonized practices in field inspections, (ii) propose harmonized regulations for seed imports and exports, (iii) propose a harmonization of seed laws. WASNET has also facilitated seed exchange between countries, eg export of 10 t of seed in 2001, from Ghana to Togo; of maize seed between Cote d'Ivoire and Ghana, and between Benin and Ghana.

A meeting in Banjul in Jan 2002, where 12 countries were represented, reviewed progress to date. It recommended that activities focus on a small number of themes for greater efficiency. Cooperation with ASN is also being considered.

Regional variety catalog

The Institut du Sahel (INSAH) has initiated work on harmonization of criteria for registration of varieties in national/regional catalogs. This work has two components:

Seed sector review. During 1999-2000, INSAH initiated a series of studies on the seed sector in seven CILSS member countries — Burkina Faso, Gambia, Mali, Mauritania, Niger, Senegal, and Chad. These studies aimed to assess seed sector performance and examine the prospects for development in the context of regional integration, liberalization and privatization. Another series of studies later in 2002 will focus on harmonization of phytosanitary legislation between CILSS member countries, and alternative strategies for seed procurement within the region.

Development of a regional variety catalog. An earlier INSAH project (1984-94) had tested drought-resistant varieties of millet, maize and sorghum. The current initiative, 1999 onwards, seeks to build on the earlier project by documenting availability and diffusion of new varieties. It includes a research component on harmonized criteria for registration of varieties in national

catalogs (eg developing standardized technical fact-sheets) and development of a regional variety catalog. This would cover rice, horticultural crops, and dryland cereals and legumes. One problem with standardization is that the standard fact-sheet proposed by INSAH is too detailed; some of the data are not available in some countries.

In developing the regional catalog, common registration criteria have been suggested, eg the variety should have been tested (DHS, VAT)[1] in at least two countries and should actually be cultivated in these countries. Varieties selected for listing in INSAH's regional catalog have been tested, either under the earlier INSAH project or by various other NARS or network programs. The proposed list contains 58 varieties: 6 maize, 2 sorghum, 13 rice, 13 groundnut, 6 cowpea, 7 onion, 7 tomato, and 4 varieties of other crops.

The regional catalog will be submitted for approval to the council of Ministers in 2003, then published and made available to all stakeholders. A Sahel seed committee will be set up to manage the catalog. The catalog will provide a basis for seed exchanges in the region. If it is adopted by governments and private stakeholders, and is widely disseminated, it could allow significant cost and time savings by enabling countries to use variety testing results obtained from other countries in the region.

However, there is one major concern. Varieties will be included in the regional catalog only if they are already in use (after testing); new varieties are excluded. This will restrict introduction of new varieties. A better solution would be to allow a new variety which has passed DUS and VAT tests in at least two countries, to be directly registered in the regional catalog even if it is not released and cultivated. The present restriction means that new varieties must first be released – this is likely to be slow, given that national release procedures are sometimes not functional. It constrains importers of new varieties and creates an incentive for non-compliance with the regulation. Another alternative would be to replace the criteria for extension and prior utilization by stipulating testing through participatory methods. This would help determine whether the new variety is well accepted by farmers and will speed up the adoption process – adoption could occur simultaneously with testing, with informal agreement from public authorities. However, this process will need to be regulated.

1. DUS = distinct, uniform (homogenous), stable, VAT = agronomic and technological value

Lessons drawn from these meetings

The main lesson that can be drawn from the meetings on harmonization is that the process is still in the initial stages. The meetings so far have simply reported on the current situation, sensitized stakeholders, and developed action plans. To date there have been no specific discussions on harmonization of seed regulations in West and Central Africa, nor has any consensus emerged on the need to harmonize.

The only exception is the common UEMOA tariff which came into effect in Jan 2000 (they cover not only seed but all farming inputs). But tariffs were *increased*, not reduced – from zero to 23%.

The meetings in Abidjan, Dakar, Rome, and Banjul did not address the core policy issues or even the technical issues related to harmonization. Rather, they helped sensitize the main actors on the advantage of harmonization, established a work plan, and identified priority areas (which country to study, which themes to address) to be addressed when discussions on actual harmonization begin.

One problem with discussions on harmonization is that seed legislators, so far, have participated only informally or as resource persons. They do not participate as government representatives, and lack the authority to approve decisions or recommendations.

Seed Exchange Between Senegal and Mauritania – a Case Study

The rice farming areas of Senegal and Mauritania are only a few hundred meters apart across the Senegal river valley. Each country produces 20-30,000 t of paddy per year, from about 30,000 ha. Proximity and similarity of environmental conditions has fostered the development of informal seed exchange between farming communities of the two countries. Most exchange is of local varieties (whatever is available). Small quantities of improved varieties are also exchanged, primarily a high-yielding Senegalese variety. Three varieties developed by the West African Rice Development Association, WARDA (Sahel 108, 201 and 202) are registered in both countries, further contributing to seed exchange between the two countries.

Formal seed exports from Senegal to Mauritania started during the 1997-98 season, involving a private Mauritanian firm along with public officials. Samples of Senegalese seed were analysed by the National Centre for

Agronomic Research in Mauritania. Because of this prior testing, imports were exempted from phytosanitary control. Subsequently, a group of private seed producers from both countries created the Association Regionale de l'Interprofession Semencière (ARIS), which aims to promote seed trade through harmonization of testing, quality control, and certification procedures. Lately, ARIS efforts have expanded to cover groundnut, sorghum, and maize. Varieties of these crops are available in Senegal but have not been released due to lack of resources – release is now likely to be expedited, in view of export prospects.

Lessons learned. The development of trade between Mauritania and Senegal was fostered by the existing cooperation between WARDA, an international research institute, and the two NARS. While WARDA varieties are registered in both countries, there has not been any formal discussion between the two governments on harmonization of seed legislation. In fact, restrictive conditions on variety registration, seed certification, and lack of resources for regulation and import authorization are serious obstacles to trade. ARIS aims to facilitate harmonization and common certification and import procedures to encourage trade.

The Horticultural Sector – a Case Study

In West and Central Africa, horticultural seeds are mostly imported from Europe; small quantities are also produced locally, mainly in Senegal. A few large firms, operating in several countries, import and supply most of the regional market. These firms must contend with a legislative and regulatory system designed for food crops, not horticultural crops. In most countries in the region, the general legislation and any special regulations for horticultural seeds require compulsory seed certification for production, import and sale – just like cereal seed. These provisions are restrictive, and applied in very few countries around the world.

Standard vs certified. In most countries, horticultural seed is considered to be standard seed, with compulsory control not in the farm (as for certified seed) but in the laboratory; after which it is 'stamped' as standard seed. This provision, adopted by most European countries, takes into account the large diversity of species produced and hence the high cost of on-farm control. In West and Central Africa, only Cameroon recognizes the category of standard seed; everywhere else, only certified seed is

permitted. Harmonization of regulations in the region could take advantage of Cameroon's experience.

Compulsory declaration of production plans. In Senegal, industry must submit to the Consultative National Committee for Seeds and Plants (CNCSP) each year, their plans for seed and plant production, including the conditions under which this production is carried out (eg area per variety and per plot). The horticultural industry demands more flexibility, with freedom to adjust planned acreage depending on the market.

Unfair competition from the informal sector. Small producers are allowed to trade part of their saved grain as seed, in order to meet social obligations. The seed industry argues that, under this cover, anybody can trade anything; it favors informal seed producers/sellers and creates unfair competition.

Intellectual property rights. In one example in Senegal, a company sold another company's pepper variety under a different name. The law at the time did not protect the breeder's rights. However, Senegal has now signed (in 2002) the convention on IPR; and the appendix related to rights of the obtainer is being studied by the Ministry of Agriculture.

Lessons learned. Senegalese legislation contains general provisions that apply to all types of seed, particularly cereal and legume seed, which are produced mainly by the public sector and also by a multitude of small-scale producers who often lack understanding of seed technology and therefore require close supervision to ensure quality. This does not apply to the horticultural sector which is mainly in the hands of the private sector and which (in most countries in the world) is not constrained by seed certification procedures.

Most horticultural seed in the region is imported. However, some local producers exist. Encouraging them to expand to more countries will create a larger, viable market and also improve biodiversity by increasing the number of varieties traded – but lack of harmonized legislation is the obstacle. Harmonization will particularly benefit landlocked countries that must obtain imported seed from Europe via coastal countries.

Seed Exchange Organized by NGOs: Sasakawa Global 2000

Maize seed exchanges regularly take place between countries, facilitated by NGOs including Sasakawa Global 2000. Between Ghana on one hand and

Mali and Burkina Faso on the other, these exchanges take place in the form of project-to-project donations, eg 14 t of certified seed were exported from Ghana to Mali in 2001 and 9 t in 2002. Since Sasakawa had signed an official agreement with the three countries, the only documents required at the borders are phytosanitary certificates and information on sale price. This type of seed trade is considered as non-profit and is therefore exempt from tariffs and taxes except for transit fees.

NGOs also distribute free or subsidized seed to farmers. However, this seed comes from multiple sources and is often bought from traders not approved to sell seed. This has two negative effects. Free distribution destabilizes the private traders' markets. It also lowers quality standards, creating confusion in the minds of farmers for whom the distinction between seed and grain-used-as-seed is not always clear.

Impact of Liberalization and Harmonization on Agro-Biodiversity

Liberalization and harmonization may affect agro-biodiversity directly (reduction of the range of varieties used) or indirectly (effects generated by the use of the technological package accompanying improved varieties).

Direct impact. Intensification of agriculture in many regions has led farmers to abandon traditional varieties in favor of a limited number of higher-yielding varieties. However, these are regions where deforestation, desertification and soil degradation are acute problems. The rapid degradation of these ecosystems and the extinction of traditional varieties due to the introduction of a reduced number of improved varieties, highlight the urgent need for inventory, analysis and conservation of traditional varieties. Such an inventory should record, for each species, the cultivated varieties and the corresponding wild species.

Indirect impact. With the reduction of subsidies for agriculture, producers tend to shift to products that are commercially more valuable – but use more pesticides. For example, in the valleys of the Niger and Senegal rivers, where rice production is still dominant, diversification is being promoted towards horticultural crops (tomatoes, okra, onions etc) which require substantial quantities of pesticides. The effects on biodiversity are already apparent and are observed on fish and non-target species.

Obstacles to Harmonization in West and Central Africa

There are many reasons for the slow progress on harmonization in West and Central Africa, notably the weak level of development of the seed sector. Several of these factors have been discussed above. In addition, other factors also play a role.

- Legislators want to first ensure seed security in their own country before engaging in exchanges – this is very clear the case in Niger.
- Because of the absence of IPR, researchers, including those from the public sector, have little incentive to introduce new technologies.
- In many cases researchers must spend long periods testing a new variety before it can be registered or released. But simultaneously, partnership with external donors allows other new varieties to be introduced in farmers' fields without any previous testing or quality control.
- Many countries do not yet have any seed legislation, and therefore they consider they cannot be involved in any discussion on harmonization. This point was raised by several participants at the INSAH regional workshop in 2001 in Dakar.
- There is little collaboration between legislators, researchers, customs officials and civil servants from the Ministry of Trade on harmonization issues.
- Too many institutions (six in West Africa alone) are involved in harmonizing legislations, as shown in Annex 2. There is lack of coordination and duplication of effort; institutions conduct their work, often on the same issue, without informing each other.

Privatization may not necessarily mean liberalization. ICRISAT conducted field surveys in five countries (Niger, Burkina, Senegal, Nigeria and Chad). The study identified several constraints – socio-economic constraints due to lack of infrastructure and equipment to produce and market seed (except in Nigeria and to a lesser degree in Senegal); and institutional constraints caused by the absence of an independent body for quality control (in all countries). Similarly, studies by INSAH have shown that most decision making bodies in charge of defining seed policies were not operational.

The only country which had legal restrictions on variety registration, seed certification and intellectual property rights is Nigeria – possibly because the private sector is the most developed, of the countries studied. The paradox is that when the public sector is in charge of most functions, seed legislation is either non-

existent, or not constraining, or simply not implemented. Development of the private sector, greater use of improved varieties, and greater demand for quality seed of these varieties, will prompt public authorities to make the regulations stricter (although they may still not be adequate).

Conclusions

The seed industry in West and Central Africa is only just starting up. Farmers do not yet clearly perceive the difference between seed and grain – neither, apparently do governments, as reflected by their tendency to supply seed of unknown quality, from different sources. The region thus faces a double challenge – first, recognition of seed quality; and then, maintaining this quality in the long term. To meet this double challenge requires better equipment and infrastructure to ensure quality control, more training for seed producers, as well as an effective demand for quality seed.

The early stage of development of the seed sector in West and Central Africa explains the priorities identified in the harmonization process – identification of new varieties, registration and release criteria, establishment of national or regional variety catalogs, phytosanitary and certification standards are at the top of the agenda. Questions related to intellectual property rights and producers' rights are not yet considered important by stakeholders, except for a few breeders and private firms involved in research and production. Questions related to agro-biodiversity, although important particularly in the Sahelian zone, are also not at the core of the discussions.

Progress on harmonization has been very limited. The only successful example of harmonization is the UEMOA external common tariff (although in this particular case, harmonization has discouraged, rather than encouraged, liberalization and trade). The reason for the UEOMA success is undoubtedly because the institution was granted supra-national authority. No other harmonization measures have succeeded, although proposals were made on variety registration and phytosanitary measures (the latter is still at draft proposal stage).

Annex 1. Regulatory provisions in West and Central Africa

Law/Rules	Institutions initiating the change	Achievements	Problems identified	Changes sought
Registration and introduction of varieties				
Variety must be registered in national catalog (if any) before dissemination. Not necessary for horticultural seed	INSAH/CILSS (between Sahelian countries) FAO, CORAF, WASNET (West and Central Africa) ARIS (Mauritania and Senegal)		Varieties must pass DUS and VAT tests to be included in national catalog, process takes up to 10 years	Develop common criteria for registration in national catalogs Develop regional catalog for CILSS countries
Intellectual property rights				
Most countries support Bangui Convention, but have yet to ratify it	OAPI OAU (model law)	16 countries adhere to convention on IPR	According to industry, conflict with rights allowing producers to sell their own seed for personal purposes	
GMOs				
Not discussed	None		Discussed informally in context of American food aid	
Phytosanitary standards				
Each country enforces its own legislation	INSAH, CILSS, FAO, CORAF (draft stage)			INSAH is considering harmonization of standards between Sahelian countries
Phytosanitary procedures				
Each country enforces its own legislation	None		Lack of resources to enforce regulation	

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Annex 1. ***Continued***

Law/Rules	Institutions initiating the change	Achievements	Problems identified	Changes sought
Certification				
Countries have their own criteria for certification; most (but not all) require that all seed be certified	WASNET, FAO, CORAF (draft stage)		Criteria too strict, too difficult to enforce due to lack of resources and widely dispersed producers	
Import rules				
Phytosanitary certificate required, variety must be registered in national catalog (except for horticultural seed)	WASNET		Inconsistent, eg regulation relaxed under emergency situations; special exemptions also granted	
Export rules				
Phytosanitary certification required in most cases	WASNET (draft stage)		Some countries (eg Niger) allow export only if local demand is met	
Tariff regulation				
Common tariff for UEMOA countries, near zero tariff for seed produced and exchanged among members	UEMOA	None – tariffs have increased from zero to 23%	New increased tariff affects importers and producers	
Foreign companies' entry rights				
Vary by country	None	Will maintain status quo in short term		

Annex 2. Legislative and regulatory provisions in countries for which information is available

Status of legislation	Certification and control	Policy for variety evaluation and registration catalog	Phytosanitary regulations, import and export	Tariff regulation	Regulation governing the exercise of the profession
BENIN					
1991 law on phytosanitary regulation is in force as seed regulation. New law specific to seed being processed	Current law authorizes National Agreement and Control Committee; new law provides for independent body for seed sector	DUS test necessary, but criteria not enforced while registering varieties on provisional list	Approval required for trade of phytosanitary and assimilated products; new law provides for seed classes (pre-basic, basic, certified). Variety must be registered in national catalog before seed is traded	UEMOA regulation in force since Jan 2000	Related to phytosanitary control system, through approval for production, import and commercialization
BURKINA FASO					
Non-existent, but under preparation	None	None		UEMOA regulation in force since Jan 2000	None
CAMEROON					
Seed law adopted in 2001	Analysis in national laboratory or an authorized lab	Varieties can be registered in one of three lists. (a) DUS and VAT tests passed. (b) passed DUS but not VAT. (c) registration for 5 years for varieties formerly known and largely disseminated; standard seed, submitted to quality control	Only registered varieties may be sold		Compliance with technical requirements prescribed, and with the govt's international commitments (Biodiversity Convention)

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Annex 2. ***Continued***

Status of legislation	Certification and control	Policy for variety evaluation and registration catalog	Phytosanitary regulations, import and export	Tariff regulation	Regulation governing the exercise of the profession
IVORY COAST 1963 law to control fraud in agricultural products; 1988 law to control trade violations in agric products; 1992 decree on protection of plant varieties, also seed production and trade. Technical committee for variety registration				UEMOA regulation in force since Jan 2000	Compliance with 1963 and 1988 legislation, also with Annex 10 of Bangui Agreement on PVP (ratified in 2000)
GAMBIA Non-existent	Made by NARI	None			None
GHANA 1987 decree in use. New seed law drafted, not yet adopted					
MALI 1995: legislation on import, export, production, diffusion, control and certification. 2000: new legislation submitted for approval, not yet adopted	Regulation governing National Seeds Committee, but not functional. Certification and control by National Seed Lab			UEMOA regulation in force since Jan 2000	No formal seed industry exists. Entry of foreign companies completely liberalized

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Annex 2. *Continued*

Status of legislation	Certification and control	Policy for variety evaluation and registration catalog	Phytosanitary regulations, import and export	Tariff regulation	Regulation governing the exercise of the profession
MAURITANIA					
1996: law on production, trade and control of seeds and certified plants; lack of regulation	Certification by Center for Control of Seeds Quality (Dept of Livestock and Agriculture)	National Seeds Council (advisory body to Ministry)	Prior authorization necessary for import		Need approval from Ministry of Agric, on advice from National Seeds and Plants Committee
NIGER					
1990: no formal law, only rules setting standards for production, conditioning, control, certification and seed trade	No tests needed because seed is produced by public sector		Exports only after national needs are met	UEMOA regulation in force since Jan 2000	Conditions under 1990 decree on production, multiplication, conditioning norms (a declaration is needed)
NIGERIA					
No law; only regulations are available	Certification norms exist	2 year testing to verify adaptability to an agro-ecological area	Imports and exports subject to prior authorization, with phytosanitary certificate and genetic viability test, mentioning origin of variety. Labeling and trade marking required		Registration system for import and export. Foreign companies subject to prior authorization

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Annex 2. *Continued*

Status of legislation	Certification and control	Policy for variety evaluation and registration catalog	Phytosanitary regulations, import and export	Tariff regulation	Regulation governing the exercise of the profession
SENEGAL					
1994: seed law adopted. Advisory Committee, catalog of species and plants, specific technical regulations per species, regulations on exchange of equipment with countries in the region	Control norms for field and lab; required level of variety and genetic purity, compliance with technological and health norms	2 year testing to verify adaptability, establish DUS and demonstrate superiority over existing varieties	Certification required for seed trade. A transaction register is maintained for each species for each operator. Detailed labeling	UEMOA regulation in force since Jan 2000. New varieties may be imported after 3 years of conclusive tests; in practice, standard seed imported without any authorization	Production must have prior authorization. Basic conditions: adequate staff and infrastructure. Documents submitted to National Advisory Committee; foreign companies must be associated with local firms
CHAD					
1996: seed law adopted, includes phytosanitary regulation for import and export, control and certification	2001 regulation on certification and control still not approved				No formal seed industry exists, but some sub-contractors in horticultural sector

Workshop Participants

Boubacar Diallo
INSAH/CILSS
Box 1530, Bamako, Mali
Tel +(223) 223 4067
Fax +(223) 222 7831 or 5980
Email bdiallo@agrosoc.insah.ml

Eddie Goldschagg
Box 72981, Lynnwood Ridge
0040 Pretoria, South Africa
Tel +(27-12) 349-1438
Email seedcert@sansor.co.za

Julie Howard
Asst Professor of Intl Development
Dept of Agricultural Economics
Michigan State University
East Lansing, Michigan 48824
USA
Tel +(517) 355 4693
Fax +(517) 432 1800
Email howardj6@pilot.msu.edu

Richard Jones
Principal Scientist (Seed Systems)
ICRISAT
PO Box 39063, Nairobi, Kenya
Tel +(254-2) 524554/6
Fax +(254-2) 524001
Email r.jones@cgiar.org

Mywish Maredia
Deputy Director Bean/Cowpea CRSP
Associate Professor, Dept of Agric Economics
Michigan State University
202 Agriculture Hall
East Lansing, MI 48824-1039
USA
Tel +(517) 355 4693
Fax +(517) 432 1800
Email maredia @ msu.edu

Mary A Mgonja
SMINET Coordinator
ICRISAT
PO Box 776, Bulawayo
Zimbabwe
Tel +(263) 838 311/8
Fax +(263) 838 253
Email m.mgonja@cgiar.org

Isaac Minde
ECAPAPA Coordinator
PO Box 765, Entebbe
Uganda
Tel +(256) 41 321780
Fax +(256) 41 321777
Email ecapapa@imul.com

Emmanuel S Monyo
Principal Scientist (Breeding)
ICRISAT
PO Box 776, Bulawayo
Zimbabwe
Tel +(263) 838 311/8
Fax +(263) 838 253
Email e.monyo@cgiar.org

Josephine Okot
General Manager
Harvest Farm Seeds Ltd
Box 8166, Kampala, Uganda
Tel +(256) 41 345825/77514576
Fax +(256) 41 344174
Email jo-harvest@nfocom.co.ug

David D Rohrbach
Principal Scientist (Economics)
ICRISAT
PO Box 776, Bulawayo, Zimbabwe
Tel +(263) 838 311/8
Fax +(263) 838 253
Email d.rohrbach@cgiar.org

Joseph Rusike
Special Project Scientist
ICRISAT
PO Box 776, Bulawayo, Zimbabwe
Tel +(263) 838 311/8
Fax +(263) 838 253
E-mail j.rusike@cgiar.org

Mariam Sow Soumaré
Economiste agricole, Consultante
BP 9027, Dakar, Senegal
Tel +(221) 864.29.66
Email mariam_sow@hotmail.com

Tobias Takavarasha
Chief Executive Officer, FANRPAN Secretariat
12th Floor Social Security Centre
Cnr J Nyerere / Second Street
Harare, Zimbabwe
Tel +(263-4) 792348 / 50
Fax +(263-4) 792411 / 792408
Email Ttakavarasha@fanrpan.org

Ajay Varadachary
Regional Information Officer
ICRISAT
PO Box 776, Bulawayo
Zimbabwe
Tel +(263) 838 311/8
Fax +(263) 838 253
Email a.varadachary@cgiar.org

Edward D Zulu
Coordinator, Regional Seed Security Network
PO Box 4046, Harare
Zimbabwe
Tel +(263-4) 736051 or 52
Fax +(263-4) 722724
Email sssn@fanr-sadc.co.zw

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political, international organization for science-based agricultural development. ICRISAT conducts research on sorghum, pearl millet, chickpea, pigeonpea and groundnut – crops that support the livelihoods of the poorest of the poor in the semi-arid tropics encompassing 48 countries. ICRISAT also shares information and knowledge through capacity building, publications and ICTs. Established in 1972, it is one of 15 Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

Contact information:

ICRISAT-Patancheru
(Headquarters)
Patancheru 502 324
Andhra Pradesh, India
Tel +91 40 23296161
Fax +91 40 23241239
icrisat@cgiar.org

ICRISAT-Nairobi
(Regional hub ESA)
PO Box 39063, Nairobi, Kenya
Tel +254 20 524555
Fax +254 20 524001
icrisat-nairobi@cgiar.org

ICRISAT-Niamey
(Regional hub WCA)
BP 12404
Niamey, Niger (Via Paris)
Tel +227 722529, 722725
Fax +227 734329
icrisatsc@cgiar.org

ICRISAT-Bamako
BP 320
Bamako, Mali
Tel +223 2223375
Fax +223 2228683
icrisat-w-mali@cgiar.org

ICRISAT-Bulawayo
Matopos Research Station
PO Box 776,
Bulawayo, Zimbabwe
Tel +263 83 8311-15
Fax +263 83 8253/8307
icrisatzw@cgiar.org

ICRISAT-Lilongwe
Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi
Tel +265-1-707297/071/067/057
Fax +265-1-707298
icrisat-malawi@cgiar.org

ICRISAT-Maputo
c/o INIA, Av. das FPLM No 2698
Caixa Postal 1906
Maputo, Mozambique
Tel +258-1-461657
Fax +258-1-461581
icrisatmoz@panintra.com

Visit us at **www.icrisat.org**

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