Pasture and Forage Seed Production in Africa and West Asia

Proceedings of the Pasture and Forage Seed Production Workshop, Addis Ababa, Ethiopia 27–31 October 1997

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Sponsors

International Center for Agricultural Research in the Dry Areas (ICARDA)
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International Center for Agricultural Research in the Dry Areas (ICARDA)
1998

Citation: Grass, L. and M.R. Turner (eds.). 1998. Pasture and Forage Seed Production in Africa and West Asia. Proceedings of the Pasture and Forage Seed Production Workshop, Addis Ababa, Ethiopia 27–31 October 1997. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. viii + 204 pp.

ISBN: 92-9217-079-2

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Foreword

Livestock production is an important component in the economies of most countries of West Asia and North Africa (WANA) and Sub-Saharan Africa. However, most of these countries face inadequate feed supplies for their livestock. Quality seed of improved varieties is a key element in improved production of forage and pasture crops, and therefore in more efficient animal nutrition. Declining soil fertility, soil erosion, and depressed cereal yields are also major concerns. Pasture and fodder crops play an important role in the management of natural resources, but the lack of seed remains a major constraint in their adoption by farmers.

Although a considerable amount of quality seed is produced for food crops, hardly any seed of pasture and forage crops is produced. Seed production for these crops is still far from meeting the needs of the region, and most countries rely on imports. Several countries have attempted to establish national pasture and forage seed programs, but with only limited impact. Difficulties are attributed to a lack of appropriate seed production techniques, low crop productivity, lack of adequate extension services, inadequate infrastructure for processing and distribution, and inadequate incentives and government support.

National policies on seed production, marketing, and distribution also affect the availability of pasture and forage seed. In fact, most of the available forage seed is currently produced by farmers through the informal sector. Where it exists, the formal sector provides only a small quantity of seed for a very limited range of species.

The International Center for Agricultural Research in the Dry Areas (ICARDA) has devoted substantial efforts to promoting forage and pasture seed. In collaboration with the National Agricultural Research Systems (NARS), activities have been undertaken to address these problems in WANA through training, dissemination of information, access to technical knowledge, and provision of small quantities of seed. In addition to promoting participatory research to encourage the adoption of forage and pasture species, ICARDA has also developed practical techniques to produce and harvest sufficient quantities of forage and pasture seed using locally manufactured machinery.

Within this context, ICARDA and the International Livestock Research Institute (ILRI) organized this workshop to bring together scientists from WANA, Sub-Saharan Africa, and other parts of the world. The purpose of the meeting was to evaluate progress within the region, discuss constraints limiting the development of the forage and pasture seed industry, and identify areas of high priority in seed research that will contribute to the development of the sector, which is an important component of the forage system.

Prof. Dr Adel Beltagy
Director General
ICARDA

About the Workshop and Proceedings

The workshop was organized jointly by ICARDA and ILRI and took place at Addis Ababa, Ethiopia from 27 to 31 October, 1997. Its purpose was to exchange ideas, look at ways to resolve constraints facing forage and pasture seed production in WANA and Sub-Saharan Africa countries, and suggest guidelines on how to strengthen collaboration within this sector.

Papers were presented during the first three days of the workshop on a wide range of topics, from the arid rangelands of Turkey to the high-rainfall areas of Tropical Africa. The fourth day was devoted to group discussions, in which the key points identified in the previous three days were debated and recommendations prepared. Discussions on the final day centered on formal and informal approaches to seed production. It was agreed that the two must be more closely integrated to increase farmer production and utilization of seed.

The workshop provided a valuable forum for scientists in the region to share experiences, gather information on the current status of national seed programs, and identify specific technical and economic problems for further investigation. The latter constitute the cornerstone of proposals for future collaborative research between ICARDA and various national and international seed programs.

In both WANA and Sub-Saharan Africa, research and development on forage issues are essential and on the increase. The workshop concluded that lack of demand is the major constraint to the evolution of better forage and pasture seed supply systems. Recommendations stress the need for participatory research to test and develop the role of forages in farming systems, the need to make the benefits of forage and pasture crops more obvious to farmers, and the need to broaden appreciation of the role these crops play in sustainability issues. Existing activities of ICARDA and ILRI should be maintained and strengthened where possible. In particular, these organizations should assist national governments and NARS by providing training in forage and pasture seed production, coordinating collaborative research in their respective regions, providing consultancy, and addressing weaknesses in the supply system.

These proceedings contain the papers presented and the recommendations from the group discussions. The papers have been edited for style and content, and some have been shortened to focus more clearly on the main theme of the meeting. We accept full responsibility for these changes. Also, we have included papers from some authors who were not able to attend the meeting.

The Editors

Acknowledgments

The workshop stemmed from an initiative by the ICARDA Seed Unit, and was cosponsored by ILRI. We would like to thank ILRI for hosting the event, and for the outstanding organization and facilities that provided an excellent working environment.

The sponsors of this workshop are grateful to the Government of the Netherlands for providing financial support to cover the expenses of ICARDA-sponsored participants and the production of this proceedings volume, through a DGIS/ICARDA Training Project in Seed Technology.

The organizers would like to pay tribute to the authors and participants for their excellent presentations, their active contribution in discussions, their positive attitude, and especially their very enthusiastic and solid support for the working groups, the output of which made this workshop a success.

We are also grateful for the lively contributions of Drs John Ferguson from Australia and Rob Rowling from England, our invited keynote speakers.

Drs Mustapha Bounejmate and Samuel Kugbei deserve acknowledgment for their suggestions and critical review of this document.

On behalf of all the participants, we would like to thank those people who worked behind the scenes to make this event a success, in particular, Messrs Emaelef and Getachew of ILRI for their unfailing assistance throughout the week.

Finally, we are indebted to Ms Sonia Noaman of the ICARDA Seed Unit for her valuable efforts during the preparation of this event and in typing some papers.

ILRI Welcome Address

A. Tall
Acting Resident Director, ILRI, Addis Ababa, Ethiopia

Good morning ladies and gentlemen,

On behalf of the Resident Director and the entire staff of ILRI-Ethiopia, I am pleased to extend to you a sincere and warm welcome to the ILRI campus for this joint ICARDA/ILRI seminar on pasture and forage seed production.

Forages, especially leguminous forages that provide high-quality protein feed to complement lower-quality crop residues, are important for livestock production. They are also important in maintaining soil fertility and for natural resource management. Despite this, lack of seed remains a constraint to wider adoption by farmers. Forage seed production is less developed than field crops seed production, but there are those within this group who have experience with the subject. We hope that by exchanging ideas and looking at ways to resolve constraints, we will be able to promote national forage seed production in the region.

ILRI and ICARDA have worked together in forage seed production since 1990. We have developed training modules, and held a joint workshop on smallholder seed production in 1994. Now we are holding this seminar to exchange ideas and experiences, review the status of forage seed production, and develop ideas on how to strengthen collaboration in the future. This is an activity within the inter-center training program for Sub-Saharan Africa.

Given the participation of the eminent scientists and practitioners gathered together, we are confident that your deliberations will lead to practical recommendations for the improvement of national forage seed production in the region.

ICARDA Welcome Address

M.R. Turner
Head of Seed Unit, ICARDA, Aleppo, Syria

Good morning ladies and gentlemen,

On behalf of the Director General, Prof Dr Adel Beltagy, the staff of ICARDA, and especially the Seed Unit, I would like to welcome you to this meeting on forage and pasture seed. We thank you for the interest you have shown in this meeting and for your efforts in preparing your presentations. I would also like to offer our special thanks to the staff of ILRI, who made the local arrangements for our arrival and stay on this fine campus.

Of all the Centers of the Consultative Group on International (CGIAR) Agricultural Research, ICARDA, from its headquarters near Aleppo in northern Syria, serves the driest regions of the world. Its geographical mandate extends from Mauritania in the west to Pakistan and Central Asia in the east, from Turkey in the north to Ethiopia and the Arabian Peninsula in the south. Within this large region, total annual rainfall varies with altitude, but seldom exceeds 500 mm, and in many areas does not achieve the minimum requirement to grow conventional crops. In such harsh environments, the keeping of livestock, especially small ruminants, has been a traditional way of life for centuries. Animals can exploit the different feed sources that are available during the year, often by moving over large distances.

This traditional lifestyle, for both farmers and their animals, is now under threat, as more land is used for conventional crop production or developed in other ways. Large herds of animals grazing in dry landscapes can lead to a familiar pattern of environmental degradation. In many dry areas, the natural vegetation cannot continue to support the demands being made upon it. This prompts an interest in alternative systems to improve feed production without resorting to intensively-managed feed lots, which are often unsustainable because of their high water requirements.

Attempts to enhance fodder and pasture production in harmony with local farming systems are not easy, especially when grazing land is seen as a common resource. However, a sustained effort must be made to achieve this goal, and improving the supply of forage and pasture seed can be a major contribution. Of course, the ecological context is different in more tropical environments, but even there, population pressures and land degradation may present problems.

This establishes the context and purpose for this meeting, which we hope you will find a valuable opportunity to exchange information and experiences. ICARDA

Section I –
International Experience

Current Status of Seed Program Development and Implications for Forage Seed Supply

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Abstract

In countries with a well-developed seed industry, there are clear divisions within the commercial trade, based on the different types of crop seed. These divisions reflect profound differences in the botanical and economic characteristics of the crops, in particular the volume/value relationship of the seed itself, the value and use of the final product, and the technical complexity of seed production. In countries with a less well-developed seed industry, it is common to find only the major staple grain crops included in national seed projects or programs. The more specialized crop groups are largely neglected, or the demand is met by seed imports, often at considerable cost. These emerging seed industries have been subjected to major policy changes in recent years as a result of pressure to reduce government spending and liberalize the economy. There has also been a keen interest in some countries, and from some donors, to support the informal channels of seed supply, which have not been influenced by the large project investments needed to establish national programs. This paper examines the place of forage and pasture seed in developing countries, within the wider context of seed supply systems, and the policies that regulate them. It emphasizes the special characteristics of these seeds due to the diverse ways in which the resulting crops are used, and the strong social and environmental implications of livestock production in many countries, especially where rainfall is the major constraint.

Introduction

The majority of the crops used by man are annuals that have to be resown each season, and for which farmers have to ensure a supply of seed. Some purchase their seed requirement from an external source, such as a seed company or agricultural merchant, while others use a local source, such as saving their own seed or buying from a neighbor or the local market. This was the traditional means of seed supply, practiced for many centuries, until a seed industry evolved with more organized channels of seed production and marketing.

These two sources of supply coexist in all countries, and are collectively part of the seed supply system. In the past ten years or so, this system has been the subject of much study and analysis. As a result, we now have a clearer understanding of this system and the factors that influence it. However, this analysis has been almost entirely concerned with the staple cereal crops, which are naturally the first concern in most countries.

Seed of forage and pasture crops has remained a rather small and specialized part of the system. That does not necessarily mean it is unimportant, for as we know livestock are a key part of the farming system in the widest sense in many different environments. However, the production of forage and pasture seed is technically more difficult, and the final delivery and utilization mechanisms are also more complex. As a result, this seed continues to be a problem area in many national seed programs. Its importance is constantly acknowledged, but development remains slow.

Recognizing these complexities, this meeting was arranged to try to bring together a wide range of experience with these crops, and to make some general recommendations to assist future development. The purpose of this paper is to introduce some basic concepts and definitions, which will hopefully provide a framework for later discussions. For convenience, the term *forage seed* is used to cover all the species of grasses and legumes used for feeding animals, regardless of the management system. Unless specifically stated, the countries under discussion are those of West Asia and Africa which have been the subject of agricultural development activities.

Development of National Seed Programs

Seed is regarded as a key element in agricultural development. It is the means by which new varieties produced by plant breeders are delivered from research to agriculture. At the same time, it is the material used to establish a new crop each year, and the quality of the seed determines how effectively that is achieved. For the past 25 years, there have been efforts to establish organized seed activities in virtually all countries of the region. Finance for these activities has been provided by external donors, both bilateral and multilateral, through the medium of development projects. These projects put in place the key elements of a seed program by providing capital investment for hardware such as processing plants, stores, vehicles, and seed testing laboratories. They also introduced the procedures for certification and seed testing, often supported by legislation and regulations. These procedures depended heavily on the availability of skilled staff, so there was often a substantial training component in seed projects.

The objective of these projects was to establish the foundations of a seed production system. A national seed program usually followed, but was still dominated by government agencies, often using parastatal companies to handle the more commercial operations such as production, distribution, and marketing. These activities were usually driven by developmental and social considerations and were seldom run on truly commercial lines. Consequently, it was difficult for the private sector to penetrate this market, because seed sold by government agencies was effectively subsidized.

This general picture is typical of many developing countries and for the staple cereal and food legume crops. One notable exception is the hybrid cereals, especially maize, and sometimes sorghum. For these crops, the multinational seed companies often have very good material at their disposal, and it is difficult for national breeders to compete in terms of quality. Consequently, these companies are represented in many countries of the region, but their activity is normally restricted to those few crops in which hybrid varieties are available. Another exception is vegetable seed, for which there is a highly-organized international trade supplying local wholesalers and retailers very effectively. Because of the greater technical specialization in producing this seed, and its relatively high value, governments have not become involved, and there is usually an open competitive market with substantial importation.

All these developmental activities were directed towards the creation of an organized system of seed multiplication based broadly on that which had evolved in countries with a highly-developed agriculture. However, the established seed industries of Europe and North America were geared to supply commercial farmers (often with large mechanized farms) with all their external inputs such as fertilizer, agrochemicals, and seed. This is a very different type of farming community to that which exists in the developing countries of Asia and Africa.

Consequently, although an organized seed supply system has been established, and in some countries works quite well, it has still not become the major supplier of seed, as was perhaps envisaged when the projects were first initiated. Indeed, there was sometimes a perception that improved seed and new varieties would provide the engine that would drive the rest of agricultural development, but that has proved difficult to achieve. In practice, the organized seed sector provides a small proportion of the total supply, typically the more commercial farmers and those in the more accessible areas.

Current Status of Seed Program Development

In the 1990s, significant changes in the political and economic climate of development have taken place. There is now an expectation that government will be much less involved in the production sectors of the economy, and will concentrate on providing a policy environment and a physical infrastructure in which others, particularly the private sector, can expand as the main producers and service providers. This approach is favored because a competitive private sector is considered to be more efficient at managing commercial activities. It is also true that in many countries, government budgets are seriously constrained and simply do not have the resources to maintain the wide range of responsibilities they have inherited.

If this shift of emphasis is interpreted in the context of seed, it means that governments should withdraw from the production and marketing of bulk certified seed, leaving those tasks to the *private sector*, which should be encouraged to develop. At the same time, governments should create a regulatory framework to support this development. Many countries within the region are now engaged in that transition, though at very different stages. It should be emphasized that the term *private sector* should be interpreted broadly to include cooperatives, farmers associations, traders, and even NGOs—in fact, any organization or entity except ministries and parastatal companies.

Although this major transformation of the seed industry has strong philosophical support from development agencies, in practice, it can be difficult to implement, particularly for the self-pollinated grain crops, which include most of the major cereals and legumes. For these crops, sowing rates are high and genetic deterioration is slow, so farmers often do not see any benefit in spending money to buy new seed each year. Instead, they continue to save seed (i.e. grain) on the farm from one season to the next. As a result, it is proving difficult to stimulate interest in these seeds within the private sector because of low profitability and weak demand. Therefore, it seems there will be a continuing need for government involvement in the supply of these seeds, at least to provide a diffusion mechanism for new varieties generated by research.

Partition of the National Seed Supply

Given this background, one way to analyze the seed supply system is to consider how farmers obtain their seed for each sowing season. The total national seed requirement for each crop/season consists of the area sown multiplied by the average sowing rate. Since both of those figures are relatively stable, there is probably a consistent quantity of seed being sown each year in any particular country—but how is that requirement obtained? One possibility is that seed is purchased from the organized seed sector—government or private company—which we now call the *formal seed sector*. The other is that seed is obtained from informal sources close to the farm, either by saving a part of the crop directly for sowing the following season or buying from neighbors or local traders. This is represented in Figure 1.

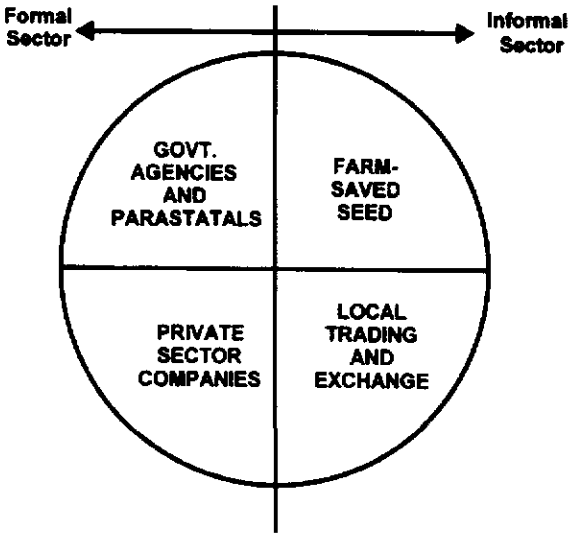

Figure 1. Major divisions within the national seed supply system.

The defining characteristics of the formal sector are:

- Planning the production of crops intended for seed (as distinct from grain).
- Using well-defined varieties, usually from plant breeding programs.
- Using mechanized processing of the seed crop to improve its quality.
- Selling seed in labeled packages.
- Providing some quality assurance by seed testing or certification.

Typically, the informal sector does not do these things in a systematic way, although it may provide improved varieties that are simply maintained by farmers, and there may be some post-harvest cleaning by simple methods. This applies particularly to grain crops, where farm saving is relatively easy. Indeed, perhaps the key feature of the informal sector is that it does not make a clear distinction between seed and grain; in practice, grain that remains in stock at the next planting season is sown as seed.

This broad partition of the seed supply is analogous to the concept of market share by which companies measure their activities in developed markets. Of course, the equal divisions shown in Figure 1 do not represent the actual volumes supplied by each sector. The diagram can be easily adjusted for that purpose, and a more realistic partition for cereal and legume crops in many developing countries is shown in Figure 2.

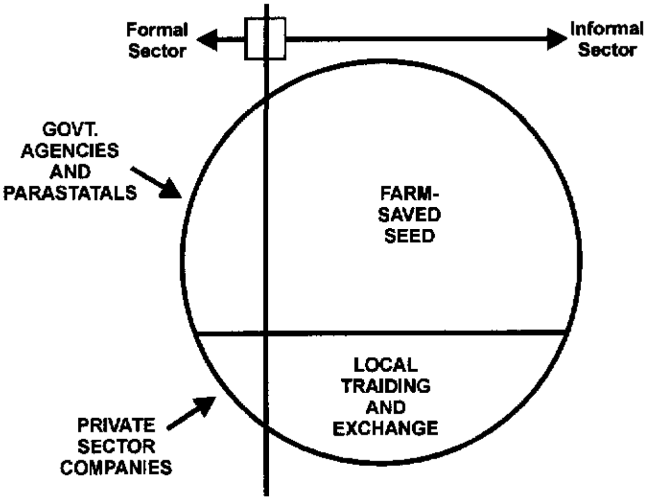

Figure 2. Suggested partition of the seed supply in many developing countries.

This conceptual partition of the seed supply is useful in many ways. For example, it may help us to consider how the private sector can make a greater contribution by expanding its activities at the interface between the formal and informal sectors, where the definition is not clear. Different developmental approaches and policies may be needed to support the two supply channels.

Characteristics of Forage Seed

All that has been said so far relates to seed of the major cereal crops, which have been the main concern of national seed programs and the projects that support them. The same considerations apply to the grain legumes, except that they are usually even more problematic in terms of commercialization, despite their importance in the diet of many poor farmers.

However, forage seed is very different in several ways. Technically, it is often quite complex, as species are recently domesticated and retain many characteristics of wild species, such as the early shedding of seed at maturity and various dormancy responses. As a result, forage seed can be difficult to manage in terms of organized seed production practices. In particular, it can be difficult to maximize seed yield without high labor input, and this can lead to high production costs, or very variable yields.

There has been relatively little systematic breeding of these forage crops, most of the "varieties" are simply selections from wild populations. This may be a perfectly good improvement technique, but it means that improved selections look the same as unimproved forms. Indeed, since the populations are variable, it may be difficult to identify and describe them as varieties.

Another obvious difference is that forage seed has no direct use as food, and unsold seed cannot be diverted to a grain consumption market. It is therefore more risky for the producer and seller, since the seed is virtually worthless if not sold for the intended purpose.

Yet another factor is that the yield and final benefit of forage crops are generally expressed in the output of livestock, not of crop. Forage crops do sometimes have a cash market as fresh fodder or dry hay, and in some countries of the region, where livestock are kept in urban areas, this can be a profitable business. Even then, the actual yield and quality of fodder are difficult to assess because of the long duration of the crop. Persistence under regular cutting or grazing regimes is an important attribute of varieties, necessitating a long trial period to obtain valid results. In short, the evaluation of forage crops and varieties, whether in terms of yield or value, is a much more difficult task than for most other crops, which are harvested only once.

The diversity of cropping systems in which forages are used adds a further complication to the evaluation of improved varieties. For production in managed forage systems, where the crop is cut regularly, reasonable measurements of productivity can be made from long-term cutting trials, although without the direct involvement of animals in the system.

When these crops are grown for direct grazing by animals in the field, assessment in either yield or financial terms is very difficult, and this indirectness of benefit is a serious problem. Therefore farmers must have great confidence in the management and control of their land resources to be sure that an investment in seed will show a return in improved livestock production over several subsequent years. When used in extensive livestock systems, for example, the re-seeding of natural pasture or rehabilitation of degraded land, an objective quantitative assessment of a particular genotype is virtually impossible, although one may assess the overall improvement in the productivity of the system.

To summarize, not only is the production of forage crop seed technically difficult and risky, but there are a number of complicating factors that make marketing more challenging than for cereal or grain legume crops. The commercial potential of this seed is therefore limited, except where a well-developed market exists to stock farmers who use managed pasture systems. For example, such markets exist for Rhodes grass (*Chloris gayana*) in East Africa and the Arabian Peninsula.

International Trade in Forage Seed

Forage seed supply is a very distinct sector of the world seed trade, characterized by a relatively small number of crops, countries, and companies. Most of the trade is in temperate crops such as ryegrass (*Lolium* spp.), timothy (*Phleum* spp.), and clover (*Trifolium* spp.). These species are normally sown in mixtures in managed pastures (leys) for conservation, as hay or silage, for grazing, or for a combination of purposes. There is also a substantial trade in lucerne/alfalfa. The major producing countries are Canada, the USA, Denmark, the Netherlands, and New Zealand. This trade is quite separate from the other main seed products, such as cereals or vegetables, in terms of breeding, production, and marketing. In fact, there is a distinct community of herbage seed companies reflecting the particular character of the crops and the trade. It is a very old trade because, unlike cereals, farmers cannot easily produce seed themselves and rely on purchasing from companies.

This trade is strongly cyclical in terms of supply and price. Because most of the temperate species are perennial, farmers do not have to sow every year, and in times of financial stress they may not purchase seed. Yields of seed are variable, and there may be occasional years of very high or low production. The combined effect of this instability in both supply and demand can be very serious, and companies that specialize in this seed must be very alert in their management of their stocks. At the time of writing, there is every sign that the trade in temperate herbage seed in Europe is entering a period of low demand. Even in the highly-developed international trade, this seed is a separate case, and involves special risks for the companies involved.

Work on the selection and organization of tropical forage species is much more recent. It started in Kenya and Australia, while latterly Brazil has assumed a key role. The international trade in these species is still relatively small. Australia also has a major interest in species such as subterranean clover and medics which are used in dry environments. Only a small number of species is traded in significant quantities.

The Place of Forage Seed in National Seed Programs

National seed programs are based around staple cereals, and sometimes grain legumes. Because of the technical problems of production and processing, and the difficulties associated with marketing, forage crops will normally be a marginal addition to the main program. They will be included for developmental and social reasons, with little commercial potential. As national seed programs move more towards the private sector, and are driven increasingly by commercial considerations, forage seed may become even more vulnerable. Managers of parastatal or newly-privatized organizations, who are given clear terms of reference to move towards financial viability, may have little interest in forage seed with all its problems and uncertainties. Indeed, if the trend towards commercialization continues, it is possible that forage seed production may be increasingly marginalized because of its technical problems. This is ironic, since the environmental need to reverse overgrazing and make livestock systems truly sustainable is at the same time becoming ever greater.

We may therefore expect to see organized forage seed production (i.e. in the formal sector) restricted to those crops produced in relatively intensive managed systems, often irrigated, such as alfalfa and forage sorghum/Sudan grass. Indeed, there is a well-established trade in alfalfa seed, on the borderline between the formal and informal sectors, in several WANA regions (along the Nile, for example, and in the Emirates).

When organized production of other species—vetches and medics, for example—is carried out, it is likely to be within the context of a development project that includes the management of grazing land in collaboration with the local communities, or for a defined export market.

Informal Approaches to Forage Seed Production

Forage crops must be considered as part of the larger system of feed supply and livestock keeping. The risks of production and the difficulties of full commercialization all point towards local systems in which seed production is an adjunct to growing the forage crop. There may be particular seasons in which seed production is easy and farmers may harvest an opportunistic seed crop. This need not greatly reduce biomass production, since there is a substantial amount of hay available after seed removal by threshing.

There are also sound ecological justifications for this localized approach. When crops are well-adapted to a particular environment and produce seed abundantly, a good basis for further seed production and utilization exists within the locality. For the perennial forage crops, maintaining selection pressure for persistence is desirable, whereas for the annual species, good seed production and the accumulation of a substantial seed bank in the soil are key elements of some management systems. Both attributes will be strongly influenced by environment and management system, therefore the production of seed *in situ* is a good way to maintain selection pressures on the population. To summarize, these forages are more strongly endemic than the typical grain crops, and this provides a sound justification for adopting a local approach in seed production.

Specific management practices may be applied to enhance seed yield, and simple harvesting or cleaning equipment may be used to improve quality. There is no need to introduce legalistic quality control procedures, since that will almost certainly impede production. On the other hand, there is a role for the monitoring of seed yield and quality in order to improve the system. This may resemble an extension activity, intended to improve the system progressively through experience and minor improvements. It is by definition participatory, because the seed growers will be farmers; there is little merit in carrying out sophisticated work on research stations to maximize yield if the practical application is likely to be firmly embedded in local forage production systems.

How does this approach to seed production fit into the formal/informal concept illustrated in Figure 1? It is essentially informal, in that it does not depend on official supervision or quality assurance procedures, and it certainly does not involve the use of well-defined or named varieties. On the other hand, production may be a planned activity by certain farmers who have a pre-arranged outlet for the seed to neighbors or a development project. This type of production system sits close to the boundary between formal and informal. Although it leans more towards the informal, it may be possible for a group of farmers to associate in some way to become regular suppliers, in which case it might resemble a more formal system.

Clearly, these definitions, although useful, cannot be precise. It may be possible to make a local system more secure if it can be formalized and institutionalized to some extent. One of the intrinsic weaknesses of local community efforts is that they often depend on the enthusiasm of one or two keen individuals, and do not have a sustainable place within the socioeconomic system. In addition, they may depend on external funding from projects and may thus break down when funding is withdrawn. For this reason, an element of economic analysis should be included in these plans to understand their economic sustainability as well as their environmental and social impacts.

The Impact of Legislation

I have already indicated that legislation and regulation need not be applied to these local seed production initiatives, but this perhaps deserves further comment. The seed regulatory system applied in most developing countries is broadly derived from the system that originated and still exists in North America and Europe. It evolved with the clear purpose of protecting consumers (farmers) from unscrupulous traders, and has had the effect of raising standards to a level where farmers expect and receive seed of very high quality. Not only is seed quality assured, but also the agronomic merit of varieties through the systematic evaluation and registration of new varieties before they are widely multiplied and distributed.

Although there is some criticism and reappraisal of seed and variety regulations, which can have negative effects, there is still a broad acceptance of their value for the main agricultural crops, and certainly for the commercial seed sector. However, for forage crops the position is less clear. The standards of seed quality (purity and germination) that can be achieved are often quite low, and germination assessment can be greatly complicated by dormancy. Therefore, the application of rigid standards can make forage seed production more difficult. Likewise, the concept of cultivar purity is not well-defined in these species; we usually have little more than selections that are still variable populations. Attempts to define these populations can be futile, since some variability is an asset under the actual conditions in which the material will be used. To summarize, it is very important to recognize the special attributes of forage species, so that they can be excluded from, or given special status within, national seed laws.

Thankfully, the controversial legislative issue of plant variety protection does not at present impact on these seeds in developing countries. The variability of the material and the lack of private sector involvement mean that there is no pressure for such protection.

Conclusion

We need to think in terms of the overall system of seed supply for forage seed, not simply the technical problems of seed production, although they are certainly important. The way in which this system works, in any particular location or crop, depends on a mix of technical, economic, and policy factors, all of which can interact. Economic factors are important in terms of sustainability and whether the system can continue to operate without external assistance from a project or government. Relevant policy issues include encouragement for the private sector, the support given to national production in place of imports, and conservation strategies for natural resources. With forage seed, there also the major social dimension that results from traditional patterns of livestock keeping and the management of grazing land at the community level.

ICARDA's Approach to Promoting Forage and Pasture Seed Production in West Asia and North Africa

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Abstract

In most West Asian and North African countries, forage and pasture seed production is insufficiently developed. Although several species have been recommended for the sustainable use of the region's natural resources, their adoption is impeded by lack of seed. Institutional, technical, and economic constraints prevent the passage of promising locally-adapted material from the evaluation stage to on-farm testing or broad scale re-seeding of the rangeland. To tackle these problems and to alleviate some technical constraints, the International Center for Agricultural Research in the Dry Areas (ICARDA) has invested in the development of human resources, and in the elaboration of new concepts and techniques in forage and pasture seed production. Substantial efforts are being devoted to strengthening national seed programs through training, dissemination of information, networking, and organization of local, regional and international seminars and workshops. In addition to the promotion of a participatory research approach to encourage the adoption of forage and pasture species, ICARDA has developed a functioning methodology to produce and harvest sufficient quantities of forage and pasture seed using locally-manufactured machinery. The creation of small seed processing units will allow farmer cooperatives to produce their own locally-adapted pasture seed mixtures outside formal seed industry channels. Furthermore, ICARDA is conducting a program of seed multiplication with the aim of supplying national seed programs with seed of improved varieties, and linking germplasm development with seed technology.

Introduction

Lack of seed at the farmer level is still an important constraint to increased livestock productivity in West Asia and North Africa (WANA). Research has resulted in the identification of adapted forage and pasture material that would rapidly improve farm profitability through its use in meat and milk production (Bounejmate et al. 1997). Lack of seed production, however, prevents the passage of promising locally-adapted material from the evaluation stage to on-farm testing and broad-scale planting (Christiansen 1993).

Forage and pasture seed production in WANA is insufficiently developed. Governmental organizations for seed multiplication deal mainly with field crop species, and seed producers are not interested in producing small volumes of forage seed with low profit margins and uncertain markets. Most WANA countries still rely on imported seed for pasture and forage crops. For instance, Morocco imports most of its alfalfa seed, and both Morocco and Tunisia regularly import oat seed. Unfortunately, imported cultivars are often not well-adapted to local conditions, and demand more intensive management.

ICARDA is committed to strengthening national seed programs and removing or alleviating constraints facing the forage and pasture seed sector in WANA. ICARDA stresses investment in the development of human resources, and the elaboration of new concepts and techniques in forage and pasture seed production.

Training

Constraints in seed programs often stem from a lack of sufficiently-trained seed technology personnel. From its inception, ICARDA's Seed Unit has been involved in technology transfer and human resource development throughout WANA.

The Seed Unit is the only specialized seed center in the CGIAR system where seed production issues are addressed, and practical seed technology courses are taught. Training courses cover diverse aspects of forage and pasture seed-related activities such as: research, multiplication, distribution systems, organization, certification, quality, etc. It organizes in-country and regional courses as well as courses at its headquarters. It collaborates with universities, e.g. the University of Jordan in Amman. The ICARDA training approach includes: (i) individual training, where participants are exposed to different aspects of seed production; (ii) regular and in-service training, aimed at satisfying seed production training needs in WANA; (iii) train-the-trainers courses, an approach that allows decentralization of training activities, quick amplification and dissemination of information, and sustainable human resource development (trainers remain as core specialists who are expected to transfer the knowledge they acquire and act as resource persons in the coordination and organization of training activities at the national and regional level); (iv) training seminars, organized for the benefit of senior staff on neglected topics such as the management of seed programs and small-scale seed production; (v) workshops, round-table discussions, and meetings where specialists address specific problems, identify major constraints, draw up recommendations, and monitor implementation; (vi) graduate training leading to a degree (PhD or MSc) in seed technology; (vii) course curricula development for universities and agricultural institutes in the region (the best way to introduce students to the profession of seed technology and to build up a core of potential seed people in the country); and (viii) development of training materials.

Dissemination of Information

To facilitate experience sharing and support research and development, ICARDA plays an important role in coordinating the collection and dissemination of information within WANA. ICARDA has developed several manuals, audio tutorials, and slide series which are distributed free of charge to seed production and research staff in WANA. A large amount of this material is in English, but much can be found in other languages. The following documents related to forage and pasture seed production have been edited and distributed to the NARS (see references):

- Manual for the ICARDA Pod Sweeper (Arabic and English versions).
- Manual for the ICARDA Roller (Arabic and English versions).
- Manual for the Maktabi/ICARDA Thresher (Arabic and English versions).
- A Medic Sweeper and a Thresher Help Farmers Produce Pasture Seed.
- Seed Production by Smallholder Farmers.
- Seed Production Technology (French and English versions).
- Seed production in and for Mediterranean countries.
- Seed Science and Technology.
- Training module: Tropical Forage Seed Production. ICARDA/ILCA.

Networking

In addition to joint efforts with individual countries, ICARDA also facilitates contact between countries within and outside WANA. Seminars and workshops, aimed at the exchange of experiences and information on pasture and forage seed production between WANA and the international community, are organized regularly. Such forums help identify policy, regulatory, institutional, and technical constraints limiting the development of the sector, and suggest measures and strategies to remove or alleviate these constraints.

To strengthen its contacts, ICARDA's Seed Unit established a WANA seed network in 1992, which links the national seed programs of the region. The aim of the network is to strengthen national seed programs and stimulate exchange and trade among the countries in the region.

In 1997, ICARDA coordinated the creation of an 'Oat and Vetch Network in the Maghreb' to strengthen exchanges among North Africa countries and to contribute to the development of the seed production sector. Both oat and vetch play a strategic role in the region, and the establishment of this network will help overcome the problem of inadequate feed supplies for the increasing livestock populations.

New Concepts and Techniques

Participatory Research to Promote New Species

One of the striking features of forage and pasture production in WANA is the limited number of cultivated species and adapted varieties. Because different soil types, climate, and production systems abound in the region, more species and genotype diversification is needed.

In most WANA countries, extensive research has been conducted and recommendations made concerning new forage and pasture species. Farmers do not ask for seed of these new species because they do not realize their potential. The adoption rate is further hindered by lack of seed. Seed producers are not interested in producing small volumes of seed with low profit margins for an uncertain market. This attitude can only be changed if farmers and seed producers realize the value of the new material.

ICARDA has adopted a participatory research approach to demonstrate that new forage and pasture species and cultivars are valuable to farmers. This means that farmers collaborate with researchers throughout the research process, resulting in frequent modification of design and method to meet their needs. Such an approach has been successful in Syria, where significant progress has been made in promoting pasture species (Ghassali et al. 1997). It enables researchers to work with farmers to overcome socioeconomic constraints to adoption at the farm level, and increases real demand for seed, which attracts the interest of commercial seed producers.

Development of Small-scale Machinery

Machinery and processing units to produce seed of recommended pasture species do not exist at the local level. Governmental organizations for seed multiplication currently deal only with field crops. Furthermore, imported varieties are often not well-adapted to local conditions and demand more intensive management. Therefore, seed production must be done at the farm or farmer cooperative level.

To alleviate some of the technical problems slowing the process of seed increase, ICARDA has invested in the development of practical methodologies to produce and harvest a sufficient quantity of forage and pasture seed using locally-manufactured machinery. The creation of small seed processing units will allow farmer cooperatives to produce their own locally-adapted pasture seed mixtures outside established seed industry channels.

Medicago spp. Seed Production

In 1990, ICARDA began a program to develop small machines that could be used for seed harvesting and processing on small farms (Christiansen 1993). Two machines were developed that allow farmers to harvest and thresh the pods of medic cultivars that show promise for improving sown pastures. The machines are simple, but the concept of starting a farmer-controlled seed industry in WANA is revolutionary.

The first is the medic sweeper. In the past, farmers have not harvested pods simply because it was too time consuming and difficult. The medic pod sweeper makes the task manageable. It has no engine and is pushed by hand, like a manual lawnmower.

Once the pods are collected, the seed must be threshed out of the pods. Thus, a medic thresher was developed jointly by ICARDA and the Maktabi Manufacturing Company in Aleppo, Syria. The Maktabi/ICARDA thresher is a portable seed thresher capable of rapidly threshing pods for a range of medic species. It yields more than 85% clean, unbroken seed.

The machines were manufactured from 1990 to 1994, and prototypes were sent to cooperators in WANA, in part through the assistance of the IFAD/AFESD Mashreq/Maghreb Development Project. It is our intention to communicate our research results to others in the region. This interchange of ideas will improve the machines and lead to improved seed processing and a fuller use of locally-adapted seed to improve rangelands as well as pasture and cereal rotations.

Vetch Seed Production

On-station and on-farm experiments in El Bab district of Aleppo Province in northwest Syria have shown that vetch is a promising species for improving farming systems. But seed production is a real bottleneck to the wide adoption of this forage legume. No machines are available in Syria for mechanical harvesting of vetch. Hand harvesting is not economical because labor is scarce and expensive at the time of the harvest. Mechanical harvesting is an option if efficient practices can be developed.

To tackle this problem, ICARDA initiated a project to develop a sustainable methodology for vetch seed production. Locally-constructed rollers to level the seedbed, and mowers to cut and swath the mature crop were tested. The availability of these rollers and mowers has added to the farmers' growing enthusiasm about vetch. In 1991, only two farmers grew a total of about 6 ha of vetch. The number of farmers growing vetch increased to 174 in 1997, with a total area of about 420 ha.

Use of Medic Pods

To develop simple ways of helping farmers create improved medic pasture, ICARDA conducted experiments to study the possibility of sowing intact medic pods instead of seed. Sowing pods is much cheaper and simpler than sowing seed.

In dry areas with annual precipitation between 200 and 300 mm, where the chance of medic establishment failure is higher than the chance of success, farmers can sow pods directly to minimize the risk of total seed loss if a drought occurs during establishment. Over the course of several years, medic plants will build up a seed bank in the soil.

Experiments conducted in both Syria (Beaufils 1996) and Lebanon (Mitri 1997) show that sowing pods can secure the first regeneration of medic by reducing the risk of seedling loss. This is significant in the region because of frequent drought and false breaks. A sowing density of 150 kg pods/ha proved to be enough for satisfactory pasture regeneration.

Seed Multiplication

The Seed Unit at ICARDA is conducting a pre-release seed multiplication and distribution program at Tel Hadya farm. Seed production of promising lines is a routine activity aimed at producing limited quantities of breeder seed for distribution throughout the region for research and seed multiplication. Moreover, multiplication fields are used as a source of information for the breeders, and as support for the Seed Unit's training activities. The amount of forage seed produced between 1992 and 1997 is shown in Table 1.

Table 1. Forage seed production (kg) at Tel Hadya (1992–1997).

Crop	1992	1993	1994	1995	1996	1997
Medic	76	215	323	145	1,170	26
Vetch (*Vicia* and *Lathyrus* spp.)	300	1,700	500	520	745	750
Total	376	1,915	823	665	1,815	776

Prospects

The resource base for traditional livestock raising in WANA has come under serious pressure, and large feed deficits are projected (Nordblom and Shomo 1995). With rangelands stocked beyond capacity, animal diets will shift toward greater use of crop residues, concentrates, and forage and pasture production. ICARDA will play a key role in promoting forage and pasture production, and initiating the supply-and-demand chain for seed. More emphasis will be placed on a participatory approach to make the benefits of forages more obvious to farmers and to ensure that research is a response to need.

Particular attention will be given to small-scale seed systems. Efforts aimed at developing functioning methodologies for the production and harvest of sufficient quantities of forage and pasture seed at the farm or cooperative level will continue. This will allow farmers to produce their own locally-adapted pasture seed mixtures outside established industry channels.

ICARDA's Seed Unit will focus its training activities on this neglected area, which includes how to link these systems to the formal sector.

Dissemination of information will be reinforced. Information on how to produce forage and pasture seed is scarce, often resulting in poor yield or quality. The current trend is to develop seed production packages and to document the available information in non-technical, easy-to-use publications, designed to be understandable and helpful to both farmers and seed producers.

Efforts devoted to bringing together the seed programs of the region will continue through the organization of workshops involving the regional NARS.

The seed industry is undergoing major structural changes, and more training is needed on neglected areas such as management of seed programs, small-scale seed production, seed business planning, and seed marketing. Furthermore, the informal seed sector, or farmer-to-farmer exchange, requires trained seed growers and farmers to guarantee the alternative seed supply. More efforts are needed, and the ICARDA Seed Unit has a significant role to play in training within WANA.

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ILRI's Role in Promoting *Forage* Seed Production

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Abstract

Research at ILRI has shown the value of incorporating forages and fodder species into sustainable farming systems, but the lack of available seed of adapted forage materials remains a major constraint to their adoption by smallholder farmers. Technical knowledge, access to seed, and economic incentives are essential. Recognizing the need to promote access to forage seed, ILRI (formerly ILCA) established a Herbage Seed Unit in 1989 to address the problem in Sub-Saharan Africa and enhance the incorporation of forages in feed resource development. It was envisaged that this would be achieved by strengthening national capacities to produce forage seed, and training scientists and technicians. This activity has now been expanded to provide a source of tropical forage seed for the establishment of national forage seed production in many countries. Past and current activities in forage seed production at ILRI are presented, and future plans for serving ILRI's global mandate are discussed.

Introduction

One of the major constraints limiting improved livestock production in Sub-Saharan Africa is the lack of high-quality feed to supplement low-quality but more abundant crop residues. Leguminous forages are an important source of high-quality protein feed and have considerable potential for sustaining crop–livestock systems in Sub-Saharan Africa. In addition to their use as livestock feed, they also provide fertilizer when used as a green manure, and increase soil fertility through nitrogen fixation. Both forage legumes and grasses, used for soil stabilization and soil water management, are also important in natural resource management. However, availability of seed of adapted forage materials remains a major constraint to their adoption by smallholder farmers. The International Livestock Research Institute (ILRI), formed in 1995 by incorporating the research programs of the International Livestock Center for Africa (ILCA) and the International Laboratory for Research on Animal Diseases (ILRAD), has developed several technological interventions for feed and feeding systems involving forages. Availability of forage seed is essential to support these ongoing activities at the smallholder level. Technical knowledge, access to seed, and economic incentives are essential for the adoption of forages by farmers.

Recognizing this need, ILCA sought to establish a Herbage Seed Unit to develop appropriate seed production techniques and strengthen national capacity in Sub-Saharan Africa in herbage seed production. In 1988 an agreement was signed with the Swiss Agency for Development Cooperation to fund herbage seed activities over a five-year period.

The Herbage Seed Unit was established to enhance the incorporation of forages in feed resource development in Sub-Saharan Africa by promoting availability of forage seed. It was envisaged that this would be achieved by strengthening national capacities to produce forage seed. In late 1988 an action program for seed production was developed through a project planning meeting. Production of basic seed, establishment of regional seed production facilities, development of forage seed production technologies and systems, improvement of seed quality, and research on marketing and policy constraints were identified as important research areas. Transfer of technology through training and provision of information to scientists in national programs were also identified as essential activities.

Support of National Seed Production

Over the course of the project (1989–1993), major emphasis was placed on establishing basic seed production to supply seed to the region, and on building a broad information base to support national seed production efforts. Although several forage species were identified as promising for use as livestock feed (Table 1), there was little information available about their seed production potential in different environments, or on methods for seed harvesting, threshing, and storage. Information on the major forage grasses and legumes was collected on fact sheets and made available in a working document (ILCA 1994a). Seed and information on how to manage it are now being distributed, with the object of establishing national seed production activity.

Much of the forage seed in Sub-Saharan Africa is produced on a small scale by farmers who may, as opportunity permits, use a good season to harvest seed (Hanson 1994).

It is not economical or practical for such small-scale producers to invest in specialized equipment. Equipment designed for other crops was tested to assess its capacity and efficiency for forage seed. In addition, simple seed processing equipment was identified and adapted for use with a range of forage species. Recommendations were developed for equipment and methods for threshing, cleaning, and scarifying a range of seed (Ephraim 1997). Information on construction of simple seed processing equipment was also provided to NARS scientists.

In addition to the provision of seed and information, ILRI is also involved in forage seed production training. A series of training materials was developed, including a forage seed production training manual (ILRI 1994b), and courses were held for technicians and graduates. Recent courses have concentrated on practical aspects for technicians. In Ethiopia, a split training course is offered, with the first part, concentrating on planting and management, just before the planting season. The trainees carry out their own seed production at their local station, returning to ILRI at harvest time to discuss and solve problems faced during the growing season and complete the second part of their training on harvesting and processing. When feasible, ILRI staff pay a site visit to the trainees during the growing season to provide advice and support.

Table 1. Number of promising species for use in major agro-ecological zones in Sub-Saharan Africa.

Species	Semi-arid	Sub-humid/humid	Highland	Total
Browse	4	4	4	12
Grass	5	9	3	17
Legume	13	34	25	72
Total	22	47	32	101

ILRI Policy on Seed Production and Distribution

ILRI endeavors to provide, without charge, sufficient forage seed to sow up to one hectare per accession for pre-basic or initial seed multiplication, for a limited range of promising accessions, depending on stock. Each year a list of available material is provided on request. In return for this service, ILRI requests the provision of information. This allows the selection of appropriate genotypes for the intended environment and use.

Some of the genotypes come from the ILRI forage germplasm collection. This is maintained under the auspices of FAO, as part of the international network of *ex-situ* collections provided for in Article 7 of the International Undertaking on Plant Genetic Resources. This germplasm is held in trust by ILRI, which has undertaken not to claim legal ownership over it, nor to seek any intellectual property rights over the germplasm or related information. To ensure continued free availability of designated germplasm, ILRI has also agreed to pass on the same obligations to all future recipients of designated germplasm. Requesters are asked to sign an order form agreeing to these conditions before seed is supplied. Other genotypes are named cultivars and are not subject to these conditions.

ILRI does not guarantee the safety, quality, viability, or purity (genetic or mechanical) of the germplasm, or the accuracy of passport or other data provided with it. It is the recipient's responsibility to comply with the biosafety and import regulations and any other rules governing the release of genetic material which are applied by the recipient country.

Regional Forage Seed Production

All of the early work on forage seed production within ILRI focused on Sub-Saharan Africa, and despite the activities of the Herbage Seed Unit, forage seed production remains poorly developed in the region. Many national seed producers lack the basic seed to begin seed production activities and do not have the resources to import forage seed. There is almost no forage seed production in Sub-Saharan Africa, although several projects are underway, supported by NGOs and aid agencies, and some activities are carried out by government extension services. Most forage seed, such as *Stylosanthes* seed in Nigeria, is currently produced in the informal seed sector by farmers (Agishi 1986). In a few countries, such as Kenya, Zambia, and Zimbabwe, commercial companies produce seed for a very limited range of species. This lack of forage seed is one of the constraints that keeps farmers from adopting forage cultivation in mixed farming systems for livestock supplementation, even when economically feasible.

At the formation of ILRI in 1995, the institute took on a global mandate and began to look at ways to work more closely with institutes in other regions to promote forage seed production. Forage seed production in Latin America and the Caribbean is much better developed than in Sub-Saharan Africa, due to active regional networking in forage germplasm from CIAT. Many national programs in that region have already established seed production programs (Ferguson 1994) and there are several commercial companies which produce seed on a large scale. This is partly due to the demand for seed to establish improved pastures. *Brachiaria* is a major grass used in the area, and is sown on over 50 million hectares in tropical America (Miles et al. 1996). Over 82,000 tonnes of seed are produced in Brazil annually to meet market demand for seed of this species (Cardozo 1994).

Forage seed production is also more developed in Asia, where the major producing countries are Thailand and China. In 1995, farmers produced over 10 tonnes of seed of the grasses *Brachiaria ruziziensis* and *Panicum maximum* and the legumes *Stylosanthes hamata* and *S. guianensis* through contract seed production in Thailand (Phaikaew et al. 1997). Indonesia, Malaysia, Lao PDR, and the Philippines are also producing smaller quantities of seed for a range of species. Most forage seed production in Asia takes place on small farms, except for China, where state farms dominate.

Future Outlook

International centers have no comparative advantage or capacity to provide the quantities of seed needed for national forage production. To meet farmer needs, seed production must be carried out in national programs or by commercial seed companies. However, national programs may lack trained staff and funds to produce their own seed. The provision of free seed is also a disincentive to commercial seed producers. ILRI should work closely with national programs, through regional networks, and with ILRI forage and eco-regional programs, to focus efforts on strengthening national capacities to produce forage seed. This should be done by:

- Developing and strengthening regional seed production facilities and involving smallholder farmers so that they become self sufficient in providing forage seed for the region.
- Training the trainers to promote national and regional training of extension workers and technicians.
- Disseminating information on tropical forage seed production and developing training materials for use in national seed production programs.

Technical backstopping, including assessment of new forages and production techniques, and the production of basic seed of new materials.

In response to requests from forage research and development workers, future involvement of ILRI in forage seed production will be demand-driven. Given ILRI's global mandate, regional balance is sought to support national programs, although considerable emphasis will be given to Sub-Saharan Africa because of the lack of forage seed production activity there. Much of this collaboration will be through existing forage networks to further strengthen capacity. ILRI will also work in partnership with its NARS colleagues as part of collaborative projects to ensure that seed production is an integral part of forage and feed research and extension.

National policies on seed production, marketing, and distribution also affect the availability of forage seed. Policies which impact adoption of forages by smallholder farmers have the most effect on demand for seed, while pricing and marketing policies effect supply. This will be an important area of research, as a part of systems analysis and impact assessment. ILRI research in the livestock sector and in natural resource management will also consider policies that effect the availability and production of forage seed by smallholder farmers.

Acknowledgments

The authors would like to thank the Swiss Agency for Development Cooperation for its support in establishing the Herbage Seed Unit and for forage seed production in Sub-Saharan Africa.

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Tropical Forage Seed Supply: Status and Systems

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Abstract

The concept of forage *seed supply systems* is introduced, and some basic components and processes of such systems are defined. The three major systems, termed *conventional*, *traditional farmer-saved*, and *integrated community-based*, are described briefly. The challenges of seed supply systems for smallholders are reviewed. An attempt is made to provide an overview of the developmental continuum within the tropical forage seed industry. The best example of a mature industry is Queensland, Australia, where the markets, both domestic and export, are open. In Latin America, countries are at all stages of the development continuum. Examples are drawn from Brazil, Bolivia, Peru, and Colombia, with an emphasis on institutional roles. The working environment within forage seed projects is discussed. Included are topics and mechanisms such as: economic demand for seed; the role of forages; application of market forces; alternative procurement mechanisms; the use of rotating funds; identification of the project nucleus and champions; and relevant linkages, etc.

Introduction

Forage seed systems are extremely diverse, and the scope of variation is broad. Each country is at a different stage of development in terms of a particular product range, socioeconomic circumstances, priorities, and aspirations. This paper provides snapshots of the status of seed systems in Australia and parts of Latin America, discusses the long and winding journey down the development continuum, and provides relevant references.

Seed Industry and Project Snapshots

Queensland, Australia

This overview is drawn from Hopkinson (in press) and Loch (1991; 1995).

The tropical forage seed industry in Queensland is part of a broader crop and grain (sorghum, millet) seed industry. While discrete, it is not totally independent of other interrelated sectors, and overlaps with what can be termed the subtropical and temperate species. It is regarded as both the industry pioneer and the most advanced in the world. This reflects the number and diversity of species, the significant role of legumes, and the volume of published research on forage seed.

Demand

It is important to realize that the majority of forage seed users are large cattlemen (graziers), dairy farmers, and some mixed farmers with rotation systems, all of whom require seed for the establishment of pastures. The largest buyer group is the graziers, who are spread over a diverse geographic area, which in turn increases the spectrum of species and varieties required. The graziers are only occasional buyers of seed, and may have limited appreciation for seed usage and handling. The requirements of graziers for seed depend on many factors, and tend to be cyclic (increased by high beef prices and decreased by drought), and are based more on price than quality. Over the last thirty years, however, demand for seed has expanded, as widespread pasture improvement has been undertaken based on the results of pasture research and successful development experiences. Domestic demand for seed has fluctuated widely, but has been complemented by variable export demand, initially from Brazil and Latin America and more recently from Southeast Asia and the Middle East. Export sales have stabilized the industry during periods when domestic sales have been depressed.

Seed products

This refers to the range of species and cultivars available in the market. The total number over the years is high and diversity is wide, an overall complexity that allows any number of interpretations.

While some 30–40 individual products are involved, about 30 have annual sales on the order of 10 or more tonnes, with 10 reaching 100 tonnes. Volumes change over the years, and with many products demand declines as the success of a perennial species leads to its ecological niche being occupied.

During recent decades many novel species have been released. This has given the industry a reputation for and experience with development of new seed markets. These experiences are relevant to other countries. Historically, the majority of cultivars were "common" and/or public releases, while in recent years, with the advent of Plant Breeders Rights (PBR), new cultivars have been mostly proprietary lines developed by public research and grown under contract to licensed seed enterprises.

Supply

Seed growers are a variable and changing group. Graziers in Central Queensland may harvest buffel grass seed when opportunity permits (years that favor good seed yields, when prices are high, and when they themselves want seed). Some mixed farmers with rotations (maize, potato, peanut) may take a seed crop of a new cultivar. Some of these farmers may evolve into long-term specialist seed growers.

Involvement in seed production is always related to the relative risks and returns of seed growing as compared to the alternative use of resources for other crops and/or livestock. Often it is the production risks (climatic) and marketing risks (erratic prices) of seed which lead growers to more stable activities.

Collectively, these growers tend to be widely dispersed geographically, exhibit only a low level of interest in acting as a group, and frustrated by the cost of uniting. Most of the time, therefore, they are not a united or political force.

Marketing

Marketing is completely open, unregulated, and governed only by the forces of supply and demand. Marketing activities are conducted by a range of private enterprises, generally small to medium-sized. These range from diversified public companies to single-owner-operated business. Merchants may purchase, process, store, and sell on their own behalf. Brokers may sell seed of another merchant for a commission. Retailers, often farm supply agencies, also sell seed on consignment from one or more merchants. The major merchants, some eight in number, are members of the Seed Industry Association of Australia, which handles both domestic (e.g. PBR legislation) and export issues (e.g. FIS participation).

While in the past merchants tended to purchase and then store some seed, the practice is now more often one of receiving seed on consignment, with payment to the grower following the final sale. In this way merchants reduce the cost of marketing and growers share in the marketing risk.

Product promotion has traditionally been minimal, passive, or indirect. When only public cultivars were available, merchants did not promote individual cultivars. The major agents of product promotion were government extension officers and private consultants. They made recommendations on pasture improvement to graziers and dairy farmers. Now, with the advent of PBR, the merchants can benefit from direct promotion and may therefore conduct advertising campaigns.

Government assistance

Various forms of assistance have been very effective, including:

- Subsidy scheme: in the early days of the industry, direct subsidy payments were made to dairy farmers for the purchase of seed and fertilizer for pasture improvement. This was a once-only grant, but it encouraged many to commence ongoing, significant improvements in pasture availability and milk production. This successful scheme has not been repeated.

- Marketing legislation: until recently, compulsory minimum standards (for physical purity and germination) made the sale of sub-standard seed illegal. A truth-in-labeling system is now in place.
- Seed certification: this has a very limited application to tropical forage cultivars, but has been applied in specific circumstances (e.g. Callide of Rhodes grass and Narok of setaria) with very positive results.
- Seed testing facilities: a well-staffed and equipped QDPI laboratory provided reliable seed testing for many years. This facility, which also provided training and seed technology research opportunities, has been closed. Two private laboratories now provide seed testing services.
- Applied research on seed systems: two QDPI seed units are staffed, each with one senior and one technical assistant, in two complementary geographic regions (Atherton Tableland and Gympie). These units have received long-term support and have been extremely successful. Their activities have included seed multiplication (for both evaluation and basic seed), problem assessment and solving with new species, and assistance to seed growers. With close contacts to seed growers and a form of participatory on-farm research, these units have advanced commercial seed production for a succession of new cultivars and contributed to improved overall seed supply, including reduced prices. The principal scientists involved, Drs John Hopkinson and Don Loch, are both of world renown, and their contributions to the scientific literature are significant.
- Basic research on seed technology: this is conducted by Prof Ross Humphreys and PhD students at the University of Queensland (UQ).

Productive programs for pasture research and evaluation: For the past 30 years, CSIRO, QDPI, and UQ have conducted programs that have provided the technology base for successful pasture improvement—one essential prerequisite for creating demand for seed supply.

Latin America

Latin America is so diverse that no attempt is made here to provide more than a few insights/snapshots of some foci of seed activity. Instead, we emphasize the institutional participation along a continuum of development stages. Relevant readings include Ferguson (1990 and 1994) and Ferguson and Sauma (1993).

Brazil

Brazil is a huge country with a large seed industry, including a large, well-organized tropical forage sector. There are many large, private seed enterprises, often associated with retailing other agricultural inputs, focusing on forage seed or crop and forage seed. In terms of capital invested, volume and value of sales, this is the largest tropical forage seed industry in the world.

Not only is Brazil large, it has had an active and expanding agricultural sector and frontier for two decades. Government policy has been very influential in promoting expansion and development of agriculture, with a resulting high composite demand for seed for pasture establishment and renovation, and crop rotation. The private sector has been very entrepreneurial in responding with seed production and marketing.

Beginning with *Panicum maximum, Hyparrhenia rufa*, and *Melenis minutiflora*, which established "seed consciousness" and the first generation of seed enterprises, the industry expanded into production of *Brachiaria* spp., starting with *B. decumbens,* followed by *B. humidicola,* and then *B. brizantha.* In general terms, the clients were large, mechanized farmers and graziers. The huge geographic scope of tropical Brazil favored regionalization and a spread of the industry. The means and magnitude of this expansion are on an unprecedented scale, described by Santos Filho (1996) and Hopkinson et al. (1996). In the late 1980s, Brazil began to export *Brachiaria* spp. seed to Venezuela, Colombia, and Central America. The economics of local production in many countries began to be influenced by the availability of seed from Brazil.

The combination of factors, such as the magnitude and continuity of demand, the identity and benefits of *Brachiaria* spp. to farmers, and an active private sector, have driven the industry forward. Additionally, the overlap of cropping (especially rice and soybean) has assisted the pasture seed industry by providing capital, infrastructure, clients, and an appreciation of seed and seed use. The industry is well-organized under the national seed association, ABSAEM, with a seed technology publication (Revista Brazilera de Sementes) and tri-annual seed conferences. The national agricultural research organization, EMBRAPA, has two active seed units, at Brasilia and Campo Grande.

In contrast to Australia, legume seed is of minor importance in Brazil. Some *Calopogonium mucunoides* is produced by intercropping with rice, and *Pueraria phaseoloides* seed is derived as a byproduct of rubber plantations. Many graziers are skeptical of legumes, based on failure with non-adapted cultivars introduced from Australia. Recent research by EMBRAPA has led to the release of new cultivars of *Stylosanthes* and *Arachis* spp., but their commercial production is small.

SEFO-SAM in Bolivia

SEFO is a private seed enterprise with headquarters in Cochabamba, Bolivia (Ferguson and Sauma 1993). It is an unusual seed enterprise in that its major shareholders are a local university, an international development organization (COTESU), and local seed farmers. The local university did the initial forage research and then wanted to see the benefits of this research reach farmers. They joined forces with COTESU, which provided both financial and technical assistance for approximately 15 years to establish SEFO as a viable seed enterprise. COTESU is now gradually transferring its shares to successful seed farmers. SEFO focuses on a range of both temperate and tropical forage species.

In addition to seed production and marketing by and for small farmers, SEFO conducts forage promotion as well as a range of community service activities. Whereas in the 1970s their initial clients were international and government social aid programs, today 80% of sales are to small farmers.

Seed production is conducted by selected small farmers in various geographic regions, chosen for their climatic suitability for the target species.

In each region, SEFO provides a range of support services to seed farmers, including a seed purchase contract, basic seed, technical assistance, key inputs (fertilizer, insecticide), key field equipment (threshers, pre-cleaners), and a re-collection service to the central facility. Seed conditioning, storage, and quality assessment are centralized at the cool dry location of Cochabamba.

A key strategy is the provision of technical assistance by local or indigenous technicians with customs and language similar to the small farmers. These technicians have a rural background along with forage seed production experience, complemented by other organizational skills. They also reside within the same region as the farmers.

Semillano Ltd. in Colombia

Semillano Ltd. is a private seed enterprise in Colombia based in the eastern plains (*llanos*). Its origins are in seed production and marketing of various rice cultivars, which it grows on its own farm. In the early 1970s Semillano foresaw the potential market for seed of *B. decumbens*, but nothing was known of seed production in the local region. With exceptional foresight, and accepting considerable financial risk, Semillano pioneered the establishment, management, and harvesting of *B. decumbens* seed crops in the Villaviocencio-Puerto Lopez region. Several years later it began to market seed. In a break with tradition, Semillano marketed seed of *B. decumbens,* which was acid scarified and of high purity (over 95%) packaged in small (1 kg) lots.

In marked contrast to Brazil, the cost of machinery in Colombia, especially combines, was very high. Semillano again showed ingenuity by designing a low-cost beater harvester mounted on a tractor. Semillano entered into share farming agreements for seed production with selected cattle raisers and farmers who were planting *B. decumbens* as pasture. Semillano received a portion of the seed crop in proportion to the cost of its contribution to the establishment, harvesting, processing, and marketing of the seed. Additionally, because of its expertise in pasture establishment, Semillano was able to market not only seed but a package of services to establish pasture areas. This was very attractive to many cattle raisers who were without experience or machinery.

Seed yield and quality, however, were low relative to Brazil, and more variable from year to year. In the late 1980s, good-quality seed from Brazil began to be imported into Colombia. From a seed enterprise point of view it was less risky and more profitable to import seed from Brazil than to produce locally. Semillano suffered from competition from new enterprises that simply imported seed. Market realities had changed and could not be ignored, so Semillano began to import seed from Brazil. In so doing, they also transferred their skills in acid scarification techniques to the Brazilian seed sector.

Apart from their leading entrepreneurial role with *B. decumbens*, Semillano also played a key role with other new forages released by the research sector in Colombia. They multiplied basic seed of several new cultivars under contract to CIAT. In the post-release phase, the opinion of Semillano regarding the merit of the new cultivar was very influential with cattle raisers. Forage researchers soon learned that if they could not convince Semillano of the role and merit of a new cultivar (especially legumes), it would not be promoted in the market.

NGO on-farm pilot project, Peru

Ferguson et al. (1993) relates a case history of a forage and seed project with small farmers in Peru. The project conducted activities in seed procurement and distribution (initially by seed multiplication on-station and then by seed production with small farmers), technical assistance, training and revision, and applied agronomic research.

Over five years, two project nuclei were formed in complementary geographic regions and consolidated via analysis of experience gained, training, and the acquisition of equipment. The institutional organization evolved from origins in research to a point where a seed-orientated NGO became project leader. This recurrent exercise developed the skills of key participants and provided a forum to widen linkages with relevant new participants. Of 24 novice farmers, four became experienced and produced seed under contract to the project. A rotating seed fund was a key financial mechanism, providing operational flexibility to promote seed production and rent equipment. Marketing risks were shifted from the producer to the project, forcing the latter towards a market orientation and, ultimately, the inclusion of other crops in the product range.

Some farmers were very innovative in their management of seed crops. On the research station seed crops of *S. guianensis* were grown in pure stands. One farmer, however, successfully intercropped *S. guianensis* for seed with maize and achieved satisfactory yields for both crops along with reduced labor for weed control. This showed the advantage of farmers integrating the new crop into their farming system.

Central America

In Central America there are many small independent republics in close proximity. All these countries have common problems and limited resources. They are also buffered by powerful neighbors and regional economies and policies. Many of the farmers are smallholders. The public sectors are under pressure, and funding for research on livestock development is declining. There are several research centers and many NGOs active in the region. Local seed supply is very minor with most seed obtained by importation.

Most states have some form of forage research unit, generally within a livestock program. On occasion, their activities have been temporarily stimulated by World Bank loans or other external donor influences. CIAT has made long-term contributions, especially via the RIEPT regional network (training forage workers), contributing significantly to ongoing evaluation of germplasm (including on-farm pasture trials) and the organization of a series of regional workshops and publications. This illustrates the long hard road of building an appreciation of the role of forages and initiating a supply-and-demand chain for seed.

Concurrent with advances in forage research (or as promising new materials were identified), the expansion of the seed supply had to be addressed. Initial seed multiplication by government agency seed units was critical to service research evaluation and cultivar release. With some species, e.g. *B. decumbens* and *B. brizantha*, importation of seed was a quick and logical option. When importation was not possible, or very expensive, local or regional production had to be both researched and pioneered. Gradually, as demand expanded, the big challenge of starting up new seed enterprises became relevant.

In such a geographic, political, and technical setting, opportunities must be sought for more regional collaboration towards research challenges related to general sustainability issues and related milk/forage/seed supply requirements. From the initial RIEPT network of initiatives on forage evaluation and seed activities, the TROPILECHE Consortium has recently evolved to reflect such considerations. Its design and progress warrant monitoring.

Seed Supply Systems

Systems depend upon perspective and boundaries. They attempt to define components and processes and how they interact. The concept of a seed supply (i.e. production and marketing) system is relatively new, and adds a broader socioeconomic perspective to the traditional biologically-oriented view of seed production and technology.

The tendency has been to describe seed systems from a national or regional perspective within a framework of formal institutions linked to the chain of seed multiplication, processing, and distribution. Recently, Cromwell et al. (1992, 1993) widened the scope of possible systems to include farmer-managed seed systems. They also recognized a wider range of institutions as providing support activities, included dimensions of research, legislation, and policy in the system, and emphasized strong two-way links between the different institutions and players and their activities.

There is a real need for further research on seed supply-systems for small farmers *per se*. This would best be done by a comparative case study of seed projects and enterprises in different countries.

Components and Processes

A seed supply system is a combination of components and processes that interact in the generation of an ongoing flow of seed to a client group. The major components and processes are:

- The clients, their needs, and the socioeconomic context.
- The role of different participants in an institutional context (users, growers, researchers, enterprises, service providers, etc.).
- The identity of priority materials (species/cultivars/accessions) and their reproductive biology.
- The physical seed produced from the priority materials, both as seed classes and as seed products in a market context.
- Production and procurement processes.
- Marketing processes.
- The role of research, legislation, and policy.
- The application of seed science and technology.

The release process for new cultivars.

Conventional Seed Supply Systems

The conventional (formal) system has evolved to serve the needs of large-scale commercial farmers, especially for seed of the major grain and vegetable crops. This client group can afford to pay cash for quality seed with improved performance characteristics. Efficient seed enterprises achieve competitive rates of return on their capital from seed production and marketing activities, with high annual recurrent sales volumes. For such a large and economically important market, governments and private companies provide strong support in the form of research and other services. A stream of improved varieties, mostly hybrids, is released, and specialized seed growers and private enterprises produce seed, often under contract and certification arrangements. Over time, an integrated industry structure develops, and this functions to consolidate, link, and adapt the system at the local, national, and even the international level.

This system is essentially conducted off-farm (to the end user of the seed product). The main driving forces are the market opportunities for profit, a stream of improved varieties, specialist seed enterprises, and the high use of seed technology. The conventional system is a nineteenth-century innovation that has become an integral part of modern agriculture. The classic examples involve hybrid maize and sorghum cultivars, and also cultivars of rice, wheat, alfalfa, white clover, ryegrass, and other mainstream arable or herbage seed crops.

End users of tropical forages are predominantly dairy farmers and large-scale livestock producers in mixed farming systems. Essentially non-hybrid cultivars of many forage species have entered this system: e.g. *Brachiaria* spp., *Chloris gayana*, and *Panicum maximum* among the grasses; and *Arachis pintoi*, *Desmodium* spp., *Macroptilium atropurpureum*, *Neonotonia wightii*, and *Stylosanthes* spp. among the legumes. The industry that has evolved to date in both Queensland, Australia and Brazil is consistent with this seed supply system, so care is needed in applying parallels to different countries in Africa where smallholders predominate.

The conventional seed supply system is very much a seed-only, sequence-linked, and market-driven system. In the future, it will remain the major delivery system for new cultivars in developed countries and/or those with a large market, especially as plant variety protection is adopted more widely. Research will focus mostly on discipline-specific seed technology components. This top–down system has had the greatest impact to date, but lacks the potential to reach most small farmers.

Traditional Farmer-saved Systems

This is the historical, farmer-saved, farmer-only system, with its roots in agricultural antiquity. Farmers conserve a fraction of their own harvest (of grain, stems, or roots) on their own farm to serve as planting material for the propagation of next season's crop. Farmers also complement their seed needs by buying from neighbors and, when necessary, from the local grain market. As farmers use their own seed, the proportion of planting material traded is relatively low. The terms of such trade are most likely to be an exchange for labor or goods in kind rather than cash. While effective over many centuries, the system is insular and, as such, is very prone to disturbance by climatic extremes and social conflicts.

The crop/cultivar component is one of traditional varieties and landraces, as defined by the farm family. Crops are used essentially for food, fiber, and fuel, or as a cash crop when opportunities exist. The crop range used by the farmers is wide and commonly includes maize, bean, rice, peanut, and such crops. New varieties are largely irrelevant as they usually do not reach this system.

Today, farmers who still practice this system are termed smallholders, small farmers, or resource-poor farmers. Their availability of capital, cash, land, and labor is low and profoundly limiting. Their socioeconomic situation is therefore in marked contrast to that of large commercial farmers. Women often play a significant role, especially in seed conditioning, selection, and storage.

The major limitations of the traditional farmer-saved system are the traditional varieties on which it is based, its rather loose and informal organization, and its susceptibility to collapse due to natural (drought) or social (civil war) disasters. When on-farm participatory research has identified relevant new materials, and community-based organizations are present, technology transfer and increased farmer usage of seed will prompt a shift to an integrated community-based system.

With tropical forages, this system is minor and confined to two situations. First, the vegetative propagation of some grasses, including *Digitaria eriantha* (pangola grass), *Cynodon* spp. and hybrids (star grass), *Pennisetum purpureum* (elephant or napier grass), *Saccharum sinense* (king grass), *Brachiaria decumbens*, and *Brachiaria brizantha*. This is most prevalent where these species are only vegetatively propagated and where seed is unavailable or too highly priced. Second, a temporal situation involving an "ephemeral" and/or "opportunistic" seed production cycle of a new (public) cultivar by early-adopting graziers on an area planted for pasture: e.g. *Brachiaria dictyoneura* in Colombia and *Cenchrus ciliaris* in Australia. After one or two seed harvests for on-farm use, management normally changes to grazing without seed harvesting.

Integrated Community-based Seed Supply Systems

Various workers have advanced the concept and mechanics of this contemporary system, termed *integrated* by Louwaars and van Marrewijk (1996) and Almekinders et al. (1994).

This system requires some external project support to develop seed supply based upon elements of the traditional, farmer-saved seed supply system. Other (non-seed) strategies relevant to the community (e.g. soil fertility, human nutrition improvement, and water catchment management) may be involved, as well as seed technology innovations. Stated another way, a socioeconomic blend of community and seed-related issues are linked and promoted concurrently.

The essential elements of integrated community-based seed supply systems are:

- Farmer and community participation.
- Building on traditional farmer knowledge and practices.
- Complementary on-farm participatory research.
- Complementary new technology, especially new cultivars (where adapted).
- External support, but transitional and building upon community strengths.
- Promotion of seed consciousness.
- Response to issues of scale (packaging, machinery).
- Decentralization to maximize distribution/delivery points.
- Widening distribution modalities (in-kind swaps, barter, and labor).
- Promotion of market forces.

Promotion of institutional linkages and networks, involving both the conventional seed system and other community-level organizations.

The integrated, community-based seed supply system is obviously hybrid in nature and draws on the perceptions and strengths of the other two. This bottom–up system is the pathway towards the equity-orientated objective of benefiting more small farmers and rural communities. This is obviously not a seed-only system, but rather a multidisciplinary one where seed provides a focal point and delivery mechanism for a range of socioeconomic elements.

In those developing countries with a predominance of resource-poor farmers, the benefits of forage research will remain unrealized if not linked to this system.

These three major systems (conventional, farmer-saved, and integrated community-based), are not mutually exclusive in any one country or time. On the contrary, the aim should be to promote their complementary.

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Increasing Forage Seed Production in a Temperate Climate by Natural Selection and Organized Seed Multiplication

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Abstract

The development of a national seed program may be divided into three distinct but related topics: (i) development of new, more productive varieties by plant breeding; (ii) multiplication of varieties by carefully-controlled seed production; and (iii) education of forage farmers on improved management to utilize the new potential. Clear objectives must be defined early in a breeding program, and initial selection for potential material can be made by collecting a range of ecotypes of targeted species. Both forage and seed characteristics must be considered during selection and in comprehensive trials. The selected new varieties should be multiplied in areas climatically suited to seed production, which may not be the same as the forage production region. A trained advisory team can assist growers to achieve higher levels of seed yield, purity, and quality. To use the potential for increased forage production, an educational program including regional trials and individual advisory support should be considered.

Defining the Problem

The objective of any research and development program is to bring about improvement towards stated goals. No program will succeed without such goals being clearly defined at the outset. As the program proceeds, some of these goals may be changed, partially achieved, or even dropped, but this is in itself progress—provided that positive attitudes lead to the use of the information gained to work towards renewed goals through a desire for success.

Although the defined objectives may be, and in many cases are, limited in terms of major achievements, the program may nevertheless succeed within its definition. Some research and development programs have a much wider and larger set of defined objectives, with a higher degree of expected achievement. Any program that sets out to improve the quality of plant crop species and which, via the food chain, improves the quality of life for humans, falls into the second category. Within a program with such large goals, it is important to ensure that, while maintaining an awareness of the overall strategy, each section of the work is carefully planned and guided.

The improvement of pasture and forage seed production is an extremely wide-ranging topic, and has involved large numbers of research workers throughout the temperate areas of the world for more than 60 years.

History

It was in the 1920s and 1930s that Sir George Stapledon and his colleagues at Aberystwyth in Wales realized that if forage production was to be increased both in quality and quantity, a new seed industry would have to be developed. At that time very little seed was produced for the re-seeding of pastures, and only the occasional catch crop of white and red clover seed in southeastern England was sold for grassland improvement.

Seed was a by-product of forage production and not regarded as an integral part of the farming system. The modern concept of variety had not yet emerged, and practically all herbage seed was bought and sold as ryegrass, fescue, or clover, etc., of unspecified origin. Stapledon highlighted the shortcomings in quality of this seed, and set about improving quality by defining his initial objectives and selecting plant material from good pastures in localized areas. He produced what were essentially the first varieties, which, although they had a wide genetic diversity, were nevertheless a substantial improvement on previous lots sold.

The onset of World War II created a crisis, as supplies of seed from Europe, America, and New Zealand were soon cut off. The continued demand proved to be the impetus for the rapid increase in production of seed in the UK, in order to sustain the country's food supplies. Seed grower associations were formed in the main seed growing areas, and these, together with the inauguration of a herbage seed crop inspection and certification scheme, provided the basis for a national home seed production industry.

Another major step forward took place in 1956 when a pedigree seed production scheme was introduced, which guaranteed the quality of the seed in bags, which were sealed with a government seal. Since then, the certification and crop inspection schemes have been continued and improved. Standards for purity and germination testing of seed crops have been raised, and a plant variety protection scheme, based on the distinctness, uniformity, and stability of each variety has been introduced, which enables a royalty to be collect by the breeder.

During the early development period, much cooperation took place between research workers, crop inspectors, farmers, and farming groups. It was this pooling of information and experience which enabled such a rapid and successful development of a herbage seed industry.

Plant Breeding

The success of a plant breeding program depends not just on achieving improvement in a single character, but on ensuring that the improved character is integrated into the plant in such a way as to give it a balanced genetic base. Thus, improved seed production of a plant must always complement, and not be at the expense of, its forage qualities.

When initiating a breeding program, there are two main approaches to be considered. The first is to work with a selection of ecotype material. This involves collecting a large number of different ecotypes with a wide range of differing genetic characters. The qualities and characters of each must be assessed in testing conditions that not only enable selection of those exhibiting the most promising traits, but also sustain the balanced genetic base. The best performing and most uniform plants may then be split and multiplied vegetatively as clones to form the basis of a new variety.

The second method of breeding is to select plants which strongly exhibit some of the required characteristics, and then cross pairs of plants in pollen-proof isolation and collect the seed set. The seed is then sown, and the resulting plants are assessed, looking specifically for those plants which exhibit the best qualities of the parent plants combined in one plant. A high selection pressure must be applied at this point, with probably only a few plants selected from hundreds or even thousands of plants grown. The selected plants are multiplied together to form the basis of the new variety.

The use of biotechnology and sophisticated laboratory techniques creates new opportunities for crop improvement which are being rapidly adopted in major cereal crops. However, when little or no breeding work has been carried out on a species, the improvement of seed production should be based on the first two methods.

The collection of ecotypes and subsequent selection, a method that has been much used throughout Europe, may be the most successful method initially, followed by the introduction of the more sophisticated method of hybridization. The two methods can be used side by side, and even integrated with plants of promising ecotypes crossed with plants from existing varieties. Ecotype selection is usually more successful initially because selection of plants can be made from existing pastures where natural selection has already eliminated the less competitive plants. The remaining plants in the sward may contain many of the desirable characters for forage production, and selection can be made with confidence for seed production characteristics such as erectness of growth, tiller number, seed set in the head, and freedom from disease. Subsequent testing of the ecotypes for improved seed production means that the plants forming the basis of a new variety already have a pedigree of forage production.

The crossing program is usually a long-term method, because although the crossed plants are selected because they exhibit specific qualities, crossing results in a wide range of genetic expression, with most of the sibling plants exhibiting undesirable characters in some shape or form. This greatly reduces the choice of plants, and further crossing may be necessary to separate the desired from the undesired characters.

Seed Production

Having produced a uniform group of plants (possibly 10–20) with the required qualities and characteristics, multiplication of the potential new variety can begin. In order to maintain stability in the variety, it is important that multiplication of the seed should be done through as few generations as possible before reaching the end user. Forage grass crops tend to produce large numbers of tillers or shoots within a short space of time, and as these tillers are vegetatively produced, the speed of multiplication can be increased by splitting off many tillers from the original plants without endangering the varietal base plants. By splitting the tillers to form individual plants, it is possible to produce 500–5,000 plants, which, when planted in an isolated plot, will produce seed known as breeder seed. It is important to regularly check the plants and remove any off-types or rogue plants. For temperate species, production of several kilograms each year, for 2–4 years, can be expected, thus producing a reasonable quantity of breeder seed.

At this point, multiplication becomes more rapid, as the breeder seed can be sown by tractor and drill. Usually between 1–2 hectares are sown, which is not a very large area, but again the crop must be carefully monitored to ensure the removal of rogue plants, and that the variety is true to type. Such an area could be expected to produce several hundred kilograms of seed, which is known as pre-basic seed.

In order for sufficient seed to be produced for forage production, at least two more generations are required. Specialist seed production farms should be used for these next two generations. Pre-basic seed is grown to produce basic seed, which in turn is sown to produce the end-user seed (certified seed). It is this seed that is used for forage production. In a temperate climate, each crop of each generation is expected to produce 2–4 years of seed. Vigorous roguing of off-types and judicious weed control at the establishment phase of the crop will reduce the workload in subsequent years. It is also necessary to apply an inter-row spray with herbicide a few weeks after harvest to control any seedlings germinating from seed dropped during harvest.

Organization and Certification

Forage seed production is a wide-ranging and complex activity, requiring much organization if the overall objectives are to be achieved. A lowering of standards at any stage will almost certainly cause the momentum of the project to slow down or even cease. It is important that while the overall strategy is being controlled, each part of the project is also being guided and supervised. No project this size would succeed without some form of steering committee, which should not be too large and should probably include government support. The committee is advised by the scientists, seed specialists, and field technicians, some of whom may even be on the committee.

In the UK and Europe, administration, guidelines, and regulations have made rapid progress difficult, with delays caused by having many committees and much legislation. The simpler the organization (within reason), the more chance of overall success without too many delays.

As the scheme develops, so the need for legislation becomes more important. In the early stages, while breeders are all working towards a common goal, the need is not great. However, as other breeders become involved, developing their own varieties, it becomes necessary to distinguish each variety by a number of morphological characters such as heading date, plant shape, leaf length, and width, etc. In Europe, it is now necessary not only to prove that a new variety is distinct from any other variety already on the list of established varieties, but that it is uniform within a population of the variety and is stable between generations.

When it can be proven that a variety has met these three criteria, it is multiplied through the generations mentioned earlier to produce sufficient certified seed for sale. As each variety is multiplied, every crop must be inspected in the field, by trained government specialists, who check for rogue plants, uniformity of heading, weed control of the field, and isolation from crops of the same species.

If the crop achieves the standards specified in the guidelines, it is certified, and the seed is officially designated for further multiplication, or sold. The present system of variety registration is complex, and involves many people and extensive paperwork.

In the early stages of a breeding and seed production scheme, progress depends more on close working relations among breeders, technical agronomists, and seed growers, rather than on legislation and regulation.

Breeders with plant material exhibiting strong traits of the characters desired, and using good scientific practices, together with well-trained seed agronomists and experienced seed growers with a desire for quality seed crops, will ensure that the objectives defined at the outset of the program may be attained ahead of schedule.

Forage Seed Activities in Sub-Saharan Countries

J. Kulish
MRI, Lusaka, Zambia

Abstract

This paper discusses forage seed activities in terms of pasture research, technology, socioeconomic factors, etc., all of which affect many Sub-Saharan countries. Different constraints often prevent implementation of new seed technologies, and some countries continue to rely on traditional practices. Production of forage seed has received little attention in many West African countries. However, South Africa, Kenya, Zimbabwe, and later Ethiopia, Malawi, and Zambia have made progress in the development of forage seed programs and seed industries. In many Sub-Saharan countries (except South Africa and to a lesser extent Zimbabwe, Kenya, Malawi, and Zambia), governments tend to prefer state-controlled seed production rather than private seed enterprises. Generally, such control places a low priority on the development of seed production infrastructure.

Introduction

Forages are major sources of nutrients for livestock used to provide meat and dairy products for human consumption. The most important constraints to improving livestock production in Sub-Saharan Africa are related to animal nutrition, which is based mainly on poorly-managed natural pastures. Improving animal production based on forages requires careful planning to optimize inputs. Of these, seed is the most important.

Compared with cereals, where high-quality seed of improved cultivars has been responsible for the success of the green revolution in developing countries, forage seed is under-developed and still in need of substantial support. Developing the forage seed program requires the involvement and cooperation of national governments, the private sector, and international agencies to meet the demands of well-informed grassland farmers.

Sub-Saharan Africa is a region of enormous diversity, where climatic conditions are frequently harsh and large numbers of soil types are infertile. Pasture seed production has mainly served mixed farming systems. For example, Rhodes grass, cv Katombora is used in rotation with tobacco to control root-knot nematode. In Kenya and Tanzania, Rhodes grass and *Setaria anceps* are used in maize or wheat rotations. In Uganda, the same grasses are used in cotton rotations to regulate disease.

The need for cultivated pasture species has long been recognized in Sub-Saharan Africa, but the entrenchment of the traditional system, and the unavailability and cost of imported pasture seed are major barriers to pasture improvement.

Forage Research and Development

Sub-Saharan Africa has a very high potential for agricultural production, but limitations, such as erratic rainfall distribution, low soil fertility, and underdeveloped infrastructure, exist. Under these conditions, extensive pasture-based livestock production is important, but there are limitations on forage quality during the dry season. Many pastures are of low quality and are dominated by coarse grasses, which are only palatable and nutritious when young, and native legumes, which are scarce. This lack of quality feed in the dry season poses a major management problem.

In arid, semi-arid, and sub-tropical (below 500 mm mean annual rainfall) areas, little improvement can be achieved. But in areas with mean annual rainfall above 600 mm, large improvements in animal production can be attained by introducing improved pasture species.

Today there is an active expansion in the number of small dairy farms. These farms usually have herds of crossbred cattle that require better feed. Accordingly, there is a growing interest in the use of improved species of pasture and fodder crops.

The increasingly high cost of inorganic fertilizers has promoted a search for leguminous species in the genera *Stylosanthus*, *Sesbania*, *Desmodium*, *Macroptilium*, *Crotolaria*, and *Leucaena* as a source of cheap biologically-fixed nitrogen. Some techniques, such as alley-cropping, green manuring, and planting, in both live and dead leguminous mulches, have been effective in many Sub-Saharan countries, where they have improved farmer income.

The introduction of pasture legumes into communal grazing areas appears to offer attractive possibilities for increasing and improving carrying capacity and livestock nutrition. However, the establishment of proper stocking rates and proper grazing management must take priority. Further development can only be carried out when this has been achieved. Nevertheless, it is important that research on species evaluation, pasture seed production, methods of establishment, and management continues.

Forage Seed Production

The history of forage seed production of improved tropical pasture species is a very young one. It started around the turn of the century in southern Africa and eastern Australia (Hebblethwaite 1980). In the last three decades, extensive pasture research has been carried out in Sub-Saharan countries (Hague et al. 1986). Countries with a history of plant breeding have developed seed production industries. Countries such as South Africa, Kenya, and Zimbabwe, and later and on a lesser scale, Ethiopia, Malawi, Nigeria, Tanzania, and Zambia, produce herbage seed both for home use and for the export market. Seed testing and certification have also reached an advanced stage in these countries. However, many problems remain. Over the last two or three years in Zambia, for example, many national and international seed companies have closed, and no one is seriously concentrating on forage seed. Recently, one new seed company started up, and there is hope that it will make real progress with pasture seed.

Of the remaining Sub-Saharan countries, very few have developed a forage seed production system beyond the research station level. In Cameroon (Pamo 1993), large quantities of forage seed have been introduced, but very little has reached the farmers because of political and institutional problems, cost, and lack of extension assistance. The Division of Range Management and Water Resources Development was created in 1976, and one of its objectives was to multiply forage seed, tested or developed by research institutions and universities, and distribute this seed to graziers. This has not been achieved because of lack of equipment and infrastructure.

In Uganda, research has shown that *Centrosema pubescens* seed could be easily and economically produced on small farms (Lusembo et al. 1993) where casava is grown. Subsequent crops might benefit from the nitrogen fixed by legumes.

Grass seed of *Chloris gayana, Brachiaria ruziziensis, Cenchrus ciliaris,* and *Panicum maximum*, and legume seed of Siratro, Glycine, Archer, and Stylo, Centro, Lablab, and *Desmodium* spp. are produced (2–10 tonnes per year) by government institutions and small-scale dairy producers in Tanzania (Kusekwa et al. 1993). Commercial forage seed production has yet to be developed. The shortage of forage seed is a serious limitation to forage research and development in Tanzania.

Forage seed production in Ghana is carried out mainly by national agricultural institutes (Barnes and Al-Hassan 1993). A tremendous effort is needed to educate small-scale farmers on the need to introduce improved pastures into farming systems. Grassland science and forage agronomy is underdeveloped, and forage seed production seems to be one of the most neglected areas in Ghana.

Botswana has a Seed Multiplication Unit, which is responsible for importation. Forage seed is imported from South Africa, Zimbabwe, and Australia. The introduction of forages would improve the low nutrition of grasses in winter.

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A wide range of grasses and legumes was found to be suitable for commercial use in pasture development in Senegal, Burkina Faso, Niger, Mali, Gabon, and the Central African Republic, but none of these countries has yet established a domestic forage seed production industry (Anon 1971).

Conclusions

The need to increase domestic production of forage seed is widespread, and requires both expertise and financial support, particularly for the importation of equipment and breeding material and for training abroad.

Serious attention must be given to the private sector. Private seed companies develop expertise and skills, and can contribute independently and by collaborating with government institutes.

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Sub-Saharan Africa has a very high potential for agricultural production, but limitations, such as erratic rainfall distribution, low soil fertility, and underdeveloped infrastructure, exist. Under these conditions, extensive pasture-based livestock production is important, but there are limitations on forage quality during the dry season. Many pastures are of low quality and are dominated by coarse grasses, which are only palatable and nutritious when young, and native legumes, which are scarce. This lack of quality feed in the dry season poses a major management problem.

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The introduction of pasture legumes into communal grazing areas appears to offer attractive possibilities for increasing and improving carrying capacity and livestock nutrition. However, the establishment of proper stocking rates and proper grazing management must take priority. Further development can only be carried out when this has been achieved. Nevertheless, it is important that research on species evaluation, pasture seed production, methods of establishment, and management continues.

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Of the remaining Sub-Saharan countries, very few have developed a forage seed production system beyond the research station level. In Cameroon (Pamo 1993), large quantities of forage seed have been introduced, but very little has reached the farmers because of political and institutional problems, cost, and lack of extension assistance. The Division of Range Management and Water Resources Development was created in 1976, and one of its objectives was to multiply forage seed, tested or developed by research institutions and universities, and distribute this seed to graziers. This has not been achieved because of lack of equipment and infrastructure.

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The need to increase domestic production of forage seed is widespread, and requires both expertise and financial support, particularly for the importation of equipment and breeding material and for training abroad.

Serious attention must be given to the private sector. Private seed companies develop expertise and skills, and can contribute independently and by collaborating with government institutes.

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Section II –
Country Reports

Pasture and Range Seed Production in Morocco

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Abstract

In Morocco, rangeland covers about 53 million hectares, most of which is bare or uncultivated because of low rainfall or rough terrain. Overgrazing and human activities are putting more pressure on these lands, leading to desertification and permanent reduction in grazing capacity. To solve these problems, the Government of Morocco has, since 1969, launched several rangeland rehabilitation and improvement programs based mainly on re-seeding and re-vegetation. However, lack of good-quality seed at the right time has limited the success of these programs. Analysis of the situation between 1973 and 1986 shows that plans for range improvement programs were too ambitious and did not take into consideration the human and financial resources available in the country. Until 1986, the country's seed needs were satisfied primarily by importing seed of foreign cultivars. During the past decade, however, local seed production has been significantly developed through the establishment of two seed centers. Although other constraints, such as lack of legislation and limited research, hinder the development of the pasture seed sector, national institutions have shown a great interest in the preservation and sustainable use of pasture resources. Many plant collections have been made, and the first local varieties have recently been developed.

Introduction

In Morocco, rangelands cover more than 53 million hectares, spread over various ecological zones (El Gharbaoui 1994). In most cases, they are marginal lands characterized by aridity and drought, low fertility, shallow arable soils, excessive erosion, and high salt level. Rangeland is collectively owned and/or state land.

Despite the large area, rangeland productivity continues to decline, as a result of overgrazing and land clearance. These lands accounted for 60% of the national livestock feed in the mid-1970s (Squalli 1974) and only 26% in the late 1980s (Ameziane and Berkat 1989).

In response to this situation, the Government of Morocco has launched large-scale programs on range management (protected areas, seedings, and plantations). The success of these operations depends on several factors, among which one key element is the availability of good-quality seed.

Importance of the Pasture Seed Sector

Background

The 1973–1977, 1978–1982, and 1981–1985 five-year agricultural plans included 63,000, 132,000, and 21,050 ha of range seeding, respectively, but only 5,000, 4,000, and 6.230 ha were actually seeded (MARA 1977, 1981, 1988). Lack of seed remains the limiting factor to the success of artificial seeding in Morocco (Squali 1974; Washington State University 1978). Drought in 1982, 1983, and 1984 resulted in severe reduction of the seeded area. Consequently, the Ministry of Agriculture opted for fodder-shrub planting, especially of the species *Atriplex nummularia,* which appears to be more tolerant to drought in the regions where tests were conducted. In 1985 and 1986, the Ministry of Agriculture launched the ley farming operation in zones receiving more than 300 mm of rainfall, which resulted in an increase in the seeded area.

Current Seed Sources

Based on the budget allocated by the Ministry of Agriculture, regional seeding programs are fixed at the end of each agricultural year. Seed requirements are then defined, and needs are met through either national production or imports.

Seed imports

Until 1986, seed imports were the only means for meeting seed needs. With the establishment of the two seed centers, imports decreased (Table 1).

Table 1. Pasture seed import by SONACOS (q)†.

Year	Quantities imported (q)	Year	Quantities imported (q)
1978–1979	477.50	1985–1986	7,815.50
1981–1982	179.88	1986–1987	2,270.12
1982–1983	298.95	1987–1988	820.75
1983–1984	181.15	1989–1990	600.00
1984–1985	205.85	1990–1991	595.40

† 1 quintal (q) = 0.1 tonne.
Source: SONACOS (1978–1991).

Local production

The national production of pasture species, notably grasses, legumes, and shrubs, is insured by the following state centers and companies: Khémis Metouh Pasture Seed Production Center (CPSP), M'da Pasture Seed Multiplication Center (MPSMC), and Société de Gestion des Terres Agricoles (SOGETA). Despite the low output, the experience gained by the two production centers shows that it is possible to produce high-quality seed locally. However, because of their public status and the non-flexibility of management, these centers cannot produce seed on a commercial scale. Instead, they concentrate on research of adapted plant material and production of foundation seed.

M'da Pasture Seed Multiplication Center

This seed production center is for pasture species adapted to forest areas. It was established in 1976 in the M'da region of Ouezzane, in cooperation with FAO, following the recommendations of the National Commission for Rangelands. Unfortunately, this center has not been endowed with the adequate human and financial means to fulfill its planned objectives.

Since 1978, MPSMC has produced significant quantities of seed of several species, particularly *Agropyron elongatum, Dactylis glomerata, Festuca arundinacea, Hedysarum* spp., *Lolium rigidum, Oryzopsis miliacea, Phalaris tuberosa, Trifolium* spp., and *Sanguisorba minor*. The evolution of production from 1989 to 1995 is summarized in Table 2. During the 1988–1992 five-year plan, 60 ha were planted for seed production of fodder shrubs. The main species produced include: *Chamaecytisus albidus, Medicago arborea*, and *Robinia pseudo-acacia*.

Table 2. Pasture seed produced (t) by MPSMC and CPSP (1989–1995).

Species	1989	1990	1991	1992	1993	1994	1995
MPSMC							
Grasses	2.7	3.8	2.6	1.7	1.4	2.1	3.8
Legumes	1.4	0.2	3.3	3.3	2.4	2.4	2.5
Shrubs	0.3	0.2	0.0	0.2	0.8	0.7	0.6
CPSP							
Grasses	6.0	6.3	31.1	10.3	37.4	11.3	6.0
Legumes	13.4	10.7	20.5	7.3	12.6	11.5	7.2
Shrubs	0.1	0.2	0.6	0.7	0.7	0.7	0.7

Source: AEFCS (1995) and Tazi (1995).

Khémis Metouh Pasture Seed Production Center

In 1982, the Ministry of Agriculture, in cooperation with USAID, established this range seed production center located in Khémis Metouh, southeast of El Jadida to promote national production of pasture seed. CPSP is equipped with seed cleaning and processing machines, agricultural equipment, a seed laboratory, and a mechanical workshop (CPSP 1989). The tasks assigned to CPSP are:

- Production of foundation seed of promising pasture species.
- Multiplication of pasture species to meet immediate needs.
- Multiplication of fodder shrubs.
- Evaluation of adaptability of herbaceous and shrub species in pasture improvement trials and by private farmers.

In parallel with these activities, the center undertakes these research missions:

- Collection of native plant genetic resources and germplasm introduction.
- Management of a gene bank.

Selection, evaluation, and multiplication of promising ecotypes.

Since its establishment, CPSP has released three annual medic varieties and multiplied several introduced species and commercial varieties to satisfy the immediate seed needs of the different pasture areas of the country (Tazi 1995). The quantities produced in 1989–1995 are presented in Table 2.

Marketing and distribution

In general, the quantity of seed sold by the state seed company Société Nationale de Commercialisation des Semences (SONACOS) each year was equivalent to the quantity imported, except for 1985 when a large quantity of annual legumes was imported for the ley-farming program. Table 3 shows the evolution of sales of pasture seeds undertaken by SONACOS.

Table 3. Pasture seed sold by SONACOS (1978–1991).

Year	Sale (t)	Year	Sale (t)
1978–1979	74.4	1986–1987	333.7
1981–1982	17.9	1987–1988	177.2
1982–1983	29.9	1988–1989	93.5
1983–1984	20.1	1989 –1990	84.6
1984–1985	21.3	1990–1991	75.9
1985–1986	414.6	1991–1992	41.5

Source: SONACOS (1978–1991).

Main Constraints to Development of the Sector

The pasture seed sector faces a series of constraints that can be divided in two categories: problems and inherent constraints to range improvement, and seed sector constraints.

Problems and Inherent Constraints to Range Improvement

General constraints

Due to an increasing demand for agricultural and animal products, farmers have been forced to over-exploit pasture resources, leading to overgrazing. Productive rangelands are being converted to marginal croplands, and woody plants are being collected for domestic use.

These ominous effects have became aggravated by:

- Absence of private investment in range equipment.
- Recurrent drought.
- Ineffective legislation.
- Limited forage reserves for feed during drought.
- Limited technical support for livestock producers in pasture regions.

Insufficient research in range-management practices.

Specific constraints to range seeding activities

Rangeland seeding activities have produced limited results because of the following:

- Weak involvement of the population in seeding activities, notably because all these programs are totally government funded.
- Limited funds allocated to rangeland rehabilitation programs.

Insufficient extension activities concerning rangeland improvement.

Seed Sector Constraints

Forage and pasture seed production faces a number of technical constraints, summarized below.

Lack of adapted species and varieties

Most introduced species and varieties for rangeland seeding are not adapted to the local environment. Several authors have emphasized the adaptation of local ecotypes of annual leguminous species (Tazi et al. 1989; Bounejmate 1994). Furthermore, several collection and evaluation studies of local pasture resources have been undertaken by different institutions over the last decade (Tazi 1995), but initial seed multiplication remains the limiting factor for the development of improved varieties.

Seed demand

Seed demand fluctuates from year to year depending on the budget allocated to rangeland seeding by the Ministère de l'Agriculture et de la Réforme Agraire (MARA). This fluctuation has negative effects on the planning of production, which is also dependent on the time and amount of autumnal rain.

Absence of legislation for pasture seed

Until now, no legislation has been instituted for the certification of pasture species. This hinders the development of varieties for these species. For other forage species (oat, barley, lupin, horse bean, vetch, pea, persian clover, berseem, alfalfa, and annual medic) for which rules have been established, the existing legislation is sometimes constraining (Tazi 1989). For instance, the rules do not take into account the means and techniques used by the farmer.

Research deficiency

Research is all but lacking in the area of pasture seed production. Studies and research remain limited to weed control in seed production fields (Regher et al. 1989; Tazi et al. 1986a, 1986b). On the other hand, the number of specialists working in this area remains limited.

Lack of farmer interest and private sector involvement

Pasture seed production by farmers and private companies is totally non-existent. There is a lack of farmer interest, even for certified seed production of other forage species for which demand is important. This can be explained by the fact that prices paid to seed producers are not competitive when compared to some other remunerative crops. Furthermore, the lack of specific equipment for seed production and the lack of technical support to farmers translate directly to low yield.

Extension and promotion

Extension efforts currently used by the Ministry of Agriculture for the promotion of forage and pasture crops are insufficient, particularly regarding the awareness of livestock producers, conservation of natural resources, and rehabilitation of degraded rangelands by seeding and planting. These efforts have to be sustained by the encouragement of private investment in the area of range management and equipment, as well as by the participation of populations in pasture improvement works. Extension efforts in the field of seed production in general have to be reinforced to allow farmers to master production techniques.

Conclusions and Prospects

Despite the increase in cultivated forage areas in high-rainfall zones through the introduction of annual legumes, areas sown to rangeland have declined since 1980, due to drought and social problems of collective land. The unavailability of plant materials adapted to the environmental conditions of different ecological zones hinders the extension of rangeland seeding operations. To overcome these constraints, certain measures can be taken, described below.

Rangeland development actions: all rangeland development actions should have positive effects on pasture seed utilization. The following should be emphasized:

- Reinforcing and expanding range improvement practices such as pitting, fertilization, seeding, and planting to re-vegetate selected rangelands.
- Promoting farmer awareness in low rainfall zones to redirect their production systems as a means of integrating forage crops with livestock breeding.
- Encouraging livestock producers to plant fodder shrubs on converted lands that were originally rangeland.

Supporting the organization of livestock producers into cooperatives.

Intensification of research: research in seed production is almost non-existent. The following research actions could be undertaken to promote rangeland seeding:

- Development and adaptation of seeding techniques appropriate to different ecological conditions.
- Collection and evaluation of plant genetic resources of the main pasture species for future use in variety development.
- Study of the pasture potential of local drought-resistant species and their conservation *in situ* for future use in the development of marginal zones.
- Development of an adapted technology for pasture seed production.

Coordination of research and seed production: because of the limitations of human and financial resources, it is essential to coordinate efforts made by seed production organizations, centers, and different research institutions to:

- Promote local production of foundation seed of range species in the existing seed multiplication centers.
- Assist farmers to master production techniques and other issues of forage crop production channels.
- Contribute efficiently, through the exchange of expertise and information, to the development of range improvement techniques and seed production in WANA.

Identification of *in situ* conservation zones: the best means to preserve pasture species threatened by genetic erosion is the protection of the ecosystem through *in situ* conservation. *In situ* conservation zones may include protected forest areas, and semi-arid and arid pasture zones such as regions of the Oriental, Errachidia, Ouarzazate, Middle Atlas, High Atlas, and the Saharan Provinces. Among species concerned with *in situ* conservation are *Artemisia herba-alba, Stipa tenacissima, Salsola* spp., and other shrubs. It is possible to harvest seed at a lesser cost in these areas of conservation. Such seed will not, of course, fulfill the legislation requirements, but it could be used, provided it undergoes the necessary seed processing and germination tests.

Proposal for legislation specific to pasture seed: it would be useful to at least set up rules for species being multiplied in the country. These rules must be adapted to farmers' conditions for minimal size of the multiplication field, number of generations, production techniques, etc.

Encouragement of training: the success of all steps leading to the development of local seed production cannot be assured without specialized training of technical personnel. Such training is currently lacking in our universities. Nevertheless, the intensification of short-term training in seed production and technology could be undertaken at the local and regional levels.

Development of international exchanges: networks are needed to exchange plant materials, expertise, and information linked to research on native pasture species and adequate multiplication techniques. The activities of such networks will be facilitated by the logistic endorsement of international organizations and the identification in WANA of "Centers of Excellence."

Acknowledgments

The author would like to thank the Administration des Eaux et Forêts et de la Conservation des Sols and the National Seed Company SONACOS for providing data used in this paper. Special thanks are due to my colleagues at the Livestock Department for their assistance and to Dr A. Birouk for his review of this paper.

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Forage and Pasture Seed Production in Tunisia

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Abstract

Tunisia has a Mediterranean climate characterized by moderate winters and hot and dry summers. These climatic conditions are very favorable for seed production. It is estimated that Tunisia has the potential to produce about 200,000 tonnes of seed, which would cover 90% of its total need. Although most of the forage and pasture seed needed could be produced domestically, large quantities of seed are imported every year. The current limitations are due to problems associated with seed research, production, industry, and marketing.

Introduction

An average area of 283,000 hectares (239,000 rainfed and 44,000 irrigated) was planted to forage crops during the last five-year plan (1992–1996). This was about 20% less than planned, because of drought in 1993/94 and 1994/95. In 1996, 313,000 hectares were planted, resulting in a production of 473,000 tonnes of hay, 465,000 tonnes of silage, and 671,800 tonnes of green forage.

Objective of the Ninth Five-year Plan (1997–2001)

The main objective of this plan is to reach self-sufficiency in red meat and milk production by 1999 and 2000, respectively. To meet this objective, meat production must increase from 104,150 to 133,850 tonnes, and milk production from 657,200 to 896,500 tonnes. This would require about 5.2 billion forage units (UF)[1], which is equivalent to 5.2 million tonnes of barley grain. At present, the total deficit in forage resources is about 540 million forage units, which is 47% of total forage need and 12.5% of total feed resources.

To meet the total need of forage resources by the end of year 2001, an equivalent of 877 million UF is needed. This means 679,000 hectares would have to be planted to forage crops, although the total potential area reserved for forage production does not exceed 350,000 hectares.

Therefore, instead of increasing area, efforts should be directed towards: (i) creation, selection, and release of adapted and high-yielding forage species and

[1] 1 UF = The energy given by 1 kg of grain barley.

varieties; (ii) initiation of a seed production program; (iii) using quality seed; and (iv) organization of the seed sector (legislation, research, seed quality control, seed production, and marketing).

Current Situation

The area planted to forage crops declined from 350,000 hectares in 1970 to 250,000 hectares in 1990. The total area reserved for forage production is about 282,000 hectares, representing 6% of the total agricultural area. The extent of the area used for forage and seed production is highly dependent on climatic conditions (Table 1).

Table 1. Evolution and distribution of total area (1000 ha) used for forage production (1987–1996).

Crop	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96
Dryland	298.1	185.2	275.2	220.4	251.0	240.1	234.0	232.4	233.5	256.1
Irrigated	43.5	32.6	37.4	40.2	44.0	30.3	37.4	43.9	53.4	48.4
Total	341.6	217.8	312.6	260.6	295.0	270.4	271.4	276.3	286.9	304.5
Winter forage						263.2	266.1	262.4	269.5	293.0
Summer forage						7.2	5.4	13.9	17.4	11.5
Total						270.5	271.4	276.3	286.9	304.5

Main Forage and Pasture Species Used

Because of limited choice, the same forage and pasture species and varieties have been used for several years. These species are: oat, barley, alfalfa, *Trifolium alexandrinum, Trifolium resupinatum,* ryegrass, fescue, *Vicia sativa, Hedysarum coronarium,* sorghum, maize, and annual medic. Area and quantity of seed needed are summarized in Table 2. Some 52% of the total forage area is covered by oat, used mainly for hay production.

Table 2. Forage areas and quantity of seed required.

Species	Area (ha)	Quantity of seed needed (tonne)
Oat	170,000	17,000
Green barley	50,000	5,000
Vetch	91,500	3,050
Trifolium alexandrinum	6,000	180
Hedysarum coronarium	5,000	225
Annual medic	4,000	80
Alfalfa	6,000	150
Ryegrass	1,000	30
Sorghum	10,000	300
Maize	4,000	160

Domestic Seed Production

The need for high-quality seed of adapted species and varieties increases every year. However, local production of seed is still very limited and covers only a few species. The deficit is always covered by seed imports. The imported varieties are usually not adapted to local conditions and are very susceptible to disease and pests.

Forage seed production is highly dependent on the amount and distribution of rain throughout the year. During favorable years, about 85% of national seed requirements for most forage species (oat, *Hedysarum coronarium*, *Trifolium*, and *Vicia*) is produced locally by farmers (Table 3). This seed is exchanged among farmers or channeled through local markets. The other 15% is imported by state or private seed companies. All seed of alfalfa and most pasture species is still imported.

Table 3. Quantities (tonne) of locally produced and imported forage seed.

Species	1992		1993		1994		1995		1996	
	Local	Imp.	Local	Imp.	Local	Imp.	Local	Imp.	Local	Imp.
Oat	36,000	0	29,300	0	4,000	10,950	8,600	10,700	30,000	0
Vetch	3,500	0	2,900	0	294	421	1,350	0	2,150	0
Alfalfa	0	0	0	22	0	189	0	57	0	40
Medics	0	0	0	20	0	17	0	22	0	2
Hedysarum	0	0	0	0	0	2	0	0	0	0
Sorghum	0	109	0	110	0	352	0	660	0	528
Maize	0	30	0	30	0	149	0	100	0	35

Seed Production and Commercialization

The organization and regulation of seed multiplication and certification have long been a subject of concern in Tunisia. The first seed laws were established in 1932, leading to the creation, within the Tunisian Botanical Service (presently the National Agricultural Research Institute of Tunisia) of a cereal variety list. This legislation was amended in 1937 and 1947 to take into account the development of cereal production and marketing structures in Tunisia (the creation of the ONIC and development of inter-professional production associations). New regulations were set in place in 1951, as a consequence of the creation of the first seed cooperative (COSEM) in 1946. These regulations, along with legislation adopted in 1947, governed seed multiplication until 1966, when new legislation was enacted. Because of the introduction of new wheat varieties, the increased production of controlled seed, and the creation of a second seed cooperative (CCSPS), this legislation was by 1969 considered incomplete. The Ministry of Agriculture, therefore, decided to develop a complete legislation to govern the organization and regulation of seed production and marketing of all categories of agricultural crops, including cereals, vegetables, forage crops, and trees. In 1976, this legislation resulted in the establishment of a National Seed Committee, the creation of a national catalogue for varieties to be used in the country, and a system of seed certification.

Organization of the Seed Sector

- **Research and training activities:** these activities include selection and development of adapted varieties, improvement of seed production techniques, and development of human resources. They are mainly carried out by the research institutions.
- **Seed catalogue:** only those species and varieties listed in the catalogue can be imported.
- **Evaluation, maintenance, and production of basic seed:** this activity is now carried out by researchers at different National Agricultural Institutions and cooperatives.
- **Seed multiplication and distribution:** this is the key limiting factor in the development of the forage seed sector. Most of the local existing seed companies import and commercialize foreign varieties. Seed production, which was the prerequisite of obtaining agreements to commercialize seed, is now absent in their activities. No certified seed of forage crops is produced in the country, although one organization (GRAFOUPAST) specializes in production and distribution of forage seed. Two other organizations (COSEM and CCSPS) are actually producing limited quantities of vetch and oat seed.
- **Seed quality control and certification:** the national seed laboratory is the official agency for controlling the quality of locally-produced or imported seed and varieties.
- **Seed marketing:** seed is either produced locally or imported. However, 90% of seed used by farmers is saved or bought from the local market.

Constraints to Forage and Pasture Seed Production

Despite favorable climatic conditions, the development of forage and pasture seed production in Tunisia faces constraints, including the following:

- Limited adapted plant material.
- Lack of coordination between research, producers, distributors, and users.
- Incomplete and inefficient legislation.
- Absence of structures able to maintain improved varieties and local ecotypes.

Contribution to the Development of Forage and Pasture Seed Production in Tunisia

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Abstract

The development of a viable seed sector is one of the priority programs of agriculture in Tunisia. During the previous decade, attempts to produce forage and pasture seed were not successful, although the required prerequisites, such as favorable climatic conditions, adapted genetic material, seed production centers, and seed companies, were available. Recently, however, new breeding programs have been established, and improved varieties of forage and pasture crops will soon be released. In collaboration with national development organizations and the national seed inspection laboratory, INRAT has been working towards the establishment of an efficient production program. The first attempt was initiated in 1994 with the multiplication of four newly-released oat varieties. Over 100 tonnes of certified oat seed were produced. Government and private seed organizations are now involved in the production, processing, marketing, and distribution of seed of these oat varieties. The second attempt involves the production of breeder and basic seed of the main perennial grasses and subterranean clover. This program is now underway, and will partially satisfy the need for pasture development in northern Tunisia. Nevertheless, the forage and pasture seed sector is still facing difficulties: lack of coordination at the production, marketing and distribution levels, inappropriate extension of newly developed varieties, and seed prices unattractive to producers.

Introduction

Livestock development is a priority in Tunisia. It depends greatly on forage and pasture resources, which continue to be deficient. The potential cultivated pasture area is around 120,000 hectares in northern Tunisia, but only 12,000 hectares have been established. Most established pastures are overgrazed and some have been converted to cash crops.

The increased numbers of livestock, the failure to establish and maintain a productive pasture, and the introduction of non-adapted varieties have created the need for an improved seed production system in the country. Although the necessary structures required for large-scale seed production are available, seed is either produced by farmers or imported by dealers representing multinational companies. This report summarizes the current situation in variety development, seed multiplication, certification, and distribution.

Conservation of Genetic Resources

Tunisia is considered an important source of biodiversity for forage and pasture species. However, considerable genetic erosion has occurred as a consequence of overgrazing, intensive cropping, and inadequate soil conservation practices. Over the last few years, the National Agronomic Research Institute of Tunisia (INRAT) has organized several collection missions in collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA), the Center for Legumes in Mediterranean Agriculture (CLIMA), the Department of Agriculture Victoria (DAV) in Australia, and the National Agricultural Institute of Tunisia (INAT). Around 3,000 accessions of more than 130 species have been collected and conserved. However, characterization and evaluation of this material are needed.

Variety Development

For the past 20 years, INRAT has carried out research on the identification and development of adapted varieties for the main pasture and forage species (Table 1). With the exception of oat, all the varieties developed have been selected from indigenous material. Failure to produce enough seed has limited the use of some of these varieties.

Table 1. Main pasture and forage species and varieties in Tunisia.

Species	Variety
Festuca arundinacea	Jebebina, Grombalia, Mornag
Lolium perenne	Thibar, Ain Melliti
Dactylis glomerata	Euchkeul
Phalaris tuberosa	Soukra
Medicago sativa	Gabes
Trifolium subterraneum	45C
Avena sativa	Fretissa, Al Alia, Meliane, Medjerda

In recent years, new breeding and selection programs on priority forage crops have been developed and approved by the Crops National Research Planning Committee (CNRPC). These programs are supported partially by National Research Program (PNM) projects and carried out by INRAT and INAT.

INRAT is actually conducting three breeding projects: on oat (*Avena sativa*), vetch (*Vicia* spp.), and annual medic (*Medicago* spp.).

The oat project is currently evaluating pure lines and segregating populations for disease resistance and yield potential from material supplied by the Quaker Oat Company. The vetch project, for which the selection of varieties with different maturity and ploidy levels as well as amphycarpic hybrids has been underway since 1989. Progress is being made, and three varieties will be released shortly. These varieties are early-, medium-, and late-maturing types. They are highly productive and can be grown in a mixture with oat, barley, and/or triticale. The objective of the annual medic project is to evaluate the local germplasm collected in 1992 and 1994 in different eco-geographical areas. Based on characteristics such as maturity, growth habit, plant vigor, dry matter, and seed production, two ecotypes of *M. truncatula* have been selected. These ecotypes are adapted to semi-arid and arid regions and are significantly higher in dry matter yield than the check cultivar (Paraggio).

The plant improvement program at INAT concerns mainly two crops: sulla (*Hedysarum coronarium*) and berseem (*Trifolium alexandrinum*). The aim of this program is to develop new cultivars that are superior to the existing ones in terms of adaptation, yield, forage quality, and seed production. The sulla project, after preliminary evaluation, has completed four cycles of selection. Selected material is being tested in multi-location variety trials. The berseem project is studying the genetic variability of 78 accessions of *T. alexandrinum* at two locations. Synthetic varieties will be developed using random mating of several parents. Plants derived from tissue culture have already been produced for this purpose.

Variety Evaluation and Registration

At present, INRAT is evaluating and registering forage and pasture varieties that have been introduced from abroad. These varieties are being compared mainly to those used by farmers in field trials for three years. The list of varieties recommended by INRAT, the official evaluation authority, includes: maize (17 varieties), Sudan grass (16), *Lolium multiflorum* (6), alfalfa (6), medic (7), subterranean clover (6), berseem (4), and fodder beet (4). New varieties developed by research and teaching institutions are presented for registration through the General Department of Agricultural Production (GDPA). Data from evaluation trials is examined and presented to the National Consultative Seed Committee (NCSC), which decides on registration and release.

Seed Production

Forage and pasture seed production started on a small scale during the 1970s and 1980s in northern and central Tunisia. This activity was carried out through bilateral projects. Inadequate management skills, low seed yield, and low economic return were the main reasons for the loss of interest by government farms and private seed growers.

At present, INRAT, in collaboration with national development organizations and the National Seed Inspection Service, is contributing to the establishment of a formal seed sector. The first attempt was initiated in 1994 with the multiplication of four newly-released oat varieties. This work was carried out with the Office of Livestock and Pastures (OEP) on the Fretissa farm. Over 100 tonnes of certified oat seed was then produced through a number of generations of seed multiplication. Government and private seed organizations are now involved in the production, processing, marketing, and distribution of seed of these oat varieties. Variety maintenance and multiplication is carried out through an official agreement between INRAT and the seed organizations.

The second attempt was the production of breeder, basic, and commercial seed of the main perennial grasses (tall fescue, perennial ryegrass, and phalaris) and subterranean clover. This program is under the supervision of the Office de Développement Sylvo-Pastoral du Nord Ouest (ODESYPANO), OEP, and INRAT. The aim is to produce seed for the establishment of 100 hectares of improved pasture in northern Tunisia annually.

Recently, a medic seed production program was initiated by the ESA El Kef in central Tunisia (Sidi Bouzid Governorate), under the Mashreq/Maghreb (M&M) Project of ICARDA.

Seed Distribution Systems

Inefficient seed distribution is a major constraint to the adoption of developed varieties on a large scale. Attempts to produce and commercialize forage and pasture seed have failed because of the absence of a marketing strategy. The GRAFOUPAST enterprise, which was created in 1976, was given the task of producing, handling, conditioning, storing, distributing, and marketing forage and pasture seed. However, this enterprise is now limited to commercialization of imported seed. At present, there are three eligible enterprises (GRAFOUPAST, CCSPS, and COSEM) involved in forage and pasture seed production. But CCSPS and COSEM specialize mostly in the production of cereal seed. Each enterprise possesses a processing plant and is represented by seed dealers in the major crop production areas. The private sector has recently started to participate actively in the national seed program. A modern plant has been built and equipped for this purpose.

Seed Certification and Quality Control

The Seed Inspection Service (SIS) and the Quarantine Service, directed by the GDAP at the Ministry of Agriculture, are responsible for seed certification and testing of seed samples for law enforcement purposes. In the official seed program, control of seed produced by either government or private growers is under the responsibility of the SIS. Among the forage crops, only oat is affected by these measures. For other forage species, SIS controls only the germination and health status of commercialized seed.

Constraints and Recommendations

Forage and pasture seed production in Tunisia faces the following constraints:

- Lack of a clear strategy for forage and pasture seed production.
- Lack of coordination of various seed activities.
- Incomplete and inadequate seed legislation.
- Lack of incentives for private seed companies.
- Limited trained and qualified personnel.

The development of a national seed multiplication system requires the following:

- Extension of newly-released varieties.
- Execution of plant improvement programs developed and approved by the Crop, Livestock, and Pasture National Planning Committees.
- Coordination between all partners involved in the seed sector (research, seed enterprises, development institutions, and farmers).
- Motivation of the private sector.
- Development of qualified manpower.

Acknowledgments

I sincerely thank my colleagues Dr Zouaghi, Mr Ben Jeddi, Mr Rouz, Mr Hassen, Mr Bouziri, and Mrs Zoghlami, who kindly reported on their respective projects.

Forage and Pasture Seed Production in Sudan: An Overview

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Abstract

In Sudan, the area under fodder crops is expanding due to increased attention to dairy production near urban centers. Rangeland rehabilitation by seeding native and exotic forage species is also expanding. However, the targets set by the Comprehensive National Strategy are far from being met. Although quality seed of improved varieties is a prerequisite to improved production, the organized seed industry generally gives little attention to seed production of fodder and pasture species. The Range and Pasture Administration (RPA), through its seed farms, projects, and adaptation nurseries, focuses on the production of seed and cuttings of a range of fodder and pasture species. Small farmers, especially in northern Sudan (Nahr En-Nil and Northern State), play a critical role in the informal supply system. Seed produced is made available to others through cash sale, barter, loan, and gift. Work done by the RPA and the National Seed Administration (NSA) has been directed at the major crops, sorghum and alfalfa, and, to a lesser extent Sudan grass, lablab, phillipesara (*Vigna aconitifolia*), and clitoria. Besides seed multiplication of cultivated fodder crops, the RPA offices in some states carry out opportunistic harvesting of seed from both seeded pastures and natural stands containing a high density of desirable species. The major constraints to forage seed production include: (i) marketing policy, price determination, and demand forecast prior to production; (ii) limited training in production and processing; and (iii) limited research to select and develop new varieties. The government has drawn up a policy to promote the seed industry by adopting the following measures: (i) drafting a national seed act; (ii) establishing a national seed council; and (iii) establishing the Arab Sudanese Company for Seed Production as a joint venture with the Arab Authority for Investment and Development and other partners. Short- and long-term plans to enhance forage seed production should: (i) give priority to major irrigated fodder crops (Abu Sabeen, hybrid multi-cut forage sorghum, alfalfa, and lablab); (ii) upgrade present efforts for collection and cleaning of seed from native stands and seeded pastures; (iii) encourage joint efforts between research and other relevant institutions to provide farmers and private companies with foundation seed of adapted and improved varieties; (iv) integrate forage seed multiplication into irrigated and rainfed farming systems; and

(v) stimulate the exchange of information, genetic material, and legislation to facilitate seed trade with other countries.

Introduction

The total area of Sudan is about 250 million hectares. The agricultural sector consists of the traditional dryland (5.2–7.1 million ha), mechanized dryland (4.2–6.3 million ha), and irrigated (1.7 million ha) farming sub-sectors. The area under fodder crops is estimated at 126,000 hectares, of which 46% is in Khartoum State. Normally, 80–90% of the area allocated to fodder crops is cultivated annually. Sudan is endowed with a large livestock population, mainly raised under traditional pastoral and agro-pastoral systems.

Agriculture is the main source of foreign exchange and is the basis of Sudan's economy. It contributes about 36% of the country's gross domestic product (GDP) and 95% of its export earnings. It also provides employment for 80% of the labor force. Livestock accounts for about 50% of the agricultural GDP and about 50% of the country's foreign currency earnings.

Background

Sudan is characterized by various ecological zones with several special areas of unique eco-physiographic features: the Red Sea coast and associated hills, mountains (Jebel Marra, Nuba, and Immatong), the Sudd region (swamps), and the inland deltas of Gash and Tokar. These areas are dominated by different vegetation types and are considered important pools of plant genetic resources in general and of forage species in particular.

Overgrazing, clearance of forests, and deliberate burning have depleted vegetation resources and endangered many desirable species. Recurrent drought has affected various parts of the country over the last three decades, accentuating this trend and intensifying land degradation.

Seed collection from natural grasslands and production of fodder crops and tropical pasture species was once carried out by the Rangeland and Irrigated Pasture Divisions. Large amounts of seed from native forage species were collected. RPA nurseries, distributed across major agricultural and grazing areas, provided seed and cuttings of introduced and native forage plants. These nurseries played an important part in the germplasm conservation of forage species. Unfortunately, activities in most of these nurseries have ended due to: (i) limited operational funds; (ii) lack of incentives for technical staff to manage the units; and (iii) change of land ownership between government and corporate institutions. The result is a loss of valuable germplasm of local and exotic species.

Seed collection and production of forage species is practiced mainly for the rehabilitation of degraded rangeland, the establishment of improved pasture, the introduction of forage legumes in fallow land and in rotation with other crops, and the enhancement of fodder crop production to improve animal production systems.

Current Situation

Most traditional farmers use their own seed for planting fodder crops such as lablab and alfalfa. Others still fulfill their requirements from neighbors or local markets for the above-mentioned crops as well as for the forage sorghum variety Abu Sabeen.

Organized seed production in Sudan commenced in the early 1930s, when a small unit was established within the Agricultural Research Center (ARC). This unit later became responsible for the multiplication of seed of released varieties. The responsibilities and duties of the unit expanded over the years to meet the requirements of development plans and improved agricultural production.

During the 1970s, the seed industry in Sudan received international as well as bilateral assistance to strengthen programs and provide services and supervision. This assistance enabled the relevant government institutions to strengthen their capacity in seed production, processing, staff training, and management.

Institutional Framework

Several institutions are involved in the seed industry, with the leading ones under the Federal Ministry of Agriculture. Public and corporate agricultural schemes play a role in the production of seed of certain crops, such as cotton. Private companies are playing an increasing role in seed production, import, and marketing, either through direct efforts or through sub-contracts with the National Seed Administration (NSA).

National Seed Administration

In its early development, this administration was a small unit within the breeding section of the ARC. It was responsible for the maintenance and bulking of varieties. In 1968 the unit was detached from the ARC and was upgraded to the Plant Propagation and Improvement Department (PPID) within the Directorate of Agricultural Services of the Ministry of Agriculture. The PPID was the official body responsible for seed multiplication of released varieties in the country.

By the beginning of 1970 major changes had taken place, and steps were taken to strengthen the role and activities of the PPID within its mandate. This was reflected in the establishment of satellite seed stations adjoining ARC stations and major agricultural production schemes.

PPID's responsibilities and programs expanded further through the implementation of the first and second phases of the FAO seed production and certification project. It was given the responsibility of supplying schemes with seed of all crops besides cotton. More duties were given to PPID following the African Development Bank (ADB) and African Development Fund (ADF) loan disbursement in 1982. This necessitated the reorganization of PPID and the establishment of the NSA. The NSA comprises two autonomous departments, the Plant Propagation Department (PPD) and the Seed Certification Department (SCD). The mandate of the NSA includes manpower training in the various fields of seed technology, production, and distribution, promotion of the use of quality seed, establishment of new seed stations, seed quality control, control of seed trade within the country and seed import, chairing of the Seed Council, and enforcement of the Seed Act. The NSA has its own marketing system for the sale of seed of different crops. Its clients are government units, projects, agricultural schemes, private companies, and farmers.

The reorganization of the Ministry of Agriculture and Forestry (MAF), and the adoption of the federal system of government, have brought about obvious institutional and functional changes. The Seed Propagation Department (SPD) and the Range and Pasture Department (RPD) were both brought under the Directorate General of Natural Resources and Production. The ARC continues to be an autonomous body under the Minister's supervision. The SPD is responsible for certification, regulation of the seed trade, and quality control. Other responsibilities, which were earlier under the NSA, have been delegated to various institutions (Table 1).

Table 1. Responsibilities of institutions in the Sudanese seed industry.

Institution	**Responsibility**
ARC, companies, universities, and institutions	Breeding
Foundation Seed Unit, ARC	Multiplication of foundation seed
Companies, seed units of corporations, schemes, and farmers	Multiplication of other seed categories
National Seed Administration	Certification and quality control
FSU, seed units, companies, seed merchants, and farmers	Marketing and distribution

Range and Pasture Administration (RPA)

The RPA was established in 1947 as a section in the Department of Veterinary Services to carry out activities related to rangeland conservation and management, and the proper distribution of water resources to allow balanced utilization of grazing resources. Later, these activities were extended to seed production of fodder crops and irrigated pasture and forage species. In 1973, the RPA was transferred to the Ministry of Cooperation and Rural Development (MCRD) and was upgraded to a department. There it pursued its former goals and responsibilities. However, the transfer resulted in the disruption and weakening of its activities and links with the animal production stations, which continued to operate under the Ministry of Animal Wealth.

When the MCRD was dissolved, the RPA was transferred to the Ministry of Agriculture as an administrative body with three main divisions: rangeland, irrigated pasture, and pastoral studies.

Agricultural Research Center (ARC)

The ARC is responsible for the collection and conservation of plant genetic resources, plant breeding, variety improvement, and chairing the Technical Variety Release Committee (TVRC) meetings. Moreover, the ARC carries out research on cultural practices that influence seed yield and quality.

The Arab Sudanese Seed Company (ASSCO)

This company (ASSCO) was established recently as a joint venture between the Sudanese government and the Arab Authority for Agricultural Investment and Development (AAAID). The mandate of ASSCO comprises: (i) production of improved seed for a number of major food crops; (ii) production of hybrid seed of maize and sunflower, which are presently imported; (iii) production of fodder crops such as alfalfa and sorghum; (iv) supply of foundation seed to produce certified seed; and (v) contribution to the development of the seed industry in Sudan through research and development.

Fodder crops are planned to be produced at El-Hudeiba, Khashm El-Girba, Sennar, and Dongola farms. Plans do not include the production of labor-intensive fodder crops such as lablab, clitoria, and phillipesara. Targeted and average production of alfalfa and sorghum seed are summarized in Table 2.

Table 2. ASSCO fodder crops seed production targets.

Crop	Year and production (tonne)					
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Alfalfa	24.2	60.7	109.3	162.0	162.0	162.0
Sorghum (Abu Sabeen)	1,377.0	1,409.0	1,458.0	1,458.0	1,458.0	1,458.0

Private sector

The private sector multiplies and/or markets seed of various crops, including fodder crops. It is also active in the import and marketing of vegetable, sunflower, maize, and fodder crop seed.

The reputation of the NSA seed production program, and local demand for quality seed of some crops, has encouraged the private sector to invest in local seed production and marketing. A multinational seed company, Pioneer, has established a branch in Sudan and invested in seed production of alfalfa and sorghum. The Pioneer breeding program has resulted in the development and release of a sorghum hybrid, Pioneer 988, that performs better than the local variety, Abu Sabeen. Pioneer has also introduced alfalfa variety 5929. This variety, however, has not attracted the interest of farmers because of its low performance compared to the local variety, Higaz.

Farmers

Farmers play a crucial role in the informal seed supply system, especially in the Nahr En-Nil and Northern States. Traditionally, all vegetable, and substantial amounts of fodder crop (alfalfa, sorghum Abu Sabeen, and lablab) seed, are produced by farmers and exchanged locally by cash, barter, loan, and gift. Still, a good amount of seed produced by farmers finds its way to the markets of Khartoum State, which is the major irrigated fodder production area of the country. The production of alfalfa and Abu Sabeen seed by farmers meets most of the country's requirement.

Seed Legislation and Control

Efforts have been made to prepare seed legislation with relevant regulations to support development of the seed sector (Leinemann and Peterson 1983). However, enactment of the Seed Act came only in 1990. Although some aspects of quality control are not sufficiently covered by the Act, many basic issues, such as the definition of varieties, cultivars, hybrids, breeder seed, breeders rights, field inspection, laboratory tests, penalties, and appeals, have been paid sufficient attention (Mohammed and Ali 1996).

Regulations associated with the 1990 Seed Act concern mainly alfalfa, barley, maize, sorghum, millet, and lablab. The Seed Act itself has not clearly addressed the issue of collection and trade of seed of native forage species, nor has it covered the multiplication and marketing of locally-produced seed of tropical pasture species.

The Seed Council

Various projects that provide funds and technical assistance to the seed industry have strongly recommended the establishment of a Seed Council (SC) to advise the Federal Minister of Agriculture on matters and programs relevant to the seed industry. The Seed Council's responsibilities and duties are stipulated as follows:

- Supervise the seed industry and organize its activities.
- Advise the Minister on aspects of production, handling, and development of seed trade.
- Endorse specifications and conditions of seed advertised for marketing and trade.
- Outline principles and procedures required for variety registration and seed to be marketed.
- Prepare plans and design suitable policies to enhance seed sector development.

Forage and Pasture Seed Production

The production of forage and pasture seed and cuttings is an important activity of the Range and Pasture Administration through its nurseries, which are specialized seed farms and animal production research stations. Seed collection of forage species is practiced in several states to meet local requirements for seeding rangelands and to provide a surplus for other states. This opportunistic harvesting of seed from improved pasture or natural grasslands is still practiced, but only to a limited extent due to lack of funds.

The NSA is also involved in the production of seed of various fodder crops through its seed farms and sub-contracts. However, the range of species for which seed is produced has been narrowing during the past few years.

Seed production by the National Seed Administration

The NSA has been involved in the production of seed of fodder crops as well as Sudan grass, clitoria, lablab, and phillipesara. The seed production area for all NSA farms does not exceed 126 hectares for Abu Sabeen and 8.4 hectares for alfalfa. However, contract growers from Nahr En-Nil, Northern, Kassala and Sennar States planted about 840 hectares of alfalfa and 210 hectares of Abu Sabeen for seed production.

Seed production by the Range and Pasture Administration

Statistics are scarce on seed production and data collection done by the RPA. What is available is fragmented data from individual states regarding their local activities.

In the early 1970s, pilot work for the introduction of forage and dual-purpose legumes in mechanized farming schemes indicated the potential for production of both forage and seed in Agadi (Table 3).

Table 3. Seed production of forage and dual-purpose legumes in Agadi.

Scientific name	Common name	Production kg/ha
Crotalaria thebaica	Sunnhemp	695
Cyamopsis psoraloides	Guar toxil	745
Cyamopsis psoraloides	Guar FB	823
Cyamopsis psoraloides	Guar Indian	750
Phaseolus aureus	Green gram	592
Stizolobium deeringianum	Velvet bean	364

Source: Zaroug (1974).

In Gedarif State, multiplication of fodder crop seed was practiced at the Kajrah nursery. Abu Sabeen was the main crop produced, but limited amounts of clitoria, Sudan grass, panicum, and buffel grass were also produced. The RPA office in Gedarif State is also involved in the collection of native forage species seed (Table 4), which are utilized in conjunction with imported pasture seed for rangeland seeding.

Table 4. Forage species seed in Gedarif State and seed source (July 1997).

Species	Amount of seed (kg)		Source of seed
	Collected	Introduced	
Blepharis edulis	15,000	-	Butana grazing land
Blepharis edulis	600	-	Gadambalieh farm
Cenchrus ciliaris	-	50	Australia
Chloris gayana	-	50	Australia
Clitoria ternatea	-	10	Gadambalieh farm
Crotolaria senegalensis	3,000	-	Kassala state
Cyamopsis psoraloides	-	450	Gadambalieh farm
Panicum coloratum	-	2,000	Kassala state

The former Eastern State and Kassala State are important areas for the collection of seed of native forage species. Up to 22.5 tonnes of seed of local and introduced forage species was collected in Kassala State in 1996. This amount consisted of 70% *Panicum coloratum*, 10% *Crotalaria senegalensis*, 8% *Ipomoea cordofana*, 5% *Eragrostis tremula*, 5% *Chloris gayana*, and 2% *Blepharis edulis* (Table 5).

The Gash Delta is an important source of seed for several native forage plants. *Cenchrus ciliaris* is collected in the Tindellie area by direct labor under the technical supervision of RPA staff. The seed is collected after it falls on the ground, and 15–45 kg/day per person can be collected, based on stand density, with seed purity of about 85%. *Cenchrus setigerus* is also part of the natural vegetation cover of the Gash Delta, but it is normally not found covering large areas in dense stands. Thus, local laborers are not encouraged to collect its seed, as it takes so much time and effort to fill one sack (the measure of labor).

Table 5. Areas seeded and quantities of seed used in the eastern region and Kassala State.

Season	Area seeded†		Quantity of seed	Type of seed
	Inside	Outside	(kg)	
1990/91	2,100	4,200	27,000	*P. coloratum, Aristida* spp.
1991/92	3,430	8,400	45,000	*P. coloratum Aristida* spp.
1992/93	2,940	8,400	37,500	*P. coloratum, C. ciliaris, Eragrostis tremula*
1993/94	3,360	10,500	60,000	*P. coloratum C. ciliaris, Chloris gayana, E. tremula*
1994/95	3,360	8,400	6,000	*P. coloratum, Aristida* spp., *E. tremula, C. ciliaris*
1995/96	2,520	10,500	52,500	*P. coloratum, Aristida* spp., *E. tremula, C. ciliaris*

† Inside or outside grazing perimeters.

Other native species, which are included in seed collection campaigns, are *Eragrostis tremula* and *Rhynchosia memnonia*, which grow in flood-irrigated areas and along irrigation canals. The latter species is a perennial legume that is collected and seeded in the form of pods, as threshing and cleaning involve additional cost and time. *Panicum coloratum* seed is also collected from flood-irrigated areas. For this species and *Eragrostis tremula* the whole seed-containing panicle could be harvested. If time and funds permit, seed may be threshed, otherwise uncleaned seed may be sown directly. Activities of the RPA office in Kassala State to multiply seed of fodder crops under flood irrigation in the Gash Delta are limited. In Darfur, the collection of native forage species includes *Aristida* spp., *Brachiaria, Blepharis* spp, *Cenchrus*, and *Echinocloa colonum*. Limited amounts of seed of Siratro, clitoria, and phillipesara are also harvested.

Seed collection from natural stands, nurseries, and grazing perimeters is also practiced in Kordofan. Native species such as *Andropogon gayanus, Aristida* spp., *Blepharis, Cenchrus* spp., *Dactyloctenium aegyptium, Echinocloa colonum*, and *Eragrostis tremula*, as well as seed of fodder crops such as cowpea, green gram, and lablab, are harvested and collected.

Seed import

Seed imports of fodder crops are limited to alfalfa and forage sorghum (Table 6). Seed imports of tropical pasture species are rare and are associated mainly with the FAO technical assistance to RPA in 1985/86 and the World Bank agricultural development project in 1993.

Tropical pasture species imported for rangeland rehabilitation include: *Cenchrus ciliaris, C. setigerus, Chloris gayana, Panicum* spp., and *Stylosanthes* spp. from Kenya, and *Brachiaria ruziziensis, C. ciliaris, C. gayana, Stylosanthes guianensis, S. hamata*, and *S. scabra* from Australia.

Table 6. Alfalfa and forage sorghum seed imports (kg).

Year	Alfalfa		Sorghum
	Higazi	5929	Pioneer 988
1989		115,000	61,428
1990			60,000
1991	1,000	40,000	305,850
1992			1,300
1993			
1994			
1995			38,000
1996			56,000

Source: unpublished data collected by M.A. Ali, NSA.

Progress

The formal seed industry in Sudan has neglected the production of seed of forage and pasture species. Seed requirements for these species have mainly been met by farm-saved seed. As dairy production around the capital and urban centers flourished, the area under fodder crops grew rapidly, leading to an increased demand for quality seed. Initially, a small proportion of this demand was met by the NSA and RPA through the production of Abu Sabeen, Sudan grass, and alfalfa seed. The Pioneer Seed Company consolidated these efforts through the introduction and production of fodder crop seed, which culminated in the release of sorghum Pioneer 988 and alfalfa 5929. The achievements of Pioneer encouraged other companies, such as Pacific Seeds, to hasten the introduction and evaluation of other fodder crops.

Making farmers aware of the importance of quality seed and the introduction of seed processing technology are among the positive aspects of the seed development program. Progress has also been made on the introduction of a system of delivering seed in small packages to suit the requirements and financial abilities of small producers.

Constraints

Socioeconomic constraints. These include, but are not limited to, the following situations:

- Multiplication contracts are normally given to larger farmers, neglecting resource-poor farmers and female-headed households, which are typically short of both labor and financial resources.
- Marketing policy, price fixation, and demand forecast prior to production constitute major constraints. Marketing is blocked by inadequate management, transportation problems, insufficient storage facilities, and inadequate credit.

Technical constraints. The most prominent technical constraints are:

- Shattering, which occurs with some grass and legume species in general and phillipesara in particular. This discourages multiplication of these species and their use in crop rotations.
- Lack of expertise in the certification of seed of forage species. Certification of forage seed is somehow different from other cereal or grain legume seed. The methodology used for field inspection, seed testing, and blending of lots constitutes a new area for training.
- Local germplasm and introduced species are lost because nurseries are abandoned and/or converted to other uses. The remaining nurseries are small and their activities are limited. Also, no regular records are kept to maintain data and information for interested scientists and technical staff.

Manpower and staff training. Important constraints in this area include:

- Poor qualification of employment manpower. Most of those involved in fodder crop and pasture species seed production have no official training in seed multiplication and technology.
- Training opportunities to improve skills of personnel engaged in seed production are scarce. Only recently have a few national universities included seed technology in their curricula. Even training provided by international organizations and research centers benefits mainly those engaged in food and cash crop seed multiplication and processing.

Other constraints. This covers policy, legislative, and other problems and includes:

- Limited mechanisms and implementation efforts to enhance seed production to match the needs and goals of national agricultural development plans. The medium- and long-term plans call for an increase of more than 150% in quality seed production to meet the requirements of an increasing human population, expansion of agro-industries, and export of agricultural products.
- The area of responsibility of the Ministry of Agriculture and Forestry, as detailed in the 1990 Seed Act, which was drafted and passed prior to the implementation of the federal system of government, is no longer adequate, as no subsequent modification has been made to deal with changes brought about the new system of government.
- The scenarios for international linkages with respect to seed policy and regulations to facilitate dissemination of seed across borders in times of disaster are not well-defined.

Conclusions and Recommendations

Policy. The government should adopt policies to encourage active involvement of the private sector in the development of seed production of fodder crops and pasture species.

The government should take action to re-activate the Seed Council, the advisory body responsible for the preparation of medium- and long-term plans for the development of the seed sector in general and forage and pasture seed in particular. It should then pursue efforts and coordinate actions to implement the approved programs. The Seed Council should take necessary measures to:

- Avoid discontinuity of policies and programs and uncoordinated efforts in order to ensure stability within production, processing, marketing, and certification systems.
- Provide sufficient funding to programs, including seed research.
- Develop and empower a subsidiary body to review plans and monitor implementation of programs in a manner that allows achievement of goals.

Legislation. Legislation should be reviewed and necessary amendments should be made to the Seed Act in order to:

- Sort out federal and state government responsibilities and duties.
- Include items to cover seed production, collection, and marketing of fodder crops and pasture species.
- Ensure the implementation of the various regulations associated with the Seed Act.
- Initiate regional coordination to facilitate cross-border movement and exchange of seed.

Integration of seed production into dryland and irrigated farming systems. Efforts should be made and incentives provided to include pasture and fodder crops within the farming systems to produce seed on a commercial basis. Annual crops such as lablab and Sudan grass can provide one or two cuttings for forage, and re-growth can be allowed to flower and set seed. Perennial crops and pasture species such as alfalfa, clitoria, buffel grass, and Rhodes grass can grow for 3–5 years and provide both seed and forage from the same stand. Seed crops, if properly handled, can prove productive and profitable and can increase farmer income. Such systems require technical assistance and guidance to ensure proper establishment and effective management of the crop to ultimately achieve seed production targets.

Seed production planning. The gaps in knowledge about forage species production and statistics on areas allocated to fodder crops and amounts of seed required hinder proper planning. Statistics and data allow effective and early forecast of needs, and assist producers to make arrangements to produce and make available quality seed. It is expected that cultivar development and the amount of seed produced in the future will depend on trends in range seeding and improved pasture establishment in areas to be put under fodder crops.

Areas for future research. These areas should be continuously addressed by the ARC, projects, and universities. They include, but are not limited to:

- Evaluation and selection of adapted and highly-productive species and varieties for specific ecological zones or agricultural production systems. This will help ensure a constant flow of improved varieties and hybrids of fodder crops and pasture species.
- Establishment of *in situ* conservation of forage germplasm in well-distributed regional nurseries. These nurseries should be managed as reserve living material and a dependable source of seed. It is essential to ensure continuity, management, and maintenance of these nurseries to form a reservoir of local and introduced forage species that can provide researchers with a pool of genetic material for selection and other breeding purposes.
- Study of the economics of seed production. This is a neglected area in the seed industry of Sudan. Data on the seed business is lacking and difficult to find in one administration. The traditional seed production system run by farmers is not well-studied or documented, which makes improvement difficult. Indeed, the economics of seed production of various sectors is an urgent issue to be studied and documented.

Technology transfer. Immediate action should be taken to effectively link and enhance cooperation and constructive interaction among research, extension, and forage and pasture seed producers. Technical assistance should be provided to these producers to motivate them to expand to the production of forage species. A core extension staff, with wide technical and practical experience in seed multiplication and technology, should be established to assist farmers and private companies to implement sound programs and adopt efficient practices to produce, harvest, process, and handle forage seed.

Training. Tropical pasture and forage species seed require handling and treatment that are somewhat different from field crops seed. Hence, forage and pasture seed programs require a well-defined training strategy that should be designed and implemented in a manner that will allow local staff to acquire knowledge and skills. The creation of a core of well-trained seed technologists and analysts is an essential element and a useful tool to strengthen the seed production capabilities of national programs.

Initiation of linkages with other countries, ARCs, and organizations. This is envisaged as being carried out through the following actions:

- Exchange of seed and planting material with similar institutions in developing countries and ARCs.
- Promotion of links between national institutions involved in the seed industry and international organizations active in the field of forage species seed production, research, and technology.
- Encouragement of regional seed trade. Such trade should be based on standards and should have a mechanism for regional forecast of possible seed requirements in concerned countries.

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Forage Crop Seed Production and Research in Egypt

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Abstract

Production of herbage seed has a long tradition in Egypt. Berseem and alfalfa seed is produced in small areas as a secondary product, mainly for forage. Egypt's marginal lands comprise smallholdings where landraces of self-fertilized forage crops and populations of cross-pollinated forage crops predominate. Despite the availability of essential factors for seed production, such as a wide genetic base of the main forage species, a favorable climate, and high seed demand by foreign markets, little effort has been made to establish a seed industry for forage crops. The public sector plays almost no role in forage seed production and supply. The Forage Crops Research Department, affiliated with the Agricultural Research Center of the Ministry of Agriculture, has contributed significantly in improving the flow of breeder seed. On-farm demonstrations using developed high-yielding cultivars of various forage species have shown that the use of these cultivars on farmers' fields could enhance forage productivity by 20–25%. One of the basic limitations to achieving this goal is the limited availability of seed of improved cultivars to replace obsolete varieties at a suitable rate.

Introduction

About 96% of Egypt's land is desert. The cultivated area, all of which is fully irrigated, accounts for only 4% of the area. The Nile River is the main source of irrigation. About half of the cultivated area (1.5 million ha) is devoted to growing berseem clover (*Trifolium alexandrium* L.), which is the main source of livestock feed in Egypt. Egypt is dependent mainly on irrigated forages for livestock feed. Seed is a major input in agriculture. Without formal seed production and distribution systems, improved high-yielding varieties cannot be made available to farmers. Improved seed supply leads to an increase in productivity and feed supply.

Forage Species Grown in Egypt

Berseem is the oldest cultivated species and the basic forage crop for a sustainable cropping system in Egypt. It is the major winter forage crop and precedes cotton in rotation as a means of enriching the soil with atmospheric nitrogen. Other forage crops of secondary importance are: alfalfa (*Medicago sativa* L.), Sudan grass

(*Sorghum sudanese*), pearl millet (*Pennisetum glaucum* L.), bonavista bean (*Dolichos lablab* Schum.), and toesinte (*Euchlanea mexicana* Schrad) (Radwan and Rammah 1992). Alfalfa is indigenous to most of the Oases in the New Valley, and there is a tendency to expand alfalfa cultivation into the newly-reclaimed land in the Egyptian desert. The area cultivated to alfalfa has reached about 63,000 hectares. Unique local ecotypes and varieties of different forage species include berseem clover, alfalfa, pearl millet, Sudan grass, cowpea, toesinte, and *Lathyrus*. Genetic variability in forage productivity, plant type, number of cuts per growing season, and tillering has been found in farmers' seed lots of berseem clover (El-Nahrawy et al. 1996b). Evaluation, utilization, and enhancement of the collected material have resulted in improved high-yielding berseem cultivars. Indigenous forage species are essential for the expansion of agriculture into desert areas, where most other plant species are unable to grow.

Breeding Program: Collection, Evaluation, and Selection

During the last decade, hundreds of local berseem germplasm accessions were collected by the Agricultural Research Center (ARC) in collaboration with IPGRI. Studies have shown a wide variation in agronomic performance among accessions that reflect regional adaptation to edaphic and climatic conditions (Table 1).

Table 1. Performance of collected seed samples of berseem.

Region	Number of seed samples collected	Trial location	Forage yield		Percent of lots that exceeded check by more than 20%
			Mean	Range	
Middle Delta	100	Giza	56.2	40.5–72.4	12.0
		Gemmiza	63.3	45.5–83.1	19.0
Southern Delta	72	Giza	54.8	27.6–73.9	06.9
		Gemmiza	63.6	45.5–80.5	13.9
Middle Egypt	46	Giza	60.2	37.6–73.1	13.0
		Gemmiza	64.3	36.9–81.4	04.3
Upper Egypt	22	Giza	53.1	35.5–61.4	04.5
		Gemmiza	56.4	38.1–71.9	04.5
Fayoum	4	Giza	65.9	58.6–70.9	
		Gemmiza	69.3	66.4–71.7	
Unknown	87	Giza	69.3	29.3–71.4	03.4
		Gemmiza	58.6	37.4–79.1	04.6

Adapted from El-Nahrawy (1980).

Selection from this material resulted in several improved synthetic varieties. On on-farm trials most of the improved berseem cultivars outyielded farmers' cultivars by 8–11% (Table 2).

Table 2. Performance of improved berseem cultivars averaged over 18 provinces (1992/93 and 1993/94).

Cultivar	Number of data years	Herbage yield (t/ha)		Percentage of superiority over farmers' cultivars
		Mean	Range	
Farmers' cvs	2	117.50	93.12–142.93	-
Hilali	2	130.29	100.84–153.76	10.89
Giza 15	2	127.58	97.69–164.95	8.58
Sakha 4	1	126.79	92.55–167.93	7.91
Gemmiza 1	1	128.71	93.50–163.92	9.54

Collection, evaluation, selection, and varietal improvement of local alfalfa ecotypes resulted in the development of high-yielding cultivars that outyielded introduced cultivars. Local alfalfa ecotypes evaluated at Ismailia Research Station outyielded DFP-S, the variety introduced from France. Alfalfa varieties developed from local germplasm outyielded WL-605 in different locations and on different soil types. Similarly, some local populations of pearl millet outyielded introduced populations and hybrids. Table 3 demonstrates the effect of soil type on forage dry matter production. Pearl millet was sensitive to salt but performed well on calcareous soil.

Table 3. Effect of soil type on dry matter production of pearl millet.

Location	Soil type	Averaged dry forage (t/ha)	
		Trial 1[†]	Trial 2
Nubaria	Calcareous	8.72 a	8.19 a
Shandaweel	Clay	6.10 b	6.13 b
Sakha Gemmiza	Moderately salt-affected	2.38 c	2.12 c
Ismailia	Sandy	1.75 d	1.79 d
El-Serw	Severely salt-affected	1.08 e	1.10 e

[†] Trials 1 and 2 included 11 and 7 populations and hybrids, respectively.

Unique ecotypes of various forage species were recognized, and their morphological identity was maintained because farmers were keen to produce their own seed.

Exceptional local ecotypes and varieties of berseem clover (El-Nahrawy et al. 1996a, 1996b), alfalfa (El-Nahrawy and Rammah 1995), and pearl millet are regarded as a pool of variability for breeding and development of important forage varieties. Variety trials show that introduced alfalfa varieties often perform less well than local ones (El-Nahrawy and Rammah 1995).

Forage Seed Production: Potential and Limitations

Despite the availability of improved and high-yielding cultivars of various species for both forage and seed production, forage seed production is not well-developed. The public sector plays almost no role in forage seed production and supply. Most of the available seed is produced by farmers. Farmers have traditionally produced their own seed or purchased what they needed from local markets. This seed is not controlled and is of poor quality (El-Nahrawy et al. 1996c). Nevertheless, villages were originally self-sufficient in berseem seed.

Seed Export

Due to the valuable and desired agronomic characteristics of Egyptian forage ecotypes and cultivars in general, and berseem clover and alfalfa in particular, large amounts of seed are currently exported to many countries. In 1989, Egypt exported almost 7,400 tonnes of berseem seed. Since then export demand has been increasing, and is now about 13,000 tonnes per year. Furthermore, local alfalfa varieties (i.e. Siwa and Ismailia 1), characterized by high levels of tolerance to salinity, have gained recognition in Argentina (Rammah, personal communication), resulting in increased export demand for seed. Argentina is currently seeking to import about 2,500 tonnes of alfalfa seed annually of these two Egyptian cultivars, but seed is not available to meet this demand.

Conclusions

Although the forage seed industry is not well-developed in Egypt, it has great potential. Most, if not all, of the essential factors for a successful forage seed industry are available in Egypt, including adequate irrigation, harvest and maturation periods free from rain, and suitable soil. Despite these natural advantages, some seed production problems remain to be solved, such as proper pollination of alfalfa, pest control (especially under intensive production), and maintaining a balance of available trace elements in the newly-reclaimed sandy soil. Improvements in these areas would increase the potential of forage seed production in Egypt, provided a sound infrastructure for a seed industry based on forage crops is established.

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Problems and Progress in Forage Seed Production in Cyprus

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Abstract

This paper presents research findings on the most important forage crops for use in the low rainfall areas (200–350 mm) of Cyprus, with reference to agronomic characteristics such as establishment, growth habit, yield, and quality. Low rainfall limits the number of crops that can give satisfactory biomass and seed yield. Experimentation under local conditions has shown that the most suitable crops are annual cereals (mainly barley and oat, and to a lesser extent triticale and ryegrass), annual legumes (vetch and fodder pea), and mixtures of cereals and legumes (vetch and pea grown with oat or triticale). These mixed crops produce more hay than pure legumes, although of lower quality. It has been shown that forage production can be maximized and quality enhanced through better cultural and management practices, such as sowing the right variety on time and using recommended seed and fertilizer rates as well as using the right harvesting method. Throughout the experiments, the production and availability of seed was a prime consideration. Seed production of barley, the main forage crop in Cyprus, and of most other cereals, is fully mechanized, while that of legumes in general and medics in particular, is not. Seed production practices are also discussed.

Introduction

Rainfall in the Mediterranean basin is restricted to a short period in the winter months (November to April), with unpredictable distribution throughout the cropping season. As a result, only a very few species can grow and give satisfactory yield. Under these conditions, it is necessary to conserve part of the winter production in the form of hay or silage for utilization during the rest of the year. The choice of crops in rainfed agriculture is limited to drought-tolerant species. Besides resistance to drought, other major considerations in the selection of forage crops include: (i) versatility of utilization (used as grain and straw, grazed, or conserved as hay and silage); (ii) high potential for forage production and ease of seed production; (iii) efficient utilization of available moisture; and (iv) ease of planting and adaptation to mechanical harvesting.

The main objective of this paper is to report the findings of research concerning the most important crops that can be used as forages in the low rainfall areas (200–350 mm) of the Mediterranean basin, with particular reference to agronomic characteristics such as growth habit, establishment, yield, and seed production.

Forage Crops Grown in Cyprus

Experimentation under Cyprus conditions has shown that the most suitable crops are: (i) annual cereals, particularly barley and oat, and to a lesser extent triticale and rye; (ii) annual legumes such as vetches (lana, common, and narbon) and fodder pea; and (iii) mixtures of cereals and legumes, such as vetch and pea grown with oat or triticale (the cereal serving as a support to prevent the legume crop from lodging). These mixed crops always produce more hay than pure legumes, although of lower quality.

Annual Cereals

Barley

This is the most important crop and is used for grain and straw. It can be grazed or converted into hay or silage, depending on need. Until 1978, the only variety grown for hay was Athenais, which is outyielded by the varieties Morocco 628 and Alger 48 (Hadjichristodoulou 1976). Alger 48 has high tillering capacity, a prostrate growth habit, and can be either grazed or repeatedly cut at the tillering stage up to four times a year. Two new barley varieties were recently released: Hooded-94 and Lyssi. Hooded-94 has no awns but has hoods. The hay of this type of barley is more palatable than awned or awnless barley if cut after the heading stage when dry matter, protein, and digestible yields are at their highest. Hooded-94 has more vegetative growth and gives about the same dry matter but produces more seed than Morocco 628. Lyssi has higher vegetative growth and produces more seed but about the same dry matter yield as Morocco 628. Lefkonico and Kythrea are new barley varieties recommended for cultivation on the basis of grain and straw yields.

Oat

Oat is grown for hay, either alone or in a mixture with fodder pea or vetch. The Agricultural Research Institute recently released two new oat varieties for hay production. Mulga is suitable for cultivation only in pure stands, while Algerian is suitable for either pure stands or in a mixture with vetch or fodder pea (Droushiotis 1989a, 1990). Algerian reaches the milk stage of grain 10 days later than Mulga, which is an advantage because hay production can be spread over a longer period for easy curing.

Annual Legumes

It is well known that legumes are more palatable and have a higher digestibility and crude protein content than cereals. However, their prostrate growth habit renders legumes difficult for mechanical harvesting. Legumes such as vetch and pea are therefore frequently sown in mixtures with cereals (triticale or oat), which serve as a support to prevent the legumes from lodging.

Common vetch (*Vicia sativa*)

This is the most important legume used for hay or forage production in the semi-arid regions of the Mediterranean basin. Two varieties are used in Cyprus: the local vetch and a new variety, Achilleas, which matures one week later than the local variety (Droushiotis 1992a).

Forage pea (*Pisum sativum*)

This legume is mainly used for making hay, and should be sown in mixtures with oat or triticale. The period for haymaking is between flowering and the time when the seed is well-formed, otherwise drying becomes difficult, resulting in moldiness of the seed and reduction in palatability. A new (dry) fodder pea variety, Kontemenos, was recently released for grain production (Hadjichristodoulou 1994).

Narbon vetch (*Vicia narbonensis*)

This species of vetch is relatively unknown as a commercial crop. In Iraq and Turkey it is used as a pulse for human consumption or as livestock feed. It appears promising under Mediterranean conditions. Dry matter, digestible organic matter, and crude protein yields of narbon vetch were 11, 15, and 14% higher than those of the local vetch, respectively. Similarly, according to Droushiotis (1992b), narbon vetch has a higher grain yield (2,470 kg/ha) than the local vetch (1,906 kg/ha).

Medic (*Medicago* spp.)

Under Cyprus conditions, medics show disappointing results when used in rotation with cereals on arable land and for pasture improvement on marginal lands. The main reasons for this failure are: (i) slow growth during winter (December–February), resulting in severe weed competition and late availability of forage for grazing; (ii) lower dry matter yield compared to other legumes (common vetch and lana vetch) and cereals; (iii) unsatisfactory regeneration for establishing a good pasture stand in the following season; and (iv) difficulties in the production of seed. In experiments carried out in Cyprus it was found that the best varieties were Borung and Cyprus (*Medicago truncatula*). Some accessions belonging to *Medicago rigidula*, recently introduced by ICARDA, have shown promising results. The recommended seeding rate for maximum dry matter yield is 10–20 kg/ha, while for pasture development 20–30 kg/ha is considered adequate. Yield, growth, and population density were not affected by application of P_2O_5 at 0, 45, 90, and 135 kg/ha (Droushiotis 1980).

Management Techniques

Compared to cereals, little work and less information is available on the cultural practices of forage crops.

Time of Sowing

Sowing cereal and legume crops too early in the dry areas is likely to be disadvantageous, because soil moisture may be insufficient to ensure adequate germination. Sowing too late is likely to reduce the length of the growing period and thus restrict plant growth and productivity. Therefore, sowing time is an important factor affecting yield in dry lands. Results from Cyprus (Photiades and Hadjichristodoulou 1984) show that under dryland conditions, there is an optimum period for sowing, which depends on the rainfall pattern. In Cyprus and Syria this period is from about mid-November to mid-December.

Seeding Rate

Under rainfed conditions seeding rate affects forage crop yield. Under this condition, competition for soil moisture is a critical factor. Results from Cyprus have shown that the optimum seeding rate for forage barley varieties is 185–200 kg/ha (Hadjichristodoulou 1975; Droushiotis 1989b). The higher rate required by triticale to obtain maximum dry matter yield is due mainly to its lower tillering capacity when compared to barley (Hadjichristodoulou 1984) and oat.

The optimum seeding rate for lana vetch and common vetch is 130 kg/ha, and 160 kg/ha for fodder pea (Hadjichristodoulou 1975). The digestibility and crude protein content of barley, oat, and triticale are not affected by seeding rate (Droushiotis 1989b), nor is the crude protein content of legumes (Hadjichristodoulou 1975). Hay yield of *Lathyrus sativus* and narbon vetch varieties increases as seeding rate increases from 60 to 140 kg seed/ha (the rates tested were 60, 80, 100, and 140 kg seed/ha).

The recommended seeding rate for mixtures depends on both the crop used and the targeted dry matter yield (Droushiotis 1989a).

Fertilizer Application

In the semi-arid regions, fertilizer requirements for forage crops depend to a large extent upon soil, climate, and particularly on the availability of moisture to the crop. Under rainfed conditions, nitrogen rates can be based on the amount of water stored in the soil and on the amount of rainfall. In Cyprus, not only is rainfall limited in amount, but it is also erratic in distribution. As a result, neither forage nor grain yield, nor the fertilizer requirement, can be predicted at seeding. Results obtained at the Cyprus Agricultural Research Institute have shown that the response of forage barley to nitrogen is significant in years of relatively high rainfall (350–400 mm) but less important in dry years. Droushiotis and Willman (1987) report no response of barley to applied nitrogen at 0, 45, and 90 kg N/ha for two successive cropping seasons. The lack of appreciable response to nitrogen is due mainly to the presence of available N reserves in the soil resulting from manuring or preceding legume or fallow (Papastylianou 1989).

Fertilization of leguminous forage crops can be considered only when there is no efficient *Rhizobium* in the soil. It has been shown that for legumes which fix N_2, application of nitrogen fertilizer does not increase dry matter yield, but in fact suppresses the fixation process (Papastylianou 1988). A small dose of nitrogen fertilizer (10–15 kg/ha) is often recommended at sowing. However, when efficient *Rhizobium* is not present in the soil, leguminous seed must be inoculated with the recommended *Rhizobium* strains or N fertilizer should be applied.

Management Practices for Forage Seed Production

In Cyprus, seed production of cereals and forage legumes is mostly conducted by farmers. A combination of knowledge and skill is the key element of satisfactory seed yield.

Management practices that are favorable for the establishment, growth, and herbage production of forages are generally also beneficial in seed production. This is particularly true when seed is harvested opportunistically after one or more cuts during the season. However, when growing forages for seed production, there are certain practices that are more important for seed than for forage production.

Seeding rate for seed production is usually lower than for forage production, unless grazing is planned. In Cyprus, barley is sown at 200 kg/ha for forage production and at 100 kg/ha for seed (Hadjichristodoulou 1975; Photiades and Hadjichristodoulou 1984). For the legumes, *Vicia sativa* and *Pisum sativum*, the recommended seeding rate for forage production is 130 kg and 160 kg/ha, respectively (Hadjichristodoulou 1975), while for seed production the normal rate is 100 kg/ha.

The seed production cost of forage legumes (*Vicia sativa* and *Pisum sativum*) in Cyprus has increased considerably during recent years because of high input costs, the shortage of labor, and inadequate mechanization. Consequently, Cyprus seed prices of common vetch are no longer competitive in the international market. As a result, seed export of these legumes has ceased and Cyprus has recently become a net importer of this product.

Some trials have been conducted on mechanical harvesting of forage legumes to reduce seed production costs, with encouraging results. However, full mechanization cannot be applied in hilly areas where *Vicia sativa* is grown mainly for seed. Consequently, the area for legume seed production is on the decline.

Another limiting factor for the expansion of seed production of legumes is the problem of weeds, particularly *Orobanche* species. After several years of trial work, pre-emergence herbicides are now recommended.

Lack of Seed Policy

Because of high costs, the shortage of labor, inadequate mechanization of harvesting, and lack of a pricing policy, the area of forage legumes in Cyprus has been significantly reduced in favor of cereals, for which seed production is fully mechanized and subsidized by the government. However, cereal monoculture, which is practiced to a large extent in the rainfed areas, is not desirable, due to reasons such as the increase of noxious weeds, disease, and deterioration of soil fertility.

Recommendations

To improve the forage seed supply system in Cyprus, the following are recommended:

- Grow forage seed crops in areas with high precipitation.
- Introduce mechanization of forage legumes where possible, in particular, for harvesting.
- Identify ways to control weeds, particularly *Orobanche* in forage pea and other legumes.
- Encourage the production of forage legumes, which can be used in rotation with cereals, as was done in previous decades. To promote the forage legume industry, compensatory payments must be made to the growers, as is done in the European Union.

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Forage Seed Production in Yemen

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Abstract

In Yemen, the seed sector in general, and forage and pasture seed in particular, are at an early stage of development. The sector suffers from a lack of organization, a weak breeding program, a lack of legislation, limited technical knowledge, and insufficient trained manpower. Most of the forage and pasture seed used by farmers is saved on the farm or purchased from local markets.

Introduction

The republic of Yemen covers an area of 55.5 million hectares. The arable land is about 3.5 million hectares, with an annual cropping area of about 1.7 million hectares, of which 579,391 is rainfed and 488,276 is irrigated. The remaining area is rangeland, forest, and desert. Forage crops cover about 88,000 hectares and produce about 86 tonnes of dry matter annually. About 70% of the forage area is covered by lucerne and sorghum. Permanent pastures occupy another 16 million hectares. Rangelands provide about 50% of the total feed supply, mainly for sheep and goats, with the remainder coming from crop residues, grazing of crop lands, and supplementary feed.

Pasture and Forage Research

Forage and pasture research started in 1983. The main activities include:

- Collection and conservation of plant genetic resources.
- Making this material available to the breeding program.
- Exchange of material with the international community.
- Establishment of a national database for plant genetic resources.
- Improvement of national awareness about the importance of plant genetic resources, particularly among local communities.

One of the most important studies carried out in the country (with financial support from FAO) was on the conservation and propagation of range, pasture, and forage plant genetic resources. This study identified the main pasture, forage, and range species, and handled the collection, characterization, recording, and preservation of 164 seed samples from key species (Table 1).

In the Tihama region (coastal plains) 20 trials were conducted to evaluate local and exotic forage species. Three cultivars from perennial forage species were released, and some promising species were identified for further evaluation.

Table 1. Seed samples of range, pasture, and forage crops.

Region	Number of collected samples
Southern coastal plain	49
Southern upland	38
Central highlands	32
Northern highlands	27
Eastern desert plateau	18
Total	164

Forage and Pasture Seed Production

In Yemen, the forage and pasture seed supply system is totally informal, with most of the farmers saving their own seed or purchasing some of what they need from the local market. The General Corporation for Seed Multiplication (GCSM) is responsible for the overall coordination of seed activities in Yemen. This organization, however, is not involved in forage and pasture seed production. Its activities focus mainly on the production of cereal, cotton, and potato seed.

Constraints of Forage and Pasture Seed Industry

Constraints to the production and use of forage and pasture seed are mostly technical, institutional, and socioeconomic. They include:

- Lack of well-organized programs for breeding and release of new varieties.
- Lack of an organizational structure.
- Lack of technical knowledge and poor infrastructure.
- Lack of technically-qualified personnel in seed production and technology.
- High cost of seed and fertilizers.
- Lack of seed demand.

Conclusions

Many recommendations for future work to overcome these constraints and to help activate and strengthen the forage and pasture seed production program in Yemen have been identified. Government intervention is needed on two levels. First, to encourage the establishment of farming systems that use pasture and forages. Second, to produce early-generation seed for multiplication. In the long term, forage and pasture seed production should be profitable.

Pasture and Forage Seed Production in Eastern Anatolia, Turkey

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Abstract

Eastern Anatolia covers the eastern part of Turkey, which is situated on a high plateau with a land area of 135,000 km^2. Agriculture is the most important economic activity in the region, accounting for more than 50% of GDP for the region and 14% for the whole country. The climate and geography are the main constraints to alternative cropping practices, but the ecology is more favorable for livestock production. An extensive grassland-dependent livestock production system prevails in the region. Although livestock provides a major part of family income, the traditional cereal-dominated farming system does not support this activity. The supplementary feed produced on private land is not enough even to maintain livestock during the winter. A joint project was conducted by the Government and the United Nations Development Programme (UNDP) to promote production and improvement of pasture and forage crops. The project aimed at initiating a self-sufficient and sustainable system in the villages. Large farmers were encouraged to specialize in seed production. After the privatization of some government seed distribution organizations, an urgent need arose for a more comprehensive pasture and forage seed production and distribution network. In collaboration with local institutions, a large-scale seed production project proposal was prepared and presented to the Government and the UNDP. The objective is to create a pasture and forage seed production union, which will produce and distribute seed on a contract basis.

Introduction

Although 40% of the population in Turkey is dependent on agriculture, the contribution of agriculture to the national economy is decreasing. This decline has been even greater in the livestock industry, which is one of the main components of the agricultural sector. Agriculture contributes 14–16% of the country's gross national product, of which 30–35% comes from livestock industry.

Eastern Anatolia is located on a high plateau, with elevation varying from 500 to 5,500 m above sea level. It has a continental climate with severe winters and short, relatively hot summers. Annual mean temperatures range between 6°C and 12°C. Average annual rainfall ranges from 360 mm to 1000 mm, which is evenly distributed across seasons, but varies considerably across the provinces. Natural pastures and meadows comprise 65.9% of the total area, and forage crop production is practiced on 8.4% of the arable land. For centuries, livestock production has played a vital role in the rural community by providing food, fuel, and clothing. Nowadays, farmers may not be as dependent on livestock as they used to be, but it is still the main source of income (60% of family income) for the majority of farmers. Thus, whenever a development project was considered for the region, livestock and forage improvement were given a priority. However, current forage production can only provide 30% of the feed requirement. Shortage of hay is aggravated during mid-winter and early spring. Farmers try to alleviate this feed deficit by supplementing poor-quality cereal straws.

Improving the living standard of the rural people in Eastern Anatolia has been one of the priority goals of the Turkish Government. In fact, the government has launched several projects in the last three decades, but most of the projects have emphasized the improvement of animal breeds rather than the integration of forage and seed production with livestock management. The planned objectives of these projects have not been realized, and little change has taken place in the existing farming system. In other words, the cereal-growing area is still eight times larger than forage crop area in the region.

In addition to national projects, some rural-development projects financed by the World Bank and IFAD have been implemented in the region. Forage crops, livestock improvement, and forage seed supply have been the main components in these projects. Although these projects have made substantial contributions to forage crop production, the problem of forage seed production still remains.

Rainfed Forage Crop Production

Due to the migration of the young labor force to the western and coastal parts of the country, old farmers prefer to grow less labor-intensive perennial forage crops. Rainfed forage crops are exclusively cut and cured for hay, thus no silage is made in the region and very little forage is fed green. Sainfoin (*Onobrychis viciafolia*) is the most widely-grown rainfed perennial species in the region, found mainly on sloping marginal lands. Common vetch (*Vicia sativa*) is grown much less frequently, and is usually cultivated on the most fertile soils. It is seeded in April and harvested in late July. Most of the rainfed crops are grown under traditional and extensive two-year cereal/fallow rotation systems. Recently, a two-year cereal/legume (vetch or chickpea) rotation was introduced into the system by the National Fallow Reduction Project. Consequently, the government introduced winter vetch (*Vicia pannonica*) into the cropping system. This type of vetch, which can survive harsh winters and benefits from spring rains, has great potential in Eastern Anatolia, and is already replacing fallow land in traditional cereal/fallow rotations. The Eastern Anatolia Agricultural Research Institute (EAARI) has given priority to the breeding, seed multiplication, and distribution of this type of vetch.

Irrigated Forage Crop Production

Irrigated forage crop production is dominated by alfalfa (*Medicago sativa*), which is familiar to farmers and grown in all provinces. Several varieties, including local landraces, are used, and thirty-year-old stands are found in some areas. Despite their relatively low yield, local cultivars persist longer than improved high-yielding ones. Thus, a breeding program was initiated at EAARI to develop long-lasting but high-yielding alfalfa cultivars, and several new varieties will be released shortly. Alfalfa is grown for hay, and can be cut 2–4 times a year, resulting in 10–20 tonnes of dry matter/ha. The other irrigated forage crops are common vetch, sainfoin, and, exceptionally, barley and oat (Fig. 1).

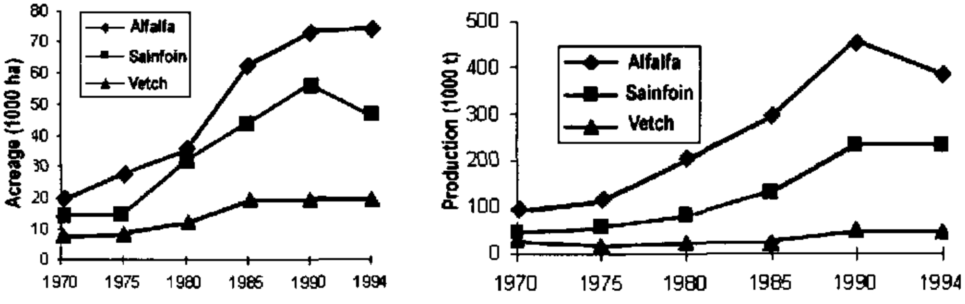

Figure 1. Acreage and production of forage crops in rainfed and irrigated land of Eastern Anatolia.

Crop rotations practiced in the irrigated areas are not systematic and do not aim at conserving soil productivity or even maximizing crop yield. The cropping pattern in irrigated land is mainly governed by farmer need and market price. Some cash crops, like sugar beet, potato, and sunflower, are given priority. Therefore, for a forage crop to become an integral part of the rotation system, it must compete economically with these crops or have clear agronomic benefits.

Pasture and Rangeland Production

The rangeland is used by the village community without management. Farmers compete to benefit from these lands in an opportunistic way. Thus, improper use and overgrazing have resulted in severe degradation of most of the rangeland in the country. Little has been done to improve these lands. The problems are not so much technical as economical, cultural, and social. Since the users refuse to participate in rangeland improvement, range rehabilitation has been left to government institutions, although this is not an effective solution. Rangeland rehabilitation has always been a component in rural development projects, but any decision to improve or alter it must have the approval of and be implemented by the users in the community. However, overall agreement of the farmers is rarely achieved and no real progress has been made.

In addition to the new EAARI project on the collection and evaluation of local germplasm to develop appropriate cultivars for the improvement of rangelands, some NGOs have recently created public interest in the environment and rangeland protection. At present, they are raising considerable funding and actively participating in range rehabilitation. This has created a great demand for seed of adapted cultivars.

Pasture and Forage Seed Production in Eastern Anatolia

Farmers are accustomed to producing their own seed by retaining part of their crop for seed production. At present, due to lack of labor and equipment, they are largely dependent on the market for the supply of forage seed.

In the formal sector, research institutes are mainly responsible for producing basic seed. The seed is then increased by regional state farms and distributed to farmers through state-owned or private companies. Privatization of many state-run seed companies has encouraged the private sector to play an active role in seed multiplication, importation, and distribution. However, most private companies in the country deal with high-value, cash crops, and operate in the western and southern parts of the country where these crops are grown. Availability of high-quality seed of adapted forage species and cultivars is of crucial importance in the region. Limited supply of certified seed of forage crops has left the farmers with an uncontrolled local market, where procurement of pure and uncontaminated seed of desired varieties is almost impossible.

Livestock and Development Projects

In addition to national livestock and fodder-crop production improvement projects in the region, there are some *foreign-financed* projects.

Erzurum rural development project

This project was jointly funded by IFAD and the World Bank, with a total budget of US$ 137 million. Improvement of forage crop production, along with the development of a sustainable seed supply network, were the main components of the project. The project focused on the introduction of new varieties into the farming system, and the encouragement of farmers to be self-sufficient in terms of seed supply. Initial seed of forage species was purchased and distributed to farmers on a contract basis. In addition to forage production, a part of the field was to be retained for seed production and the seed produced would go back to the project. To some extent the system worked well, and new high-yielding varieties were adopted by the farmers, and a considerable increase in forage crop acreage was realized. However, this measure was not sustainable and failed in the end. Seed production was abandoned by farmers because it was considered an additional activity and labor demanding.

Pilot project for production and improvement of pasture and fodder crops in eastern Anatolia

This project was financed by the UNDP and the Turkish Government, executed by FAO, and implemented by EAARI. The objective was to improve forage and livestock production in selected villages of the 12 least-developed provinces of Eastern Anatolia. It aimed at developing a pilot forage crop production system for Eastern Anatolia. Integration of livestock and crop production was an outstanding element in the project.

Initial surveys indicated that farmers were not willing to change from cereal to forage crop farming systems, because of the high establishment cost, mainly attributable to the high seeding rate. Identifying this obstacle, the project introduced drills to the farmers. Consequently, seeding rate and establishment cost were cut threefold. The required seed in pilot villages was produced by EAARI during the project implementation phase. To ensure a smooth supply of forage seed after the end of the project, selected farmers were provided with basic seed and technical assistance to grow seed for local sale. Farmers who benefited from this operation are, as of this writing, still carrying it out. However, this model needs to be extended to the whole region.

Eastern and southeastern Anatolia forage and livestock development project

This project adopted the same philosophy as the previous project and has worked on selected villages with an integrated approach. Pilot villages were supported with equipment, seed, and technical assistance. The initial phase of the project was very satisfactory, and proven technologies were easily adopted by local farmers. However, budget cuts, addition of new provinces, and staff turnover had a negative impact on the project. Supply of forage seed to the pilot villages has been undertaken by the project at about half the production cost, which attracted farmers to grow more forage but not seed.

Bingöl and Mug rural development project

This project, jointly funded by IFAD and the Turkish Government, was implemented in two provinces of Eastern Anatolia in 1991. Procurement of forage seed was undertaken by the project, and seed was distributed to the farmers with a 50% subsidy. Regional promotion of forage seed was not foreseen in the project.

Improvement of forage seed production in Eastern Anatolia

This proposed project has been specifically prepared for the promotion of seed production in Eastern Anatolia. In collaboration with the Provincial Directorates of Agriculture, the project will be implemented by Atatürk University and EAARI, and financed by the UNDP. The overall objective of this project is to overcome the low seed supply and provide farmers with a regular and cheap supply of seed of desired species. Basic seed will be produced under the supervision of the University and Research Institute, and then multiplied by foundation seed organizations (state farm or private company) before it is distributed to the contract growers for further increase. The final seed will be collected from the contractors, cleaned, packed, labeled and then distributed to the end users.

Conclusions

To merely maintain the existing forage crop acreage in Eastern Anatolia, the annual certified seed requirement for alfalfa, sainfoin, and vetch is 600, 1,500, and 2,500 tonnes, respectively. Moreover, there is an increasing trend towards forage crop acreage, while at the same time fewer and fewer farmers are producing their own seed. These figures may grow rapidly, and thus firm measures need to be taken urgently.

Privatization of state-run seed distribution will create a gap in seed production and distribution. To take over these organizations and ensure the smooth supply of quality forage seed, the government should encourage the private sector or farmer unions to establish solid seed foundations. These foundations should have the responsibility of producing and disseminating certified seed in the region. Rather than encouraging farmers to grow their own seed, contract growers should be encouraged to produce forage seed under the supervision of an official seed certification agency.

To meet the increasing demand for forage seed, national and regional research institutions should focus on the improvement of rangeland-type cultivars and the production of breeder seed. There is a constant demand for lucerne, sainfoin, and vetch seed, but grass species must also be introduced to the region. Some grass species, such as brome grass and crested wheat grass, are much more tolerant to unfavorable conditions and produce high-quality hay for long periods. These species are tolerant to adverse environmental conditions and could also be used to reduce fallow and improve already deteriorated rangelands.

The climate in Eastern Anatolia is favorable to forage seed production. However, there has been no attempt, public or private, to establish a network to produce forage seed locally. Instead, seed is imported from other regions or from abroad. Establishment of local seed production will generate an alternative income for the country.

Forage Seed Production in Ethiopia: Potential and Limitations

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Abstract

Native pastures are an important source of livestock feed in Ethiopia, but due to their low productivity they fulfill only about 50% of the country's animal feed requirements. Natural grasslands occur in conditions considered adverse for crop production, but increased human population pressures are forcing the extension of cropping onto the grasslands. The introduction of improved forages into different farming systems is therefore crucial to overcome the feed shortage problem, which is limiting livestock productivity. Considerable research has been carried out to test the adaptability of different forage crops under varying environmental conditions in order to select suitable species for Ethiopia's different agro-ecological zones. As a result, many high-yielding and better-quality grass and legume species have been selected. However, most of these selected forage crops have not been introduced to the different farming systems in the country, one of the limiting factors being lack of seed. This paper describes the current status of forage seed production in Ethiopia and makes suggestions for its future direction.

Introduction

Ethiopia is a country with a favorable environment and wide resources of traditional skill and experience in livestock raising. The livestock population, which is considered the highest in Africa, is the source of a considerable part of the country's national income. Agriculture contributes about 60% of the gross domestic product and the livestock sector about 25% (FAO 1975).

In Ethiopia, cattle are an investment and also provide draft power for the plowing and cultivation of land. In addition, cattle play a major role in the diet of farmers and their families. In spite of these multiple uses, the potential of this sector has not been fully exploited because of low productivity.

Low productivity of Ethiopian livestock is a result of several factors, among which nutrition is the major limiting factor. For the country as a whole, the existing feed does not meet more than 53% of the amount required (AFRDA 1978). Natural pastures provide more than 90% of animal feed. In almost all parts of the country natural grasslands are confined to degraded shallow upland soils, fallow crop lands, and soils that cannot be successfully cropped due to physical constraints such as flooding and waterlogging (Jutzi et al. 1987). They are low yielding and their production is insufficient. The dry matter of heavily-grazed grasslands does not exceed 1.5 t/ha in the highlands above 2,600 m or 2.5 t/ha below this altitude. In several parts of the country grazing conditions are favorable for only four or five months per year.

In recent years, grazing areas have been shrinking all over the country because of rapid expansion of cultivated lands for crop production to provide food for the ever-increasing human population.

Because of limited feed resources for the existing livestock population, selection of high-yielding and better-quality forage varieties, and development of improved feeding packages are of critical importance. In the past three decades, extensive research has been carried out in Ethiopia to test the adaptability of different species of pasture and fodder crops under different environmental conditions in order to select suitable species for different agro-ecological zones of the country. As a result, various species have been selected for the different zones (Lulseged and Alemu 1985). The selected forage crops in general have better yield and quality than naturally occurring swards.

The introduction of improved forages into different farming systems is expected to help solve the severe feed shortages the country is presently facing. But most of the selected forage crops have not yet been introduced to the farming community. This is due to various limiting factors, among which unavailability of seed is foremost.

Improved Forages in the Farming System

Some previous extension programs tried to introduce selected forage crops into the different farming systems. This was attempted mainly by establishing demonstration plots in different agro-ecological zones and distributing seed of the selected forage crops to farmers. In spite of this, most of the selected forages, except oat, vetch, and fodder beet, are not used outside a few large-scale livestock farms and demonstration plots.

Projects implemented to enhance the productivity of this sector include:

- Arsi Rural Development Unit (ARDU). This project helped develop the widespread use of oat, vetch, and fodder beet in the Arsi region. This program is not functional at present, but farmers in the area have a better concept of fodder production and utilization than farmers in other regions.
- The Extension and Project Implementation Department (EPID) was established in 1971 with the general aim of increasing production by peasant farmers with the emphasis on food crops. The livestock component received comparatively

little attention in this program and forage development was not adequately considered (Gryseels and Anderson 1983).

- A forage development program was initiated in Ethiopia in 1987 by the Fourth Livestock Development Project (FLDP), implemented by the Livestock and Fisheries Development Department of the Ministry of Agriculture. The emphasis of the project was on using more intensive feeding systems, such as the cut and carry system, which leads to a gradual shift away from uncontrolled grazing, particularly on slopping areas. Various forage development strategies were developed. Among these, planting mixed pastures and annual fodder crops did not meet their targets, due to competition from food crops for land and labor. Other strategies, such as strip establishment of forages, backyard forages, under-sowing of legumes with food crops, and over-sowing of legumes on grazing lands, were technically successful and acceptance by farmers was better (Alemayhu and Robertson 1989). This project was phased out a few years ago, and at present there is no adequate information on the level of sustainability of the different forage development strategies introduced.

Overview of Forage Seed Production in Ethiopia

Development Efforts

The success of any forage development program depends upon the establishment of a local seed production capacity for the supply of a large volume of seed. In Ethiopia, though there are large areas with suitable environments for the production of a wide range of pasture and fodder crops, there has been a tremendous lag in forage seed production. As experience indicates, farmers are slow to accept the production of forage crops, because they are reluctant to devote their limited land and labor to the production of forages. They give a higher priority to the production of food crops for subsistence. But, in spite of this, there is an increasing demand for forage seed.

Institutions Involved in Forage Seed Production

- Arsi Rural Development Unit. Forage and pasture seed production began in 1970 in Ethiopia by ARDU. The major emphasis of this project was production of seed of fodder crops, mainly oat and vetch, for distribution to farmers involved in the project. Around 1984, commercial quantities of seed of these herbage species were produced by ARDU (Jutzi 1986).
- Ethiopian Seed Enterprise (ESE; formerly Ethiopian Seed Corporation). Seed production of agricultural crops is the mandate of the ESE, which is a state-controlled company set up in 1979 (Jutzi 1986). The ESE is mainly involved in the production of seed of cereal grains, food legumes, and oil crops. The

Enterprise produces relatively small amounts of oat and vetch seed for use on some privately-owned dairy farms and for sale to some institutions, but does not have a seed production program for the other forage crops.

- Institute of Agricultural Research (IAR). The IAR has a program for the production of seed of various forage crops in small quantities at its centers in the different agro-ecological zones of the country. The primary target of the IAR's micro-forage seed increase program is to meet its research requirements and distribute seed to other government organizations for research and demonstration purposes.
- International Livestock Research Institute (ILRI). ILRI has a forage germplasm unit, which produces seed of different forage species for the National Agricultural Research Systems (NARS) in Africa, including Ethiopia, and other parts of the world. ILRI provides forage seed to the NARS in small quantities for research purposes.
- The Fourth Livestock Development Project. The FLDP of the Ministry of Agriculture initiated a contract system of forage seed production in 1987/88 in Ethiopia. Its forage seed production program aimed at producing better-quality seed at lower prices and greater quantities in centrally-controlled seed production systems using individual farmers and farmer cooperatives. The program placed emphasis on the production of forage legume seed, with a capacity of 100–120 tonnes of forage seed per year during its period of operation. The project is not functioning now, and the seed production program ended as soon as the project was phased out.

Research on Forage Seed Production

Pasture research in the national program of the IAR has gained momentum in the past 25 years, but research on forage seed production began only recently, and only a very few problems have been addressed so far.

The production of seed of perennial grasses meets with difficulties in the tropics. Ripening seed may shed easily and early. Flower spikes appear gradually, and when some shoots have ripe seed, others have only begun to flower (Bogdan 1977). All these factors can reduce the potential yield of the grasses. Grasses such as *Phalaris aquatica* and *Panicum coloratum* retain the seed shattering characteristics of their wild ancestors. This is often aggravated by uneven ripening and low seed viability. As a result, there are often serious harvesting problems resulting in low yield and inferior seed quality (McWilliam and Gibbon 1981).

Seed production methods for forage crops are quite different from those used with cereal crops. Each herbage plant has its own peculiarities. It is important to know the proper rate, time, and method of seeding, as well as the best stage of plant development at which the seed is sufficiently mature to harvest.

A trial was conducted at the Holetta Research Center for three years, starting in 1991, to determine the optimum time of seed harvest at which maximum seed yield and high viability could be obtained from three perennial grasses. The results, presented in Table 1, show that maximum yield was obtained when seed was harvested six weeks and four weeks after full flowering, respectively, for *Phalaris aquatica*, *Chloris gayana*, and *Panicum coloratum*. This coincided with the highest germination.

Table 1. Seed yield (kg/ha) and germination (%) of three perennial grasses as affected by time of harvest at Holetta.

Weeks after full flowering	*P. aquatica*		*C. gayana*		*P. coloratum*	
	Yield	Germ. %	Yield	Germ. %	Yield	Germ. %
1	23.4	14	55.5	79	45.6	2
2	40.9	24	76.4	76	61.4	9
3	36.7	35	92.4	82	78.2	12
4	35.8	45	92.7	89	94.8	31
5	50.1	54	92.5	75	83.8	22
6	61.4	65	81.8	75	64.6	21

Source: HRC Progress Report (1993, 1994, and 1995).

Observations made on the seed production potential of some forage crops in the sub-humid, mid-altitude environment of Ethiopia indicate that *Chloris gayana*, at optimum seeding rate and row spacing on small plots, can yield up to 700 kg of seed per hectare. *Panicum coloratum*, *Desmodium uncinatum*, and *Stylosanthes guianensis* gave seed yields of about 500, 400, and 350 kg/ha, respectively. *Lablab purpureus* yielded about 1,700 kg/ha (Alemu 1989).

In an experiment at two locations to determine the optimum row spacing and seeding rate for maximum seed production of *Vicia atropurpurea*, the optimum seeding rate was found to be 20–30 kg/ha, with a row spacing of 60 cm (IAR 1986).

Another experiment was done at the same locations to determine a suitable support system for maximum seed production of vetch (*Vicia atropurpurea*). In this experiment, the highest average seed yield of 5,000 kg/ha seed was obtained with a fence-supported treatment, whereas the control plants, grown without support, gave a seed yield of 700 kg/ha (IAR 1986).

A trial was also conducted at the Holetta Research Center for two years to determine the optimum maturity dates at which high seed yield is obtained from four *Trifolium* spp. on two soil types. All the species tested on the red soil gave their highest average seed yield when harvested a week after full flowering. On the black soil, *T. tembens* and *T. steudenari* gave their highest seed yield when harvested a week after full flowering, while *T. quartinianum* and *T. decorum* yielded better when harvested two weeks after full flowering (Table 2).

Table 2. Average seed yield (kg/ha) of *Trifolium* species harvested at different stages of maturity on two soil types at Holetta.

Species/variety	Weeks after full flowering				
	1	2	3	4	Mean
Red soil					
Trifolium quartinianum	292	255	241	95	221
T. rueppellianum	385	377	150	69	245
T. steudenari	571	438	471	347	457
T. decorum	356	266	150	81	213
Mean	401	334	253	148	284
Black soil					
T. quartinianum	500	560	445	265	443
T. tembens	345	318	184	78	231
T. steudinari	379	264	226	240	277
T. decorum	343	590	481	199	403
Mean	392	433	334	196	339

Source: HRC Progress Report (1993, 1994).

When average seed yields of all the *Trifolium* species were considered, yield decreased by 17, 37, and 63% when seed was harvested two, three, and four weeks, respectively, after full flowering on red soil. On black soil, yield dropped about 23% when seed was harvested three weeks after full flowering, and about 55% when harvested a month after full flowering. The results of this study suggest that, for the best seed yield, *Trifolium* spp. should be harvested a week after flowering on red soil and two weeks after flowering on black soil. If harvesting is delayed beyond the recommended maturity dates, the yield will be low due to shattering.

To maintain maximum viability, most seed must be stored at a fixed moisture content and at a fixed temperature, usually 0–4°C (Dorrell 1984), but this may not always be possible because of lack of facilities. A trial was conducted in the highlands, at an altitude of 2,400 m, to determine the shelf life of locally collected herbage seed stored at ordinary temperature and humidity. Results show that, after six years, the viability of most of the grasses was reduced by about 50%. Not much reduction was observed on the viability of vetch seed, while reduction of the viability of alfalfa seed was about 25% (Table 3).

Table 3. Germination of seed of different forage crops after five years of storage at normal temperature and humidity in the highlands of Ethiopia.

Species	Germination (%)				
	1980	1981	1982	1983	1984
Phalaris tuberosa	64	51	34	39	31
Lolium perenne	46	33	14	20	21
Festuca arundinacea	68	43	51	26	36
Setaria anceps	07	04	02	02	03
Chloris gayana	28	23	19	17	17
Panicum coloratum	61	45	26	18	19
Panicum antidotale	20	09	11	07	09
Oat	93	77	73		
Alfalfa	95	87	86	89	72
Vetch	89	91	91	93	93

Future Considerations for Increased Forage Seed Production and Supply in Ethiopia

The commercial demand for herbage seed depends on the emphasis placed by the government on pasture development in its livestock policies. If the government seriously intends to promote livestock production it should devote much more attention to applied research on forage production. Extension services should emphasize forage production and utilization as part of their routine work. Provision should be made for seed production and distribution as well as technical support services.

If adapted forage grasses and legumes are to be widely used in Ethiopia, as an initial step there must be a capacity for basic seed production to maintain supplies of seed for distribution to growers. Seed production centers with staff, buildings, and equipment should be established. The centers should also have adequate land available for seed production.

Most of the time, herbage seed production is not considered in the national seed industry program, and even if considered, it is given a very low priority in Ethiopia. This has seriously affected forage seed production in the country. Therefore, the capacity of the Ethiopian Seed Enterprise needs to be strengthened so that it can include forage seed in its production program. In the mean time, mechanisms should be designed by which farmers are encouraged to produce their own seed to meet their needs and also to exchange excess seed with other community members. In this respect, much can be learned from the experiences of other developing countries, such as Kenya and Zimbabwe. Homegrown seed production and exchange, for example, has been practiced by large- and small-scale farmers in Kenya, because it is often easier to obtain a small quantity of the best seed available and multiply it to meet individual requirements. Homegrown seed is easy to produce (Boonman 1993), and there is no reason why this cannot be practiced in Ethiopia. All that is needed is a reliable and well-organized extension program to promote the system. The extension system is currently growing stronger.

Substantial seed production programs conducted on a contract basis with farmers have been successfully implemented in Kenya. This was also practiced successfully in Ethiopia by the FLDP forage seed production program a few years ago. But the program didn't sustain after the project phased out. Ways and means by which this program could continue should be investigated.

Forages, except on a very few specialized dairy farms, have to date not been produced on-farm by smallholders in Ethiopia. Because of this, demand for high-quality forage seed has been low. Because of the low demand, no private industries dealing with forage seed production have been established in the country. To increase the availability of feed from improved forage crops, seed supplies must exist, but seed supplies will not grow unless there is a demand for them. Nowadays, because of the severe feed shortage problem, the importance and benefits of improved forages is being recognized by farmers, and demand for improved forage seed is increasing. Therefore, it is now high time for industries dealing with forage seed production to be established.

The correct choice of location for forage seed production is very important. Most forage seed production programs fail due to poor site selection. The most important factors contributing to seed yield are influenced by weather conditions. Therefore, sites with a favorable environment should be selected (Clements and Cameron 1980). Experience in Ethiopia indicates that in sub-humid, mid-altitude areas where enough rainfall is available and the temperature is relatively high, there is a possibility of getting two seed harvests from grasses such as *Chloris gayana* and *Panicum coloratum*. But in high altitude areas with low temperatures, there is only one annual harvest and yields are low.

National efforts to increase domestic production of forage seed can be enhanced by regional and international support activities, including training, germplasm exchange, and provision of documentation. Such support is minimal in Ethiopia at present. Ways and means of establishing such support systems should be sought.

Seed production of forage crops at a high level is a specialized business that demands considerable experience and knowledge of the special requirements of each crop. People involved in this activity, be they are researchers, extension workers, or farmers, need training on the methods and equipment used in countries where forage seed production is highly developed.

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A Decade of Pasture Seed Programs in Uganda (1987–1997)

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Abstract

Pasture seed activities were initiated in the early 1960s at Serere in eastern Uganda. Seed research and production were based there until the mid-1980s, when the insurgency stopped all economic activities in the area. Legume seed was produced at the institute and grass seed was opportunistically harvested from surrounding natural grasslands. Distribution was through the Ministry of Agriculture offices in the districts. From the mid-1980s to the early 1990s, pasture seed activities were moved to Namulonge in central Uganda. Seed production was initiated by a development project, which revamped the dairy industry in Uganda. It contracted small-scale farmers to produce legume seed for distribution in the project area. Production started in 1989 at just over 1 tonne. By 1995, when the project ended, annual production had risen to over 35 tonnes. Currently, there is some production of pasture seed around Namulonge, but at a reduced level. Trade is from farmer to farmer. Pasture seed activities have been resumed at Serere, where *Chloris gayana* and *Centrosema pubescens* seed is opportunistically harvested. There are two ongoing development projects on pasture seed production: (i) a project to produce *Desmodium intortum* and *D. uncinatum*, supported by FAO; and (ii) a project on production of *Panicum maximum* seed, funded by the African Development Foundation. The pasture seed industry has always been informal, and production levels have been dictated by available technology and effective demand.

Introduction

In Uganda, pasture seed research and production started at the Serere Agriculture and Animal Production Research Institute (SAARI) in the early 1960s. Legume seed was produced at the research institute, while grass seed *(Chloris gayana* and *Hyperrhenia* spp.) was harvested opportunistically from natural grasslands. Although a number of progressive farmers, especially in peri-urban areas, purchased seed and established pastures for dairy farming, most of the seed went to government and mission farms.

Pasture seed production in Uganda has always been under the informal system, and seed certification, processing, and quality control have not been applied as in formal seed production. During the time when seed was produced at SAARI, the

UK Overseas Development Administration (ODA) made funds available to the Department of Agriculture to purchase seed from farmers (Kabeere 1992). Such seed was sent to the various District Agricultural Offices, from where it was sold to livestock farmers after little or no further processing. The Uganda Seed Project (the only seed company) has not involved itself in forage seed production because it considers pasture seed to have low effectiveness and often unrealistic demand (Muhuku 1992). The quality of legume seed is relatively high, as seed harvesting is carried out on individual pods that are visibly mature. On the other hand, grass seed quality, especially in *Brachiaria* spp. and *Panicum maximum*, is usually low. This is attributed to the protracted flowering of most grasses and to a harvesting method whereby all the available seedheads are cut, even though the seed is at different stages of maturity. The relatively higher level of mature seed content of *Chloris gayana* compared to other grasses may imply that the low quality of those grasses is genetic. This means that a number of spikelets are harvested although they have immature caryopses or none at all.

Research Activities

Research activities over the past decade have aimed at developing technologies for seed production of forage legumes by small-scale farmers (Lusembo et al. 1997). Most of the production and research activities have been directed to legume rather than grass seed production. This is because Uganda is considered to be at the center of diversity for most tropical grasses, and thus has many grass species growing naturally in most parts of the country.

Studies were carried out on *Macroptilium atropurpureum* (Siratro), *Centrosema pubescens* (Centro), *Desmodium intortum, Lablab purpureus*, and *Clitoria ternatea* spp. Studies on Centro and Siratro have involved fertilizer (phosphorus) and plant population requirements. In a sward system, where inter-row spacing was 100 cm, there was no significant difference when inter-plant spacing ranged from 30 to 120 cm (Lusembo et al. 1993a). Under support systems, a spacing of 1 m gave the optimum seed yield. The two legumes did not respond to soil phosphorus treatments up to 400 kg/ha for a single superphosphate applied once during two years of production. In a study on various forms of support, it was found that, while both species require some form of support for increased seed yield, Centro could be inter-cropped with cassava (used for support) and at the same time produce tubers (Lusembo et al. 1993b). Under the conventional support system, where wooden stakes are used, a positive association was found between seed yield and staking height up to 3 m (Lusembo 1993).

Desmodium intortum was studied to determine the optimum plant population and most appropriate harvesting method for quality seed. The method in which mature pods are striped off the seedhead, dried under the sun, and pounded in a wooden mortar gave better results than the method that simulated combine harvesting, where all the seedheads are cut at the same time (Lusembo and Sabiiti 1995).

There are studies in progress at Makerere University to determine the effect of different cutting methods on the seed and herbage production of *Clitoria ternatea.* The preliminary findings have not yet been released. There is also an on-going project on *P. maximum* seed production. The main objective of the project is to find out the causes of low seed quality. The techniques being tested are: (i) panicles are cut when seed is still immature: (ii) some locations are better sites for seed production than others; (iii) grass seed quality is better during the long rainy season than in the short rainy season; and (iv) smut (a major disease of *Panicum* seed) is more prevalent in the long rainy season than in the short rainy season. Preliminary results for the first month of seed harvesting in the first rainy season indicate that some locations produce seed with higher mature seed percentage than others. The time of harvesting does not seem to be an important factor in the mature seed percentage of harvested seed. Analysis of different samples for caryopsis content and degree of development indicates that a high percentage of formed seed is devoid of any caryopses at any stage of development. Moreover, seeds from the same locations show a high degree of variability (0–36%) in spikelets with caryopses (Table 1). Considering the high degree of apomixis in *P. maximum*, this may indicate that there is considerable genetic variability within populations of the grass on the same site, an observation that requires further study.

Table 1. Quality characteristics of *Panicum maximum* seed harvested between 15 April and 15 May 1997 at various locations in central Uganda.

Location	Percentage mature caryopsis content			Percentage immature caryopsis content		
	Highest	Lowest	Mean	Highest	Lowest	Mean
Kabanyolo (8)†	3.44	1.76	2.60	1.78	1.22	1.50
Gayaza (6)	24.19	3.20	14.10	6.72	4.22	5.50
Magigye (12)	36.53	0.00	5.40	4.56	1.08	2.07
Namulonge (12)	16.35	1.28	6.73	3.18	0.62	1.42
Kawoto (18)	6.12	0.31	2.28	3.34	1.00	1.94
Wambwa (5)	4.52	1.38	2.78	1.58	1.41	1.50
Vuru (7)	6.70	1.37	3.93	2.95	0.85	1.86
Gha I (13)	6.56	0.43	2.57	2.17	0.52	1.18
Kawempe (6)	6.21	0.95	2.34	1.92	0.45	1.88

† Figures in brackets indicate the number of farmers whose seed was analyzed.

Pasture Seed Production Projects

Dairy Development Committee

Until the late 1980s there was no specialized pasture seed production by farmers in any part of Uganda. In 1988, the Dairy Development Committee (DDC) project was set up to revive the dairy industry, which had become run down due to insurgency in central Uganda. Pasture seed was identified as one of the most important inputs needed to improve pasture productivity on dairy farms. At that time, seed production from the Serere area was no longer possible due to civil strife in the region (Lusembo et al. 1997). Importation of seed was found to be expensive and unsustainable after the end of the project. It was therefore decided that local seed production should be encouraged. Farmers around the Namulonge Agricultural and Animal Production Research Institute (NAARI) were encouraged to produce seed (especially legume seed) which would in turn be purchased by the project. The major species produced were *Centrosema pubescens, Macroptilim atropurpureum, Lablab purpureus*, and *Leucaena leucocephala*. Other species were *Desmodium intortum*, *D. uncinatum*, and to a less extent *Stylosanthes guianensis*. Attempts were made to purchase *Panicum* seed from opportunistic pickers who use the panicles to make brooms. The quality proved to be so low that purchase was terminated. By the end of the second year the project had purchased more seed than it had anticipated (2 t) and, as the project ended, funds ran out (Table 2).

Table 2. Seed sales by small farmers around NAARI.

Year	Quantity (kg)
1989	1,113
1990	2,019
1991	1,529
1992	1,740
1993	3,738
1994	13,238
1995	37,570

Livestock Services Project

The Livestock Services Project (LSP), financed by the World Bank, was created in 1991 and took over some of the activities of the DDC. Up to that time lack of forage seed was still considered a major constraint in improving the dairy industry. In order to revive the interest of farmers in producing seed, the LSP entered into a contract to buy all seed produced over the following three years. As with the DDC project, the emphasis was on legume seed production. The project contracted farmers in two districts in the central region of the country. Farmers around

NAARI produced the highest quantities of seed. This success was attributed to the availability of a market for seed as well as techniques of pasture seed production acquired from the research institute. By the end of the contract (1995), farmers were producing over 35 tonnes of seed per annum.

Desmodium spp. Production

The Grasslands and Pastures section of FAO is funding a small project for *Desmodium intortum* and *D. uncinatum* seed production. Under this project, farmers in two districts of central Uganda are being trained in the agronomic practices of seed production. The seed is produced under contract. Production started in May 1997 and is expected to last for at least two years. Because *Desmodium* spp. are well-adapted and naturalized in many parts of central Uganda, farmers have been encouraged to opportunistically harvest seed from the wild, which the project will buy and distribute to farmers for future on-farm research.

In view of the expanding dairy industry, and after some degree of success in forage legume seed production, attention is now being focused on the grass component of pasture management. Improved pasture productivity, essential to meeting the needs of high-yielding exotic animals, requires complete establishment of the grass and legume components. At present, there is a high demand for grass seed. The little seed that is available is produced opportunistically from natural grasslands or from fields that were established for forage. Hence, the project encourages farmers to produce quality seed of *Panicum maximum,* a species that has high forage value but whose widespread use has been hampered by the extremely poor quality of the seed.

Panicum maximum Production

The USA-sponsored African Development Foundation (ADF) ran a project on *Panicum* seed production. The policy of the ADF is to carry out research in which farmer participation is of profound importance. Research funds are provided to projects aiming to improve existing technologies. *Panicum* seed is produced as a by-product of the panicles that are widely used to make brooms. However, the quality of that seed has always been so low that, despite farmer interest in establishing *Panicum*-based pastures, farmers will not pay for it. Under the project, broom producers from different areas in central Uganda are encouraged to collect the seed from the panicles. The broom makers are provided with bags in which to put the produced seed, which is sampled and manually analyzed for mature caryopsis content at NAARI. The project is to run for two years. Provision has been made to pay for the seed according to the degree of mature caryopses. The seed is later blended and sold to the farmers with a seeding rate recommendation based on the percentage of mature seed.

Current Pasture Seed Production by Farmers

During 1989–1995, when project funds were available and pasture seed was being produced by small-scale farmers, especially around NAARI, livestock farmers who received seed from the projects learned about the source of that seed. Farmers not under the project area went to those who were to purchase seed. After the project ended, an informal seed trade developed. This was because the dairy industry has been revived and is expanding at a fast rate. In the last five years, three modern milk processing plants have been established in the country. This development has ensured a ready market for most of the produced milk. After the end of civil strife in the Serere area, pasture seed production resumed and substantial quantities of *Chloris gayana* and *Centrosema pubescens* seed are now being opportunistically produced and sold direct to farmers.

Since 1995, *Chloris gayana* seed has been widely produced by farmers who established pastures, initially for grazing, and then for harvesting seed. A farmer in Mbarara, western Uganda, established over 20 hectares of *Chloris gayana* on a dairy farm. A delay in the delivery of the animals, and the high initial cost of the seed, encouraged the farmer to resort to seed production to reduce the establishment cost. The farmer has been producing an average of 700 kg of seed per year since 1995. It is possible to produce *Chloris gayana* seed because it is a good seeder and its quality is usually relatively high, even without any processing. This type of seed production is directed by the farmers themselves with little assistance from researchers. It is attributed to the availability of a market for the produced seed. It is highly likely that, as long as a market is available, pasture grass seed can be produced easily by any farmer who has ventured into the establishment of pastures. An intensive, specialized system for grass seed production does not seem economically viable, and most of the farmers who have attempted it have failed. Therefore, it appears that the only economically feasible system for production of grass seed is through opportunistic harvesting from either natural grasslands or established pastures intended for grazing.

The Role of Research and Market Availability

One of the major constraints to successful seed production is ignorance about the requirements of the various species. The specialist nature of seed production requires the generation of appropriate technology by research in collaboration with farmers. However, the presence of a ready market for seed greatly motivates farmers to look for knowledge from research institutes and also encourages them to take initiatives towards generating their own technology.

Conclusions

Sustained pasture seed production in Uganda will depend on the availability of appropriate seed production technology and, more importantly, on a strong dairy industry that requires highly-productive pastures and thus provides a ready market for seed.

Acknowledgments

The authors are grateful to the National Agricultural Research Organization of Uganda, the International Livestock Research Institute, the International Foundation for Science, and the African Development Foundation for funding the research projects cited in the paper. Attendance at the seminar was made possible by ILRI.

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Outlook on the Zambian Pasture and Forage Seed Industry

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Abstract

The climate and the soil of Zambia favor the production of a wide range of pasture and forage species. This is confirmed by earlier studies undertaken when the methodologies and techniques of local pasture seed production were first developed. Consequently, from 1981 until six years ago, when the Zambian economy was liberalized, there was an increase in commercial activity concerning pasture crops, such as Rhodes grass, forage sorghum, Siratro, sunhemp, and velvet bean. The liberalization of the economy has had a negative impact on the local seed industry as a whole, and, as pasture crops are regarded as of minor importance, they have suffered the most. The slow transfer of seed production technologies to farmers, the lack of pasture specialists, and the lack of development of the pasture seed industry are other factors that prevent Zambia from realizing its potential to produce enough pasture seed to meet local and regional seed demand. This paper discusses the options and strategies that need to be in place to develop and improve the Zambian pasture seed industry.

Introduction

Zambia lies between latitude 8–18° S and longitude 23–33° E. It has a surface area of approximately 752,972 km^2. The country has a tropical climate with temperatures that range from 16 to 27°C in the cool dry season and 27 to 38°C in the warm wet season. The rainy season is from November to April, with an average annual rainfall of approximately 1,200 mm in the high rainfall regions and 400–600 mm in the drier south.

Zambian agriculture is a contrast between the commercial sector at one end of the spectrum and subsistence farming at the other. The commercial sector is involved in seed production for crops such as maize, wheat, and soybean. The area dedicated to these crops is significantly greater than that dedicated to pasture.

Pasture seed production and supply have continued to be lower than demand, in spite of the favorable climate and technologies developed in pasture production. Most pasture seed producers are basically opportunistic seed growers. During the growing season, they do not know for certain what species in what amounts will be in demand. This is because the pasture seed industry is not well-developed.

Organizational Structure of the Zambian Seed Industry

The organizational structure of the Zambian seed industry is based on the following five principal components (Fig. 1).

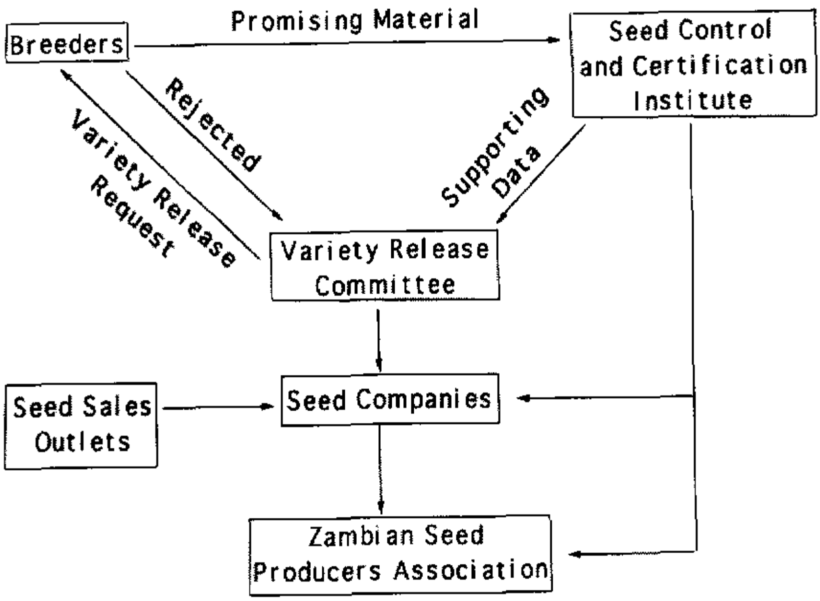

Figure 1. Organizational structure of the Zambian seed industry.

Soils and Crop Research Branch

The SCRB of the Ministry of Agriculture, Food, and Fisheries (MAFF) is responsible for plant breeding and crop production research of all locally-bred hybrids and varieties. Furthermore, the breeders are responsible for the maintenance of genetic purity in parental materials. The mandate crops include cereals (maize, sorghum, wheat, and millet), food legumes (soybean, groundnut, and cowpea) and oil seeds (sunflower and castor). It also conducts research on forage and pastures.

The two main centers for plant breeding work are at the Mt. Makulu and Golden Valley Research Stations.

Variety Release Committee

This committee is responsible for approving the release of all new varieties in the country. The committee is made up of different institutions, which include seed companies, the Seed Control and Certification Institute (SCCI), and the Zambia Seed Producers Association (ZSPA). The committee must be satisfied of the need to release a particular variety. The variety release committee is headed by the Director of Agriculture.

Seed Control and Certification Institute

The (SCCI) is responsible for quality control and certification of seed that is produced and/or imported into the country. This institute ensures that the seed being sold is of the highest genetic and physical quality possible and free from disease and noxious weeds. In this regard, the SCCI is responsible for enforcing legislation pertaining to seed testing and certification.

Zambia Seed Producers Association

This is the mother body for all seed growers. It provides a forum for:

- Farmer collective bargaining for seed prices and agreements on other contract conditions.
- Growers to share experiences and learn new ideas from each other.
- Information flow and advice to growers.

Seed Companies

Seed companies are responsible for the multiplication, procurement, processing, storage, and distribution of seed. Seed production is by contract with members of the ZSPA. Once crop allocations are completed, the companies register all crops intended for certification with the SCCI.

Does the Pasture Seed Industry Exist?

Even though the structure for pasture seed production does exist, the production and sale volume of pasture crops is extremely low. For instance, the volume of pasture seed sales by seed companies such as Zamseed, Pannar, and Advanced is negligible compared to maize seed sales. Thus, to a great extent, and as some farmers have put it, the pasture seed industry in Zambia is non-existent.

Constraints and Strategies to Improving the Zambian Pasture Seed Industry

There are six areas that need to be addressed if the Zambian seed industry is to improve.

Identifying Demand

Local market

At the moment, the demand for pasture seed is unknown. A rough estimate of seed demand is important for planning purposes, especially for those producers who would like to enter into this venture. At present, however, it is not uncommon to receive inquiries for tonnes of one species or another, which no one meets. Thus the need to assess the demand for pasture seed cannot be overemphasized.

To overcome this problem, the first thing is to name a volunteer pasture seed production coordinator, so that buyers can make their requirements known, and producers can set their production targets. In the absence of a strong pasture seed company, the Pasture and Forage Research Team of MAFF could possibly do this job.

International market

The most successful and active seed company for pasture seed export in eastern and southern Africa is the Kenya Seed Company. This company exports pasture seed to the Middle East, and it too cannot meet demand. It might be possible to grow seed for the Kenya Seed Company in Zambia.

In 1996, South Africa was in need of tonnes of buffel grass (*Cenchrus ciliaris*), which no seed company in Zambia could supply. This emphasizes the point that the market for Zambian pasture seed goes beyond the borders of this country.

Creating Demand

Kawonga 1996 (unpublished data) shows that there is a general desire by most farmers, large and small, to expand pasture acreage. In creating the demand, it is clear that the needs of the commercial sector and the methods used will be different from those of small-scale farmers. Thus, the creation of pasture seed demand must be on both the commercial and small-scale levels.

Commercial sector

In the commercial sector, the niche for improved pasture species ranges from complete replacement of natural species to incorporation into rangelands. The concept that improved pasture production and/or management increases livestock productivity is well known. In my opinion, this knowledge is still only a theory to most farmers. What is needed in order to expand the use of pasture seed (creating a seed market) is to demonstrate the gains that livestock producers can get by improving pastures. There is a wealth of knowledge from Australia and elsewhere that can be adapted to the local situation fairly cheaply and easily to prove the point.

Small scale/emergent farming sector

This sector comprises approximately 80% of the farming community. The small-scale farming system is characterized by low product output and low exogenous input inflow. But, as the case of maize shows, the small-scale sector is a strong and dependable market when it can be proved that using improved seed benefits farmers.

The introduction and use of pasture should be carried out within the context of a low-input management system. The sector will appreciate and benefit more from the use of pasture legumes that relate to soil fertility improvement. Studies in Zambia and elsewhere have shown that pasture legumes in cereal-based cropping systems improve the protein content of crop residues by 20–80%, and, as green manure, improve maize grain yield by two to four fold.

Under Zambian conditions, where fertilizer costs have soared, a stronger advocate for the use of pasture legumes in soil fertility improvement could create an increased demand for pasture seed.

Poor-quality Seed

A lot of pasture seed trade takes place in the informal sector, mostly from farmer to farmer. With Rhodes grass, most of the commercial seed lots are of poor quality (0–20% germination). In a recent study, Kawonga (1997) showed that Rhodes grass cv NIRS Boma exhibits dormancy, which breaks four months post-harvest. Thus, the problem of low quality observed in commercial seed lots can be attributed to a problem that farmers do not know exactly when and what to harvest. Further, it is necessary to conduct germination tests four months post-harvest. Thus, there is a need to extensively educate farmers so that better Rhodes grass can be produced and market confidence restored.

Low Seed Prices

Price is a major determinant factor on which enterprise farmers base their decisions. With the liberalization of the economy, price is determined by the forces of supply and demand. In general terms, liberalization has had a negative impact on the local seed industry as a whole, and pasture crops, considered minor, have suffered the most. Seed companies are taking crops that will enable them to keep afloat in the short term.

Seed growers have indicated that the difference between what they get and what the seed company makes is too large. This is a disincentive to the seed growers (ZSPA), who feel that more of the profits should go to them rather than to the company. As pasture seed is generally a secondary enterprise, farmers would rather sell low-grade seed (quality declared) at a low price on the informal market rather than endeavor to produce certified seed at additional cost.

It is amazing that some pasture legumes fetch the dismal price of $1.5/kg on the local market, but in Uganda the same seed fetches as much as $15/kg.

Human Resource Development

To tap the international market, adequate human resources in pasture production need to be available to cope with the extension and seed certification requirements of the trade. This does not mean that the numbers of people dealing with forage species need to be changed. The economics of pastures do not allow for the deployment of new people, for example, at the seed company level. However, there has to be at least one person specialized in seed production techniques for pastures. This can be achieved through national or regional training programs. At the moment, the greatest need, in my opinion, is to train extension workers adequately in techniques of pasture production, and pasture seed in particular. The whole sector needs training of one sort or the other.

Who Should Produce Pasture Seed?

Any farmer who is willing and able to produce pasture seed should do so. The goal is for seed to be available when needed at an affordable price. In a country as large as Zambia, with a diversity of farms in terms of size and management level, seed should be produced as near to where it is used as possible. In sorghum and food legume crops, such as cowpea, seed production is being done by small-scale farmers with the aid of non-governmental organizations. Seed growers are selling the seed to other farmers nearby. There is no reason why pasture seed cannot be grown this way. In fact, under the Livestock Development Project, this concept has already been initiated, and the goal is to develop markets within and beyond individual localities.

Conclusions

The organizational framework for pasture seed production exists in Zambia. With a favorable climate to produce tropical pasture seed, Zambia has the potential to produce enough seed for both the local and export markets. However, there is a need to resolve the supply, demand, and price uncertainties, as well as the quality of seed produced. This requires investment in human resource development. Seed production should be available at an affordable price.

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Pasture and Forage Seed Production in Nigeria

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Abstract

Livestock is a very important part of the agricultural sector in Nigeria. Due to the expansion of crop production, there is less natural grazing available now and a greater demand for managed pasture for feeding livestock. Previous studies in Nigeria have shown that pasture species have the potential to contribute to the development of livestock. Many species with wide adaptation and high productivity have been identified. However, seed production for pasture species is still very limited. Seed requirements are mainly satisfied through importation. Previous projects established some pasture fields in the northern, western, and eastern regions of the country using imported seed, but they did not last. Recently, efforts have been renewed to introduce pasture species, in particular dual-purpose legumes, into the production systems. This has created an increase in seed demand. Many organizations (NAPRI, IAR, and IITA/ILRI) are now involved in seed production, which indicates that prospects for local seed production are improving. Seed multiplication needs to be undertaken on-station initially, and then by farmer groups and NGOs.

Introduction

Nigeria has a land area of 923,768 km^2, with an estimated human population over 100 million. The livestock population is 13.9 million cattle, 34.5 million goats, 22.1 million sheep, 0.09 million camels, and 104 million poultry (FDLPCS 1992). The climate is highly diversified, and is characterized by distinct wet and dry seasons (Fig. 1). Annual rainfall varies from 500 mm in the northern semi-arid regions to over 4,000 mm in the lowland humid regions. This climatic diversity makes the country suitable for production of a wide variety of crops and livestock. Grains, fibers, and some root crops are grown in the northern sub-humid and arid climatic zones, while tree crops and most of the root crops are produced in the southern sub-humid and forest zones (Manyong et al. 1996).

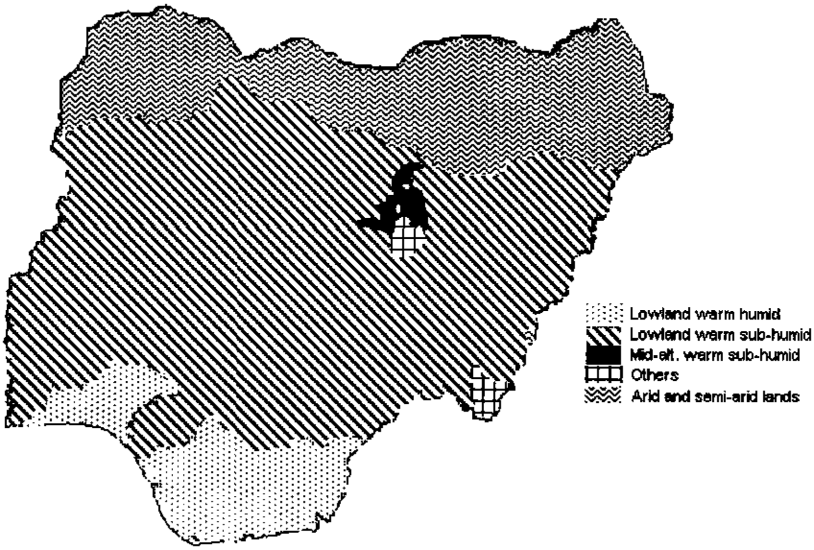

Figure 1. Map of Nigeria showing major agro-ecological zones (IITA 1996).

The keeping of livestock has a long history in Nigeria. It plays significant economic and socio-cultural roles by providing food (milk, meat), manure, traction, and contributing to foreign exchange (especially hides). The value of the livestock was estimated at about $6 billion in 1991. Rural livestock accounts for 98% of the traditionally-managed livestock population, with the remaining 2% urban stock. Until the late 1980s, about 99% of the cattle population, 97% of goats, and 95% of sheep were raised under extensive systems which ranged from exclusive pastoralism, through transhumant pastoralism, to agro-pastoralism. Livestock production is found mainly in the subhumid and semi-arid zones (Bourn et al. 1994).

Natural range, supplemented by crop residues during the dry season, is the main source of feed for ruminant livestock. Within the main livestock producing regions, these feed resources are scanty, highly seasonal, and of poor nutritional value for much of the year. As a result, the major problem for the livestock industry in Nigeria is inadequate nutrition. This problem has recently been compounded by the rising human population, which puts pressure on land for food, shelter, and infrastructure development. Among the effects of the on-going agricultural intensification is the spread of cropping to marginal areas, formerly available for grazing. This is forcing closer integration of crop and livestock enterprises, with a still greater dependence on crop residue as a fodder resource (Naazie and Smith 1997). Natural rangeland is not only becoming limited to the least productive land, but is also facing degradation through intensive grazing. In the past, one of the solutions to this problem was the implementation of the grazing reserve law by the former Northern Nigerian governments. Several grazing reserves were set up and many more were planned for the northern states. None of the reserves are now operational, although revitilization plans are underway, including the introduction of pasture species.

Pasture species have the potential to alleviate the constraints facing the livestock enterprise in Nigeria. Many tropical herbaceous legumes, initially promoted as pasture plants, have the potential to improve soil fertility and can therefore promote sustainable crop–livestock integration. Such opportunities mean that seed production of these potentially valuable species should be developed. In this context, the present article reviews past and current research activities on pasture species, emphasizing seed production and opportunities for promoting the adoption of herbaceous legumes.

Sown Pasture and Forage Production in Nigeria

Research on sown pastures in Nigeria started as early as 1945 (de Leeuw and Brinckman 1974) at the National Animal Production Research Institute (NAPRI) in Zaria, and involved both grass and legume species. In 1952, similar studies were undertaken at the Moor Plantation in Ibadan (Olubajo 1974). Results derived from these studies were impressive in terms of identifying pasture species with high adaptation to the different ecological zones of the country, good biomass yield, and nutritional quality (de Leeuw and Brinckman 1974; Rains 1963; Haggar 1971, 1975; Oyenuga 1959a, b; and Chheda 1974). Recently, in view of the changing production systems described above, efforts have focused on the introduction of these and other herbaceous legumes into integrated crop–livestock systems (Mohamed-Saleem and Fischer 1993; Tarawali 1991, 1994a, 1994b; and Tarawali and Peters 1996). Other more recent approaches have included the fodder bank concept (Otsyina et al. 1987), alley cropping, intersowing or undersowing forages with food crops (Mohamed-Saleem et al. 1986), and the promotion of dual-purpose legume crops (Tarawali et al. 1997). Despite the extensive research, adoption of improved pastures among livestock producers has been limited (Thomas and Sumberg 1995). One of the reasons for this stems from the fact that livestock producers are usually reluctant to make substantial investments in their production system. They still rely on the traditional extensive production system, which is dependent on free-range grazing, and they are generally not commercially oriented. Such a system operates on a low-input–low-output basis, but, with the changing production scenarios as described above, free-range grazing will be inadequate. One indication that this is already happening is the increased frequency and intensity of clashes between cattle herders and other farmers. The introduction of herbaceous legumes to increase fodder availability can contribute to solving some of these livestock production problems.

Historically, cattle herders do not own any land, and the majority depend solely on their stock for sustenance. Recently, many have taken to crop farming in addition to livestock production (agro-pastoralism), which requires settlement and land acquisition (Jabbar et al. 1995; Jabbar 1996). In most cases the land, which is often small (<2 ha), is leased to them by the land owners. Such arrangements mean that the settled agro-pastoralists do not hold title to the land they use. Therefore growing permanent pastures is a risky enterprise, and in some cases may even be precluded by the land tenure arrangement. However, they are conversant with the use of crop residues (e.g. legume haulms) as livestock feed. Indeed, the use of grain legume haulms as a supplement, especially during the dry season, is a common practice among livestock producers, and such fodder has a high market value (Tarawali et al. 1997). The introduction of crops with potential for both food and feed has been found to be acceptable by agro-pastoralists in the north. It is essential for the development and introduction of more species and varieties of these multipurpose legumes to take into account differences in ecology and farming systems. Varieties of groundnut, cowpea, soybean, and lablab have been identified as possessing dual-purpose characteristics for grain and forage. Most of these legumes are very familiar to farmers and are, therefore, good candidates for integration into the farming systems of settled agro-pastoralists.

Pasture and Forage Seed Production

Since the contribution of sown pastures to the livestock industry is, at present, insignificant, pasture seed production is likewise limited. NAPRI in Zaria and the International Livestock Research Institute (ILRI) in Ibadan are the only two organizations making major efforts to address this problem. Government agricultural policy has not been strong on pasture development, and this is reflected in the absence of a pasture and forage seed component from the seed program of the National Seed Service (NSS), which was established in 1975. Likewise, in the Federal Department of Livestock and Pest Control Services, animal-health-related matters are given priority. The only pasture issue in the department on which some work was carried out concerns grazing reserves. There has been little policy support towards pasture seed production.

Due to the lack of policy support for improved pastures, and the unfamiliarity of farmers with the species concerned, efforts to produce pasture seed have been sporadic and largely unsuccessful. It can be anticipated that, with the recognition of the potential of many species to contribute to both crop and livestock systems, and their role in promoting sustainable agriculture, this picture will change. Nevertheless, there are lessons to learn from the history of such ventures to date. As far back as 1956, seed of improved pasture species was imported and distributed to the northern, western, and eastern regions. This led to the establishment of pasture fields at government livestock breeding and multiplication centers. However, most of these pasture fields are now farmland or devoid of the sown species due to poor management. In 1977/78, the Federal Livestock Department again imported large quantities of seed from Australia, which were distributed to all the states of the federation. Individual entrepreneurs have also participated in pasture seed importation. The majority of these ventures have failed, as evidenced by the continued (albeit sporadic) importation of pasture seed, the lack of material, and the limited local production of pasture seed.

Availability of local seed is therefore one of the constraints to the popularization of improved pastures and the promotion of herbaceous legumes for multiple uses. The cost of continued importation of seed is enormous, and it is a risky investment. Of the wide range of pasture species introduced into the country (Table 1), most are selected for their good herbage production, but for the majority, potential seed yield is also good (Tables 2 and 3).

Table 1. Adaptation to different ecological zones of Nigeria of pasture species promoted by NAPRI.

Legumes	Ecological zones of adaptation†	Grasses	Ecological zones of adaptation†
Alysicarpus sp.	1,2,3	*Andropogon gayanus*	1,2,3,4
Arachis hypogea	1,2,4	*Andropogon nigratana*	1,2,3
Calopogonium muconoides	3,5	*Brachiaria brizantha*	1,2,3,4,5
Crotalaria macrocalyx	1,2,3	*Brachiaria decumbens*	1,2,3,4,5
Desmodium spp.	3,4	*Cenchrus biflorus*	1,2,4,5
Glycine max	1,2,3,4	*Cenchrus ciliaris*	1,2,4
Indigofera bracteolata	1,2,3,4	*Cenchrus prieurii*	1,2
Indigofera pulchra	1,2,3	*Chloris gayana*	1,2,3,4
Mucuna pruriens	3,5	*Digitaria smutsii*	2,3,4
Lablab purpureus	1,2,3,4	*Eragrostis tremula*	1,2
Stylosanthes fruticosa	1,2	*Panicum maximum*	2,3,4,5
Stylosanthes guianensis cv. Cook	1,3,4	*Pennisetum pedicellatum*	1,2,4
Stylosanthes hamata cv. Verano	1,2,3	*Pennisetum typhoides*	1,2
Stylosanthes humilis	1,2,3,4	*Pennisetum purpureum*	1,3,4,5
Tephrosia bracteolata	1,2,3,5	*Sorghum almum*	1,2,3
Trifolium spp.	4	*Vetiveria nitritana*	1,2,3,4
Vigna spp.	1,2,3		
Zornia glouchidiata	1,2,3,4		

† 1= Sudan/Sahel savanna; 2 = Northern Guinea savanna; 3 = Southern Guinea/Derived Savanna; 4 = Mid-altitude; 5 = Humid forest.

Table 2. Examples of seed yield for some pasture crops obtained at NAPRI (grown at Shika, Zaria).

Species	Seed yield (kg/ha)	Longevity†	Species	Seed yield (kg/ha)	Longevity†
Legumes			**Grasses**		
Centrosema pascuorum	707	A	*Andropogon gayanus*	643	P
Centrosema pubescens	784	P	*Brachiaria decumbens*	382	P
Chamaecrista rotundifolia	653	A/P	*Cenchrus ciliaris*	390	A
Mucuna pruriens	960	A	*Chloris gayana*	552	P
Stylosanthes guianensis	450	A/P	*Digitaria smutsii*	23	A
Stylosanthes hamata	847	A/P	*Eragrostis tremula*	115	A
Stylosanthes humilis	948	A/P	*Panicum maximum*	287	A
			Pennisetum pedicellatum	275	
Dual purpose legumes			*Sorghum almum*	692	A
Arachis hypogea	785	A			A
Cajanus cajan	652	P			
Glycine max	539	A			
Lablab purpureus	1,135	A			

†A= annual; P= perennial.

Table 3. Seed yield for selected forage legumes at ILRI (grown at Kaduna).

Species	Seed yield (kg/ha) 1988–1994	
	Minimum	Maximum
Aeschynomene histrix	80	887
Calpogonium muconoides	44	737
Centrosema acutifolium	3	117
Centrosema brasilianum	8	1209
Centrosema pascuorum	9	798
Centrosema pubescens	1	774
Chamaecrista rotundifolia	10	570
Clitoria ternatea	30	173
Lablab purpureus	52	1869
Stylosanthes guianensis	50	541
Stylosanthes hamata	66	702
Stylosanthes humilis	142	634
Stylosanthes scabra	21	200

To save the livestock industry from collapse and promote more sustainable agricultural practices, a renewed effort is being made to introduce pasture species, herbaceous legumes in particular, into the production systems in Nigeria. NAPRI, in collaboration with the Institute of Agricultural Research (IAR) in Zaria, is already introducing some dual-purpose legumes into the agro-pastoral systems in an attempt to promote pasture production among livestock producers. The International Institute of Tropical Agriculture (IITA) and ILRI are also working on the development of dual-purpose legumes (e.g. cowpea and soybean) that have the potential to fit into the agro-pastoral system. Recently, some elite farms have sprung up in different parts of the country, and requests for pasture seed have increased. Within the past two or three years, NAPRI has faced an increase in demand for pasture seed, but has found it difficult to satisfy all requests. In recognition of the potential of improved pasture, the National Agricultural Research Project (NARP) is sponsoring a breeder and foundation seed program in NAPRI for five grasses (*Andropogon gayanus, Pennisetum pedicellatum, Panicum maximum, Sorghum almum*, and *Chloris gayana)* and five legume species (*Lablab purpureus, Stylosanthes hamata, Alysicarpus* spp., and *Mucuna pruriens)*. Another organization playing a positive role in this area is the National Livestock Project Division, which is promoting the fodder bank concept, developed by ILRI, among livestock farmers. Some NGOs are also working towards enhancing the income generation capability of the rural populace through improved livestock production.

Prospects for Promotion and Adoption of Herbaceous Legumes and Pasture Species

It is clear that traditional production systems are changing in relation to the increases in human and livestock populations and the resultant greater demand for land. Such agricultural intensification could lead to the degradation of the natural resources if solutions are not sought. Herbaceous legumes, many formerly promoted as pasture species, have the potential to contribute to the production systems by enhancing livestock productivity and various aspects of soil management.

In view of these changes, and the closer integration of crops and livestock, the promotion of sustainable crop–livestock systems is one of the goals of the recently launched Eco-regional Program for the Humid and Sub-humid Tropics of Africa (EPHTA), convened by IITA (IITA 1996). This program includes three consortia: the inland valley, the moist savanna, and the humid forest. EPHTA aims to promote regional alliances to develop and transfer more productive and sustainable agricultural systems for each of the zones.

Crop–livestock production systems are a very significant component of the agricultural system in the moist savanna, for which one EPHTA benchmark area is located in the Northern Guinea savanna of Nigeria. To date, work in this area has included collaboration among all regional stakeholders working on-station and in selected villages with farmers. The potential of several herbaceous legumes is being explored, using both on-farm and on-station testing, together with aspects of dissemination, including seed production.

In the Northern Guinea benchmark site, the Catholic Resource Centre, an NGO working to promote rural development, has initiated on-station and on-farm seed production of a number of herbaceous legumes, including both green manure and fodder crops. Nigeria's Federal Livestock Department and Pest Control service has initiated another attempt to procure large quantities of *Andropogon gayanus* and *Stylosanthes hamata* from NAPRI for distribution to interested farmers. These efforts, in combination with those of NAPRI, IAR, and IITA/ILRI as described above, indicate that the prospects for seed production, and promotion of herbaceous legume species, are improving.

One of the research themes in the Northern Guinea benchmark area is crop–livestock integration. Many aspects of this integration are well known in the region, but there is scope for improvement. For example, farmers are used to the production and utilization of crop residues, especially legume straw for supplementary feeding during the dry season. Since 1988, NAPRI has been promoting the adoption of selected varieties of dual-purpose legumes among agro-pastoralists. The current research portfolios of IAR, ILRI, and IITA in this region include the development of improved dual-purpose varieties of groundnut and cowpea. On-farm trials of dual-purpose and herbaceous legumes have been established, and preliminary observations indicate that these options are promising for optimizing the benefits of such legumes to crops, soil, and livestock. Such options are important in view of the rising cost and limited availability of chemical fertilizers, pushing inorganic inputs largely out of reach for small-scale farmers.

If the introduction of herbaceous legumes is recognized as an attractive option for farmers, there is another potential source of income in the form of seed production. This will further optimize the resource use of small-scale farmers. It will also ensure local availability of the seed of suitable herbaceous species within the system, thus cutting down on importation. Both national and international research centers therefore need to take into consideration a number of aspects with respect to herbaceous legumes. These include the appropriate introduction and promotion of the species according to the biophysical and socioeconomic environments, and the provision of back-up seed multiplication facilities. Initially, seed multiplication needs to be carried out on-station, but with time, and the increasing adoption of such technologies, seed production by farmer groups, or by contract farmers, will also need to be explored. Collaboration with NGOs is also likely to be fruitful in this respect.

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Section III –
Research Activities

A Study on the Informal Vetch Seed System in the Central Highlands of Turkey

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Abstract

A study was initiated in 1995 on the informal vetch seed system in the central highlands of Turkey. Vetch is an important crop in Turkey. It covers approximately 265,000 hectares, of which 60–70% is located in the Central Highlands of Turkey (CHT). Although both common vetch (*Vicia sativa*) and Hungarian vetch (*Vicia pannonica*) are grown in the region, common vetch is the most important, and is grown for seed and straw. It is mainly in the CHT that farmers still use local landraces, which are well-adapted to local conditions but have low seed and straw yields. Interestingly, the area under Hungarian vetch, which has a reasonable cold tolerance, has increased in the CHT over the last five years. According to market surveys, vetch seed collected from different counties in the region is sent to the main market town of Çubuk in Çubuk County, where it is sold to private merchants and transported to Mersin for export. However, no seed of Hungarian vetch is sold in the Çubuk market. Sales of common vetch have been declining since 1992 because of decreasing demand from major importing countries and unfavorable marketing policies. Seed quality, in terms of physical purity and germination, though variable, is not considered a major problem. In the second phase of the study, 40 farmers from five villages in Çubuk County were surveyed. For common vetch, farmers use their own seed, but they purchase new seed every three to four years, either from neighbors or from seed merchants. The plots reserved for seed to be used for the coming season are mostly selected before harvest. This seed is usually cleaned, treated with chemicals, and stored. The remaining harvested seed is sold in the market and only a small part is saved as livestock feed. In Çubuk County, Hungarian vetch is only produced by major livestock producers with an average farm size over 20 ha. Common vetch is generally grown by resource-poor farmers, whereas the Hungarian vetch is grown by relatively larger and richer farmers.

Introduction

The total area of Turkey is about 77.66 million hectares, of which 25.4 million hectares is arable land. Annual rainfall varies from 250 mm in Central Anatolia to 2,500 mm in the Eastern Black Sea region. The average rainfall in the CHT does not exceed 400 mm. Seventy percent of rain falls between December and May. A cereal/fallow rotation is the traditional pattern practiced by the majority of farmers. Thus, approximately one third of the cropland remains fallow for 12 to 14 months.

The major forage crops grown are vetch (*Vicia sativa* and *V. pannonica*), alfalfa (*Medicago sativa* L.), and sainfoin (*Onobrychis sativa* Lam.). The areas under cultivation in Turkey and the CHT are given in Table 1.

Table 1. Area (ha) of forage crops *in Turkey and Central Highlands of Turkey.*

Crop	Turkey (ha)	CHT (ha)	Percentage of total in CHT
Vetch	257,000	130,230	50.6
Alfalfa	172,625	38,190	22.0
Sainfoin	85,637	15,253	17.8
Total	515,262	183,673	35.5

In general, livestock feed in the CHT is mainly dependent on common village pastures, cereal straw, barley grain, vetch straw (mainly in mountainous areas), and supplementary feed.

The CHT can be divided into two areas: the plateau where cereals are major crops, and the mountains (transition zone), where vetch production is widely practiced. Although farms are small in the mountains, with almost no fallow land, livestock still contributes about three-fourths of the annual income (Firincioglu et al. 1996). On the plateau, where farms are large and fallow is available, livestock contributes only one-third of the annual income. This explains why vetch cultivation is mostly located in mountainous areas.

Although both common and Hungarian vetches are grown in the CHT, common vetch is the most important crop, grown for grain and straw. In fact, most farmers still use local landraces of this crop, which are well-adapted, but not very productive. Vetch is still grown as a spring crop because of the lack of cold-tolerant cultivars. The area under Hungarian vetch, which is reasonably cold tolerant, has increased in the CHT over the last five years.

The present study was initiated in 1995 to: (i) identify cultivated area and cultural practices; (ii) study market systems; and (iii) characterize vetch seed quality and variability in the local market.

Materials and Methods

This study was conducted in the highlands of Çubuk and Kalecik counties. The methodology consisted of formal surveys and informal contacts/interviews with farmers and seed merchants. Two questionnaires were designed, one for vetch-seed marketing (merchant survey) and one for seed supply systems for major crops (farmer survey).

For the merchant survey, a questionnaire based on informal contacts was formulated to investigate characteristics of merchants, seed purchasing, selling and pricing of vetch, and questions related to Hungarian vetch.

The farmer survey covered five villages and was conducted at the farm level to collect information about cultivation and marketing of vetch and other major crops. The questionnaire was based on whether seed was purchased from government, neighbors, or grown by the farmer. Forty farmers were randomly selected and interviewed in Büyüdüz, Meliksah, Sihlar, Sünlü, and Yazir villages in Çubuk County.

The farmers were interviewed in the field while planting, in their houses, or in coffee shops. The surveys were conducted in collaboration with the Agricultural Directorate of Çubuk County, which provided information on these issues. Information was also obtained from the Agricultural Directorate.

Results and Discussions

Vetch Production and Marketing

Çubuk is the main marketing center for vetch in Central Anatolia. Eight of the 32 merchants interviewed are permanent suppliers of vetch seed, while others act as temporary merchants and farmers according to the season.

Vetch seed is collected from other counties (Kalecik, Pursaklar) and provinces (Çankiri and Çorum) and channeled to the Çubuk market, from where it is sold or exported.

Most of the seed in the market is of common vetch; no Hungarian vetch seed is sold. According to merchants, 1990 marked the decline of vetch seed production in Turkey and most merchants have stopped handling it. Some merchants mentioned that it is difficult to transport quantities of seed less than a truckload to the Mersin seaport.

The marketing channel for common vetch consists of farmers, merchants, and export firms. The seed flow starts with the farmer and reaches the exporters via the merchants (Fig. 1). A reverse flow between the farmers and merchants indicates that farmers also purchase vetch seed from merchants when needed (in case of crop failure or loss).

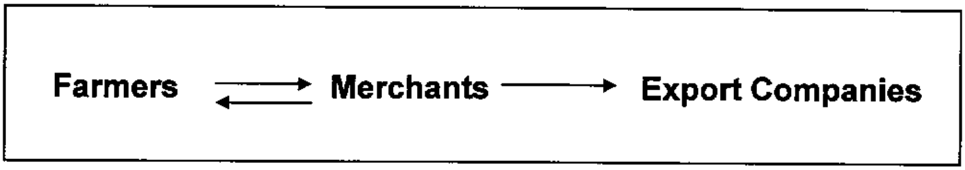

Figure 1. Common vetch seed flow in Eastern Anatolia

Merchants play a basic role in connecting farmers to export firms. Important quantities of vetch seed come from Akyurt, Sihlar, Sünlü, and Yazir villages, where most of the production is located. More than 60% of merchants purchase 900–1,200 tonnes of seed per year each.

Cultivation of Vetch and Other Major Crops

The main crops cultivated in Çubuk County are wheat, barley, and common vetch. Chickpea and lentil are also produced for marketing, although production has decreased sharply since 1993 and they are now used only for private consumption (Table 2).

Table 2. Area (ha) planted to major crops in Çubuk County.

Crop	1990	1993	1996
Wheat	30,915	32,007	34,500
Barley	7,645	9,582	10,100
Vetch	39,181	33,175	24,400
Lentil	7,400	4,100	1,900
Chickpea	6,800	2,600	1,400

Of the 40 farmers surveyed, 25% grow vetch/wheat/barley or vetch/wheat/chickpea, 37% grow vetch/wheat/barley/chickpea, and 13% grow all crops.

Farmers used their own seed for common vetch. If seed was not available because it had been sold on the market or the crop had failed, farmers purchased the seed from neighbors (74%) or seed merchants (26%).

Small-scale farmers reported that the three major factors limiting the use of certified seed are: (i) high cost of certified seed (double that of local market seed); (ii) doubts about seed quality; and (iii) difficulty in obtaining the seed because of the long distance to market.

For cereal production, farmers use inputs such as fertilizer, pesticide, and herbicide. Both phosphate and nitrogen are applied at planting, and an additional nitrogen treatment is applied in spring. All farmers clean and treat the seed with chemicals. Cleaners are provided free for public use. In contrast, farmers do not use mechanical planters, apply fertilizers, or control weeds for vetch production. Inputs such as fertilizers and pesticides are available in sufficient quantity, but the farmers agreed that high prices prohibit their use. All farmers said that they need credit regularly, although they have problems with the terms and conditions of the credit system. Credit cooperatives in some villages were not able to meet their clients' needs. As a result, farmers get credit from the Agricultural Bank, which provides credit based on the mortgage value of the farmer's arable land.

An average of 30,000–40,000 tonnes of common vetch seed was produced annually from 1990 to 1992 (Fig. 2), and hundreds of tonnes of seed were exported. After 1992, exports started to decline, as a result of which vetch seed production also decreased.

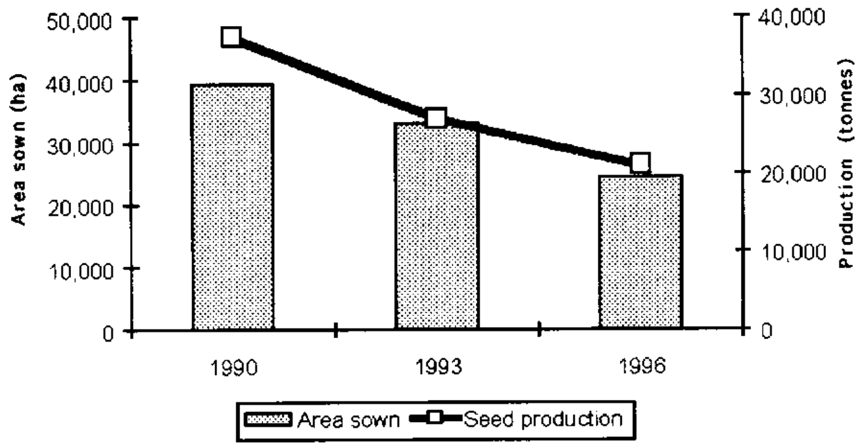

Figure 2. Area (ha) and seed production (t/ha) of common vetch grown in Çubuk County from 1990 to 1996.

Hungarian vetch is grown by 2–3 farmers from each village of Çubuk County. According to the farmers' survey, 9 of the 40 farmers interviewed grow Hungarian vetch. These are mainly large farmers (>20 ha) whose income depends largely on livestock production (15–20 head of cattle, about 30 sheep).

Vetch Seed Quality

During the merchant survey, 300–400 g of vetch seed was collected from each merchant in Çubuk Town to assess seed quality. Physical purity and germination of the samples were variable, with an average of 80%. It seems that most of the farmers use cleaners before selling their seed to merchants. Thus, seed quality is not considered a major issue.

Conclusions

Vetch is an important crop for livestock feed and income generation in the remote areas of the Central Highlands of Turkey. A majority of the vetch growers are resource-poor farmers with small landholdings, dependent mainly on livestock production. An extensive farming system is practiced by most of the farmers. In fact, common vetch is primarily grown for seed, which has a market value. It can be concluded that demand for export substantially contributes to common vetch production. The importance of livestock in income generation, and small land size, make this crop appropriate for rotation with cereals.

Vetch production has decreased since 1992, because of a government policy that has encouraged meat imports and subsidized cereals. Also, the export market has decreased due to a lack of transparency by merchants in international transactions.

The area of Hungarian vetch has expanded substantially over the last five years. Some innovative farmers have actually shifted to Hungarian vetch. Despite its absence in the market, it is considered an important crop due to high yield potential and feed value.

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On-farm Annual Medic Seed Production in Morocco: Achievements and Constraints

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Abstract

Moroccan farmers who have tested annual *Medicago* spp. as an alternative to weedy fallow are convinced of their agronomic and economic benefits. Farmers have developed their own management system and prefer planting the pasture every year. Medic seed is, however, very rare in the local market and its price is very high. To continue promoting the establishment of medic pastures, the Institut National de la Recherche Agronomique (INRA, Morocco) and the International Center for Agricultural Research in the Dry Areas (ICARDA) tested different technologies to help farmers produce their own medic seed. On-farm trials were conducted on 21 and 11 fields over two years to test harvesting and threshing machines in the farmers' fields. A hand broom, the ICARDA sweeper, the ICARDA thresher, and the straw thresher were tested. About 90% of farmers managed the medic pasture well and produced high pod yield. Sweeping with a hand broom was time consuming. The ICARDA sweeper pushed by hand needed two persons, and rocks, clods, and dry vegetation had to be removed first. Pulled with a donkey, the ICARDA sweeper was very fast and allowed the harvest of about 500 kg of pods per day. Minor modifications are needed to adapt this machine to donkeys. The ICARDA thresher proved very efficient but needs electricity. Threshing pods with the straw thresher was not suitable. Farmers expressed their willingness to adopt the harvesting technique and plant pods in their weedy fallow.

Introduction

The potential economic value of annual *Medicago* spp. (medics) for Morocco has been pointed out by several authors (Leeuwrik 1976; Bounejmate 1984). Research in Morocco confirms the agronomic and economic benefits of the cereal/medic system compared to the cereal/fallow system (Mazhar 1987, 1994).

In 1985, the Ministry of Agriculture and Agrarian Reform launched "l'opération ley-farming" which aimed at converting 150,000 hectares of grazed fallow to annual legume (mainly medic) pasture, over 15 years. Despite considerable optimism and effort, the rate of adoption was very low. Lack of medic seed was a major constraint to the dissemination of these pasture species. Farmers developed their own method of management. The medic is considered a forage crop, seeded every year as a pure stand or in a mixture with a cereal. It is grazed, cut, fed as green, or conserved as hay or silage (Mazhar 1994). The non-availability of medic seed near the farm and the high price fixed by the Seed Company discouraged farmers from planting medic every year.

To continue promoting the establishment of medic pastures, INRA, in collaboration with ICARDA and the Ministry of Agriculture of Morocco, tested small-scale machinery developed by ICARDA. Preliminary tests of the sweeper and the thresher at experimental stations were very successful (ICARDA 1992; INRA 1994a, 1994b). To transfer these technologies to farmers, several on-farm trials were conducted for demonstration and evaluation. The objective was to teach farmers how to produce their own medic seed, to test the sweeper for collecting pods in the field, to evaluate different threshing techniques of medic pods, and to identify the different pasture management practices used by farmers and their influence on medic-pod yield.

Materials and Methods

Trials were conducted on farmers' fields during two years (Table 1). Two provinces and seven Centres de Travaux (CT) were represented. Fields of 1–2 ha were seeded with a mixture of five medic cultivars. Farmers were informed of the objectives, the management of the pasture, and the grazing method. However, during the growing period, the practices of each farmer in managing the grazing pattern were not the same. Each practice was recorded. Farmers were advised to protect a part of the field (1,000–2,000 m^2) for seed increase. Medic pod yield was estimated by harvesting 6 quadrats of 0.25 m^2 from each field.

Table 1. Site, number of farmers, and area planted to medic pasture (1995/96, 1996/97).

Province	CT	Number of farmers		Area planted (ha)	
		1995/96	1996/97	1995/96	1996/97
Settat	Ben Hmed	6	3	7	2
	Settat	2	0	2.5	0
	Ouled Said	2	0	4	0
Safi	Chemaia	3	4	5.5	3.5
	Sebt Gzoula	4	3	3.75	2
	Jemaa Sahim	4	0	6.25	0
Khouribga	Khouribga	0	1	0	0.5
Total		21	11	29	8

Harvesting techniques tested included a hand broom and the ICARDA sweeper (Christiansen 1993). The sweeper was either pushed by hand or pulled by a donkey. The ICARDA thresher (Christiansen 1993) and the straw thresher were used for threshing.

Two field days were organized each year at two sites to demonstrate the use of the sweeper, hand broom, and thresher. Farmers tried out the machines, expressed their views, and made suggestions.

Results and Discussion

Pasture Establishment

In 1995/96, 29 hectares of medic pasture were established on 21 farms, and in 1996/97, 8 ha were established on 11 farms. Establishment requirements were applied by most farmers during both years. Phosphate was applied by 78% of farmers, and about 87% of pasture was seeded early. Weeds invaded the sown medic pastures late in the year (December).

Grazing Method and Pod Yield

Different grazing methods (Table 2) were practiced. The flock size varied from 40 to 120 head for sheep, and from 4 to 14 for cattle. Most farmers used the medic pasture as a complement to weedy fallow.

About 16% of the farmers practiced continuous grazing for a few hours every day. A second group (31%) practiced rotational grazing with short periods in and out. The third group (23%) overgrazed the medic pasture before flowering and then stopped grazing. These three methods were favorable to medic pod yield. Grazing during flowering and seed set was practiced by 21% of the farmers. This method was destructive to pod setting. This group did not put the animals on the medic pasture earlier because enough herbage was available from weedy fallow or because the pasture was established late. The last group (9%) planted medic in a mixture with a cereal (barley or oat). The pasture was cut as green forage or as hay. Hay yield was 200–300 bales/ha, and was of high quality. It was a very good source of protein during the fall. The average pod yield of 300 kg/ha is not surprising, because the medic plant regrows quickly after cutting. With special care, it is possible to develop a future medic pasture from this amount.

In conclusion, 90% of farmers realized high pod yield, but only 70% managed the medic pasture well and produced a high yield of medic pods. When the pasture was cut green or for hay, the average pod yield was reasonable, showing that medics are adaptable to farmer practices.

Table 2. Influence of pasture management on production (kg/ha) of medic pods over two years.

	Year	Cg	Rg	Og/f	G/f+p	Mx/gh
Pod yield	1995/96	1513	1087	1208	532	568
	1996/97	1060	1175	1088	491	334
Farmers (%)	1995/96	14	13	19	14	9
	1996/97	18	18	27	27	9
Pod yield	Average	1286	1131	1148	511	451
Farmers (%)		16	31	23	21	9

Cg = continuous grazing a few hours per day; Rg = rotational grazing; Og/f = overgrazed before flowering stage and stopped. G/f+p = grazing during flowering and seed set; Mx/gh = harvest green or hay from mixture of medic and cereal.

Seed Yield

On average, pod yield was high: 1,000 kg/ha (Table 3). Since seed weight represents 30% of pod weight (Mazhar 1987), average yield of seed was 300 kg/ha. This production is twice that reported by Tazi (1990) in commercial medic seed production. Medic seed can thus be produced on-farm at a very low cost.

Table 3. Medic pod production at different sites (1996/97, 1997/98).

Province	CT	Pods (kg/ha)		
		1995/96	1996/97	Average
Settat	Ben Hmed	1,260	1,004	1,132
	Settat	910		910
	Ouled Said	820		820
Safi	Chemaia	1,300	671	985
	Sebt Gzoula	900	901	900
	Jemaa Sahim	860		860
Khouribga	Khouribga		1,143	1,143

Evaluation of Small-scale Machinery

Harvest of Pods

Pod harvest with the ICARDA sweeper and a hand broom was demonstrated on four farms at two locations (CT Ben Hmed and CT Chemaïa). A total of 52 and 70 farmers attended the on-farm field days in the first and second years, respectively. Seventeen people participated in the extension exercise.

The ICARDA sweeper was first tested in 1995/96. This machine was difficult to push and needed two persons. The land had not been leveled after seeding, and the presence of rocks and clods on the surface made harvesting painful and slow. Farmers at the field day in Chemaïa suggested using animal traction.

Thus in 1996/97 the sweeper was pulled by a donkey, which made the job easier and faster. Constraints from soil were no longer a problem. In half a day, 6 sacks of 50 kg each were collected at Ben Hmed, and 10 sacks were collected at Chemaïa in one day. Ten sacks are equal to 500 kg of pods, which is enough to plant at least one hectare of weedy fallow. Farmers in both CTs were willing to plant pods in their weedy fallow.

At the Ben Hmed site, farmers tried the hand broom. It is better adapted to soil with rocks and clods on the surface than the ICARDA sweeper, but it was time consuming, and may prove to be more expensive than the sweeper.

The participants at the field days made different suggestions concerning modifications that should be made to the sweeper to increase harvesting efficiency and adapt it to animal traction.

Threshing Techniques

Because it needs electricity, the ICARDA threshing machine was tested only at an experimental station. This machine is also heavy to transport. Farmers considered the technique complicated and not adapted to their conditions.

The straw thresher, available at several farms, was tested in the field. About 50% of pods were not threshed and 10–15% of seeds were broken. Nevertheless, farmers preferred the technique since pods which escape threshing can be fed to sheep.

Future Concerns and Focus

The farmers' attitude towards medics is positive. Some of the benefits they see are: fast regrowth of medic after grazing, bread wheat performs better after medic, lambs are healthier when grazing medic, and ewes are more productive.

Because availability and price of medic seed are major obstacles to adoption, and in view of the promising results obtained in promoting an informal medic seed system, short-term efforts will concentrate on the following:

- Adapting the sweeper to animal traction.
- Verifying and demonstrating the sowing of medic pods.
- Creating a market for pods to be sold or exchanged between farmers within the same rural community.
- Verifying the feasibility of using the sweeper in a cooperative organization.

There is also a clear need to develop a long-term project between all agricultural institutions and the rural community. The broad focus will be on:

- Supplying medic seed to 20 farmers located in one rural community. The community of Sbiâte at the Chemaïa site expressed its willingness to support the establishment of 20 hectares of medic pasture.
- Constructing three sweepers every year.
- Supporting the establishment of 20–40 ha each year in the rural community.
- Urging farmers to collect at least 500 kg of pods from each hectare,.
- Providing technical assistance to farmers interested in improving their weedy fallow and producing medic pods.

Acknowledgments

We would like to thank INRA, the ICARDA Forage Program, and the Maghreb-Mashreq Project for their assistance and financial support. Special thanks are due to the Direction d'Elevage and the CPSP for supplying medic seed.

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Impact of Phosphorus Fertilization on Forage and Pasture Seed Production: From Research Stations to Farmers' Fields

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Abstract

Forage crops occupy less than 10% of the cropped area in Morocco. This low production area is a result of the many problems that face the forage seed sector in the country. Problems with seed production and commercialization remain key constraints. Forage seed production is low, and what is produced is not available to farmers. The objectives of this study were: (i) to improve seed production of fodder legumes to increase feed production and quality in order to motivate farmers to cultivate more forage crops; and (ii) to find ways to increase seed stocks and their dissemination at the farm level. Two experiments were conducted on the effect of phosphorus fertilization on pasture and forage legumes. The first experiment was conducted on phosphorus fertilization of medics at two stations during the 1984/85 and 1986/87 growing seasons, followed by verification trials at the farm level from 1987 to 1992. To facilitate seed increase at the farm level, a small sweeper to harvest medic seed was introduced and tested by research farmers and extension agents in collaboration with ICARDA staff. The second experiment, which started in 1996/97, investigated the response of grain yield and size of nine forage and pasture legume species to different phosphorus rates. The fodder legumes concerned were *Medicago* spp., *Vicia ervilia, V. narbonensis, V. sativa, V. villosa, Lathyrus ochrus, L. cicera,* and *L. sativus*. Rates of phosphorus fertilization varying from 45 to 90 kg P_2O_5/ha improved grain yield by 20–300%. Grain number and size of *V. narbonensis, V. ervilia, Medicago* spp., and *Lathyrus* spp. were increased by phosphorus. On-farm trials showed that in many cases (more than 70% of farms) applying only phosphorus fertilization (90 kg P_2O_5/ha) to the weedy fallow without any seeding of commercial medics improved grain yield of native legumes, particularly medics, by more than 100%. In conclusion, applying low-cost and simple seed production techniques to improve seed yield of forage legume species will improve feed and animal yields, and will therefore motivate farmers to cultivate more forage crops.

Introduction

Farming systems of semi-arid North Africa are characterized by integration of livestock (sheep) and crop (barley and wheat) production to cope with the high-risk environment (low and irregular rainfall). In addition, fertilizer inputs are low, and what is added or recommended is not done so within a systems context. Thus, crop fertilization recommendations in low-rainfall areas, while considering sustainable inputs such as species, rotation, and the economic advantage expected from fertilizer use, do not consider ways of improving soil fertility. Phosphorus (P) fertilization is generally applied in wheat-based farming systems where food legumes, such as chickpea and lentil, are grown in rotation with wheat. However, in areas where forage legumes are cultivated, P fertilization of these crops is not a common practice.

Since the early 1920s, many studies have been conducted on the effect of P fertilization on forage yield and pasture botanical composition and yield. Positive and significant effects of P fertilization on legume forage yield have been reported by many investigators (Anderson and Lachlam 1951; Martin 1958; Ozzane 1969; Gates 1974; El Mzouri 1984).

The contribution of P to seed yield increase has also been reported for many legume species. Indeed, increases in chickpea seed production of 60, 28, and 71% were obtained by direct, residual, and cumulative P application, respectively (Amrani 1997). Grain production of *Medicago truncatula, M. polymorpha, Trifolium subterraneum*, and *Vicia villosa* was improved by 30, 40, 20, and 40%, respectively, after application of 45 kg P/ha in low-P soil in the rainfed area of central Morocco (El Mzouri 1984). In Australia, a linear seed yield response for two *subterraneum* subspecies and five *Ornithopus* species (*O. compressus, O. sativus, O. pinnatus, O. perpusillus*, and *O. isthmocarpus*) was obtained by applying 0–100 kg P/ha (Bolland 1985). The same study showed that applying increasing amounts of P (20–200 kg/ha) increased seed yield of *Medicago* spp. (*M. truncatula, M. polymorpha*, and *M. tornata*). The response increased linearly, but declined with increasing P application without reaching a response plateau (maximum yield response).

High P concentrations in forage legume seed have positive effects on both herbage and seed yield in the field. In fact, Bolland and Baker (1989) demonstrate that increasing P concentration in the seed of *T. balansae* and *M. polymorpha* is associated with increased seed yield. Similarly, the effectiveness of superphosphate increases when drilled with the seed, so that less fertilizer is required to produce the same yield as P concentration in the seed increases.

Few studies have considered the response of forage crops to P fertilization in the mainly rainfed areas of the North African countries. Therefore, there is a need to access the effects of P fertilization on seed production and quality of forage crops in order to improve these species, particularly when most soils cultivated with cereals are also low in P. Some results, from on-station research concerning the effects of P application on *Medicago* seed production, need to be transferred and verified in farmers' fields to encourage *in situ* seed increase and multiplication.

The objectives of our work were: (i) to evaluate the response of total biomass yield, seed yield, and grain size to P application of nine annual forage legume species under three different soil P levels (low, medium, and high); and (ii) to conduct on-farm P fertilization trials to increase native *Medicago* seed production *in situ*.

Materials and Methods

Two phases are presented in this paper, in accordance with our objectives: first, the response to P application of nine annual forage legume species, and second, native medic fertilization on farmers' fields.

On-station Fertilization Trials

Three sites with different levels of soil P (0.5 M $NaHCO_3$) were chosen for this study. They were: (i) Manasra (low available P, 7 ppm), shallow loamy clay (Calcixeroll) without cropping for the last 10 years, and used only as pasture; (ii) Jemaa Riah (medium soil P, 10 ppm), a red moderately-deep clay soil (Xerochrept) used for wheat and barley production; and (iii) Sidi El Aydi (high soil P, 17 ppm), deep dark clay soil (Chromoxerert) used for wheat production. The three sites are on the Chaouia plain near Settat, an area important for cereal production in Morocco. The average annual rainfall for the region is 350 mm. The fields used for the study had either wheat, barley, or weedy fallow pasture as the previous crop.

The plant species used for the experiment were *V. narbonensis*, *Pisum sativum*, *Lathyrus cicera*, *L. sativus*, *L. ochrus*, *V. ervilia*, *V. sativa*, *V. villosa*, and a mixture of four species of medic (*M. truncatula*, *M. polymorpha*, *M. littoralis*, and *M. scutellata*). The land was prepared by deep plowing followed by a disc-harrow in early November, 1996. Planting was done using the Wintersteiger experimentation seed drill with a row spacing of 30 cm on November 27. The seeding rates for each species were as follows: *narbonesis*, *ochrus*, *cicera*, *sativus*, and *sativum*, 90 kg/ha; *sativa* and *villosa*, 70 kg/ha; *Medicago* spp.,. 30 kg/ha; and *ervilia*, 40 kg/ha. Weeding was done manually at emergence, ramification, flowering, and maturity. Fertilizer use at planting, other than P, was limited to 20 kg N/ha and 80 kg K/ha.

Phosphorus was applied at three levels in the main plots on each set of the species: no fertilizer (control); 20 kg P/ha (medium); and 40 kg P/ha (high). These are the rates recommended to farmers. The experimental arrangement applied here was a split-plot design, with species as the experimental unit (sub-plot). At each site, the treatments were replicated three times.

The data collected were total biological yield, seed production, and seed size by weight. Statistical analysis, using the Three–Way Analysis of Variance and T-test for means comparison, was carried out with SAS tools (1985).

Rainfall

Rainfall during the 1995/96 growing season exceeded the annual average of the region, but its distribution was skewed (Fig. 1). In fact, more than 270 mm was received from September to December, with 232 mm during the month of December alone, which affected crop establishment and soil characteristics. After this abundant rainfall, a severe mid-season drought, with above-average seasonal temperatures, which persisted from mid-February to late April, delayed crop growth and hardened the topsoil. However, the planted forage crops in the trials did not suffer seriously from the drought, mainly because of their early rooting and drought-tolerant traits. In addition, weeding helped reduce soil moisture loss and helped take advantage of the late season rains. Plant development was advanced by one week. The early-maturing species (less than 110 days) were: *P. sativum*, *L. ochrus*, and *V. ervilia*. The late-maturing species (125 days) were *V. villosa*, and *V. sativa*.

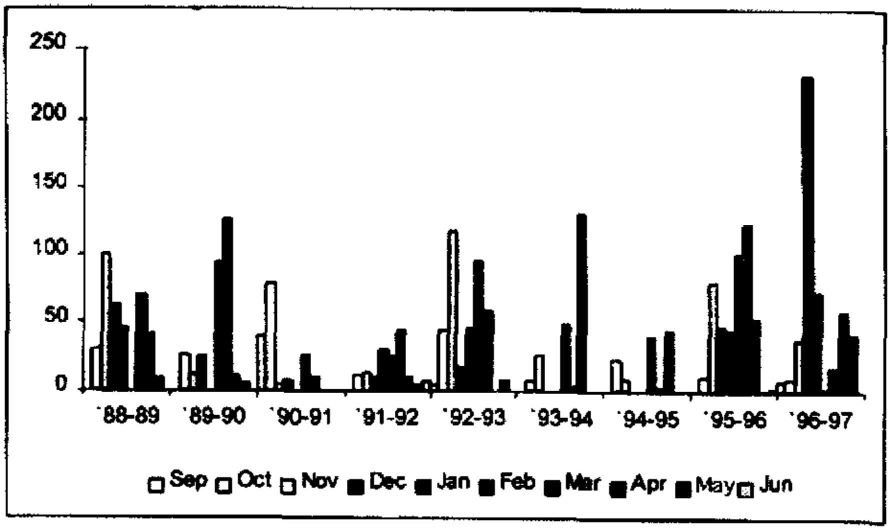

Figure 1. Monthly rainfall in the region (1988–1997).

On-farm Fertilization Trials

These trials were conducted for eight years, from 1988/89 to 1995/96, on a total of 40 farms, selected from different areas of Settat Province. Soil types varied from sandy coastal soil, to deep clay soil, to shallow stony calcareous soil. Available soil P content was generally low (<8 ppm). Land use was dominated by cropping systems characterized by a barley/pasture rotation with low fertilizer inputs.

Each year 4–9 farmers' fields that still had enough native medic seed were selected for P fertilization trials. The idea was to show farmers that the use of fertilizer (triple superphosphate, 45% P) would benefit the legumes in the pasture by increasing both forage and *in situ* seed production, and also benefit barley in rotation by the residual effects of both the legume-fixed N in the soil and the residual P from the previous year. The treatments involved one fertilizer rate (20 kg P/ha) and a control without P fertilization. The data collected during the first year included botanical composition, forage yield of legumes, and seed yield of native medics. Given the variability between the experimental sites, years, and farm practices, a modified stability analysis approach was used to determine the effects of P fertilization on forage and grain yields by recommendation domains.

Results and Discussion

On-station Trials

Herbage yield response

Biological yield varied with the site, being a function of soil type (especially depth) and rainfall (Table 1). Thus, Sidi El Aydi (Chromoxererts) gave the highest dry matter (DM) yield when compared to Manasra (Calcixeroll) or Jemaa Riah (Xerochrept). Soil P concentration positively affected biological yield for most species. However, yield response to P application was related to soil P; evidence of grain yield from P application was more pronounced in the low-P soil. There was a species × P fertilizer rate × soil type interaction; species responded positively to increasing P in the Jemaa Riah and Manasra soils, whereas in the black Vertisol of Sidi El Aydi it responded positively only when 40 kg P/ha was applied.

Table 1. Mean biomass, grain yield, and grain size of several forage species grown at three experimental stations in central Morocco.

Species	Manasra			Jemaa Riah			Sidi El Aydi		
	Biomass	Grain	Size	Biomass	Grain	Size	Biomass	Grain	Size
	(t/ha)		(mg)	(t/ha)		(mg)	(t/ha)		(mg)
Vicia									
narbonensi	5.9	1.2	248	6.6	2.2	252	7.7	2.6	240
sativa	5.5	1.3	51	7.2	1.5	51	7.6	2.0	54
villosa	5.2	1.2	42	7.1	1.2	45	7.2	1.8	40
ervilia	5.7	1.4	54	6.5	1.6	53	7.3	2.3	54
Lathyrus									
ochrus	4.5	1.0	123	5.5	1.1	121	5.4	1.8	121
cicera	4.8	2.2	78	5.8	2.2	80	7.0	3.1	82
sativus	3.8	1.4	102	5.7	1.7	98	5.9	2.2	94
Pisum									
sativum	3.6	1.1	157	4.0	1.0	170	5.9	1.9	154
Medicago	4.0	1.0	55	6.2	1.6	58	6.7	1.5	56

There was a differential response in terms of species (Table 2). Accordingly, *V. sativa* responded in the low-P soil (Manasra), but not in the others. *Lathyrus ochrus* reached its maximum yield in the high-P Sidi El Aydi soil when 40 kg P/ha was applied. At other sites, it was still responding to increased P fertilizer in the same way as *V. ervilia*, thus showing the need for more P in those soils. *Lathyrus sativus* showed a plateau response to P fertilization in all soils. These results demonstrate that forage legume species have different needs for P, particularly under different soil types. Soil test P calibration and fertilizer P management need to be more carefully studied in crop rotations that involve these different forage legume species.

Table 2. Biomass yield of forage legumes with phosphorus fertilization at three experimental stations in central Morocco.

Species	Phosphorus application rate (kg/ha)								
	Manasra			Jemaa Riah			Sidi El Aydi		
	0	20	40	0	20	40	0	20	40
Vicia									
narbonensis	5.0	6.0	6.6	5.1	6.3	8.4	7.4	7.6	8.1
sativa	5.0	5.4	6.1	7.3	6.9	7.5	7.8	7.5	7.6
villosa	4.2	5.4	6.1	6.5	7.2	7.5	6.7	7.2	7.8
ervilia	4.2	6.1	6.7	4.2	7.5	7.8	6.8	7.0	8.0
Lathyrus									
ochrus	3.8	4.2	5.5	4.6	5.6	6.2	5.3	5.9	4.9
cicera	4.3	4.9	5.1	4.9	5.8	6.7	6.8	7.2	6.9
sativus	3.3	4.2	4.0	5.6	5.7	5.9	5.9	5.7	6.1
Pisum									
sativum	3.0	3.5	4.2	3.5	4.5	4.0	6.3	5.6	5.9
Medicago	3.2	3.5	4.2	3.5	4.5	4.0	6.3	5.6	5.9

Seed yield response

Seed yield response of these forage legumes correlated positively with increasing P fertilizers for all species and each soil type (Table 3). Higher yield gains were obtained in the low-P (Calcixeroll) and medium-P (Xerochrept) soils than in the high-P soil (Chromoxerert). Highest seed yield was reached in the high-P soil of Sidi El Aydi for all species. Significant positive effects of P fertilizer on seed yield were registered for all species in the study. Indeed, in the low-P soil (Manasra), the increase from P application varied from 30 to 180%. These values varied from 11 to 17% for the medium-P soil, and from 28 to 44% for the high-P soil. At all sites, relative seed yield gains varied from 14 to 30% for the 20 kg P/ha rate, and from 25 to 90% for the 40 kg P/ha rate.

Table 3. Grain yield of forage legumes with phosphorus fertilization at three experimental stations in central Morocco.

Species	Phosphorus application rate (kg/ha)								
	Manasra			Jemaa Riah			Sidi El Aydi		
	0	20	40	0	20	40	0	20	40
Vicia									
narbonensis	0.8	1.3	1.6	1.9	2.1	2.5	2.4	2.6	2.8
sativa	1.0	1.3	1.5	1.3	1.5	1.8	1.8	2.1	2.0
villosa	0.7	1.3	1.7	0.7	1.2	1.9	1.8	1.5	2.1
ervilia	0.9	1.6	1.8	1.3	1.6	1.8	2.1	2.3	2.4
Lathyrus									
ochrus	0.6	1.2	1.3	0.7	0.9	1.7	1.6	1.8	2.1
cicera	1.5	2.1	2.9	1.8	2.5	2.9	2.8	2.9	3.6
sativus	1.0	1.5	1.7	1.4	1.6	2.1	1.8	2.4	2.5
Pisum									
sativum	0.7	1.3	1.4	0.8	1.0	1.1	1.6	1.7	2.3
Medicago	0.5	1.1	1.4	1.4	1.9	1.5	1.8	1.3	1.5

There was significant species × P fertilizer rate × site interaction. For example, *Vicia* reached its maximum yield in the high-soil P of Sidi El Aydi when 20 kg P/ha was applied, but at other sites it was still responding favorably to increasing rates of P fertilizers. Low P in the soil significantly limited seed production of *V. narbonensis, V. villosa, L. ochrus, L. sativus,* and *P. sativum.* Both *P. sativum* and medics produced very limited amounts of seed in each soil type, even when P fertilizer was applied.

Seed size

The size of seed, as reflected by weight, was the parameter least affected in this study (Table 4). Neither location nor station had an effect on seed size. However, seed size was positively affected by P application for all species and all sites, indicating, therefore, the positive impact on seed quality (energy) and survival. Studies by Bolland (1985) show that high seed P concentration increases the effectiveness of P fertilizers, so that less fertilizer was required to produce the same yield as P concentration in the seed increases. Seed size varied to produce the same yield as P concentration in the seed increases. Seed size varied among sites, mainly because of soil characteristics that affect grain-filling, particularly after prolonged mid-season drought.

Table 4. Grain size of forage legumes with phosphorus fertilization at three experimental stations in central Morocco.

Species	Phosphorus application rate (kg/ha)								
	Manasra			Jemaa Riah			Sidi El Aydi		
	0	20	40	0	20	40	0	20	40
Vicia									
narbonensis	233	244	248	250	250	254	238	249	240
sativa	47	53	54	48	54	52	55	53	53
villosa	38	42	47	43	45	46	38	37	43
ervilia	52	54	57	58	46	54	54	53	54
Lathyrus									
ochrus	115	126	129	121	118	125	119	120	123
cicera	76	78	79	79	89	95	80	82	87
sativa	97	102	106	94	101	99	93	96	94
Pisum									
sativum	148	154	157	157	153	152	155	152	156
Medicago	53	55	57	55	56	57	54	55	57

On-farm Trials

Botanical composition

Botanical composition responded positively to P application, particularly in good rainfall years. The overall average (40 farms × 15 samples) of legume dry matter contribution to the total DM harvested each spring (March) varied from 24% for the control to 54% in the superphosphate-treated pastures. This difference of 20% between the two treatments had a great impact on soil-fixed N, herbage yield and quality, seed yield and quality, and yield of the subsequent barley crop.

Total biological yield

Dry matter yield, when averaged over both treatments (control vs 20 kg P/ha fertilized), gave what is known as the "environment index." The environment index, which represents the overall average production by site, varied from 15 to 14,000 kg DM/ha (Fig. 2). Each environment index is a synthesis of the management packages, the growth conditions of native medic, and the dominance of medic species. When the index is low, it means unfavorable production and management conditions prevail for native medics, while a high index implies favorable production and management conditions for native medics.

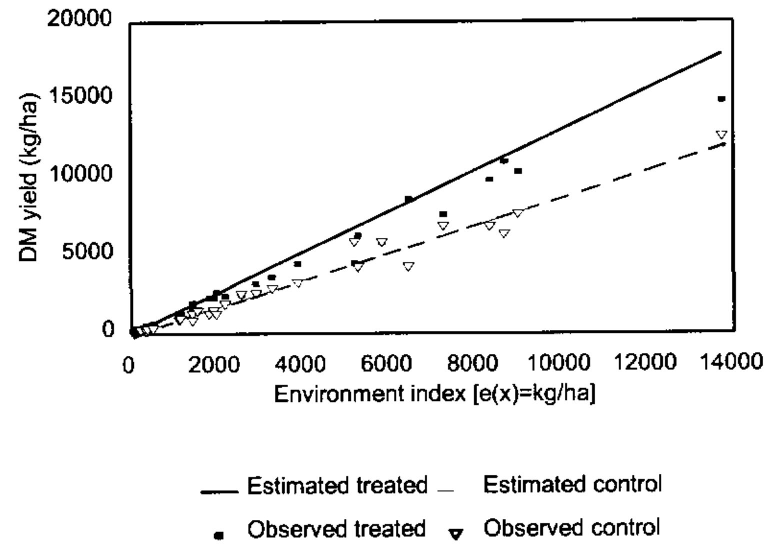

Figure 2. Native medic dry matter (DM) yield response to P fertilizer.

This high variability is the result of differences in soil type and fertility. Soils on which trials were established with less than 5 ppm P were classified as follows: 21.3% Calcixerols; 64% Vertisols; 4% Xerochrepts; 5.7% sandy soils (P Samments); and 4.3% other. Differences in rainfall (150–550 mm/year) and pasture management were also major factors. Given the high variability obtained in these kinds of trials, the use of modified stability analysis allows us to distinguish between response and recommendation domains.

The response of DM yield to increased environmental index was linear at this stage and did not reach a production plateau. Maximum yields obtained in high conditions for control and P-fertilized pastures were 1.4 and 17.5 Mg DM/ha, respectively. These results show the impressive effect on the improvement of feed production and quality by applying only 20% kg P/ha.

Native medic seed yield

The same analysis made for DM production applied to seed production of native medics (Fig. 3). The environment index varied from 0.01 to 2.75 t/ha. The seed increase response to the environment index was linear, showing the improvement that might be realized under more favorable conditions by applying more P fertilizer. Under a high index, the P-fertilized pastures produced 40 tonnes of pods, whereas farmer practices produced only 1.4 t/ha. These results demonstrate the possible impact that could result from transferring all research results in the area of seed production to the farm level in order to increase and promote new varieties and to protect and maintain *in situ* the present native genetic biodiversity of palatable species.

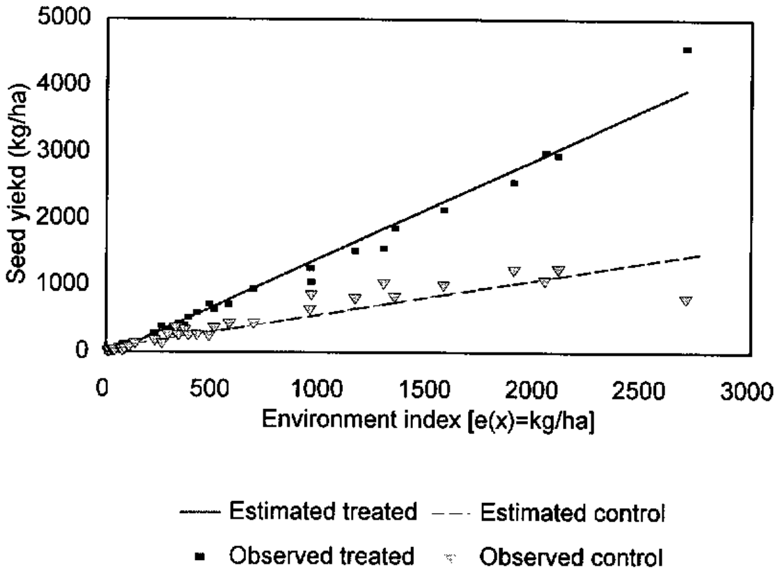

Figure 3. Native medic seed yield response to P fertilizer.

Conclusions

These trials show that P fertilization still remains under-exploited, particularly when these high improvements of harvested DM, seed yield, and seed size are obtained in one of the richest countries for P mining in the world. In fact, these results demonstrate that forage legume species have different needs for P, particularly when considering different soil types. Soil P test calibration and fertilizer P management need to be more carefully studied in crop rotations that involve these different forage legume species. Also, soil P test calibration needs to be established for these crops, as is done with cereals. Research on ways to increase seed production of native and introduced species needs to be developed to resolve seed availability and cost issues for farmers, especially for those who raise sheep and do not practice farming and are far way from extension sites.

Acknowledgments

The authors are grateful to Mrs Zuka Istanbouli for typing various drafts of this paper.

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Fitting High Seed Yielding Forage Varieties to the Climatic Patterns of the Cereal Growing Highlands of Algeria

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Abstract

The most common forage crops grown in the cereal highlands of Algeria are vetch and oat. However, a drastic decrease in winter rainfall over the last two decades and the occurrence of frost have hindered the production of seed of existing varieties of forage legumes. Because of these climatic changes, the early-maturing cultivars of vetch, Languedoc, and forage pea, Sefrou, released in the 1950s, are no longer suitable for local conditions. Therefore, a selection program was undertaken to develop tolerant varieties using introduced genotypes of *Vicia* spp., *Pisum arvense*, and *Pisum sativum*. Wide variability characterized the overseas plant material. Late-maturing genotypes were found to be more adapted to the conditions of the cereal highlands. Dry matter yield exceeded 7 t/ha for forage pea and 5 t/ha for vetch. Seed yield was also more than 1 t/ha. Furthermore, the dry matter production of these varieties grown in a mixture was even higher (12 t/ha). The results support the hypothesis that there is a need to select late-maturing genotypes that make the best use of spring rains at a time when photoperiod and temperature are more favorable.

Introduction

The most common forage grown in the cereal highlands of Algeria is a mixture of vetch and oat, which is cut for hay. However, a drastic decrease is winter rainfall during the last two decades and frosty conditions have compelled farmers to grow pure stands of oat or barley as animal feed. The old varieties of vetch and forage pea released in the 1950s remain the most cultivated varieties in the Sersou plateau. However, they are no longer adapted to the seasonal changes characterized by reduced and erratic rainfall.

The objective of the present paper is to investigate the possibilities of developing varieties of vetch and forage pea that are adapted to the changed climatic patterns of the Sersou plateau in midwestern Algeria.

Materials and Methods

Environmental Conditions

The Sersou area has an altitude of 800–1,400 m. The growing season extends from October to early June, when hot wind dries off the vegetative cover. Average annual rainfall is currently about 367 mm, which is 197 mm less than the amount received during the 1960s. This deficit appears mainly during the months of December, January, and February (164 mm). A deficit of 32 mm rainfall also appears in March, which coincides with flowering of early-maturing forage legume varieties. This is aggravated by late winter frosts (-4 to -7°C). Drought is less frequent in spring, and there is a tendency towards late rains, which enhance dry matter production and seed yield of late-maturing varieties.

Field experiments were conducted at Sebain (900 m altitude, minimum temperature -7°C), and advanced trials were undertaken at Haydar (1,000 m altitude, minimum temperature -8°C). The soils are a deep alkaline brown at Sebain and shallow sandy calcareous at Haydar.

Plant Material

Selection from introduced plant material was initiated during the 1985/86 growing season and carried out for five years.

- Nursery observations were conducted at Sebain, including a collection of 64 genotypes of vetch and forage pea from southern France, Syria, Argentina, and New Zealand. Equal numbers of genotypes of *Vicia sativa*, *Vicia villosa* subsp. *dasycarpa*, *Vicia pannonica*, *Vicia narbonensis*, *Pisum arvense*, and *Pisum sativum* were also evaluated for plant vigor, tolerance to frost and water stress, resistance to disease, and seed pod shattering.
- Selected genotypes were evaluated in replicated plots (1.5 × 5 m) at Sebain. The aim was to compare very early flowering (90–105 days from emergence), early flowering (106–115 days), late flowering (120–136 days) and very late flowering (>136 days) genotypes.
- Advanced trials were carried out at Sebain and Haydar to confirm the potential of the selected genotypes in terms of dry matter production and seed yield from mixed legume–oat sowings. The oat varieties used were the newly selected late-maturing cultivar WI 78 from southern Australia and the local check Noire 912.

For preliminary and advanced trials, a randomized block design with four replicates was used. Soil was shallow-cultivated twice (10–15 cm) and harrowed. The seeding rate was 100 kg/ha. The phosphate application was 45 kg/ha.

Results and Discussion

Nursery observations showed a very large variability among the introduced material. Flowering of forage pea genotypes occurred earlier than most vetches. The early-maturing vetches *Vicia pannonica* and *Vicia narbonensis* flowered 93–96 days after emergence. *Vicia villosa* subsp. *dasycarpa* was characterized by slow winter growth, rapid spring growth, and late pod maturity. Consequently, its seed production yield was affected by late drought. *Vicia sativa* showed a wide range in flowering dates (93–143 days). *Pisum arvense* flowered 15 days earlier than *Pisum sativum*. Forage peas were less affected by water stress, since late rains enhanced regrowth, and biomass production was two-fold higher than the vetches. This confirms farmer experience that early rain favors vetch, while late rain enhances forage pea production. For both species, dry matter yield of late-maturing genotypes was two to three times higher than that of early maturing species. The best-yielding forage pea genotype was Gali (French strain), with 7 tonnes DM/ha, while the highest yielding vetch variety, 46–80, gave only 2.7 tonnes DM/ha.

The rainfall for the 1989/90 growing season was only 189 mm, and 45% of it occurred in spring at the southern site of the Sersou at Haydar. At Sebain, both species suffered from drought and dry matter yield did not exceed 3.3 t/ha. Late rains at Haydar allowed a 67% increase in dry matter production of forage pea genotypes. This increase did not exceed 50% for vetch, when compared to yields obtained at Sebain.

The 1990/91 growing season was very rainy (435 mm) and allowed maximum biomass production from both species. Yield reached 8 tonnes DM/ha for forage pea and 5 tonnes DM/ha for vetch. However, the excess vegetative material was prejudicial to seed production, except for the late-maturing forage peas, Gali and Assas, which produced 1.4 tonnes seed/ha, and the vetch genotype 46-80, at 1.1 tonnes seed/ha. The local check Languedoc produced 0.38 tonnes seed/ha.

The selected genotypes, Gali (*Pisum sativum*) and 46-80 (*Vicia sativa*), combine both high dry matter and seed production capability. Their potential was confirmed in a legume–oat mixture, using a late-maturing oat variety. The forage mixture yield (>12 tonnes DM/ha) was two times higher than the pure legume stand. The yield of the forage mixture was significantly higher than that of the local check (Languedoc), Noire 912, and Sefrou (Tables 1 and 2).

From this study, it can be concluded that there is a need to select late-maturing varieties which make best use of late rains at a time when photoperiod and temperature are more favorable for growth and seed production.

Table 1. Time and variation in dry matter production (t/ha) of promising genotypes of vetch and pea at Sebain and Haydar.

Species and genotype	Days to flowering	1987/88 Sebain	1988/89 Sebain	1989/90 Sebain	1989/90 Haydar	1990/91 Sebain
Pisum arvense						
51-83 L	93	2.19	3.40	2.58	6.80	8.20
52-83 L	95	2.43	3.30	1.79	7.10	7.60
50-83 L	96	2.49				
Sefrou	105	2.29	3.10	2.09	5.20	6.50
Pisum sativum						
Gali	120	2.42	7.10	3.30	7.30	7.20
Assas	125	2.90	5.13	1.43	8.00	7.20
Mean	105	2.43	4.60	2.23	6.88	7.34
LSD		8.15	0.23	0.16	0.62	0.55
Vicia sativa						
Sylphis	96	3.22	2.18	3.12	4.40	5.20
Hifa	104	3.46		2.49	4.30	5.86
Presta	114	4.47	2.17	1.80	4.20	3.73
Languedoc	112	3.93	1.91	2.79	5.00	4.33
16-80 L	135	4.05	2.71	2.03	4.90	5.88
19-80 L	136	4.27	2.36	1.87	4.70	3.53
Valor	147	4.24				
Mean	120	3.95	2.26	2.35	4.58	4.75
LSD		0.35	0.26	0.45	0.33	0.25

Table 2. Seed yield and contribution to forage mixture productivity of selected genotypes of vetch and pea (1990/91).

Species/genotype	Seed yield	Legume–oat mixture DM yield (t /ha)	
	(t/ha)	WI 78	Noire 912
Pisum arvence			
51-83L	1.14		
52-83L	1.34		
50-83L	0.85		
Sefrou	0.46	11.00	9.60
Pisum sativum			
Gali	1.41	12.25	8.66
Assas	1.36		
Vicia sativa			
Sylphis	0.33		
Hifa	1.27		
Presta	0.59		
Languedoc	0.38	7.8	10.2
46-80L	1.10	12.4	12.2
19-80L	0.95		
Valor	0.53		

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Small-scale Seed Harvesting Methods of *Stylosanthes guianensis*, *Stylosanthes scabra*, and *Desmodium intortum*

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Abstract

Efficient and economical methods of seed harvesting are required for use by small-scale forage seed producers in developing countries. Three common, simple methods (hand picking as seed ripens, beating ripe seed from standing plants, and cutting the entire plot when seed is at maximum ripeness) were studied using three common small-seeded forages (*Stylosanthes guianensis, S. scabra*, and *Desmodium intortum).* Yield of mature seed, labor, and time were compared. For both *Stylosanthes* spp., maximum seed yield from minimum labor input were obtained by cutting the plot at maximum ripeness and threshing out the mature seed. The highest seed yield from *D. intortum* was achieved by using a combination of picking and cutting. However, this required more labor than cutting the entire plot at peak maturity.

Introduction

Production of tropical forage seed requires development of methods that optimize seed yield per unit of land and unit of labor, and can be easily applied by smallholder farmers. Small-scale seed harvesting methods for use by farmers or small producers should be practical and cost effective, and also recover as much seed as possible. Many tropical forage species are perennial and have a long flowering period, with seed produced and ripening over several months (Humphreys and Riveros 1986). This characteristic has led to: (i) hand picking of ripe seed throughout the season; and (ii) harvesting the entire plot when the majority of seeds are mature, as the most common seed harvesting methods used for legumes. Although hand harvesting is an easy and efficient method for forage species with larger seed pods such as *Centrosema, Macrotyloma*, and *Sesbania,* it is time consuming and often difficult for small-seeded species such as *Stylosanthes* and *Desmodium.* Threshing of these species is also difficult because single seeds are firmly encased in small pods that are difficult to remove. Threshing machines are usually required for efficient de-podding of these seeds.

Studies on forage legumes have found that hand picking of *Neonotonia wightii, Centrosema pubescens*, and *Macroptilium atropurpureum* results in seed of excellent quality and high yield (Humphreys and Riveros 1986). Mechanical harvesting with a header machine has also been used to harvest large-scale plantings of forage legumes, and gives good results for *Stylosanthes* spp. Hand cutting and rolling the entire plot when a large number of seeds were mature, followed by sweeping fallen seed, resulted in good seed recovery in *Stylosanthes humilis* (Wickam et al. 1977).

These earlier studies indicate that both hand picking and harvesting by cutting, drying, and threshing can be used to harvest good-quality forage legume seed. In this study, different harvesting methods for legumes grown on small plots were compared for seed yield and efficiency of harvesting from plants of two erect, determinate legume species, *Stylosanthes guianensis* and *S. scabra,* and one with a sprawling determinate growth pattern, *Desmodium intortum*.

Materials and Methods

The experiments were carried out at Wollayta Soddo in southern Ethiopia, on a site at an altitude of 1950 m. The site is sub-humid, with an average annual rainfall of 800 mm. Soils are red nitosols with a pH of 4.4 (in H_2O). The area has a dry season from mid-December until the end of March, which is the usual seed ripening time for *S. guianensis, S. scabra,* and *D. intortum*.

The materials used for the trial were *S. scabra* cv Seca (ILRI accession 441), *S. guianensis* cv Cook (ILRI accession 4), and *D. intortum* cv Greenleaf (ILRI accession 104). Seed was sown in rows 50 cm apart in 4 m^2 plots in five replications for *S. scabra* and *D. intortum* and six replications for *S. guianensis*, in a randomized block design. Pathways were kept mown and plots were weeded regularly. Seed was harvested in the second and third year, because most perennial forage legumes do not produce seed in the establishment year in this environment.

Seed of *Stylosanthes* was harvested by: (i) hand picking ripe seed at intervals during the seeding period; (ii) cutting the plants at peak seed maturity with a sickle; and (iii) beating the standing plants at intervals during the seeding period and collecting the ripe seed on a plastic sheet spread below the plants. The first two methods were also used to harvest *Desmodium* seed, and then compared with a combined method of hand harvesting during the seed period and harvesting the whole plant by cutting at the end of the seeding period.

The time needed for harvesting, threshing, and cleaning the seed was recorded. The bulky material was threshed with a Saatmeister drum thresher, and the seed was further threshed and de-podded with a Seedburo belt thresher. Final cleaning was done by hand and a Seedburo laboratory seed blower. Total seed weight harvested from each plot was determined. Thousand seed weight was determined after the first harvesting season by weighing six samples of 100 seeds each from each plot.

Data were analyzed using the ANOVA procedures in the SAS program (SAS 1987).

Results

The highest seed yield of *S. scabra* and *S. guianensis* for both harvesting years was obtained by cutting the plot (Table 1). Cutting was also the most efficient method in terms of labor. The most labor-intensive method, picking the seed, gave the lowest seed yield for *S. scabra,* although the difference between picking and beating was not significant. The lowest seed yield for *S. guianensis* was obtained by beating the plants; it gave less than half the seed yield obtained by cutting. The labor input for hand picking was very high. Plots of *S. scabra* were hand picked an average of 10 times during the first season and eight times during the second. Plots were harvested by beating eight times during the first season and five times during the second. The high labor input was partly compensated by a lower labor input for threshing and cleaning of the seed. Seed of *S. guianensis* does not shatter as easily as *S. scabra*, and the plots were harvested less frequently with less labor input. Seed yield of *S. scabra* was higher than that of *S. guianensis*.

Desmodium intortum did not show significant ($P > 0.05$) differences in weight of seed harvested for the three harvesting methods in the first year (Table 2). In the second year, there was a significant difference between seed harvested by cutting alone and seed harvested by the combined method of hand picking and cutting. Although the combined hand picking and cutting method gave the highest seed yield it, also required the most labor.

For all three species, a higher labor input at the time of harvesting was partly compensated by a lower labor requirement for threshing and cleaning of the seed. Seed processing required the most labor for those treatments that involved cutting the whole plot.

There were no significant difference of 1,000 seed weight for the three harvesting methods. This indicates that harvesting method had no influence on seed quality.

Table 1. Comparison of labor requirement and seed yield of different harvesting methods on *Stylosanthes* seed.

			Harvesting method		
		Year	Picking	Beating	Cutting
		***Stylosanthes scabra* ILRI 441**			
Labor (man h/m^2)	Harvesting	1	2.92	1.03	0.06
		2	1.30	0.28	0.07
		Mean	2.11	0.66	0.07
	Threshing	1	0.18a	0.17a	0.30a
		2	0.12b	0.20ab	0.27a
		Mean	0.15a	0.18a	0.28a
	Cleaning	1	0.09a	0.09a	0.22
		2	0.07a	0.09a	0.11
		Mean	0.08a	0.09a	0.17
	Total	1	3.19	1.29	0.58
		2	1.50	0.57	0.45
		Mean	2.35	0.93	0.52
Seed yield (g/m^2)		1	60.5a	68.0a	118.5
		2	53.8a	69.1a	73.9
		Mean	57.2a	68.6a	96.2
		***Stylosanthes guianensis* ILRI 4**			
Labor (man h/m^2)	Harvesting	1	2.10	0.75	0.08
		2	.54	0.17	0.06
		Mean	1.32	0.46	0.07
	Threshing	1	0.03a	0.03a	0.28
		2	0.09	0.05a	0.05a
		Mean	0.06	0.04	0.17
	Cleaning	1	0.11a	0.08a	0.21
		2	0.08a	0.07a	0.10
		Mean	0.09a	0.08a	0.15
	Total	1	2.24	0.86	0.56
		2	0.71	0.29	0.21
		Mean	1.47	0.58	0.39
Seed yield (g/m^2)		1	22.1	11.0	27.3
		2	20.5	12.4	29.2
		Mean	21.3	11.7	28.6

Means in rows followed by the same letter do not differ (P >0.05, Tukey).

Table 2. Comparison of labor requirements and seed yield for different harvesting methods on *Desmodium intortum* ILRI 104.

			Harvesting method		
		Year	Picking	Cutting	Mix
Labor (man h/m^2)	Harvesting	1	0.72	0.05	0.53
		2	0.26a	0.06	0.20a
		Mean	0.49	0.05	0.36
	Threshing	1	0.06	0.25a	0.26a
		2	0.10a	0.12a	0.20
		Mean	0.08	0.19	0.23
	Cleaning	1	0.05	0.11a	0.11a
		2	0.03	0.17a	0.25a
		Mean	0.04	0.14a	0.18a
	Total	1	0.82a	0.41	0.89a
		2	0.39a	0.35a	0.64
		Mean	0.60	0.38	0.77
Seed yield (g/m^2)		1	41.1a	43.4a	53.0a
		2	25.5ab	22.5b	39.0a
		Mean	33.3a	33.0a	46.0

Means in rows followed by the same letter do not differ ($P > 0.05$, Tukey).

Discussion

Previous studies have indicated that hand picking might result in higher-quality seed of forage legumes (Humphreys and Riveros 1986). None of the harvesting methods tested had any significant effect on seed quality as determined by percentage of full seed, which was measured by 1,000 seed weight.

For both *Stylosanthes* species, the highest seed yields were obtained by cutting the plot, and much lower seed yields resulted from hand picking ripe seed at intervals throughout the growing season. Time of cutting was not very critical to obtaining maximum yield of Stylosanthes *scabra*, making it a good method for farmers. This longer cutting period was also observed by Thomson and Medeiros (1981). For *Desmodium,* the highest seed yield was obtained by a combination of cutting and picking.

For *S. guianensis*, each harvesting method gave a significantly ($P > 0.05$) different seed yield. The method of beating ripe seed and collecting it from the ground was not very suitable for *S. guianensis* seed because it does not shatter as easily as seed of *S. scabra*, and seed recovery was poorer. The high yields obtained from cutting and threshing are consistent with results reported for seed production of *S. humilis* in Thailand by Wickam et al. (1977).

Yield obtained from hand picking ripe seed of *D. intortum* did not differ significantly from the methods that involved harvesting the entire plot. This may be explained by a combination of factors. *D. intortum* has a sprawling growth habit and forms a thick sward. Seed matures progressively from the bottom (Skerman et al 1988), and thus the ripe seed is hidden within the sward and difficult to see, making it difficult to pick. Flowers and vegetative growth may be damaged during hand picking. Medeiros and Thomson (1981) found that seed of *D. intortum* shatters once peak maturity has been reached, making it very important to choose the correct time of cutting. Both harvesting methods therefore have their disadvantages. By using a combination of picking and cutting, the timing of the cutting of the plot was less critical and at the end of the season the hidden seed was harvested and not left in the field.

The labor requirement varied for the different techniques and species. Although harvesting by cutting requires less labor than hand picking, threshing and cleaning after harvesting the whole plot takes more time than hand picking. In this study, using small plot management, hand picking took longer and produced the lowest seed yield. In areas where there is competition for labor and land for forage seed production, it would be most efficient to cut the entire seed crop only once at optimum maturity for all three species.

Acknowledgments

The authors would like to thank the Swiss Development Cooperation for financial support to carry out this research, and Jemal Mohammed and Demissie Goa for providing technical assistance.

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Discrimination Among Populations Forming Ecotypes and Cultivars of Lucerne (*Medicago sativa* L.) using Random Amplified Polymorphic DNA

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Abstract

RAPD (Randomly Amplified Polymorphic DNA) was used in this study to discriminate among 10 cultivars of lucerne (*Medicago sativa* L.). Twenty six primers (10-base oligonucleotide) were tested individually to amplify RAPD from bulk DNA samples of the cultivars. Ten primers generated polymorphic fragments, four of which generated RAPD profiles, by which all 10 cultivars, including those with a closely-related genetic background, could be discriminated. Replicated PCR reactions were carried out using two primers alone, and in combination with the standard reaction mixture using different batches of enzyme from the same manufacturer. The findings of this study demonstrate that the results obtained by RAPD can be reproduced. The results also illustrate that the number of distinct RAPD fragments generated by a combination of two primers was less than those produced by each individual primer.

Introduction

Field-based morphological data collected in plot tests have long been used to fulfill the requirements for registration of new cultivars, and are a requirement for OECD seed certification. However, the problems with plot testing are well-recognized (Cooke 1995b), and the need for alternative methods of cultivar discrimination is reflected in the number of techniques developed recently. The most promising cultivar verification technology is the use of fingerprinting techniques, based on either protein electrophoresis or DNA restriction fragment hybridization. Extensive reports in the literature (Brummer et al, 1991; Gardiner and Forde 1992; Steiner 1993; Kidwell et al. 1994; Cooke 1995a, 1995b) suggest that electrophoretic techniques could provide alternatives for plot testing. Among cross-pollinating (allogamous) species, ryegrass (*Lolium*) is the only one for which the electrophoresis of seed storage protein has been accepted by the International Seed Testing Association for cultivar verification (ISTA 1992; Cooke 1995a). The possible use of isozyme electrophoresis for registration of new cultivars of this species has also been considered.

While most of the electrophoretic work has been on inbreeding species, results by Gilliland (1989) and Gardiner and Forde (1987, 1988) suggest that this technique might be useful for outcrossing species. However, little has been reported on the application of electrophoretic techniques for discrimination among lucerne (*Medicago sativa* L.) cultivars.

Gardiner and Forde (1992) examined the SDS-PAGE technique for identification of lucerne cultivars. As the protein banding profiles from the bulk seed samples were identical for most of the cultivars tested, they concluded that lucerne cultivar differentiation by SDS-PAGE was not feasible.

Although restriction fragment length polymorphism (RFLP) has been used by some researchers for genetic analysis of lucerne species (Brummer et al. 1991), no report is available in the literature on the application of this technique for differentiation of lucerne cultivars.

RAPD (Williams et al. 1990) has been shown to be a powerful tool, not only for identification of cultivars of inbreeding species, such as barley and wheat (Francisco-Ortega et al. 1993), but for discrimination of cultivars of outcrossing species, e.g. *Brassica napus* L. (Mailer et al. 1994). However, there is no report in the literature on the application of the RAPD technique for discrimination of lucerne cultivars.

In this study, the possibility of discrimination, on the basis of RAPD profiles from the bulk DNA sample, among lucerne cultivars with a wide range of adaptation origins and diverse genetic background, was investigated.

Materials and Methods

Plant Material and Sample Preparation

Certified seed lots from six Iranian, two New Zealand, and two USA cultivars were tested (Table 1). The Iranian cultivars were provided by the Seed and Plant Improvement Institute, Ministry of Agriculture, Karaj, Iran, and the others by the Margot Forde Germplasm Center, Agricultural Research Grasslands, Palmerston North, New Zealand.

One hundred randomly drawn seeds of each cultivar were sown in peat pellet No. 7 Jiffy pots, which were then placed in a growth chamber (20±2°C and 60±5% RH) and watered every second day. At 45 days after emergence, all leaves were harvested from 40 randomly selected individual seedlings per cultivar, and frozen at -70°C prior to DNA extraction.

DNA Isolation

Following the protocol of Sambrook as adapted by Gardiner, three to five leaves from a single seedling were ground to a pulp in a sealed plastic bag containing 2 mL of extraction buffer (140 mM sorbitol, 220 mM Tris-HCl pH 7.5, 20 mM Na_2 EDTA, 0.8 NaCl, 0.8% w/v cetyl trimethylammonium bromide, 1% w/v N-lauroylsarconine, and 1% w/v polyvinylpyrrolidone). A 1.6 mL sample of the resulting pulp was extracted with 0.4 mL of chloroform:octanol (24:1 v/v) at 65°C for 30 minutes and then centrifuged at 15,000 rpm for 10 min. DNA was precipitated from the aqueous layer by the addition of 1 mL of ice cold isopropanol. The DNA pellet was recovered by centrifugation at 12,000 rpm for 5 min, and then washed twice with 70% ethanol, dried under vacuum, and resuspended in up to 0.1 mL of sterile distilled water.

Because it is a cross-pollinating species, a lucerne cultivar is a population comprising different genotypes. For DNA fingerprinting of such a cultivar, it is necessary to assess the minimum number of seedlings adequate to represent the gene pool. In a series of preliminary experiments, RAPD profiles from five bulk DNA samples of cv Esfahani constructed from DNA samples of 5, 10, 20, 30, and 40 individual seedlings were compared. The DNA amplification (see below) in this study was directed by two individual primers: OPB13 and OPB19. The results suggested that the bulk DNA sample from 40 seedlings was adequate for DNA fingerprinting of this cultivar. This sample size was then used for fingerprinting all the cultivars.

RAPD Amplification

The PCR reaction mixture (12.5 µL) contained 10 mM Tris-HCl pH 8.8, 50 mM KCl, 2.5 mM $MgCl_2$, 0.01% gelatin, 0.8% formamide, 0.1 mM of each dNTP, 0.2 µM of each primer, 5 ng of lucerne DNA, and 1.2 units of Taq polymerase (Stratagene) overlaid with 15 µL of paraffin. Amplification was in a Perkin Elmer Cetus DNA Thermal Cycler programmed for 40 cycles with the following temperature profile: 1 min at 94°C (5 min for the first cycle), 1 min at 40°C, and 2 min at 72°C. Cycling ended with a final extension at 72°C for 10 min.

Amplification products were electrophoresed for 20 cm on a gel consisting of a mixture of 1% BRL Ultra-Pure agarose (Life Technologies, Gaithersburge, MD, USA) and 1% NuSieve GTG agarose (FMC, Rockland ME, USA) in TAE buffer at 80 volts (4 volt/cm) for approximately 5 h. One hundred bp ladders [1 µL of 100 bp ladder (conc. 1 µg/µL), Life Technologies], 3 µL of 10×SB, and 23 µL water (sufficient for two ladders) were loaded in the first and last lanes of the gel. Gels were stained with 0.35 µg/mL ethidum bromide, visualized under UV light, and then photographed in color (Kodak Ektachrome 64T). Size of the RAPD products was estimated using the standard ladders. Individual RAPD bands (which ranged from 0.5 to 2.5 kbp) were scored as present or absent from color photographs of each cultivar. These data were then used for pair-wise comparisons between cultivars. Faint bands, where there was doubt about reproducibility, were ignored, and bands which were very faint compared with others in the same position were scored as absent.

Oligonucleotide Primers

Twenty-six 10-base arbitrary primers (Operon Technologies, Inc., 1000 Atlantic Ave., Alameda CA 9401) were screened, using bulk DNA samples of the cultivars and consistent amplification conditions to select the primers which gave rise to the clearest polymorphism between the cultivars.

Table 1. Name, origin, and autumn dormancy of study cultivars.

Cultivar	Origin	Autumn dormancy	Cultivar	Origin	Autumn dormancy
Azari	Iran	Dormant	Nikshahri	Iran	Non-dormant
Bami	Iran	Non-dormant	G. Oranga	New Zealand	Semi-dormant
Hamedani	Iran	Dormant	Saranac	USA	dormant
Esfahani	Iran	Semi-dormant	Wairau	New Zealand	Semi-dormant
Moapa	USA	Non-dormant	Yazdi	Iran	Non-Dormant

Results

Minimum Sample Size for DNA Fingerprinting

RAPD analysis of the individual seedlings of cultivars, using some of the oligonucleotides primers, produced distinct but highly-polymorphic fragments, an indication of great genetic diversity within each of the cultivars (Plate 1). RAPD analysis of bulk DNA samples of cv Esfahani, constructed from DNA extracted from 5, 10, 20, 30, and 40 seedlings, showed that the similarity of the RAPD profiles among samples was increased by an increase in the number of seedlings contributing to the bulk sample. However, the difference between the RAPD profiles was small for 30 and 40 seedlings per bulk.

Primer Selection

Of the twenty-six 10-base oligonucleotides tested individually to amplify bulk DNA samples from the 10 lucerne cultivars, 10 primers generated polymorphic fragments. Four of these (OP08, OPB13, OPB19, and OPC10), gave distinct, readily evaluated, RAPD fragments. The sequence of these primers is illustrated in Table 2.

Table 2. Sequence of four oligonucleotide primers†.

No.	Sequence (5' to 3')
OPA08	G T G A C G T A G G
OPB13	T T C C C C C G C T
OPB19	A C C C C C G A A G
OPC10	T G T C T G G G T G

† Information supplied by Operon Technologies.

Discrimination among Cultivars

Among the arbitrary primers screened to generate RAPD profiles from bulk DNA samples of the 10 cultivars, primer OPB19 produced the highest number of distinct polymorphic DNA fragments (Plate 1). Pair-wise comparisons between the RAPD fragments of the cultivars demonstrated that all 10 cultivars could be discriminated using primer OPB19 alone (results not shown).

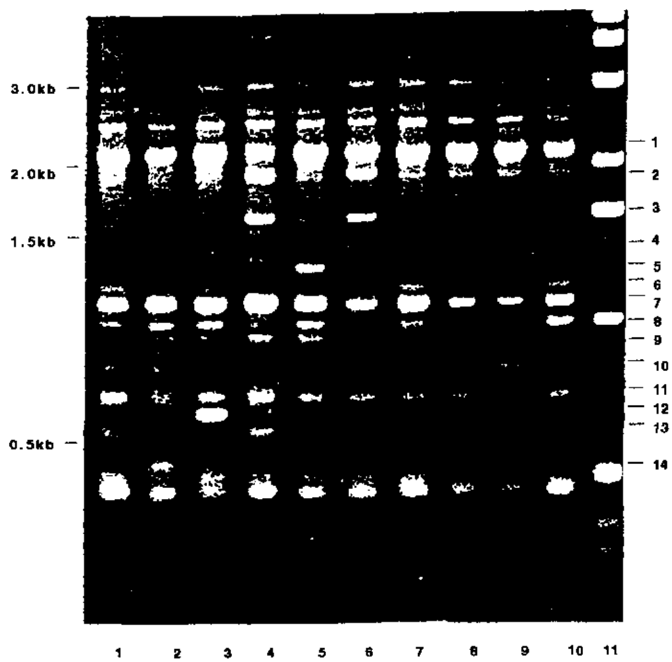

Plate 1. RAPD profiles generated by the 10-base oligonucleotide OPB19 from bulked DNA samples from cultivars. The profiles (left to right) belong to cultivars Yazdi, Wairau, Saranac, G. Oranga, Nikshahri, Moapa, Esfahani, Hamedani, Bami, and Azari.

The second best primer (OPB13) produced polymorphic DNA profiles by which the majority of the cultivars (all except Azari and Moapa) could be distinguished (plates not shown). Primers OPA08 and OPC10 generated fewer RAPD fragments than OPB19 and OPB13 (Plate 2). Primer OPA08 generated RAPD fragments by which all but six cultivar pairs could be discriminated. Primer OPC10 failed to generate polymorphic fragments for 11 cultivar pairs. Although all of the cultivars could not be discriminated using primers OPA08, OPB13, and OPC10 individually, a combination of the results from these three primers provided sufficient information for discrimination among all 10 cultivars.

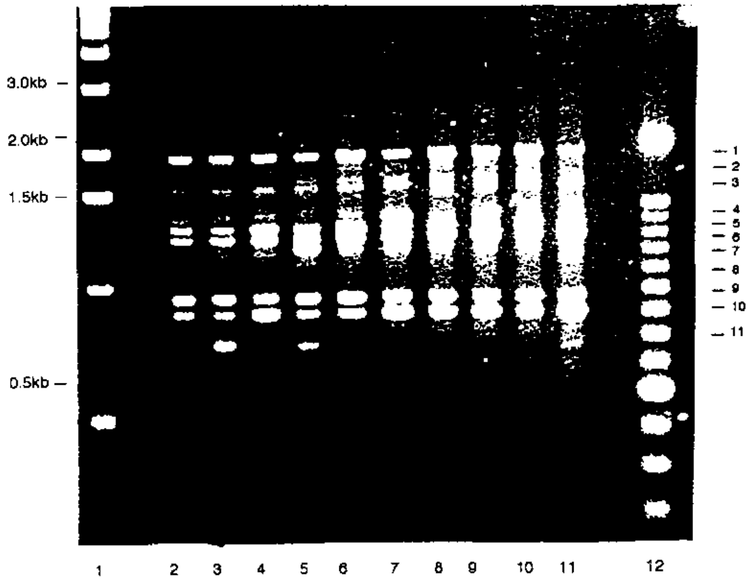

Plate 2. RAPD profiles from the bulked DNA samples from cultivars amplified using the 10-base oligonucleotide OPC10. The profiles (left to right) belong to cultivars Yazdi, Wairau, Saranac, G. Oranga, Nikshahri, Moapa, Esfahani, Hamedani, Bami, and Azari.

Pair-wise comparison between polymorphisms from the cultivars demonstrated that cultivars with genetically divergent background (Moapa and Saranac, the two USA cultivars, and G. Oranga and Wairau, the two New Zealand cultivars) could be discriminated from each other using the RAPD fragments generated by any of the four primers, while the closely related cultivars (i.e. Hamedani and Esfahani) could be differentiated using any of the three primers OPB19, OPB13, or OPA08.

As some of the individual primers generated distinct polymorphisms between cultivars, it was suggested that a combination of two primers might generate more polymorphisms than one primer in a single reaction. This hypothesis was tested by using primers OPB19 and OPC10 alone and in combination to amplify bulk DNA samples of the 10 cultivars. However, the number of distinct RAPD fragments generated by a combination of these two primers was less than those produced by each individual primer alone (plate not shown).

To check the reproducibility of the RAPD results for discrimination among the lucerne cultivars, replicated PCR reactions were carried out using two primers (OPB19 and OPC10) alone and in combination with the standard reaction mixture using different batches of enzyme from the same manufacturer. The results (plates not shown) demonstrate that a high degree of reproducibility of results obtained using the RAPD technique is possible.

Discussion

Discrimination of lucerne cultivars using RAPD analysis of individual seedlings is time consuming and probably not cost effective. One way to overcome this problem is to bulk genomic DNA samples prior to the RAPD analysis. While there are some reports in the literature about the application of RAPD for discrimination of cultivars of out-breeding species, e.g. *Brassica napus* L. (Mailer et al. 1994), there is no published work on the application of this technique for DNA fingerprinting of lucerne cultivars.

The ten lucerne cultivars had a wide range of adaptation and genetic background. Among the 26 primers screened, four produced distinct RAPD fragments. Primer OPB19 generated the greatest number of RAPD fragments, and allowed all 10 cultivars to be discriminated. This suggests that RAPD is powerful enough not only to discriminate among cultivars with divergent genetic backgrounds (e.g. Moapa and Saranac), but also to illustrate genetic polymorphisms between closely related cultivars (e.g. Hamedani and Esfahani, the two Iranian cultivars).

The other three primers were not able to discriminate all of the cultivars individually; however, they provided polymorphisms that were sufficient for discrimination among all cultivars when results were combined. This indicates that if one individual primer does not generate sufficient polymorphism profiles to enable discrimination among cultivars for all cultivars, differentiation can be rapidly obtained by using the results from two or more primers. Although primer OPC10 was able to differentiate the Iranian cultivars from the others, it was not able to discriminate among five of them. This may suggest that those five cultivars are genetically related, although distinct from cv Nikshahri, the other Iranian cultivar. This suggests that it is possible to estimate the genetic relatedness of the cultivars on the basis of RAPD. However, this requires further work.

Since the development of RAPD (Williams et al. 1990; and Welsh and McClelland 1990), the reproducibility of the RAPD fragments generated has been a major concern of many researchers (Steiner 1993; Weeden et al. 1992). A high degree of reproducibility of RAPD profiles was obtained in this work, using two primers individually, and in combination, in replicated PCR reactions. The results were consistent with those of Yu and Pauls (1993), who report reproducible RAPD results using genomic DNA from three lucerne cultivars with diverse backgrounds, with two primers and 3–5 repeated reactions. This suggests that when experimental variables (for example, tag polymerase brands, temperature profiles during DNA amplification, and the type of thermal cycler) are not the same, it may not always be possible to generate identical RAPD profiles from a given genotype. Thus, optimization of PCR conditions by individual laboratories will be necessary to obtain reproducible results.

The RAPD technique is therefore a powerful tool for DNA fingerprinting of lucerne cultivars because:

- There is no need for the isolation of cloned DNA probes, such as are required for RFLP analysis, as libraries of arbitrary 10-base primers are now commercially available. This provides, at minimal cost, a vast range of potential primer sequences that give the technique great diagnostic power.
- PCR-based methods require only small amounts of DNA, and mini-preparation procedures often yield sufficient quantity and quality.
- The technique involves fewer steps than RFLP analysis and is faster to perform.

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Section IV –
Working Group Reports

Guidelines for Working Groups

Three themes were identified in a round table discussion, and the participants were divided into working groups to develop guidelines for the development of the forage and pasture seed industry in both WANA and the Sub-Saharan Africa countries. The working groups dealt with: (i) the formal sector, policy and institutions; (ii) the informal sector and local seed supply systems; and (iii) seed research, technology, and training. Each group was provided with working guidelines, key issues, and questions to debate as a platform for discussion.

Focus: Forage and Pasture Seed Production

Objectives

Discuss key issues relating to forage and pasture seed production. Reach consensus on how to address priority issues and formulate recommendations.

Steps

- Review and prioritize the issues and possible solutions.
- Agree on appropriate solutions for both local conditions and regional application.
- Identify opportunities to develop collaborative work.
- Formulate recommendations or guidelines.

Output

Identify priorities and formulate recommendations to be used in development of future forage seed production activities, and to form the basis of future project proposals and collaboration.

Group I – Formal Sector, Policy and Institutions

Key Issues

- Breeding, variety release
- Extension, technology transfer
- Farmer participation, sharing information
- Role of international centers

- Institutional roles and participation
- Legislation, property rights, variety protection
- Government policies and subsidies
- Commercialization, private sector, merchants
- Seed import/export, quarantine
- Seed quality standards
- Project planning, funding

Questions to Debate

- What policy initiatives by governments could encourage local forage seed supplies?
- Is there a need to involve the formal sector in forage seed production? How can the participation of the private sector be stimulated?
- Should variety and seed legislation be modified to assist the production of forage seed and the release of new varieties?
- What are the essential elements of a formal forage and pasture seed system that need special attention?
- How can demand for forage and pasture seed be stimulated, and the benefits of forages in farming systems promoted? Can governments assist the informal sector in any way?
- How can the international centers (e.g. ICARDA, ILRI) contribute to the strengthening of formal seed systems?

Group II – Informal Sector, and Farmer-based Seed Systems

Key Issues

- Farmer awareness of forage and pasture seed
- Definition of priority materials for multiplication
- Farmer participation, gender issues
- Demand issues
- Small-scale seed production
- Promotion of community seed production
- Extension, technology transfer
- Commercialization, role of merchants
- Involvement of private sector, linkage to formal sector

- Project planing and management, funding
- Need for socioeconomic research
- Need for agronomic research

Questions to Debate

- The importance of informal seed systems has only recently been recognized; do you feel that you understand the issues involved? How can these systems be strengthened and promoted to make them more sustainable?
- How can the development of small-scale enterprises be assisted?
- How can the formal and informal seed systems be linked?
- What is the role of the international centers and NARS in helping NGOs, community groups, and farmer associations to develop informal systems?
- How can farmer participatory research be integrated with informal seed systems?
- How can the development of informal forage seed systems be linked with crop seed and other sustainability themes?
- How can real demand for seed be defined and stimulated?

Group III – Research, Technology, and Training

Key Issues

- Seed technology and physiology
- New techniques for seed testing
- Appropriate equipment
- Linkages to the formal and informal seed sectors
- Technology transfer, publications
- Gender issues
- Training
- Promotión of indigenous species, biodiversity
- Emphasis on themes for natural resource management

Questions to Debate

- What are the research priorities for seed production and seed technology?

- What are the most suitable species for promotion and seed increase in different environments? What should be the balance between indigenous and imported materials?
- How can seed testing techniques in the formal sector be adapted to solve local problems in informal seed systems?
- How can the development and adoption of small-scale equipment be encouraged?
- How can training be matched to the needs of evolving projects?
- What role can networking play in both research and technology transfer?
- How can publication of research be stimulated and exchange of information be speeded up and increased?

Recommendations

Policy and Institutional Issues

Livestock production is a strategic issue in many countries, but despite this, it has not proved easy to commercialize forage seed supply. For this reason, private sector participation will be very limited and governments may have to accept a leading role for the time being.

Policy Initiatives by Government to Encourage Local Seed Supply

The workshop recognizes that policy is a matter for national governments and that the stage of development of individual countries will determine the policies most appropriate for them. The following guidelines are suggested:

- Providing credit facilities to seed producers who grow seed of new varieties.
- Promoting contract seed production of high-yielding varieties by guaranteeing purchase and price.
- Supporting seed production activities within cooperatives.
- Reinforcing the extension effort for new forage varieties, especially by means of field demonstrations.
- Maintaining seed security stocks.
- Providing subsidies for seed production, as long as these do not distort the system or discourage other participants.
- Monitoring seed imports.
- Encouraging research on indigenous plant materials (collection and evaluation).

Increasing Formal Sector Involvement in Forage Seed Supply

In general, the private sector will not participate in the forage seed system unless and until there is a real demand for seed. Therefore, government participation in the formal system will still be required to achieve improvement. The workshop suggests that this be achieved by:

- Maintaining a commitment to develop, register, and release new high-yielding varieties.
- Initiating basic seed production of these varieties.
- Stimulating involvement of the private sector, initially by incentives for companies that undertake local production of new varieties, e.g. tax relief.

Legislation and Regulations Related to Varieties and Seed

Legislation already exists in most countries, but it has usually been developed to meet the needs of the cereal seed sector. The workshop recommends that the legal framework relating to forage seed should be reviewed with the following objectives in mind:

- Developing appropriate legislation where it does not exist.
- Ensuring that the technical procedures, e.g. for variety release and certification, are flexible and appropriate to forage species and varieties.
- Ensuring that seed quality standards are realistic in terms of species characteristics and the production capabilities of local farmers.

Formal Sector Involvement

The workshop suggests that the following elements of the formal sector should be emphasized:

- Research to develop high-quality seed production.
- Training in seed production techniques, seed technology, marketing, extension, quality control, and certification.
- Developing the supply chain by encouraging extension to use good-quality seed.
- Enhancing distribution and marketing channels.

Role of International Centers

The workshop recommends that the existing activities of ICARDA and ILRI should be maintained and strengthened where possible. In particular, they should assist national governments and NARS with:

- Training in forage seed production.
- Coordinating collaborative research in their respective regions.
- Providing consultancy, e.g., to improve seed legislation.
- Developing projects that address weaknesses in the supply system.

For ICARDA, specifically, the WANA seed network should take more account of forage seed issues and support initiatives such as the Regional Variety List, the harmonization of testing procedures, and seed standards.

The centers might act as joint sponsors for exhibitions of small-scale machinery relevant to farmers in their geographical regions.

Informal and Farmer-based Seed Systems

Concept

The workshop recognizes that the concept of informal, or farmer-based systems is extremely complex and not widely understood or well-defined. Therefore, the workshop suggests a rough definition of the concept as follows: "All components and processes related to the production, marketing, and use of seed by and for small farmers on a regional or community basis. Implicit in this definition is some understanding of and separation from the formal seed system."

Basic Considerations for a Forage Seed System

If forage seed production is to be developed, the workshop considers the following elements to be critical to success:

- Lack of demand is the major constraint to the evolution of increased seed supply: Producing more seed will not create demand if farmers are not convinced of its value. Real demand will come only when farmers see a direct financial benefit from buying improved varieties and quality seed. Therefore, the priority is to promote the use of forage and pasture crops within local farming systems. In order to create/stimulate/increase the demand for forage seed, there is a tremendous need for:
    - On-farm participatory research on the role of forages in production systems. This should lead to the identification of species and cultivars with definite values for farmers. Farmer benefits include increased milk production and cash flow, increased ability to carry more animals, increased number of calves, less weed control, more hay, more dung, etc.
    - Broadened appreciation of the multiple roles of forages. In addition to the traditional role of forages as animal feed, it must be recognized that forages can make a significant contribution to sustainability issues, e.g. watershed management, erosion control, and soil fertility.
- Balance between forage yield and seed yield in species selection: A compromise may be necessary between the use of species with high potential for forage potential and ease of seed production. Characters such as prolific flowering, high seed set, high seed recovery, and high seed yield will contribute to the success of seed production.
- Initial seed multiplication and seed availability: Resources must be made available to allow seed multiplication of promising materials by selected farmers. These initial seed stocks are essential for both the initiation of on-farm participatory research and on-farm seed production.

- Financial viability: Forage seed production involves careful management of risks. Not all farmers are likely to succeed as seed producers, nor do the essentials needed to establish this system exist in every community.

Essential Components of a Farmer-managed Seed System

If initiatives are to be taken to specifically promote the development of a farmer-managed seed system, the following elements are critical:

- Suitable institutional arrangement: Cooperation with development projects, NGOs, farmer associations, seed enterprises in other crops, cooperatives, etc., is required to initiate and coordinate activities. Traditional research organizations may not necessarily be effective in promoting seed production at this stage, although they may be involved in some way.
- Selection of pioneer seed producers: Initial participation will be based on those farmers who are more likely to ultimately succeed as seed producers. They should already be convinced of the benefits of forage use, have the desire to expand their own areas, and have access to productive resources such as labor, land, and extension. They should be trustworthy, respected, and linked to other farmers in the farming community
- Technical assistance: Participating farmers must receive technical assistance, related especially to the management of their seed crops, and possibly assistance in harvesting and processing. The most probable sources of such assistance are existing research institutions.
- Identification of distribution channels: Various distribution channels should be identified within the community (dealers, extension agents, general merchants, and other farmers). Use should be made of the most effective and sustainable systems. The lead institution should only become directly involved as a last resort.
- Need for financial capacity to trade in seed: Operational capacity is needed in the form of management of revolving funds to facilitate both the purchase and sale of seed.
- Definition of achievable quality standards: Some definition of minimum, practical, and attainable quality standards within the community is required to create awareness about quality seed.
- Facilities for processing and storage: Supporting institutions should investigate suitable and simple processing equipment (possibly mobile) and storage arrangements applicable for particular forage species, since all issues are species-specific.

Linkages and Support Needs

It is probably impossible to build independent or forage-only seed systems. Therefore it is essential that we achieve complementary elements such as the following:

- Involvement of NARS: The NARS must take the lead in initiatives to develop these systems, but share responsibility with other institutions, e.g. NGOs and farmer associations.
- Linkages with other markets: Encourage the evolution of broader linkages with sustainable market opportunities, e.g., seed of other crops and agrochemical inputs. This ultimately brings the system closer to the formal sector.
- Participation and support from the formal sector: The formal sector may be able to make a significant contribution regarding, e.g., some aspects of quality control or marketing. Conversely, the formal sector should not depress the informal sector.
- Training of key personnel: Training should be made available to key personnel, such as those providing technical assistance to seed producers.
- Research efforts on farmer-managed seed systems: Research efforts should be via pilot projects with socioeconomic components and case-study analysis.
- Governments should recognize the role of the informal system in seed supply, although it may be difficult to assist it directly. However, they may help some small producers improve their production practices or quality standards and become more formal.

Research, Technology, and Training

The workshop stresses that research and development on forage in general and on seed issues in particular are essential and increasing.

Research Priorities for Seed Production and Technology

Seed production. For major species, currently cultivated, the following aspects need to be investigated:

- Pollination of forage seed legumes, particularly alfalfa and berseem.
- Harvest losses (shattering, harvest techniques, etc.).
- Improvement of existing techniques for the informal sector.
- Development of simple techniques to assess seed germination and viability at the community level.

For newly introduced species, research gaps include:

- Crop establishment.
- Weed and pest control.
- Harvesting and threshing.

Seed physiology: Particular attention should be given to the following aspects:

- Hardseededness, dormancy, viability, and seed storage.
- Assessment of the actual seed health situation and identification of seed-borne diseases.
- Mechanical damage during harvesting, threshing and processing.

Breeding strategies: When selecting and developing new forage and pasture cultivars, seed yield and quality characteristics must be taken into consideration.

Farm surveys: To better target research and technology transfer, there is an urgent need to conduct surveys to identify key researchable issues that hinder the development of pasture and forage seed sector.

Criteria for Selecting Species for Promotion and Seed Increase

Few forage and pasture species are currently used, and efforts are ongoing to promote the use of new species. To ensure the success of introducing new plant material, the workshop suggests that particular attention should be given to the following criteria:

- Adaptation to agro-ecological conditions.

- Farmer acceptance.
- Technical and economical feasibility of seed production.
- Priority should be given to the use of indigenous materials where possible, particularly in the informal, small-scale seed systems.

Development and Adoption of Small-scale Equipment

Lack of adapted machinery remains one of the main obstacles to the promotion of forage and pasture seed production in the informal sector. To overcome this problem and encourage the use of small-scale equipment, the workshop suggests that consideration be given to the following aspects:

- The need for small machinery should be expressed by the farmers' community.
- Users should participate in the equipment development process.
- Equipment should be simple, made from local, available material, affordable, and preferably of multiple use.
- The private sector should be involved in the dissemination process.
- On-the-job training of farmers and technicians should be conducted.

Training

The workshop recommends that development of human resources should be strengthened and on-going, so that skills are constantly being improved.

- Previous efforts in training concentrated mainly on cereal crops. More emphasis should be given to the various aspects of forage and pasture seed production.
- The ongoing training activities of the formal sector must be maintained, and training in the informal sector initiated. The following issues should be addressed: socioeconomics, seed production and technology at the farm level, use of small equipment, gender issues, and natural resource management.
- Management of seed projects in general, and on-the-job training of farmers and extension people, should be given special attention.

Networking

At present, there are six networks dealing with forage and pasture seed production issues: the WANA Seed Network, Genetic Resources WANANET, REMAV, Africa Feed Resources, Small Ruminant Network, and Large Ruminant Network. These networks aim to: (i) strengthen national seed programs; (ii) exchange information, research results, germplasm, and seed; (iii) join efforts to tackle common problems; (iv) avoid duplication of errors; (v) encourage common use of facilities; (vi) standardize methods; and (vii) develop projects of common interest.

The workshop recommends the following:

- Strengthen the pasture and forage seed components in the existing networks.
- Improve the exchange of information between existing networks.
- Establish links with international networks such as the International Herbage Seed Production Research Group.

Publications

The workshop recommends that publication of research results should be stimulated and the exchange of information speeded up and increased by:

- Strengthening the existing newsletters (Seed Info and Dryland Forage, Pasture and Range Network News) and encourage the NARS to use them.
- Publishing proceedings of various seminars and workshops.
- Encouraging the NARS to publish their findings in scientific journals.

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