Current and future needs for forages
Forage technology adoption: linking on-station research with participatory methods

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Abstract

Improved forages play an important role in sustaining the livelihoods of small- and medium-scale farmers in the tropics, mainly as a result of their positive effects on livestock production and contribution to economic and environmental sustainability. However, in many regions of the tropics, the potential of forages for sustainable development is largely untapped and adoption of forage legumes in particular has so far been limited. In general, compared with forage legumes, grasses are often better known as cultivated species by farmers, are more resilient and have broad environmental adaptation. Currently, farmers have limited understanding of the benefits of leguminous species that can be used on their farms.

This paper explores reasons for the lack of wider adoption of improved forages and suggests pathways and strategies to meet the needs of smallholder farmers more effectively. Close linkages between farmers, researchers and extension workers are essential for both the development and diffusion of improved multipurpose grass and legume species. In this context, the importance of developing functional seed-delivery systems is emphasised. However, continuous development of forage germplasm to respond to existing and evolving constraints and changing demands and opportunities is mandatory to ensure wide adoption of improved forages by smallholder farmers.

Introduction

Livelihoods (see Chambers and Conway 1992 for definition) of smallholders in the tropics are threatened by biophysical (i.e., resource degradation and environmental stresses) and socio-economic (i.e., food security, poverty, market access and education) constraints. Further deterioration of livelihoods is likely to increase social imbalance and conflict. This paper is based on the assumption that forage-based technologies play an important role in improving smallholder agricultural production systems in the tropics through sustainable intensification and by counteracting these negative trends.

Numerous papers have been published on the potential benefits of forages, particularly of legumes (Humphreys 1994; Schultze-Kraft and Peters 1997; Peters et al. 2001). Forages can be utilised as a feed resource for livestock and play an important role in maintaining the natural resource base. Synergism between crop and livestock production could be exploited and, while reducing the dependence on external inputs, could enhance the overall productivity of the system. However, technically sound, forage-based technologies have not been adopted widely in developing countries in the tropics. The exception is the widespread use of grasses, in particular Brachiaria spp. introduced from Africa into South America (Thomas and Sumberg 1995; Argel and Keller-Grein 1998; Pizarro et al. 1998; Sumberg 2002). In this paper, we highlight reasons for the lack of adoption and suggest pathways to enhance acceptability of forage technologies by small- and medium-scale farmers of the tropics.

Emphasis is placed on the importance of interactions between biophysical and socio-economic parameters and linkages between farmers, researchers and extension workers. However, without appropriate germplasm and resultant technology options, these approaches are likely to be of limited attractiveness to farmers. Hence, for the adoption of forage-based technologies, germplasm development, including germplasm collection, maintenance, selection, improvement and diffusion, remains of high priority.
To meet these challenges, there is a need to link closely on-station with on-farm research, and participatory with researcher-managed approaches. Germplasm development in this context is an iterative process of supply and demand, taking into account current and evolving demands in dynamic agricultural systems. Thus, long-term sustainability, economic and environmental effects of technology changes and intensification need to be considered in the process of selecting and improving forages.

**Forage germplasm characterisation**

In the Centro Internacional de Agricultura Tropical (CIAT), forage germplasm characterisation aims to explore the available genetic diversity of a particular species from core collections of selected forage germplasm options. It is anticipated that, over time, methods and emphasis of genera/species will need to be adapted according to changes in smallholder production systems. Current efforts to collect and acquire grass and legume germplasm are limited and are based on occurring needs and demands, i.e., they are reactive rather than proactive.

In CIAT, the following complementary actions are in place for assessing, documenting and sharing knowledge on genetic diversity of forage species:

- Morphological and agronomic characterisation;
- Utilisation of molecular markers to define genetic diversity;
- Utilisation of Geographic Information Systems (GIS) tools for germplasm collection and extrapolation; and
- Development and maintenance of databases for knowledge sharing and targeting.

**Advances and limitations in developing forage germplasm with and for smallholders**

The release of grass and legume cultivars continues to play an important role in delivery of germplasm to farmers. Table 1 shows the number of grass and legume cultivars released in South America based on CIAT’s germplasm. As mentioned previously, release of cultivars alone has not resulted in wide-scale adoption of most forage species and genotypes. However, the exception is the adoption of tropical grasses across the South American tropics where private seed companies are promoting uptake of superior species.

Major limitations to wider adoption of forage-based technologies, beyond germplasm not adapted to target farming systems, include the problems of: seed supply not matching demand; poor identification of entry points; limited exploitation of the multipurpose nature of many forages; isolated efforts in feed and soil improvement; and often difficult socio-economic environments. This final factor includes limitations in human, social and financial capital and related policy, and land tenure issues.

<table>
<thead>
<tr>
<th>Type</th>
<th>Decade</th>
<th>No. of cultivars</th>
<th>No. of countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses</td>
<td>1980–1989</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>1990–2000</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Legumes</td>
<td>1980–1989</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1990–2000</td>
<td>6</td>
<td>5</td>
</tr>
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Taking these factors into account, a stronger client (farmer) participation in the entire forage germplasm development process is necessary. Successes from south-east Asia (Stür et al. 2000) and initial results from central America (Holmann and Lascano 2001; M. Peters, unpublished data) indicate the potential for this approach. Selected forage germplasm is delivered in iterative processes to partners, with feedback obtained on the suitability of the germplasm for various production environments, taking into account social, economic and environmental constraints and opportunities.

Notably, all these efforts are capitalising on past germplasm characterisation activities; however, for long-term sustainability of the approach, participatory germplasm development needs to interlink with germplasm collection and on-station and on-farm germplasm characterisation. The risks and costs implied in early characterisation and evaluation of forage germplasm should be borne by public and private sector research and not be transferred to resource-poor farmers. As production environments are continuously changing (in biophysical and socio-economic terms), germplasm development also needs to be an iterative process. Beyond responding to the immediate perceived needs of farmers, the
development process includes the challenge of developing forage germplasm that responds to current constraints and can exploit opportunities that are expected in the future. Ignoring this aspect could otherwise result in failure to respond to the evolving needs of farmers.

In addressing a client-driven approach for forage germplasm development and delivery, CIAT is focusing on 2 groups of forages with distinct characteristics (see Figure 1). There are a number of forages not belonging to either of these groups, which may complement grasses and legumes in specific situations.

For SSA and many other regions in the tropics, wide-scale adoption of planted grasses is rare; however, there are a few exceptions such as kikuyu (*Pennisetum clandestinum*) and napier grass (*Pennisetum purpureum*), which is used in cut-and-carry systems in eastern and southern Africa. Thus, in SSA, development of grass technology needs to begin with a diagnosis of the production environment, followed by an analysis of problems and opportunities in the system; and definition of possible niches and entry points for forages. Technicians and researchers should closely link development and supply of improved grasses to farmers’ demands.

Given that, in SSA, the utilisation of cultivated grasses is limited, it is anticipated that demand will be problem-oriented rather than a demand for specific grass-based technologies. In a participatory process, such technology demands by smallholders would be defined and addressed with farmers, keeping in mind that land tenure issues are likely to influence the likelihood of long-term investments. However, we consider that, in extensive production systems, based on native grazing lands where native grasses provide a satisfactory fodder for livestock, there is a ‘niche’ for improved grasses only in market-driven environments such as dairying.

In SSA, it is likely that market-driven environments will gain importance over time, given current urbanisation and intensification trends. Attention will need to be given to availability of land, privately or communally owned, for the cultivation of grasses. Moreover, it will be necessary to examine how land for forage production interacts with areas reserved for crops. In eastern and southern Africa, there may be particular ‘niches’ in such systems for re-introducing grasses, such as *Brachiaria* spp., which originated from the region, but have been improved through breeding.

For LAC, the situation is different; there are large areas of planted grasses and private seed companies are often engaged in seed supply and distribution of selected materials released as cultivars.

Consequently, in this region, CIAT is addressing the major biophysical constraints in *Brachiaria* (spittlebug, *Rhizoctonia*, quality and acid soil tolerance) through a breeding program. Other components of the breeding program include tolerance to drought and seed production. Great progress has been made in identifying breeding lines that are highly tolerant of spittlebug...
and have good agronomic characteristics. In addition, progress is being made in breeding *Brachiaria* with high levels of resistance to aluminium in the soil. The first *Brachiaria* hybrid from the improvement program is now being distributed in many regions of LAC as cv. Mulato.

Figure 2. Adoption pathways for grasses in sub-Saharan Africa.

As the private seed sector has shown considerable interest in multiplying and marketing seed of improved *Brachiaria* hybrids, there are few constraints in getting elite lines into farmers’ fields. However, to ensure that improved grasses reach smallholders, there is a concerted effort to multiply and distribute seed in market-driven environments, in particular dairy systems. Re-introduce grasses improved in LAC through selection/breeding processes. Exploit opportunities in cut-and-carry and pasture systems. Identify niches for more intensively and less extensively farmed areas.

Figure 3. Adoption pathways for grasses in LAC.

Adoption strategies for forage legumes

The situation for forage legumes is more complex given their limited adoption by farmers in both SSA and LAC. Possible reasons for the limited adoption of forage legumes are:

- Legume introduction affects systems, hence it often implies complex changes;
- Extension staff and farmers often do not know that legumes can be beneficial components of smallholder production systems;
- Benefits of legumes are largely long-term in nature;
- Legume seed supply is limited given the low demand; consequently, there is little incentive for private seed multiplication;
- Legumes are often less resilient than grasses to pests and diseases, and to climatic, edaphic and management changes;
- Legumes have higher management requirements than grasses; in some cases, there are inherent limitations to using legumes in particular schemes (e.g. persistence in grazed pastures);
- Legume use is influenced by socio-economic limitations, such as land tenure and scarcity; and
- Multiple roles of legumes in mixed systems are ignored or not exploited; moreover, in some cases, the entry points in production systems are poorly defined.

In general, the role of forage legumes as components to enhance sustainability of smallholder production systems is in many cases ignored or not fully exploited by smallholders with mixed crop-livestock systems. The situation is aggravated further because, for long-term investments, security of land tenure is a necessity. Beyond these socio-economic considerations there are technical limitations, such as the lack of persistence of most legumes in grazed pasture systems and their higher management requirements, which may be beyond the capacities of many farmers. However, many researchers and development workers view legumes as a major component in ensuring sustainability of pasture and cropping systems. Therefore, more attention needs to be given to pathways for adoption of forage legumes by farmers. Figure 4 summarises some possible approaches, bearing in mind that research needs to be directed in the best ways to reach both farmers and extension/development workers.

- Identify and define production environments and potential needs and opportunities for grasses.
- Address land tenure issues.
- Identify opportunities for improved grasses in market-driven environments, in particular dairy systems.
- Re-introduce grasses improved in LAC through selection/breeding processes.
- Exploit opportunities in cut-and-carry and pasture systems.
- Identify niches for more intensively and less extensively farmed areas.

Figure 2. Adoption pathways for grasses in sub-Saharan Africa.

- Build on large adoption of introduced forage grasses, mainly *Brachiaria* spp.
- Identify limitations of current grass cultivars.
- Concentrate on biotic and abiotic constraints (i.e., spittlebug, soil acidity and drought) and develop genotypes that overcome these constraints.
- Involve private/public sectors and non-governmental organisations in development of farmer-led forage seed production and distribution systems.
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Figure 4. Adoption pathways for shrub and herbaceous legumes.

Participatory approaches seem to offer the best way (Thomas and Sumberg 1995; Sumberg 2002; see also other papers this volume) to get legumes into farmers’ fields; however, it is necessary to define clearly the stages of the research-to-development continuum and where participatory or non-participatory approaches are most efficient in terms of getting technology to the farmers. A farmer-centred approach requires identification of biophysical and socio-economic niches and well defined potential entry points for legume technologies. This approach provides better chances of exploiting the multipurpose nature of many legumes so that short-term and long-term production and natural resource management (NRM) benefits can be addressed.

As legumes are often less resilient than grasses, genotype × environment (G × E) studies and targeting tools are particularly important so that appropriate environmental niches can be defined. Geographic Information Systems (GIS) technologies and databases, addressing biophysical and socio-economic constraints and opportunities, could be utilised to integrate available information and reduce costly duplication of efforts (Maass and Pengelly 2001; O’Brien et al. 2002).

Within the framework for defining niches for legumes, it is important to define the key beneficiaries of forage-based technologies. Small- and medium-scale farmers are the focus for CIAT’s work on forage legumes. These farmers tend to be located on the more fragile and less fertile land, and in environments affected by recurring drought periods where there are limited possibilities for feed conservation and/or external purchase of feed. Hence, CIAT places particular emphasis on the development of germplasm for such conditions, focusing on species and genotypes adapted to acid infertile soils and drought. Most available shrub species adapted to such environments contain a number of anti-quality factors such as tannins (Lascano et al. 1994). Consequently, studies on how environment influences the concentration and structure of tannins in selected legume species are a major component of research at CIAT.

In LAC, CIAT is currently prioritising the development of legumes for areas with prolonged drought and legumes for use as cover crops in plantations or as green manure species, and for production of silage, hay and protein leaf meal for concentrates. Many of these uses offer income and conservation options for both livestock and non-livestock owners.

As there is limited private sector activity in seed multiplication and distribution for legumes, facilitating efforts to match demand and supply of planting material will be crucial for the large-scale adoption of forage legumes (A. Schmidt and M. Peters, unpublished data). Addressing the above limitations affecting adoption of forage legumes should enhance opportunities for deploying legume-based technologies in smallholder livestock and crop production systems.

Adoption pathways common to grasses and legumes

Beyond the above specific considerations for grasses and legumes, there are various actions to enhance adoption that are common across forages:

- Identify production environments, and potential needs and opportunities for legumes.
- Define and implement approaches that combine long-term and short-term benefits of legumes.
- Implement genotype × environment (G × E) studies for targeting legume genotypes to specific environments.
- Develop decision support tools for targeting germplasm (applies also to grasses).
- Develop and deploy appropriate participatory methods to enhance adoption of legumes and to provide feedback to researchers.
- Adapt/combine/develop participatory methods that address NRM (natural resource management) issues in complex production systems.
- Investigate and promote the multipurpose characteristics of legumes to define entry points better.
- Focus on major biophysical constraints (fertility, drought, soil degradation) in systems.
- Address biological constraints in selected legume species, e.g. persistence and anti-quality factors.
- Facilitate development of linkages between private, public and farmer organisations to promote legume seed production and distribution.

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- Facilitate development of linkages between private, public and farmer organisations to promote legume seed production and distribution.
• Involve farmers at an early stage;
• Define entry points to deal with production and NRM in agricultural systems;
• Target genotypes to environmental and socio-economic ‘niches’;
• Focus on the use of forages that provide value-added products;
• Facilitate linkages between smallholders and markets;
• Catalyse the development of seed systems; and
• Develop methods to facilitate dissemination of forage-based technologies by farmers and private enterprises.

There is a wealth of information highlighting the importance of including farmers early in the research-development continuum. Results and experiences summarised in this volume and by Stür et al. (2000) give an overview for the case of forages. Nevertheless, entry points need to be defined for forages in complex farming systems.

Often forage adoption needs to be encouraged indirectly, as forages often require long-term investment without immediate benefits to farmers (positive effects become apparent only after 1–2 years and not during a single vegetation period). For example, in collaborative work with Fundación para la Investigación y el Desarrollo Agrícola (FIDAR), a Colombian non-governmental organisation (NGO), CIAT started with selection of bean varieties as an entry point to introduce soil conservation techniques based on forages. Improving bean varieties (the main staple crop) provided an immediate return to farmers and at the same time began to create trust and a means for more long-term options (FIDAR and M. Peters, unpublished data). Further studies, using participatory methods to address complex situations relating to production and NRM, are underway (R. van der Hoek, personal communication).

The concept of entry points needs to consider potential niches for forages, both biophysical and socio-economic, particularly for legumes that have narrower biophysical adaptation than grasses. Therefore, a careful assessment of niches and entry points should be the starting point for introducing forages into systems. CIAT is working on GIS-based targeting tools to define such niches. In view of CIAT’s focus on poverty, particular attention is given to the direct (production of feed concentrates by smallholders for sale) and indirect (forages to improve milk production) roles of forages in providing opportunities for resource-poor farmers to produce value-added products.

There are many ways of interacting with farmers within this framework, often centring on the offer of potential options. Currently, a model is being developed for the participatory development of forages for hillsides in central America (Hernandez and M. Peters, unpublished data). Models for other environments and using different approaches have also been developed (Roothaert et al. 2003; Pengelly et al. 2003).

Effective seed systems, involving alliances of farmer-led seed systems, National Agricultural Research Institutes (NARIs), NGOs, the private seed sector and international research centres will remain the basis for ensuring forage adoption (A. Schmidt and M. Peters, unpublished data). Methods to scale-up and -out require refinement of forage-based technologies, especially for participatory approaches. The Forages for Smallholders Project in south-east Asia (see Roothaert et al. 2003) is making rapid progress in this respect. In central America, similar approaches, adapted to the prevalent production environments, are being developed with financial assistance from BMZ/GTZ, Germany.

Future needs

Adoption of multipurpose forages can result in increased incomes for smallholders and benefit NRM. However, to promote the adoption of forage-based technologies by small- and medium-scale farmers in tropical developing countries, there is a need for sustained funding of strategic research on forages, for linking on-station with on-farm research, and for farmer-driven research and development. Greater efficiency needs to be achieved through integration across disciplines and better linkages between farmers, NARIs, NGOs, Advanced Research Institutes (ARIs), research centres and the private sector.

There is increasing recognition of the need to work together with farmers. However, to contribute efficiently to this partnership, forage options need to be developed in an iterative process of supply and demand. In this process, forage and animal nutritionists need to interact closely with experts in other disciplines, such as soils, agro-enterprise development, organisational development and participatory research.
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References


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