Linking Demand with Supply for Tropical Forage Genetic Resources to Reach Impact at Scale

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Abstract
Over the last decades a wealth of information on tropical forage genetic resources has been collated and is accessible to users ranging from farmers, development practitioners and researchers to decision makers and academia, e.g. through online tools such as *Tropical Forages: An interactive selection tool* (www.tropicalforages.info). However, while genetic diversity is being conserved by international gene banks, adoption of improved tropical forages is still far from reaching its full potential. Major bottlenecks in our view include lack of awareness of available forage genetic resources, confirmation of adaptation in a wide range of bio-physical, socio-economic, political and cultural contexts and functionality of financing, extension and seed supply systems. This paper discusses the potential for adoption of tropical forages in the context of new opportunities by market driven innovation, and presents early successes using as examples improved *Urochloa* spp., *Megathyrsus maximus* and other grass and legume germplasm, while describing possible pathways to go to scale with small and medium size livestock producers. We use examples of approaches from the tropical Americas, tropical Africa and tropical Asia, including partnerships with the private sector in diverse market environments (e.g. Africa and Latin America) and network approaches (Asia).

Introduction
Background. A key trend is the fast-growing demand for animal-source food in consumer baskets in the developing world as incomes rise. This is set to continue in coming decades, and will be pervasive across all livestock commodities and all developing countries (CGIAR Research Program on Livestock 2016). Feed is a key limiting factor and often the most expensive input in livestock production, accounting for about 50 to 60% of total production costs in ruminant-feeding systems (Swanepoel et al. 2010).
While there has been considerable development impact from planted forage cultivars, notably for *Urochla* spp. and *Megathyrsus maximus* in Latin America (e.g. Jank et al. 2014), the adoption in tropical Africa and Asia is still lacking behind despite a widespread limitation in feed quality and quantity. There exists a wide range of suitable forages (Cook et al. 2020) and great variety of germplasm is available in gene banks. However, the so far limited adoption at farm level is attributed to a lack of awareness of available forage genetic resources, confirmation of adaptation in a wide range of bio-physical, socio-economic, political and cultural contexts and functionality of financing, extension and seed supply systems, the latter critical to ensure availability, accessibility and affordability of planting material. This paper aims to address potential approaches to overcome such bottlenecks and describe some examples of success.

Results and Discussion
Access to information and lack of awareness. There is considerable information on diversity and utilization of tropical forages. *Tropical Forages*, a tool for selecting forage species for local conditions, launched in 2005 (www.tropicalforages.info), is among the most widely used (~250-480k annual visits) and cited (450 citations) tropical forages databases, allowing selection of suitable forages according to specific agro-ecological conditions and then providing in-depth information. A new version of *Tropical Forages* was launched in 2020 with content updates and notable technical improvements, such as a revamped interface responsive to multiple devices, a mobile application and automatic translation, in particular the latter two aimed at enhancing reach at smallholder level. However, increasing the awareness of such tools and specific adaptation of information to local conditions are still needed to reach a much larger number of farmers. This would need to be supported by policy engagement reaching a wide range of stakeholders e.g. through roundtables and other multi-actor/innovation platforms.

Functional seed supply systems. A critical bottleneck to scaling forages are functional seed supply systems. Important criteria are a) availability, b) affordability and c) accessibility of seeds. To address a) and b), genetic characteristics, such as seed production potential, definition of suitable seed production environments and seed management production technology to maximize exploitation of the seed production potential, are required. For local seed production schemes, capacity building on seed production and business skills are essential. For long-term sustainability, this needs to go hand in hand with commercial viability, including market segmentation and providing cost-benefit calculations – both essential for an involvement of the private seed sector to reach impact at scale. For the latter, two main approaches are cost reductions (in particular for products without property rights) and developing differentiated products for targeted markets (protected for certain geographies or times). This is required to ensure return on investment and dedication, as can be seen with tropical grass breeding more recently gaining importance. Intimately connected is the accessibility of planting material, i.e. which is in the reach of potential clients, requiring suitable distribution schemes being formal and/or informal, dissemination and knowledge management, including various efforts such as social media platforms, TV and Radio programs, fact sheets and strategic piloting of the most promising options, e.g. through demonstration plots, farmer-to-farmer spread, and field days. Engaging policy (e.g. to unlock bottlenecks in seed certification), functional plant quarantine facilities and networks are also crucial.

Examples of success in adoption of planted forages. A large part of forages adopted until recent are selections from wild relatives. In Latin America, a strong private sector in collaboration with the national research system has been instrumental to ensure adoption of planted forages. Exact data are scarce but Jank et al. (2014) estimate about 120 million ha planted with *Urochoa* (syn. *Brachiaria*) spp. and *Megathyrus maximus* (syn. *Panicum maximum*), in Brazil alone. Planted forages are distributed through all of tropical America with large areas planted e.g. in Colombia, Argentina and Mexico.

For Asia, Stür et al. (2006, 2013) report more than 10,000 farmers adopting intensive grass production. The legume *Stylosanthes guianensis*, based on the accession CIAT 184, is reaching about 300,000 farmers as a cover crop and for leaf meal production in tropical China's poultry and pig sectors (Guodao and Chakraborty 2005) and various *Stylosanthes* spp. are used by 250,000 farmers in India (Shelton et al. 2005). In Africa, the International Centre of Insect Physiology and Ecology (ICIPE) estimated the adoption of the push–pull system including forages by more than 30,000 farmers (Khan et al. 2011). Recent work coordinated by ILRI and CIAT in East Africa estimates scaling of *Brachiaria* germplasm selections (S. Ghimire, personal communication) and *P. purpureum* by up to 25,000 households in Eastern and Central Africa (Negawo et al. 2017; Staal et al. 2002).

More recently, there is an increased importance of bred forages supported by public-private partnerships as illustrated in the following example. In 2001, a *Urochloa decumbens* × *brizantha* × *ruziziensis* cultivar coming out of CIAT's breeding programme was released (Lynam and Byerlee 2017) as the first bred *Urochloa* cultivar to be documented. *Urochloa* hybrids have since then been commercialized through interaction with the private seed sector, namely the Papalotla Group (including Tropical Seeds) and Dow AgroSciences. Many adopters appear to be small- and medium-scale livestock producers (Papalotla, personal communication), although not equivalent to 'smallholders' as used in the African context. Recently, Papalotla registered advanced cultivars in Kenya and is commercializing through licensing agreements, aiming to expand in Eastern and Southern Africa. The original cultivar Mulato had limited commercial success due to low seed production and was replaced by Mulato 2 while higher seed production was included as an additional breeding objective. In subsequent years, a series of *Urochloa* hybrid cultivars were released, namely Cayman (tolerant to water logging), Cobra (more erect growth habit), Camello (better drought tolerance), Mestizo (synthetic mixture of 3 hybrids for better establishment and pasture utilization) by Papalotla and Converse by Dow Agrosciences. Additional cultivars and synthetic mixtures with increased tolerance to drought and shade (e.g. for silvo-pastoral systems) are to be commercialized in the next 2–4 years (Papalotla, personal communication). The Alliance of Bioversity International and CIAT and Papalotla are also advancing the development and commercialization of *Urochloa humidicola* and *Panicum maximum* breeding lines.

The commercialized hybrids are planted on more than 1 million ha in more than 60 countries (see Table 1), the largest expansion so far in Latin America but expanding to other regions in particular in Eastern Africa.

Table 1. Area planted with *Urochloa* hybrids released under a PPP of the Alliance of Bioversity International and CIAT and Papalotla

Region	Cultivated area in ha*			
	Total	2000-2011	2012-2014	2015-2019
Latin America and Caribbean	970,692	244,186	274,710	451,796
Africa	5,147	400	2,291	2,456
Asia	9,572	2,325	2,137	5,110
Elsewhere	28,205	16,143	3,589	8,473
TOTAL	1,013,615	263,056	282,726	467,834

*based on a seed rate of 7 kg/ha; vegetative propagation not accounted for

Estimates by Fuglie et al. (2021, unpublished) indicate that across Latin America, Africa, and Asia (excluding China and southern cone countries of South America), it is likely that there are at least 158 million hectares under cultivated forage crops producing yield worth around $63 billion per year (at 2014-2016 prices). For Sub-Saharan Africa (excluding South Africa), this approximation suggests there may be 1.6 million hectares of cultivated forage crops currently grown in Sub-Saharan Africa. These estimates suggest that forage crops may be worth as much as $578 million per year in these countries. About 95 percent of this value is concentrated in East Africa, where about 60 percent of cow milk in Sub-Saharan Africa is produced (69 percent excluding South Africa) and where smallholder dairies in mixed crop-livestock systems predominate., mostly in Eastern African countries.

In another study, Born et al. (2020, unpublished) highlight the potential of improved forages for replacing feed crops in the global tropics under future scenarios of aggravating climate change, increased population growth and demand for animal source foods.

In Asia, an attempt to link supply and demand was the creation of a research platform around forage legumes in 2018. Several research and governmental organizations from various countries committed to collaborate on research studies on the agronomic and environmental benefits of the integration of forage legumes into smallholder local production systems, as well as on a number of initiatives, including the establishment of a forage legumes rhizobia bank and the development of quality control guidelines to ensure high-quality inoculants. Information and germplasm exchange have been initiated in Vietnam, China, the Philippines, Cambodia, Indonesia and India, and testing of selected legume species have started in tree plantations.

Conclusions and outlook

We anticipate that over the next decades there is a continued and growing demand for animal-source food in consumer baskets in the developing world. One of the major costs of livestock production is feed production, while at the same time environmental concerns for livestock production are rising. Improved forages could be a pathway to sustainable intensification, addressing cost of production, productivity of increasingly constrained land resources, providing ecosystems services (e.g. greenhouse gas mitigation), and maintaining soil fertility. Adoption of forages however is still below its potential in particular in tropical Africa and Asia. In intensifying systems however, we observe an increasing demand for improved forages and various institutions are addressing the constraints to obtain accessible, affordable and available planting material. In various countries, in particular in Eastern Africa, we observe rapidly increasing adoption of improved forages and expect to see at least 100,000 forage adopters over the next 5 years (starting from 2019).

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References

Born, L., Prager, S., Burkart, S. and Gonzalez, C.E. 2020. Draft analysis for the Forages Programme. Unpublished report.

CGIAR Research Program on Livestock. 2016. Livestock Agri-Food Systems: Full Proposal 2017-2022 https://cgspace.cgiar.org/handle/10947/4398

Cook, B.; Pengelly, B.; Schultze-Kraft, R.; Taylor, M.; Burkart, S.; Cardoso Arango, J.A.; González Guzmán, J.J.; Cox, K.; Jones, C. and Peters, M. 2020. Tropical Forages: an interactive selection tool. www.tropicalforages.info

Fuglie, K., Peters, M. and Burkart, S. 2021. The Extent and Economic Significance of Cultivated Forage Crops in Developing Countries. Unpublished report.

Guodao, L. and Chakraborty, S. 2005. Stylo in China: a tropical forage legume success story. In: O'Mara, F.P., Wilkins, R.J., 't Mannetje, L., Lovett, D.K., Rodgers, P.A.M. and Boland, T.M. (eds.) *Proceedings of the XX International Grassland Congress: Offered Papers*, Dublin. Wageningen Academic Publishers, Wageningen, Netherlands, p. 322.

Jank, L., Barrios, S.C., Do Valle, C.B., Simeao, R.M. and Alves, G.F. 2014. The value of improved pastures to Brazilian beef production. *Crop and Pasture Science* 65, 1132–1137.

Khan, Z.R., Midega, C.A.O., Pittchar, J.O., Murage, A.W., Birkett, M.A., Bruce, T.J.A. and Pickett, J.A. 2014. Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020. *Philosophical Transactions of the Royal Society B: Biological Sciences* 369, 20120284.

Lynam, J. and Byerlee, D. 2017. The Tropical Forages Program. In: *Forever Pioneers – CIAT: 50 Years Contributing to a Sustainable Food Future… and Counting*. CIAT, Cali, Colombia, pp. 80–91.

Negawo, A., Teshome, A., Kumar, A., Hanson, J. and Jones, C. 2017. Opportunities for Napier grass (*Pennisetum purpureum*) improvement using molecular genetics. *Agronomy* 7, 28.

Schiek, B, González, C., Mwendia, S. and Prager, S.D. 2018. Got forages? Understanding potential returns on investment in *Brachiaria* spp. for dairy producers in Eastern Africa. *Tropical Grasslands-Forrajes Tropicales 6(3):117–133*

Shelton, H.M., Franzel, S. and Peters, M. 2005 Adoption of tropical legume technology around the world: analysis of success. In: McGilloway, D.A. (ed.) *Grassland: A Global Resource*. Wageningen Academic Publishers, Wageningen, Netherlands, pp. 149–166.

Staal, S.J., Baltenweck, I., Waithaka, M.M., de Wolff, T. and Njoroge, L. 2002. Location and uptake: integrated household and GIS analysis of technology adoption and land use, with application to smallholder dairy farms in Kenya. *Agricultural Economics* 27, 295–315.

Stür, W.W.; Phengsavanh, Phonepaseuth; Gabunada Junior, Francisco A.; Horne, P.; Truong Tan Khanh; Phimphachanhvongsod, Viengsavanh; Connell, John; Holmann, Federico José. 2006. A survey of adoption of improved forages in Southeast Asia. In: Centro Internacional de Agricultura Tropical. Tropical Grasses and Legumes: Optimizing Genetic Diversity for Multipurpose Use: Project IP-5: Annual Report 2006. CIAT, Cali, CO. p. 129-135. https://cgspace.cgiar.org/handle/10568/55565

Stür, W.W., Khanh, T.T. and Duncan, A.J. 2013. Transformation of smallholder beef cattle production in Vietnam – technology, innovation and markets. *International Journal of Agricultural Sustainability* 11, 363–381.

Swanepoel, Frans & Stroebel, Aldo and Moyo, Siboniso. 2010. The Role of Livestock in Developing Communities: Enhancing Multifunctionality. Co-published by The Technical Centre for Agricultural and Rural Cooperation (CTA). 213 p.

Urrea-Benítez, J.L.; Schultze-Kraft, R.; Peters, M.; Burkart. 2020. ICTs in agriculture: State of the art tools for broader access to tropical forage knowledge. In Tielkes, E. (ed.) *Tropentag 2020. International Research on Food Security, Natural Resource Management and Rural Development*. Food and nutrition security and its resilience to global crises. Book of abstracts, p. 148. https://www.tropentag.de/2020/proceedings/proceedings.pdf