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RECOMMENDATIONS
PERENNIAL AGRICULTURE AND LANDSCAPES OF THE FUTURE

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INTRODUCTION

Agriculture has always integrated perennial plants (fruits and forages) and annual crops in different farming systems to enhance diversity and productivity of landscapes while enabling functional ecosystem services and processes to build long-term resilience. But only in the past thirty years have the potential benefits of perennial grain-based cropping systems been recognized as contributing to preventing soil erosion and soil biodiversity degradation, as well as holding the potential to contribute to carbon sequestration. Perennial crops also require reduced amounts of energy, and capture nutrients and water more efficiently relative to their annual counterparts.

As feeding nine billion people in 2050 with increasingly scarce and degraded natural resources is the main challenge faced by humankind, reinvigorating agriculture in a sustainable and productive way on a large scale will take nothing short of a significant shift in agriculture as we know it. With this in mind, there have been a handful of progressive scientists, pioneering practitioners and investors that have been working for over several decades to advance the development of perennial versions of staple crops to be integrated into agricultural systems as a means for operationalizing a true sustainable intensification and the makings of perennial agriculture.

WHAT IS THE CURRENT CONTEXT REGARDING MAJOR STAPLE CROPS?

Globally, there are over 100 million hectares of maize, 240 million hectares of wheat and 158 million hectares of rice. The yields per hectare of these main staples vary widely depending on the presence of abiotic and biotic stresses, inputs and management practices (irrigation, nutrients, pest management, technical support, etc.). And, even though yields have doubled to quadrupled over the past 40 years, these yields have stabilized in the last decade and are further under scrutiny for the concomitant trade-offs in environmental health. It is currently estimated that demands for these products are going to increase dramatically over the coming decades (a doubling in demand for maize is expected by 2050 and a 22 percent increase in demand for rice by 2020) accompanied by increases in demand for inputs (energy, water, fertilizers) if production, consumption and losses systems are not transformed. At the same time, climate change is going to negatively affect yields and reduce the areas conducive to growth. (For example, it is anticipated that maize yields will drop by 10 percent in sub-Saharan Africa and 17 percent in South Asia; wheat yields by 20-25 percent in South Asia; rice will also suffer from yield reductions due to expected water shortages, floods and other extreme weather patterns (Global Futures, 2013). Agricultural systems need to be transformed to be able to address the demand, environmental degradation and issues associated with the impacts of climate change. Perennialized agriculture is an avenue that offers great promise to address some of these issues.

How to get perennial crops?

While historical efforts saw limits in technologies, plant breeding of grains, oilseeds and legumes has undergone a number of advances that promise to make the development of perennial grain crops possible in the next 10 to 20 years. These advances take advantage of traditional breeding techniques such as domestication and wide hybridization to hybridize annuals with perennial relatives in combination with new technologies such as marker assisted selection, genomic in situ hybridization, transgenic technologies and embryo rescue (Glover and Reganold, 2010). Traditional and new technologies are being applied to a host of species including wheat, rice, maize, sorghum, secale, flax, oats, lepidium, camelina, pigeon pea, adlai grass, field pennycress, intermediate wheatgrass and sunflowers - as well as underutilized fruit trees and forages – to serve in new farming systems as perennial food, feed, fibre and fuel crops for the future. In the breeding process, characteristics from wild relatives can be drawn upon to make crops more nutritious, more resistant to pests and with greater adaptive capacity to the impacts of climate change, all of which can increase the capacity of agriculture to address food demands and security.

Progress on all perennial crop species needs to continue, however there are a few systems for which expectations in both the timeline and potential contribution tend to place at priority, including perennial rice systems, dual purpose wheat for grain production and grazing, intercropping perennial legumes and cereals, and boosting of existing perennial systems such as agroforestry and grasslands.

HOW TO FAST TRACK EFFORTS TO TRANSFORM TO A MORE PERENNIAL AGRICULTURE?

The domains that need the greatest attention in the short and long term fall in the categories of research, communications and mainstreaming, enabling policies and public and private investments. While integration among these is needed, the immediate actions needed are articulated by category.

Research

1. **A new generation of breeders and breeding programmes.** Within the context of research, there are a number of tools and assets, include germplasm collections, genomic resources, evolutionary information, cytogenetics and breeding capacity. But above all there is an urgent need for more breeders and breeding of perennial crops, grains and legumes to date, to be adapted to developing country contexts and to investigate new cropping system options. Historically, research in this domain has been more or less supply driven, predominately coupling scientists' interests in a particular crop and the agro-ecosystem of choice. Thus, participatory approaches that fully engage farmers' priorities in diverse contexts must be integrated into the breeding programmes. This can be done through building constituencies and capacities among researchers from Africa, Asia, North America and Europe of relevant disciplines in National Agricultural Research Institutions and programmes and the CGIAR. Simultaneously, farmer-based platforms for assessing, monitoring and promoting practices

can be put in place. Possibly a Centre for Perennial Grain Research could be established allowing for a global collaboration for integration and application of perennials to diverse farming systems and landscapes.

2. **Get the evidence into circulation.** The onus is on the scientific community to provide hard evidence to clearly demonstrate the contribution of perennials to agriculture in order to generate further research investments and farmers communities engagement. There is clearly a need to implement a systematic analysis to screen the highest potential crops, farming systems, and regions and socio-economic contexts in order to achieve short-term goals and early successes for maximum return on investment early on. Field trials and modelling can assist in this prioritization. There is also a need to incorporate robust economic studies to better quantify the overall value of the contribution of perennials.

3. **Breed for innovative farming systems.** There is a need to recognize the short-comings of monocropped farming and embrace efforts to integrate perennials into complex systems including intercropping, rotational cropping, and multi-story cropping systems and integrated crop-livestock-tree systems. Increasing grain production is important, but the added value may be greatest in terms of dual-purpose crops and the co-benefits of perennials for ecosystem services. A coordinated action by the public and private sector, policies, market, and farmers with an integrated effort to assure food security, environmental maintenance and economic returns is fundamental if we have to continue producing food for future generations.

Communications and mainstreaming

1. **Framing the concept.** Language matters in all fields and caution must be taken not to pit annuals against perennials. It is better to frame perennialization as an innovative, complementary and parallel breeding and management effort. That said, it is imperative that perenniality is integrated into mainstream agro-ecological farming and sustainable intensification concepts, and sustainable agriculture and landscape approaches in temperate, humid and dry tropic environments. In this regard, the concepts and benefits of perennial landscapes and perennial agriculture need to be brought more strongly into the conversation as a means to contend with climate change, enhance biological diversity and get back on track to attain safe space in terms of food and environmental security.

2. **Naming new crops.** Some breeders have chosen to provide new names to perennialized annuals as they can be considered new crops. This may be a valuable dimension for markets as well as for increasing the uptake by farmers. Examples include Kernza (perennial wheat) and Montina and Timtana (gluten free Indian rice grass and timothy grass used as grains, respectively).

3. **Actively participating in fora and media.** Each breeding programme needs to emphasize communication and coordination with the global community, taking learning beyond the specific crop dialogues for greater overall learning and benefit. There is a public good on offer that needs to be demonstrated. From the scientific community, communications will be bolstered through key meetings of professional societies (e.g. AAAS, Tri-Societies), dedicated journal issues (e.g. Field Crops Research, Crop Science), and collaborative scientific meetings, particularly held in regions such as Africa and Asia. The Perennial Grain Blog at Michigan State University is a valuable way to share insights among the perennial grain community. (See pwheat.anr.msu.edu/index.php/about/).

Enabling policies

The adoption of perennial crops, agroforestry, and mixed crop/livestock systems to sustain production, food security and rural livelihood, contribute to moving farming systems towards providing multiple economic, environmental and social performance.

Policies promoting this shift of agricultural systems at farm, territory and food chain levels require great commitment and vision coupled with a concrete approach to fit the many local situations. Direct public support (regional and national policies, programmes, subventions, tax, credits) and indirect public support (research, education, development) have contributed in the last sixty years to increase total agricultural production and food chains, but this increase has been obtained with increased energy consumption, Green House Gas emissions, loss of biodiversity, and soils and water degradation.

Renewed policies and programmes need therefore to be developed to reverse this negative trend and also assign a value to public goods such as the maintenance of biodiversity (above and below ground), or the generation of other ecosystem services which are essential to sustain the agriculture of the future.

Some countries have already moved along this direction and developed research programmes adopting a cohesive vision and engaging multiple stakeholders (farmers and their associations, agricultural industry and consumers), schemes to reward production of ecosystem services, land rehabilitation programmes, measures to reduce water and air pollution. Many different labelling schemes have been developed (e.g. organic agriculture, integrated pest management), national programmes to support family farmers, use and maintenance of minor crops, adoption of green technologies and biofertilizers and bio pesticides. Recently some countries have also adopted agroecology laws and are committed to enhance the full potential and diversity of agriculture by combining its economic and social potential while maintaining natural resources.

Hopefully all these programmes and policies will play a catalytic role to promote the shift of agriculture towards securing the food, profitability and ecosystem services that societies want.

Public and private investments

1. **Invest for the long-term outcome**. To develop and scale up the use of perennial grains, oilseeds and legumes take years. Historically, those progressive breeders who undertake these challenges have to do so on the periphery of their other work. Donors need to be willing to invest for the long term with the knowledge that it will be cheaper in many respects than continued short term investments. The recent USAID investment in grain sorghum for sub-Saharan Africa is an excellent example. Farmers and supply-chain companies will need to be sustained in their willingness to engage in testing and adopting innovative farming practices including agroforestry and some of the perennial crops which are in advanced stages for adoption.
2. **Imbed perenniality into programmes and projects**. Both scientists, practitioners, donors, NGOs and other investors have an opportunity to ensure that perenniality gets placed in different programmes and projects that are being designed to enhance progress toward sustainable development goals.

WHAT ARE THE NEXT STEPS FOR FAST-TRACKING PERENNIAL CROPS?

In summary, the integration of perennial species into farming systems, whether crops, forages, or trees can contribute to achieving multiple functions including increased food security and nutrition, climate change resilience and mitigation, increasing energy efficiency and production, and enhancing ecosystems services such as biological diversity, water, nutrients, and land health. In addition, perennial systems can reduce input and labour costs, but many relevant aspects require additional research and extended field tests. Breeding and testing of new management practices will need to provide responses beyond increasing annual yields including evaluation of resistance to cold, dry, humid weather conditions, new pest and weed cycles, soil feedback, and water uptake.

Among the next steps that would be most valuable for enhancing the integration of perennials of all kinds into agriculture, and for fast-tracking the development of perennial grains, oilseeds and legumes forward would include key investments in:

- Ramping up research to advance promising perennialized species, ensuring a global network that is addressing demand and co-research and learning with farmers' platforms in the context of developed, emerging and developing country contexts;
- Ensuring cross learning and collaboration among scientists globally working on various species and hosting workshops and conferences in key regions and countries (e.g. East, West and Southern Africa, China, Brazil);
- Enhancing communications of the evidence of perennialized species' contributions to addressing local and global development challenges;

- Mainstreaming the concept of perennial agriculture into research, practice and national, regional and global policy and investment fora as well as through a variety of communications and social media;
- Identifying a small team to articulate the specific architecture and costs of a virtual and ultimately bricks and mortar Centre for Perennial Grains Research or Centre for Perennial Agriculture;
- Articulating and developing an impact pathway for achieving a global target of hectares of annual-based agriculture transitioned to perennial agriculture in a diverse set of countries.

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