GSDR 2015 Brief

Conserving Traditional Seed Crops Diversity

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Related Sustainable Development Goals

Goal 01 End poverty in all its forms everywhere (1.5)

Goal 02 End hunger, achieve food security and improved nutrition and promote sustainable agriculture (2.4, 2.5, 2.a)

Goal 15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss (15.5, 15.6, 15.c)

Introduction

Over the last two decades, 75% of the genetic diversity of agricultural crops has been lost;[1] 100 to 1000-fold decrease overtime.[2] This phenomenon results in the decrease of ecosystem abilities to provide food for people and decrease the function of other ecosystem services.[3] Crop varieties, as an integral part of genetic diversity, are the result of human selection and management[4,5], as well as natural mechanisms of evolution. Evolution, based on mutation, natural hybridization, introgression[6] and selection, adapts plant populations to the (agro-) environment.[7] Plant breeding by farmers and specialists builds on these phenomena, makes them more efficient, and focuses them on farmers' needs. Genetic diversity is the basis of all crop improvement.[8]

Meanwhile the crop diversity has been decreasing, the World Bank estimates that about one billion of world's population will still live in extreme poverty in 2015.[9] 70% of world's poor people are living in rural areas and they are relying on the agriculture sector[10], particularly on traditional agricultural systems.[11] FAO suggests that efforts to eradicate hunger require an integrated approach especially to increase agricultural productivity and strengthen farmers' resilience to environmental changes.[12] In regard to FAO suggestion, it is important to restore crop diversity.

International concerns about the loss of plant diversity were discussed in the Commission for Plant Genetic Resources at FAO in 1985[13], and more recently in the Conference of the Parties for the Convention on Biological Diversity (CBD) in 2002, resulting in the Global Strategy for Plant Conservation (GSPC).[14] GSPC is intended to restore plant diversity as a part of eradicating poverty and promoting sustainable development.[15] GSPC includes in situ and ex situ conservation as main ways of preserving seed crops. Both conservation methods have the same goal, but do not exactly have the same ability in sustaining crop diversity and sustaining farmers' ability to preserve and utilize seeds.

Currently, scientific communities are debating on resilience and adaptive capacity of traditional seed crops and the effectiveness of their conservation methods. Thus it is important to summarize scientific arguments and the evidence of these issues as a base to make right solutions to eradicate hunger and to

FOOD FOR THOUGHT

- Global crop production is dominated by four staple foods: wheat, rice, maize, and potato. In some areas this has led to a loss of genetic diversity in crop production and to a hypothesized increase in disease susceptibility.[i]
- 6 years of practicing intercropping system in Yunan. China, resulted in the significant increase of rice varieties.[ii]

restore biodiversity. In this paper we focus on discussing traditional seed crops, which derived from wild plants that are domesticated and planted locally based on certain climate zones and have been developed through local knowledge. Traditional seed crops are differ from hybrid seed crops and GMO seed crops in some respects.

Scientific Debate

Resilience and adaptive capacity of traditional seeds

Currently, within the scientific community there is not a consensus regarding whether traditional seeds are really resilient and carrying adaptive capacity to face climate change. On one hand, some scientists state that local farmers develop adaptive and resilient plant varieties. Those plant varieties differ in terms of their adaptation to soil type and drought resistance.[16] Moreover, traditional varieties and the genetic diversity of the wild relatives of domesticated crops provide rich resources for facing changing climate.[17] Altieri and Merrick state that traditional seeds become adaptive to climate through natural hybridization and introgression as processes from in situ evolution (even though they do not provide the genetic evidence).[18] Other scientists mention that natural hybridization may be an important process in the shaping of the evolutionary trajectories of many plant species.[19] Some archeological data that can support the statement of evolution in situ are the discovery of a *Cucurbita pepo* seed in Guila Naquitz Cave in the Valley of Oaxaca, Mexico. The *C. pepo* was domesticated in 8,750-7,840 14C years BC[20], a type of squash that is now being cultivated in some parts of the world. In addition, Berglund-Brücher and Brücher[21] assume that *Phaseolus aborigineus* (a wild bean species), which first dated 7,000-10,000 14C years BP, is the ancestor of *Phaseolus vulgaris*, a domesticated and a current cultivated bean. This assumption is based on phylogenetic evidence between these two species. Another example of evolution in situ is the ancestor-descendant relationship; from teosinte to maize. Furthermore, Benz study on *Zea's* inflorescences from Guilá Naquitz Cave revealed evolution evidence of teosinte inflorescences by 5, 400 14C years BP.[22]

We only found one genetic evidence of evolution related to adaptation capacity of wild plant species, the relatives of traditional crops. A study on genes sequence in domesticated lineages of rice shows low rates of adapted genes of traditional rice in comparison to wild rice.[23] This could be refuting the arguments of the scientists that state evolution of traditional seeds in situ has been occurred. The study found that evolution occurred in the genes of five wild species of Oryza[24], wild rice that are native to four different continents. The specific genes allow different varieties thrive in to particular climate condition in the different continents. Furthermore, the research found genes have capacity against pathogens, and genes adapted to allow different ways of pollination and natural diffusion of seeds.

In regards to evidence of resilience capacity in traditional seeds, we only found one experiment at genetic level that analyzes gene expressions of traditional seeds. The experiment tested three Mexican traditional maize (varieties tested: Michoacan 21, Cajete Criollo and 85-2) in a greenhouse. The scientists measured their gene expressions and physiological responses to overcome drought stress, and reveal two of three traditional maize showed drought stress tolerance.[25]

Theoretically, resilience is not a permanent solution because the crops only return to an equilibrium[26], while adaptation is what allows a crop to persist, because the genetic changes imposed by the changed environment create adaptation.[27]

Traditional Seed Crops Conservation Methods

In situ and ex situ are the two common ways of conserving traditional seed crops, however there are ongoing debates among scientists about each effectiveness to restore biodiversity; resulting preference of some communities to only choose and prioritize one of those two methods. In situ conservation means to conserve crop species in their natural habitat such as natural reserves, conservation corridors[28] and on farm.[29] Ex situ conservation means to conserve seeds varieties under controlled and artificial environment, such as gene-bank[30], botanical garden, agricultural research station[31] and tissue culture collections.[32] While these methods have consequences once they are applied, knowing each method's advantages and disadvantages (Table 1) could be useful to determining solutions most suitable to local environment and socio-economic situation.

Table 1. The Advantages and Disadvantages of In Situ and Ex Situ Conservation Methods

In situ advantages	Ex situ advantages
Increasing local adaptive capacity on climate change and preventing farmers desire to leave the farm because of climate and environmental change [33,34]	Breeders can use the seeds to increase agricultural productivity in different parts of the world [41]
Nurturing crop biodiversity; increase significant varieties of crops, including those that were locally extinct [35]	Providing assurance in saving genetic resources from the loss because of human ecosystem domination [42]
Supports resilience when the old diversity is well adapted to the environment and farmers 'knowledge [36]	Can save large variety of seeds in relatively small space [43], with many accessions, save room, and require relativity little labor [44]
Supports empowerment of communities as they have the future of their crops in their own hands [37]	Can save several landrace species for longer time [45]
Ensuring new variations of plants are generated [38]	Genetic change is much less compared to in situ [46]
Provide continuous seeds supply [39]	The safety is guaranteed especially when the duplicate samples are stored elsewhere [47]
Local communities as the main actor [40]	Allows saving the seeds anytime [48]
In situ disadvantages	**Ex situ disadvantages**
Slowly adapt to climate change [49]	Longlivity of the germplasm in seeds banks remains for a limited time in storage [57]
The genetic resources are not ready for the outsiders who want to breed the seeds for global food security purpose [50]	Seeds that have slow rate of germination or the ones that germinate fast cannot be stored [58]
Disasters and development give pressure to the existence of the crops [51]	Some gene-banks and botanical gardens do not have comprehensive data about the seeds demographic information and their cultivation methods as well as mislabeling have been occurred [59,60]
Only suitable for countries where their biodiversity conservation efforts and economic development do not contradict each other [52]	A large collection is lying unutilized in global ex situ collections [61]
Farmers' decision on preserving diversity depends on their socio-economic situation [53] culture governmental policy and environmental condition [54,55]	It costs a considerable amount of money and energy which causes extra difficulties for some developing countries where funding and electricity are limited [63]
When people in the area are displaced the local knowledge is gone and so are the seeds [56]	It creates conditions where the crops stop or pause evolving [64]
	Local communities normally cannot control their crop diversity [65]
	The storage of the seed-banks often results in partial or complete loss of seed viability [66]

In situ and ex situ are complementary strategies; with ex situ providing the much-needed resources for global food security and in situ strategies supporting local food security of specific types of smallholder farmers.[67] However, there are some different arguments among scientists about their effectiveness to restore genetic diversity. On one hand, some scientists tested that the genetic variety of seed crops between in situ and ex situ are not much different, while some scientists reveal the opposite fact (e.g. ex situ seeds have less genetic variety), the same thing also happens in the tests of seed viability. Moreover, in general ex situ is being practiced more than in situ, as there is a tendency that ex situ is a better conservation method.[68]
A new method that combines in situ and ex situ has been proposed by some scientists; it is called 'quasi in situ'.[69] Quasi in situ proposes the use of ex situ collections in natural or semi-natural environments as a part of a complex ex situ–in situ conservation strategy. However, there is no evidence whether this new proposed method is effective.

By combining these two (or and to try the new proposed method) in an area, could be an effective solution for restoring biodiversity and improve agricultural productivity. Despite ex situ can assure the availability of genetic resources for global food production, in situ has the ability to empower farmers and local communities to be resilient to environmental changes. However, in situ or ex situ can only be solutions for farmers and local communities around the world if there are assurances (policies) for farmers, peasants, small holders and local communities to have access to genetic resources[70] and rights to plant the seeds. It is also necessary to protect the lands or areas where in situ is being practiced to maintain biodiversity.[71] Consider that the convenience of GMO seeds for poor farmers and environment are still in debate, while the hybrid seeds are known to require inputs (such as fertilizers) that poor farmers cannot afford, thus it is important to reinforce efforts and managements to preserve traditional seeds, while the different debates will be resolved and the uncertainties will be overcome.

Goals & targets

By conserving traditional seed crops diversity, the efforts gap between restoring biodiversity and improving agricultural productivity can be bridged (SDG 2, 2.4, 2.5). The conservation methods can restore biodiversity loss (SDG 15, 15.5) while peasants and farmers empowerment can be implemented, which can support the efforts of eradicating poverty and hunger (SDG 1, 2). By improving conservation management and assistance to increase farmers access and rights to get and plant the seeds can save local knowledge, increase community resilience and insure agriculture productivity (SDG 1.5, 2.a, 15.6, 15.c).

Recommendations

A policy to ensure management of in situ and ex situ attributing rights and access for farmers, smallholders, peasants, breeders, and local communities to get the seeds to be planted in their field is needed. Ex situ way should not make us ignoring and aside in situ method since in situ sustaining local knowledge and carry other benefits for human and biodiversity relationship. Combining them could be the most effective to achieve sustainable management on biodiversity and agricultural productivity.

Moreover, since there are uncertainties among scientific communities, more researches are needed related to:

- Gene flow, since there is uncertainty that natural hybridization and introgression have been occurred.
- Genetic evolution of traditional seeds related to resilience and adaptation on climate change.
- Conservation methods related to genetic evolution, genetic variety, seeds viability and seeds adaptation capacity and resilience to climate change.

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Appendix 1: Research methodology

Conserving traditional seed crops diversity topic was chosen based on personal interest in never end debates between scientists on this topic, especially since 1990s. We are very concerned about the loss of traditional seeds crops diversity, because it will also contribute to the biodiversity loss and the disappearance of local knowledge. Once biodiversity and local knowledge have lost, there will be other emerging problems related food security and ecosystems.

A background research on this topic was conducted to make sure that this topic is one of the emerging issues within scientific communities. We checked the frequency of citation on this topic in scientific journal databases. The scientific journal databases we checked were ScienceDirect, Scopus, and Google Scholar from 1995-2014 (20 years) with key words: 'crop resilience on climate change', 'plant crop adaptation to environmental changes', 'seed crops conservation', 'in situ seed conservation' and 'ex situ seed conservation'. During the past 20 years the numbers of citation frequency has increased over time, even though a slight decrease in citations between 1996 and 2000 is indicated (see Figure 1).

Furthermore, after we have collected topic related data, we contacted some experts to review our brief. The experts who review our brief are Prof. Dr. Ir. Niels P. Louwaars and Prof. Charles A. Maynard, Ph.D. Prof. Dr. Ir. Niels P. Louwaars is a professor in Wageningen University and Research Center. He has expertise in law, plant breeding, seed production, plant genetic resources and biodiversity. Prof. Charles A. Maynard, Ph.D. is a professor in State University of New York College of Environmental Science and Forestry. He has expertise in plant genetics, plant breeding and genetics, and transgenic.

We collected different arguments and evidence among scientists and the experts, and discuss them in this paper to give a clear view of current news relating the topics, thus be able to provide recommendations. Additionally, we fully understand that we cannot include all evidence and scientific arguments due to paper length limitation and constraint of time. Any shortcoming in this paper is our responsibility.

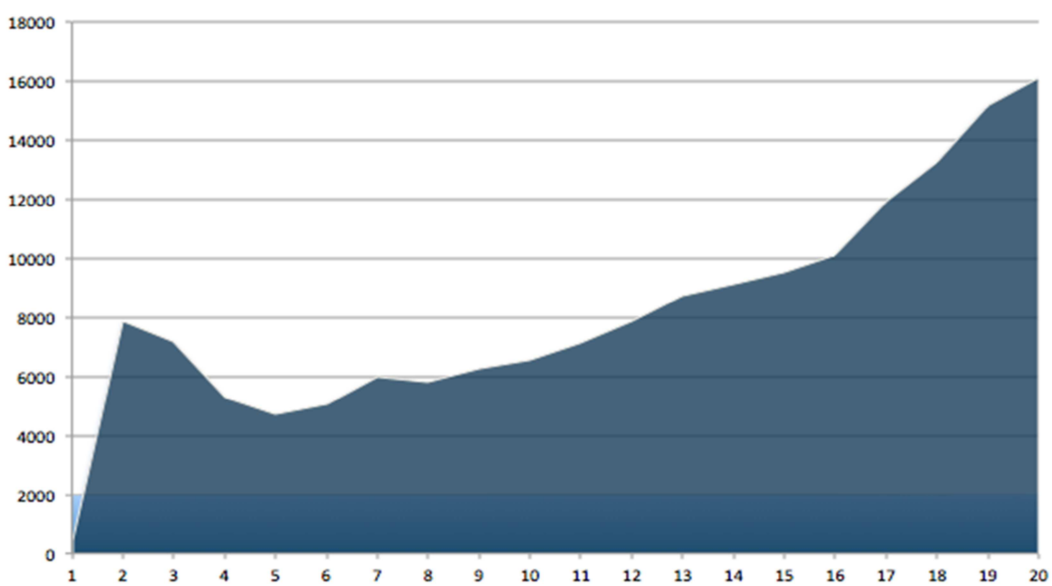

Figure 1. Frequency of Citation on Conserving Traditional Seed Crops Diversity from 1995-2014.