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PERSPECTIVE

Game-changers: The Role of Students in Plant Genetic Resources Research

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Abstract

Plant genetic resources (PGR) conservation is not yet a household phrase, unlike biodiversity conservation. PGR, a subset of biodiversity, are primarily used for plant breeding or crop improvement. Better crop varieties are essential to sustain food crop productivity, as well as, other crops for other uses. Sustaining crop breeding programs critically needs the availability of diverse PGR that are increasingly at risk of genetic erosion. PGR conservationists are still few and perhaps rare, compared to the work that needs to be done. Including and involving students to do research on PGR and their conservation, management and utilization could address many of the research gaps such as discovery of less known PGR and characterization of conserved PGR for pre-breeding work. However, research may change the course of the game, that their research experience on PGR and their findings could be transformative that they become future conservation leaders, champions and influencers.

Keywords: *conservation, genetic erosion, plant genetic resources, research, students*

Biodiversity conservation is almost a household phrase in Philippine society, and in many other countries. Many people are aware, although, not everyone who is aware may be substantially educated about biodiversity conservation. Nonetheless, awareness is always an important start. Perspectives and level of knowledge on biodiversity protection and conservation were determined on 268 randomly selected students of Aurora State College of Technology in northern Luzon, Philippines through a survey questionnaire [1]. These students generally showed moderate knowledge level on biodiversity. Hence, the researchers recommended that curricular programs of their academe be reviewed and enriched to guarantee that all students, regardless of degree program, are substantially "environmentally educated" especially on biodiversity conservation.

How about plant genetic resources (PGR) conservation - is it a household phrase? Or, at the very least, do students who are pursuing degree programs in crop sciences and allied fields know PGR conservation? In a class for a PGR conservation course under the Bachelor of Science in Agriculture program of the university, several years prior to the COVID-19 pandemic, students were asked if they knew what PGR was. Many replied that they did. For them, PGR was plant growth regulators, not plant genetic resources.

Therefore, the answer is no, i.e. PGR conservation is many distance away from being a household phrase. Only few are aware that the conservation of PGR, especially those for food and agriculture (PGRFA), is under the umbrella of biodiversity conservation. Hence, there is a need to "increase the critical mass" of people who are trained, skilled, and competent in all processes involved in PGR conservation and management [2]. Every substantially educated student could be the catalytic agent to also directly and indirectly educate their households, current or future workplaces about PGR conservation. This could be the added push to rethink and to re-strategize how to cultivate more awareness, curiosity and knowledge about PGR conservation, management and utilization (PGR CMU) in many academic institutions.

PGR refers to the diverse array of plant materials that include traditional varieties, landraces, heirloom varieties, farmer's varieties, formally registered varieties, mutant stocks, clones, crop wild relatives (CRWs), indigenous crops, and neglected and underutilized plant species (NUPS). These, and more, are essential sources of useful genes for crop improvement or plant breeding programs, hence specifically referred to as "plant genetic resources" and not just plant resources.

The best cultivated crops are never perfect and have plenty of room for improvement through traditional breeding, modern crop breeding, or both. These days with severe challenges in crop productivity due to the increasing effects of the changing climate, genes controlling desirable plant traits such as tolerance to abiotic stresses (e.g. drought, flooding, soil salinity, soil acidity, high temperatures) and resistance to biotic stresses (e.g. new pests and pathogens, more virulent pathogens), can be sourced out from these PGR.

The vast array and diversity of PGR is a "societal insurance policy" [2] and important for the "country's sustainable development" [3], as of other countries as well. Agriculture is the backbone industry of any society and food crop production is the most basic service of all. Regardless of economic status, developed or developing, a country needs to sustain its crop production systems for food, feed, fiber, medicine and other industries. Food and other products from the animal sector are still dependent on crop production systems. Therefore, whether on the aspects of local to global challenges, PGR are essential "solutions for such challenges" [3].

PGR are one of the subsets of biodiversity, which are intended for use in agricultural production systems. Whereas, biodiversity conservation circles talk about species extinction, PGR conservation circles talk about genetic erosion, i.e. the loss of genes and alleles or basically genetic diversity, due to many causes, which is the primary threat or bottleneck to crop breeding programs. Genetic diversity and variations are valuable materials for crop improvement programs. Diverse and variable PGR conserved *in situ* and *ex situ* are the reservoir of such programs.

PGR conservation and management is relatively a young science or discipline, largely conceived and developed in response to the growing concern of genetic erosion in the plant kingdom. The first few scientific papers on PGR published in the Crop Science journal as part of the new section C-8 (PGR) were in 1991 [2]. Genetic erosion or the loss of PGR as populations or the reduction of species variability due to several reasons: stressful/difficult environments, climate change, anthropogenic activities (e.g. slash and burn), land use conversion, natural calamities (e.g. landslides), can be further aggravated if there are only few people who are aware and educated about this discipline.

Accordingly, plant breeders are becoming a rare breed [4]. In hindsight, PGR people may be even rarer. Involving students through PGR research solidifies their experience about PGR awareness, education, conservation, challenges and opportunities. This could help reduce the rate and speed of PGR loss *in situ*, help increase the conservation of PGR *ex situ*, and help promote the utilization of PGR and consequently increase their value. With the first realization of critical magnitude of plant genetic erosion due to various causes, the most primal response of plant breeders was to collect, gather and assemble the most amount of PGR available to be immediately conserved for safe-keeping for their use. *Ex situ* conservation methodologies were developed and facilities were built where the easiest and least costly was seed genebanking. However, not all PGR can be kept safe using their seeds hence, field genebanking or maintaining living collections of PGR needs to be sustained. As every method has limitations, other *ex situ* conservation strategies were also developed – *in vitro* culture, cryopreservation, DNA library, pollen banking, and more. However, PGR conservation is more than just assembling PGR and keeping them in containers. More protocols need to be developed, better techniques, conserved PGR need to be characterized and evaluated because PGR are only valuable and useful when their traits and characteristics are known. Therefore, more hands need to be on bat and on deck, more minds need to be cultivated and inspired, and more hearts need to be engaged.

While a number of students may consider that doing research is just another class or degree requirement, doing a study on PGR conservation is definitely that but more, whose benefits could be transformative and catalytic for the students themselves, their households and communities. Cultivating curiosity, inspiring the pursuit of knowledge, and encouraging contributions of meaningful solutions to societal concerns are time-tested approaches. To do research and to be mentored how to do good research are both opportunities for personal and professional growth. To train more students in PGR research and to provide them opportunities to do so are additional societal insurance policies.

Therefore, past, present and future research on PGR, either at the amateur level by senior high school and undergraduate students to the most seasoned crop researchers and scientists, will always have value, directly or indirectly, on every country's sustainable development. Research on PGR by students range from simple laboratory learning activities, print and online literature research, special projects, short-term research (STRs), investigatory projects, capstone projects, undergraduate thesis, and graduate thesis or dissertation. The field of PGR conservation has a lot of gaps and therefore, many opportunities for student research and contribution that could help change the course of the game.

1. Assembly of germplasm and pre-breeding work. Either as a simple STR or thesis work, students can help collect and document valuable PGR from their communities for ex situ conservation and for initial characterization and/or evaluation, followed by other students who can do validation. Their findings are important components of pre-breeding work (PBW) such as selection of potential parent materials for desired crosses. Students who do PBW lessen the bulk of work of public plant breeders who often toil with inadequate funds.

2. PGR discovery. NUPS and CWRs are two major groups of PGR that may have the highest risks for genetic erosion. NUPS are already at a huge disadvantage because these are unpopular, not mainstream, underappreciated, and unknown to many even if most NUPS are nutrient-dense and easy to grow. Surveys and interviews are simple research tools that could unearth new or long-lost NUPS and document their utilization as food, beverage, feed, medicine or others. Most NUPS are considered multipurpose crops and are amongst the best examples of PGR for CTU or conservation through use. Student investigations are initial steps to get these plant species a little attention and some useful information that are valuable for their increased utilization. Eventually, with small, creative and concerted efforts to popularize or mainstream NUPS, some could become WUPS or well-utilized plant species. After research, students could help promote NUPS through brochures, leaflets, social media info-posts, scientific posters and oral papers in conferences, seminar talks, journal articles, learning videos, as part of PGR fairs or exhibits, and as processed foods or products. The development and availability of new and better crop varieties with better yields, plant architecture, adaptation to difficult environments, improved nutritional quality, and better physiology, among others, takes time. It makes logical sense while the crop breeding programs are on-going, NUPS can be promoted for larger-scale production and wider utilization. Many CWRs may be also dually categorized as NUPS. However, often the primary consideration for CWR conservation is for use in crop breeding. These species are sources of genes for hardiness, resilience, or tolerance and/or resistance to biotic and abiotic stresses that limit crop productivity. Although, several CWRs are already edible and useful even in their wild forms.

3. Documentation and conservation of traditional knowledge systems (TKS). It is not only PGR that are under increasing threats of genetic erosion, so does TKS. Simple activities and/or studies like surveys, pictorial documentation, interviews and conversations with their community elders or older relatives about useful plants in their lifetime provide valuable information. Less known species, indigenous species, or again, NUPS, can be further probed about their useful traits, phenology, natural habitats, cultivation practices, uses, preparation or processing methods for utilization, and local practices of conservation. Aside from community elders, the local "manambalay" or healers/medicine persons also are good sources of information re useful medicinal plants available in their communities and how these are utilized. Definitely however, such ethnobotanical information needs to be validated by science, which opens another opportunity for students to contribute to science.

4. Increasing/improving crop literacy. Basic human literary is based on ability to read, write and do simple maths. Perhaps, basic crop literacy also needs to be developed among people. Results of simple surveys among students on how many agricultural crops they know based on uses or as per category (e.g. cereals, legumes, oil crops, root crops, biofuels) usually recorded low counts, i.e. low crop literary, based on a simple scale of 0-5 crops (low literacy), 6-10 crops (moderate literacy), and >10 crops (high literacy). Increased or higher crop literacy could consequently amplify CTU. Therefore, PGR research by students could directly and indirectly improve their food use through food crop diversification. Such personal changes can bring us closer to the goals of individual and household food and nutrition security. Health security is an added bonus because many PGR are medicinal or have medicinal properties, or if everyone takes heed of the old wisdom of Hippocrates that food is our medicine. Even additional income opportunities are possible when tapping into outputs of PGR research by students, especially those with the entrepreneurial savvy.

5. Promotion of PGR and their conservation. Any kind of research endeavor with good mentoring and objectives, can become a transformative experience for students. PGR conservation, evaluation, and utilization can be championed by students whose research experience on PGR have resonated with their core values and aspirations. These students can become influencers of PGR conservation. Students are the first beneficiaries of their research findings and of the other information/knowledge they gained from their research engagements. The next beneficiaries are their professors, families, friends and relatives.

6. Assessment of a community's level of crop species diversity. Survey visits to local or public markets on market or "tabo" days and

conversations with vendors are opportunities to assess and monitor PGR diversity in a community. This includes crop varietal diversity, food crop diversity, as well as, to document the sources of PGR and areas of cultivation, and to assess some aspects of a community's level of food security. Even food places (e.g. food courts, eateries, school canteens) can provide insights on the involvement and conscientiousness of business establishments and their management re regional, national and international goals of food and nutrition security. Educational institutions can also be partners for PGR conservation through regular landscaping or edible landscaping. Identifying and document PGR in school campuses is educational and useful for school administrations to sustain or improve current practices of landscaping for aesthetics, environmental services, and other purpose.

Concluding Statement

PGR CMU, as a discipline, will never be as prolific as engineering or information technology. However, a small solid circle of PGR conservationists can reach out to other circles of people concerned about their food, nutrition, health, and environment; because more than infrastructures, digital information and software, people's most basic needs are provided or sourced from plants. Students can address many of the gaps in PGR research. In return, PGR research, in various ways, could be the tool that transforms students' perspectives and commitment to champion the causes of PGR conservation.

The country had committed to a number of international agreements such as the Convention on Biological Diversity (CBD) in January 1, 1992 [5] and the International Treaty on PGR for Food and Agriculture (ITPGRFA) in September 28, 2006 [6], PGR conservation programs should be initiated and sustained by the focal government agencies like the Department of Agriculture and the Department of Environment and Natural Resources, and their relevant units. Nonetheless, grassroots efforts are needed such as from the academe. Simple researches of students, even those without formal PGR subjects, courses or degree programs, because plants and crops are basic resources of every household and community. Young people, students, could become the future conservation leaders and influencers. They are needed to significantly slow down the rate of plant genetic erosion, add knowledge about PGR, and help educate their households, peers and communities.

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