Chapter

Legume Genetic Resource Security as Main Requirement for Future Challenges

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Abstract

Evaluating the genetic diversity of landraces has exposed us to the diverse relevance of wild line contributory to a wide range of systems ranging from morphology, physiology, biochemistry, anatomy, toxicity, etc., allowing to their genetic constituent. Today, the world is facing many global challenges. This has put the world in disarray and poses a threat *via* its impact leading to non-promising food security for a rapidly growing population, an increase in the production and release of greenhouse gases as a consequence of anthropogenic activity, and an increase in the level of pollutants in the environment. A well-characterized crop genetic resource is a precondition for effective breeding and genetic conservation in the world of legume security. There is a need to collect, study and conserve legume genetic resource to tackle future challenges. This will help project latent benefits of undescribed leguminous lines of various crop species.

Keywords: genetic diversity, genetic resource, legume security, genetic conservation, wild lines, environment

1. Introduction

Global climate change has contributed to the decrease in food production, increasing the demands for food by the world populace. Impedes to food production can also be owed to terrorism, poverty, natural disasters among others. To meet the global food demands, the focus should be on promoting the cultivation and utilization of other crops, which have been neglected and underexploited but have the potential to enhance food and nutrition securities, especially in the developing countries [1]. Leguminous plants are known to be second to cereals in the entire accessions of crops found in the world genetic resource. There is a need to study extensively the genetic resource of legumes and their underexploited species. Legumes are known for their nitrogen-fixing ability, a powerful tool for soil fertility retainability. Symbiotic bacteria are contained in the nodules of legumes, which help to fix nitrates and supply the host plant with nitrite in exchange for carbon metabolites. Legumes are tagged “poor farmers’ crop” because of their significant role in signaling economic benefits relevant to agriculture at a low-input subsistence level.

Despite its use in crop rotation or intercropping, farmers' preference for legumes in agriculture has declined over recent decades. This can be attributed to the certain factors such as production constraints (weed, pest, disease, etc.) and consistent usage of inorganic fertilizers (nitrogen-rich) in agriculture. The practice seems good to many farmers notwithstanding the depleting impacts of nitrogen percolates. The success of future agriculture depends on bridging the gap between ecological sustainability and yield-related economic constraints. If the use of nitrogen-rich fertilizer persists, there is an obligation to proffer an economically and eco-friendly solution to protect soil quality in a sustainable manner through the instrumentality of legume-based conservation agriculture [2] and the development of improved legume varieties with effective rhizobial strains, which can be introduced to different cropping systems. The aim of this review on legumes security is to identify gaps in knowledge that should stimulate the need to prioritize areas in legume research.

2. Legume security

It is quite true that "When the purpose of a thing is not known abuse is inevitable." Interestingly abuse is not limited to wastage but also *underutilization of resources*. Legumes generally are known to have originated from different regions and domesticated in another. The world crop production has revealed farmers-consumer preferences as demand and consumption increase for some crop over another. Leguminous plant species is a typical example of an underutilized crop despite its massive constituent of economic importance. The contribution of legumes to the world food basket is not significant despite its rich sources of dietary protein to millions of people, more so in the developing countries [3]. Leguminous plant species production has been reported to be minimal because of certain production constraints that have discouraged farmers from cultivating them. Legumes are known to be greatly sensitive to the unfavorable environment resulting in unstable and inconsistent yield. This has discouraged farmers from cultivating legumes. This is a major concern whose root needs to be addressed with immediate effects else we keep losing valuable genetic resources ranging from the wilds to landraces and domesticated cultivars. It is quite unfortunate how that some species of *Phaseolus* common to the sub-Saharan African countries are no longer available in the location where they are endemic, most likely the case of other leguminous plant species in places they are known to be *native*. The exploitation of leguminous plant species that are considered to have potentials for greater use by humans, particularly for grain and fodder legumes, is increasingly threatened.

2.1 Leguminous plant genetic resource

Plant genetic resources are plant genetic materials of actual or potential value. They describe the variability within plants that comes from a human and natural selection over millennia. Their intrinsic value mainly concerns agricultural crops. Grain legumes contribute greatly to the world's overall food production. Legumes are the primary source of dietary proteins in many developing countries, where protein hunger and malnutrition are widespread. Grain legumes constitute about 15% of the 7.4 million accessions conserved globally in gene banks, of which more than half of germplasm in gene banks have not been characterized and lack evaluated data, which ultimately limit the utilization and exploitation of germplasm in legume improvement programs. Characterization of all gene bank accessions should be of prime priority for enhancing the utilization. Legumes are among the most valuable gifts of nature to man, animals, and the environment. They are sustainable, affordable, water-efficient, and low-carbon footprint crops.

The development of core, mini-core, reference sets, and trait-specific germplasm has presented a platform for breeders to exploit gene banks for possible improvement of crops. New sources of variation were easily identified with these developed lines (genotypes), but notwithstanding there is still a need to evaluate these collections for unique and rare traits undisclosed and underutilized. Generally, crop species such as leguminous species known for their narrow genetic base get to be widened by adopting a breeding approach, simply by the utilization of crop wild relatives and new resources of legume cultivars [1]. Legumes and cereals among other crop plants played an impeccable role owing to the development of modern-day agriculture. The legume family, *Fabaceae*, is rated one of the first three largest families of flowering plants, with 946 genera and 24,505 species respectively according to hierarchical classification [2]. For most non-wild cultivars, they have proven to be incontestable in their nutritional contents and value for both humans and animals which attest to their recognition as the second most important plant source of nutrients [3]. Legumes are extensively distributed in diverse agroclimatic zones globally, from the mountain and north pole regions to the tropic and subtropics.

Specific features of legumes include taproot, trifoliate leaves, flower with corolla and petals (winged), and keel, which facilitate nitrogen fixation in the soil. The family is composed of three subfamilies, namely, *Caesalpinioideae*, *Mimosoideae*, and *Papilionoideae* [4]. Among them, the subfamily *Papilionoideae* is of great economic importance as it constitutes majorly most of the commercially known leguminous crop species. Naturally distributed among pulses are *Lathyrus* and *Vicia*, which have the largest number of the genus.

Legumes perform a significant role in meeting humans' and animals' nutritional and dietary needs. The major known grain legumes include cowpea, chickpea, lentils, dry beans, pigeon pea, green gram, fava beans, and black gram. Soybean and groundnuts are industrially utilized and known to be oil-producing legumes. The vegetable types of legumes identified include beans, yard long bean, and garden pea, consumed as immature seeds and pods. Lucerne, berseem, and grass pea serve as forage legumes inclusive of cowpea, while tuber legume consists of zombi pea, winged bean, African Yam bean (now beginning to gain attention), etc. *Abrus precatorius* possesses poisonous seeds that contain the toxin abrin. Additionally, grain legumes such as cluster bean, horse gram, moth bean, and pillipesara are underutilized promising legumes primarily grown in the Indian subcontinent, China, and Southeast Asia, and they are also equally important in ensuring food and nutritional security.

Legumes are the reservoir of protein, carbohydrate, fiber, and other minerals in trace amounts. In addition to these, legumes contain constituents that are beneficial to the health of humans and animals. Too much but a few of such constituents include low glycemic index (GI), which makes them superfood that provides long-term health benefits. The isoflavone content in legumes (soybean, chickpea, fava beans, groundnut, etc.) plays a role in plant defense [5] and improvement in human health can also be traced to root nodulation. Legumes serve as fodders (vegetative parts) for livestock. Nitrogen fixation is very peculiar to legumes through which the fertility and texture of the soil are enriched and improved for other crops to thrive adequately. Legumes also play a vital role in the intercropping system [6].

Hence, there is a need to explore sustainable improvable working strategies to develop and diversify legume production. To make progress to the exploration plan, there is a need to adopt diverse genetic resources in any crop improvement program. This can be considered a most suitable sustainable strategy among others to conserve vital genetic resources for the future. Germplasm with a rich reserve of genetic diversity would forever remain a powerful tool in any crop improvement program. Reviews have it that globally, gene banks hold about 1 million accessions of the leguminous crop.

A vast category of genetic resources is conserved *ex situ* in gene banks, wherein a considerable amount of reserves remains underutilized in nature. Hence, it becomes a matter of concern and priority to collect the maximum amount of diverse genetic resources into the germplasm before it is lost forever. Recently on the Plateaus (in Nigeria), some lines of *Phaseolus* were discovered to be extinct and no longer available in a location within the region where it is expected to be endemic (Bokkos and Mangu). Crop wild relatives (CWR) are the reservoir of genes for breeding. To explore the potential of CWRs in today's changing climate, collection and conservation have to be of the topmost priority else we are left with no tool to improve cultivars.

For progress in the sustainability in agricultural production, "*Conservation through use*" approach is a possible way. Continuous storage of the genetic resources in gene banks will not solve the purpose until it is effectively and judiciously utilized. In handling germplasm, genetic integrity is required and should be maintained solely to the end that the variability of genetic resources would still be available for use in the future majorly in conventional breeding programs (this cannot be over-emphasized notwithstanding advances in technology). It is so unfortunate how an ample amount of genetic resources available in gene banks are without characterization and evaluated data.

Genetic resources are the fourth most essential input after water, soil, and light. It is relatable to harness legumes to solve global challenges such as population explosion, land infertility, malnutrition, and hunger. There is not much of a priority on leguminous crop plants and hence get masked by cereal production across the globe. In addition, farmers no longer find it appealing to cultivate legumes for either consumption or profit-oriented. This has led to a substantial decrease in research on legumes. Global climatic change and environmental instability have in a way to pose a strong need for research on landraces and crop wild relative of legumes in an effective manner, although still at a threshold state. Legumes have the potential to contribute significantly to the economy and ecological framework of (eco-friendly agricultural land use and sustainable forage production) a community particularly in the tropics [7].

Initially, the purpose of germplasm has been to preserve genetic resources only, but recently, attention has shifted to conservation through use. Interestingly, legume genetic resource has been harnessed to develop agro-ecological cultivars, which include zombi pea, winged bean, grass pea, etc., with new alleles, which has helped in developing biotic and abiotic stress-tolerant varieties. Making such progress for sustainability in agriculture would be labor in futility if we fail to identify various possible constraints to the utilization of germplasm tools for legume production. With the current advancement in technology, trait discovery and markers-assisted selection of traits need to be explored for possible large-scale screens to eventually help to reveal the latent genetic potential of the legumes' germplasm conserved in the gene banks.

2.2 The underutilization of germplasm is a route to legumes extinct

Germplasm is the lifeline and heart of plant breeding. It is the genetic tool used to preserve the genetic pool of crop species. There is no plant breeding program without a germplasm reserve. The management of legume genetic resources begins with germplasm collection, conservation, identification, characterization, evaluation, and documentation. The most research institute has worked tirelessly to ensure a proper management of legume genetic resource. The CGIAR centers such as CIAT (Centro Internacional de Agricultura Tropical), ICARDA (International Center for Agricultural Research on Dryland Agriculture), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), and IITA (International Institute for Tropical Agriculture) remain custodians of the largest germplasm collections for bean, chickpea, cowpea, faba bean, lentil, and pigeon pea, while the Australian gene bank (ATFCC, Australian Tropical Crops & Forage Genetic Resources Center) has the largest collection of pea germplasm. It is of interest to know that from the known gene banks, legumes constitute about 15% of the whole accessions [8].

Based on plant utilization and conservation, legumes are categorized into mostly and less cultivated species. Legumes categorized as mostly cultivated are popular and common with the well-established domestication, agronomic practices, utilization, and conservation. Examples include broad bean (*Vicia faba*), chicken pea (*Cicer arietinum* L.), cowpea (*Vigna unguiculata* L.), groundnut (*Arachis hypogaea* L.), pea (*Pisum sativum* L.), common beans (*Phaseolus vulgaris* L.), soybean (*Glycine max* L.), among others. The less cultivated legumes are scarcely known, less exploited, neglected, and considered underutilized. Several species in this category include rice bean (*Vigna angularis* L.), Hyacinth bean (*Lablab purpureus* L.), winged bean (*Psophocarpus tetragonolobus* L.), jack and sword bean (*Canavalia sp*.), pigeon pea (*Cajanus cajan* L.), lima bean (*Phaseolus lunatus* L.), mung bean (*Vigna mungo* L.), bambara groundnut (*Vigna subterranea* L.), African yam bean (*Sphenostylis stenocarpa* H.), marama bean (*Tylosema esculentum* L.), and Hausa groundnut (*Macrotyloma geocarpa* H). The wild species of the less cultivated grain legumes include Hausa groundnut (*Kerstingiella geocarpa* H), marama bean (*T. esculentum*), and the wild Vigna species such as *V. ambacensis*, *V. vexillata*, *V. luteola*, *V. oblongifolia*, and *V. racemosa*, among others. As stated above, several of these species are natives of sub-Saharan African countries and could be explored for food, medicine, agriculture (as to cover crops and fodder), and more importantly for genetic improvement of cowpea (possible sister lines) and related species [9, 10].

Detailed germplasm study (collection, identification, characterization, conservation, evaluation documentation, and cataloging) on leguminous plant species would not be attainable as attention is focused on specific cultivars over others. Beyond the *ex situ* and *in situ*, there is a need to (i) evaluate the morphological and biochemical traits in wild lines of minor legumes, (ii) do better cataloging that would communicate the characterized feature desired by a breeder to initiating a breeding program, and (iii) reduce the selective pressure on major legumes to avoid genetic erosion of certain of this species. Most legumes do not have improved cultivars developed from breeding initiatives. This is true of many underutilized plant species that mostly exist as landraces with many potential genetic bottlenecks and constraints on both the available genetic diversity and its distribution within and between landraces [11].

2.2.1 Plant domestication: a step forward to germplasm utilization

Genetic erosion due to the collection of new strains from known populations and domestication deficits are the two main characteristics of cultivated crops. Domestication disorder is defined as the modification in the physiology and morphology of cultivated crops that make them different from their wild ancestors, enabling them to adapt to deliberate cultivation by a man called agriculture [12, 13]. Some of these include loss of germination inhibition, changes in growth habits, seed dispersal mechanisms, etc. Different regions of the earth have contributed to the modification in cultivars independently [14]. A technical overview is long designed to separate known domestication with crop varietal traits, that is, between short incidences and ancient processes such as cultivation [15]. It is worthy of note that paleoethnobotany has also been categorized into various forms of domestication in relation to leguminous and nonleguminous crop plants (grain and forage). Regarding the seed size, grain legumes do not show evidence of seed size increase with domestication whereas forage legumes do (or ards) [16]. Others have proposed that the sowing depth by humans might have contributed in instances to increase the biomass of the seed, but this did not seem to have a firm premise after testing [17]. This explains how agriculture adopts both art and science to function together on the available genetic diversity of plants. Plant domestication is incomplete without a discourse on selection. Provided the practice of cultivation and managements are known to being strong selection pressures during the domestication of crops, and it is expedient to study the preference and decision of humans [18]. There is an increasing indication suggesting that humans have actively changed certain ecosystems to increase the availability of certain plant resources centuries before the appearance of the pointers of domestication [19]. Notwithstanding the recent happenings, it is promising to evaluate the advance and prospects of the trends in domestication 0f germplasm [20]. Finally, it is important to bring to mind the recent occurrences of plant collection and domestication process [21] as it is not only an old practice. There is still great potential yet with domestications of germplasm with the unprecedented development of conservation tools that would allow us to produce higher and improved strains for quality food for consumers globally.

2.3 Ecological significance of legume

The nitrogen-fixing ability of leguminous plants is of crucial importance in agriculture. Prior to the use of fertilizer supplements in the developing countries of the world, the cultivation of crop plants aside from rice was dependent on legumes and waste from plants and animals for nitrogen fertilization. Crop rotation is a common practice usually carried out by alternating an economic crop such as corn (maize) with a legume, often alfalfa (*Medicago sativa*) as seen in the temperate world. Legumes are also known for their usage as animal forage (hay or silage). Pastures or other grazing areas must have legume forages, such as alfalfa (*M. sativa*), Clover (*Trifolium repens*), Gliricidia (*Gliricidia sepium*), Hyacinth bean (*L. purpureus*). Meanwhile, most of the vegetation of forests, grasslands, and deserts of the world are primarily dependent on forage legumes and could not exist without them. Ecosystems with few legume species have alternate biological means for fixing nitrogen. Too much but a few of the biological means include a symbiotic association between woody species other than legumes, actinomycetes, or bacteria and are limited mostly to boreal evergreen forests and certain coastal areas. Nitrogen fixation by free-living cyanobacteria seems to be important in aquatic ecosystems. However, irrespective of the alternative mechanisms for nitrogen fixation, they are relatively secondary to legumes.

2.4 Supplementary functions of rhizobia relationship

Legumes have the ability to form a symbiotic relationship with rhizobia (a nitrogen-fixing bacteria). A specialized organ in legumes called nodules embeds the bacteria, wherein the concentration of oxygen is very low, allowing the enzyme nitrogenase to fix atmospheric nitrogen gas. Studies on *Medicago truncatula* (Clover) have shown that nitrogenase iron-molybdenum cofactor and nitrogenase activity are synthesized by *M. truncatula* molybdate transporter (MtMOT).

The identification and characterization of regulatory components contributing to nodulation can make an offset of genetic targets and polymorphic markers to enhance the selection of superior legumes cultivars and rhizobia strains that promote food security and agricultural sustainability [22, 23].

Communications through chemical signals are the initial steps that define plant-microbe interactions, especially when between considerable inter-species. The initial recognition in the rhizosphere requires the release of some plant metabolites including flavonoids, strigolactones, and N-acetylglucosamine as well as microbial nod factors, which are lipochitooligo saccharides creating the obnoxious environment for pathogens. The legume host maintains and manages the number of nodules; it forms in association with the nitrogen-fixing rhizobial partner. This enables the plant to balance its need to acquire nitrogen with its ability to expend resources developing and maintaining nodules. Molecular mechanisms are involved in the said process [24].

The interactions between legumes and different symbiotic partners are not mutually exclusive. Moreover, reports have it that tripartite associations between legumes, rhizobia, and mycorrhiza are beneficial [25], which explored carbon allocation and the availability of resources in *M. truncatula*. Such tripartite interactions led to synergistic growth responses and stimulated the phosphate and nitrogen uptake of the plants, which allocated more carbon to rhizobia under nitrogen demand, but more carbon to the fungal partner when nitrogen was available [25]. The changes in carbon allocation were accompanied by changes in the expression of sucrose transporters, providing insights into how the host plant controls carbon allocation to different root symbionts to maximize its symbiotic benefits. A study on the effects of arbuscular mycorrhiza on plant growth and gene expression was illustrated. Twenty (20) geographically diverse *M. truncatula* accessions inoculated with the AMF *Funneliformis mosseae*, a diverse range of responses in plant physiology and gene expression, were observed among the accessions [26]. Physiological and genetic responses from the legume-rhizobia symbiotic relationship have opened up possible prospects in controlling pathogens beyond the nitrogen fixation.

Consequently, there is minimal knowledge on the resistance mechanisms against soil-borne pathogens in grain legumes, providing evidence for genetic variation of rhizosphere-related traits. The role played by root exudation in microbes-mediated disease resistance is considered together with how such characters can be introduced into legumes breeding programs [27]. There is a strong need to adopt the collection, characterization, and domestication of closely related wild lines of *M. truncatula* or other possible cultivars that serve the same functions, to be holobiont in future breeding strategies seeking to improve complex defense mechanisms in leguminous crop plants *via* nodulations as described above.

2.5 Prospects for legume production in Africa

Legumes have culturally played a key role in African agriculture on the basis of the provision of natural fertilization to the soil for small-scale farmers and have also been a cheap source of protein to African consumers. Current data from the Food and Agriculture Organization (FAO) of the United Nations legume crops in Africa were modeled [28]. FAOstat reported in 2020 that about 21,303,488 tonnes of legumes are produced in Africa, a prospect for the future of leguminous crop plants in Africa. The upscale in cultivation, production, and processing of underutilized leguminous crop plants may serve to reduce dependence on oil-producing legumes. This will generate economic opportunities as well as the ecological refurbishment through the development of legumes-based supply chains across different producers, consumers, and regions. However, the consistent production of legumes across Africa will require not only an intensive research and development effort but also the backing of active extension services accompanied by the food chain and marketing assurance and government policy incentives.

The deficient in microelements is among the most common and disturbing global nutritional problems, posing serious health challenges within the African population. Micronutrient deficiencies have increased in recent decades due to a decrease in the quality of the diets, in both developing and developed countries. The problem is further aggravated by widespread poverty, where access to the more expensive but nutrient-rich products are difficult. Meanwhile, supplements are available to easy-to-reach consumer groups at a relatively low cost. This strategy is not sustainable in a long run and it does not build consistency in a population. Moreover, supplementation requires an intricate distribution network as it often escapes the vulnerable groups and the rural poor supplementation strategies that have therefore only achieved modest success, even in African countries that have responsive legislation and processing capacities. Legumes are major sources of dietary protein, particularly in agriculture, a developing sector of the economy. These dietary proteins are significant for nutritional trait improvement in crop breeding programs. Bio-fortified legumes would offer a diversity of micronutrients and amino acids [29], necessary to complement the comprehensive evaluation of the challenges in breeding approaches that are being used for the nutritional enhancements of leguminous crop plants. The potential of the legume microbiome in the agronomic trait improvement is also an important prospect in agricultural research.

3. Conclusion

There is a need to make rich the advance in plant genetic resource *via* the careful handling and management of germplasm to avoid genetic erosion of leguminous plants of economic importance. Underutilized legume species should be characterized, evaluated (morphologically and biochemically), and well cataloged for subsequent use by breeders for genetic gain and advance. Legumes in general are used to revive nutrient-depleted soils, especially for abandoned agricultural and grazing lands. Generally speaking, native legumes are common in these habitats because they are able to survive nitrogen-poor soils than other plants. They also produce secondary compounds such as alkaloids, flavonoids, terpenoids naturally that provide protection against predators. Some of these secondary compounds are being studied for their pharmacological potential. They are found in the leaves and fruiting parts. Owing to the future prospects in legumes there is a strong need to preserve the genetic resource *ex situ* and *in situ*.

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Conflict of interest

The authors declare that they have not known any competing financial interests or personal relationships that could have appeared to influence the work reported in this book.

Acronyms and abbreviations

AON	autoregulation of nodulation
FAO	Food and Agriculture Organization
N_2	nitrogen
AMF	arbuscular mycorrhizal fungi
MtMOT	Medicago truncatula molybdate transporter
LysM	lysin motif
AM	arbuscular mycorrhizal
RL	rhizobium-legume
RLK	receptor-like kinase
Germplasm	it is the lifeline and heart of plant breeding. It is the genetic tool used to preserve the genetic pool of crop species
Symbiotic	it is a close and long-term biological interaction between two different biological plant organisms
Mycorrhiza	it is the role of fungus in the plant's rhizosphere, its root system. The mutual symbiotic association between a fungus and a plant could also be termed mycorrhizae
Rhizobia	they are diazotrophic bacteria that fix nitrogen after becoming established inside the root nodules of legumes (Fabaceae)
Genetic	this arose out of the identification of *genes*, the fundamental units responsible for heredity
Nitrogen	it is essential to life on Earth. It is a component of all proteins, and it can be found in all living systems
Microbiome	it is the genetic material of all the microbes—bacteria, fungi, protozoa, and viruses
Agronomic	it is the science and technology of producing and using plants in agriculture for food, fuel, fiber, recreation, and land restoration
Nodulation	*Nodulation* involves the production of a special organ, the *nodule*, and also what has been called a novel organelle, the symbiosome, consisting of nitrogen-fixing bacteroids enclosed in a primarily host-derived peribacteroid membrane
Trifolium	red clover belongs to the Fabaceae family, is a legume, and has long been provided noteworthy contributions to agricultural and animal production all over the world
Kinases	it is an enzyme that catalyzes the transfer of phosphate groups from high-energy, phosphate-donating molecules to specific substrates
holobiont	it is an assemblage of a host and the many other species living in or around it, which together form a discrete ecological unit, though there is controversy over this discreteness

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References

[1] Popoola J, Ojuederie O, Omonhinmin C, Adegbite A. Neglected and underutilized legume crops: Improvement and future prospects. Recent Advances in Grain Crops Research. 2020. pp. 1-22. DOI: 10.5772/intechopen.87069

[2] Stagnari F, Maggio A, Galieni A, Pisante M. Multiple benefits of legumes for agriculture sustainability: An overview. Chemical and Biological Technologies in Agriculture. 2017;**4**:2

[3] Upadhyaya HD, Dwivedi SL, Sharma S, Lalitha N, Singh S, Varshney RK, et al. L. Enhancement of the use and impact of germplasm in crop improvement. Plant Genetic Resources. 2014;**12**:155-159. DOI: 10.1017/s147926211 4000458

[4] Kuldeep T, Padmavathi GG, Mamtha S, Ravi KP, Reena M and, Gayacharan C. Legume Genetic Resources: Status and opportunities for sustainability. Legume Crops. 2020; 1-12

[5] Bhat R, Karim AA. Exploring the nutritional potential of wild and underutilized legumes. Comprehensive Reviews in Food Science and Food Safety. 2009;**8**:305-331

[6] Kumar S, Sane PV. Legumes of South Asia, A Check-List. Kew: Royal Botanic Gardens; 2003. p. 536

[7] Graham PH, Vance CP. Legumes: Importance and constraints to greater use. Plant Physiology. 2003;**131**(3):872-877

[8] SWPGRFA. Draft second report on the state of world plant genetic resources for food and agriculture: Commission on genetic resources for food and agriculture (CGRFA-12/09/Inf. rRev.1). In: Twelth Regular Session; 19-23 Oct 2009; Rome, Italy

[9] Popoola JO, Adebambo A, Ejoh AS, Agre P, Adegbite AE, Omonhinmin CA. Morphological diversity and cytological studies in some accessions of *Vigna vexillata* (L.) A. Richard. Annual Research and Review in Biology. 2017;**19**(5):1-12

[10] Ojuederie OB, Balogun MO, Fawole I, Igwe DO, Olowolafe MO. Assessment of the genetic diversity of African yam bean (Sphenostylis stenocarpa Hochst ex. A Rich. Harms) accessions using amplified fragment length polymorphism (AFLP) markers. African Journal of Biotechnology. 2014;**13**(18):1850-1858

[11] Mayes S, Massawe FJ, Alderson PG, Roberts JA, Azam-Ali SN, Hermann M. The potential for underutilized crops to improve security of food production. Journal of Experimental Botany. 2011;**63**:1075-1079. DOI: 10.1093/jxb/err396

[12] Bellucci E, Bitocchi E, Rau D, Rodriguez M, Biagetti E, Giardini A, et al. Genomics of origin, domestication and evolution of *Phaseolus vulgaris*. In: Genomics of Plant Genetic Resources. Dordrecht, The Netherlands: Springer; 2014. pp. 483-507

[13] Gepts P, Papa R. Evolution during domestication. eLS. 2002. pp. 1-7. DOI: 10.1038/npg.els.0003071

[14] Fuller DQ, Denham T, Arroyo-Kalin M, Lucas L, Stevens CJ, Qin L, et al. Convergent evolution and parallelism in plant domestication revealed by an expanding archaeological record. Proceedings of the National Academy of Sciences of the United States of America. 2014;**111**:6147-6152. DOI: 10.1073/pnas.1308937110

[15] Abbo S, Van-Oss RP, Gopher A, Saranga Y, Ofner I, Peleg Z. Plant domestication versus crop evolution:

A conceptual framework for cereals and grain legumes. Trends in Plant Science. 2014;**19**:351-360. DOI: 10.1016/j.tplants.2013.12.002

[16] Fuller DQ. Contrasting patterns in crop domestication and domestication rates: Recent archaeobotanical insights from the old world. Annals of Botany. 2007;**100**:903-924. DOI: 10.1093/aob/mcm048

[17] Kluyver TA, Charles M, Jones G, Rees M, Osborne CP. Did greater burial depth increase the seed size of domesticated legumes? Journal of Experimental Botany. 2013;**64**: 4101-4108. DOI: 10.1093/jxb/ert304

[18] Abbo S, Lev-Yadun S, Gopher A. The "human mind" as a common denominator in plant domestication. Journey of Experimental Botany. 2014;**65**:1917-1920. DOI: 10.1093/jxb/eru068

[19] Zeder MA. The origins of agriculture in the Near East. Current Anthropology. 2011;**52**:S221-S235. DOI: 10.1086/659307

[20] Larson G, Piperno DR, Allaby RG, Purugganan MD, Andersson L, Arroyo-Kalin M, et al. Current perspectives and the future of domestication studies. Proceedings of the National Academy of Sciences of the United States of America. 2014;**111**:6139-6146. DOI: 10.1073/pnas.1323964111

[21] Meyer RS, DuVal AE, Jensen HR. Patterns and processes in crop domestication: An historical review and quantitative analysis of 203 global food crops. The New Phytologist. 2012;**196**:29-48. DOI: 10.1111/j.1469-8137.2012.04253.x

[22] Gil-Diez P, Tejada-Jiménez M, León-Mediavilla J, Wen J, Mysore KS, Imperial J. MtMOT1 is responsible for molybdate supply to Medicago truncatula nodules. Plant Cell Environment. 2018;**41**:310-320

[23] Ferguson BJ, Mens C, Hastwell AH, Zhang M, Su H, Jones CH, et al. Legume nodulation: The host controls the party. Plant, Cell and Environment. 2018;**42**:41-51

[24] Hastwell AH, Corcilius L, Williams JT, Gresshoff PM, Payne RJ, Ferguson BJ. Triarabinosylation is required for nodulation-suppressive CLE peptides to systemically inhibit nodulation in *Pisum sativum*. Plant Cell and Environment. 2018;**42**:188-197

[25] Kafle A, Garcia K, Wang W, Pfeffer PE, Strahan GE, Bucking H. Nutrient demand and fungal access to resources control the carbon allocation to the symbiotic partners in tripartite interactions in *Medicago truncatula*. Plant, Cell and Environment. 2018;**42**:270-284

[26] Watts-Wlliams SJ, Cavagnaro TR, Tyerman SD. Variable effects of arbuscular mycorrhizal fungal inoculation on physiological and molecular measures of root and stomatal conductance of diverse *Medicago truncatula* accessions. Plant, Cell and Environment. 2018;**42**: 285-294

[27] Wille L, Messmer MM, Studer B, Hohmann P. Insights to plant-microbe interaction provides opportunities to improve resistance breeding against root diseases in grain legumes. Plant, Cell and Environment. 2018;**42**:20-40

[28] Foyer CH, Nguyen HT, Lam HM. A seed change in our understanding of legume biology from genomics to the efficient cooperation between nodulation and arbuscular mycorrhizal fungi. Plant, Cell and Environment. 2018;**4**:1949-1954

[29] Rehman HM, Cooper JW, Lam HM, Yang S. Legume biofortification is an underexploited strategy for combatting hidden hunger. Plant, Cell and Environment. 2018;**42**:52-70