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EDITORIAL

Omics of neglected and underutilized crop species: one small step for NUCS, one giant leap for addressing global hunger

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Shrinking diversity in food and its effect on marginal crops

Evolution, domestication, and breeding have given the global population a rich spread of plant-based foods that still continues to feed the human race. However, due to preferential factors and related issues, the count of consumed crops has been narrowed down and are called staple crops. Consequently, the current world predominantly relies on rice, wheat, and maize for their food. These three crops were projected to cater to more than 50% of the world's population, while another twelve crops altogether with five animal species cater to the food requirements of more than 75% of the population. This shrinkage has resulted in focussed research on the improvement of these mainstream crops, whereas the remaining species have remained neglected and underutilized. The crops cultivated and consumed by marginal communities and those that have not received much research attention are called neglected and underutilized crop species' (NUCS). These NUCS can strengthen food security, alleviate poverty and increase the resilience and sustainability of farming systems [1]. The notable characteristics of NUCS are; (i) they are adapted to marginal environments and can thrive under low-input, and stressful growing conditions that limit agricultural productivity around the world and will become more prevalent with climate change, (ii) NUCS are highly nutritious, such that they can contribute to healthier diets worldwide and particularly for the rural poor, (iii) owing to their potential, they can produce novel consumer products to generate income for smallholder farmers and their communities, and (iv) NUCS are typically embedded within local cultural traditions, and their increased use could strengthen local identities and contribute to empowering marginalized communities. Owing to the potential of NUCS we can say "one small step for NUCs, one giant leap for addressing global hunger". Realizing it to be the high time, in this article, we have discussed NUCS and their research progress to bring these crops into mainstream research and innovation.

Role of omics in NUCS research

The term 'omics' emphasizes the word 'all' or 'whole'. When it is added as a suffix to the cellular molecules like gene, protein, transcript, ion, metabolite, etc., it becomes genome, proteome, transcriptome, ionome, metabolome, respectively. The omics-based approach would provide a more comprehensive understanding of the cellular process than the analysis of individual biomolecules. The term multi-omics approach refers to the harmonious analysis of all these omics together using bioinformatics approach to explore the complex biological trait. To date, no such integrated approach has been employed to the millets or other NUCS; however, the recent advancements of NGS technologies, phenotyping platforms, and computational biological skills are drawing researchers' attention for their collegial application. For the first time in India, we organized the national conference on 'Neglected and Underutilized Crop Species for Food, Nutrition, Energy and Environment' on August 2, 2019, at NIPGR, New Delhi, to bring together the researchers working on neglected but essential crop species. The conference was supported by all the National Science Agencies, including SERB, DBT, ICAR and CSIR, highlighting the commitment of these organizations in mainstreaming the biodiversity and revisiting the under-studied crops. The entire scientific programme was grouped into three technical sessions: (1) Genetics and genomics of orphan crops, (2) Underutilized millets for food and nutritional security and (3) Tapping the biodiversity for sustainable agriculture; a rapid oral presentation session for the young researcher;

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poster session, panel discussion and finally a session for the Networking and industry interaction. This conference's outstanding accomplishment was a common consensus amongst the scientific community to accelerate the application of multi-omics for these less-studied crops and exploit their potential to address the food and nutrition security. The conference also provided an interdisciplinary platform for researchers, industry members, and educators to present and discuss the most recent innovations, trends, concerns, practical challenges encountered, and solutions adopted while working on orphan crop species. Despite their low profile, NUCS has gained enough limelight among researchers and now, are being studied extensively.

Research in NUCS is seeing a dawn irrespective of less funding

In this special issue, a total of eight research articles and three reviews covering medicinal to food crops, genetic variability to genomic improvement, and mechanism exploring abiotic stress tolerance are included. India is the host for a large number of indigenous species with immense nutritional and therapeutic values; the genetic and chemotypic portrayal of such species would enhance their conservation and expedient utilization. The *de novo* transcriptome analysis of unexplored, environmental stress-tolerant genotypes would definitely reveal a large number of unique stress-responsive genes that might be employed in further crop improvement [2]. To overcome the limitation of cross-genera gene transferability and targeted genome manipulation, genetic transformation methods are continuously expanding for trait enhancement in economically significant plant species and NUCS. A gist of a few major studies has been discussed here. In a study, different genotypes of common bean (*Phaseolus vulgaris* L.) are analyzed using SSR markers to depict their molecular characterization and possible origin [3]. In another study, forty cultivars of Indian *Amaranthus hypochondriacus* were screened for their relative susceptibility to ozone stress [4]. Variability exists between the cultivars of *Amaranthus hypochondriacus* towards ozone response, and the identified tolerant genotypes may be recommended for cultivation in elevated ozone regions. Jayaramachandran et al. [5] have demonstrated the application of mutation breeding for genetic improvement of sesame (*Sesamum indicum* L.). Interestingly, they found that the application of a lower sodium azide concentration as a potential mutagen would be beneficial for the sesame crop. Laishram et al. performed a comparative assessment of biolistic- and *Agrobacterium*-mediated genetic transformation methods that suggested the particle bombardment works more efficiently for *Cenchrus ciliaris* than the *Agrobacterium*-mediated system [6]. They also suggested that, in buffelgrass cv. IGFRI-3108, the use of immature inflorescences derived embryogenic calli as an explant would serve best for genetic transformation. On the other hand, Ahlawat et al. [7] have used shoot tip for in vitro micropropagation of an underutilized medicinal shrub, *Capparis decidua,* through standardizing the type and concentration of plant growth regulators, polyamine, and anti-oxidants. Further, Shah et al. [8] have explained the role of selenium (Se) in combating salt stress in *Setaria italica* L. and *Panicum miliaceum* L. through triggering the anti-oxidative defense system. RNA-sequencing is also being extensively used nowadays for comparative assessment of contrasting cultivars. For instance, comparative assessment of RNA- seq data of contrasting cultivars of pearl millet (*Pennisetum glaucum* L.) identified a large number of differentially regulated genes under terminal drought stress [9]. The above mentioned are only a few of the studies but there are multiple ongoing researches on NUCS that would provide a useful genomic resource and valuable information for crop improvement in the offing.

The special issue provides comprehensive information on NUCS

The present issue encompasses three review articles presenting an overview of omics approaches for the genetic and nutritional quality improvement in millets and pigeonpea. The advances in phenotyping and genotyping technologies have prompted the utilization of varied germplasms of small millets for genetic resource development, molecular breeding programme, and biotechnology-aided crop improvement [10]. Besides, Vetriventhan et al. have also discussed the current status of global small millet production, germplasm resources, available trait-specific genomic resources, their breeding strategies for further improvement. They have also advocated the promotion of small millets for global nutritional accomplishment [11]. For example, pigeonpea is a climate-resilient legume crop, serving as a source of high protein supplements for more than a billion people throughout the globe. Its productivity, seed quality, and nutritional traits could be further enhanced to overcome the existing malnutrition problems in developing countries [2]. Hence, in one of the studies, Khound and Santra [12] have emphasized the application of 'omics' in proso millet genetic improvement. A large proportion of nucleic acid-based resources are available in proso millet than the proteome or metabolome. They suggested that the dimensions be extended beyond the genomics and transcriptomics to phenomics, proteomics, and metabolomics for unlocking their genomic complexity.

Multi-omics, therefore, can be an integrated tool to decipher the correlation between the genotype and phenotype, and also help bring these traditional NUCS crops among the new trendy crops [13].

NUCS research and the way forward

These information have reinstated the need for research in the areas of increasing grain weight and numbers, developing climate-resilient traits, improving nutritional qualities of crops, and lessening their dependence on synthetic fertilizers. In the 2000s, when our lab initiated working on foxtail millet, the forgotten was reminisced and explored. With time, it has gradually become a model plant to study C_4 photosynthesis, abiotic stress tolerance, and bioenergy traits. Our progressive research efforts have significantly contributed to the structural and functional genomics of this crop. Eventually, from being an orphan crop, foxtail millet has developed into a model crop rich in genetic and genomic resources. A similar approach needs to be extended to other millets as well as economically significant though less-studied crops. These crops hold the potential to address global concerns such as increasing hunger index, crop failure due to climate change, and promotion of biofuel consumption [14]. Global warming due to climate change and food insecurity amidst the global pandemic have proved the need for NUCS. Mission-mode challenge programs on problems relevant to the Nations are the need of the hour, be it on health, agriculture or environment. Thus, working on food, nutrition, energy, and environment must require a synergistic involvement of multidisciplinary approaches. Multi-omics tools, hence, could be utilized to venture out the neoteric horizons of NUCS' potential that would lead towards a hunger-free world.

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