doi: 10.1038/nindia.2015.121

Plant proteomics: A potential approach for food security

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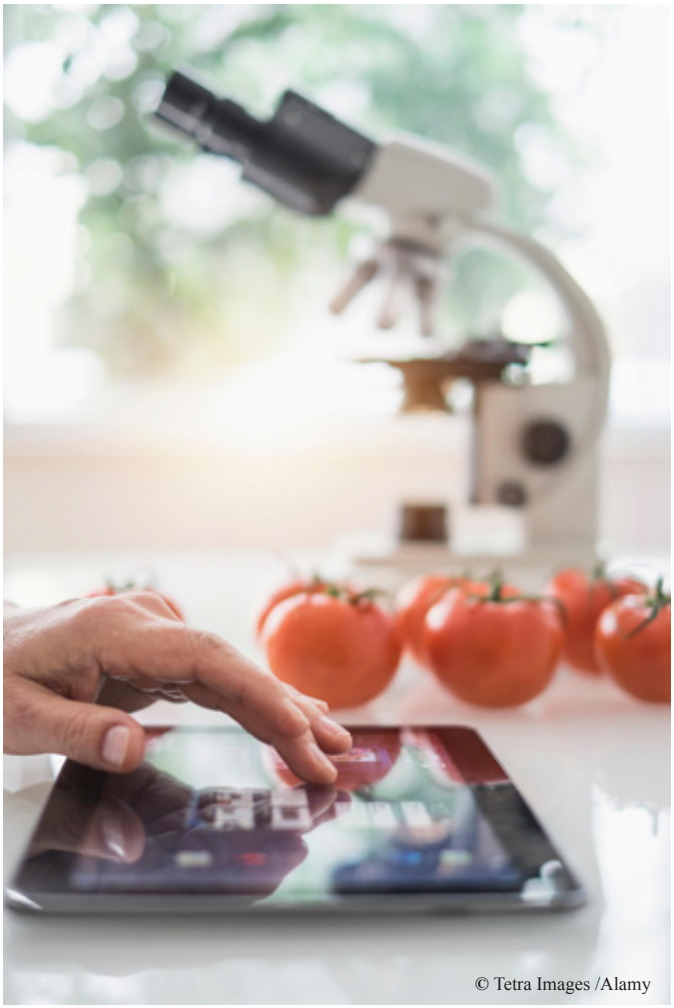

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Genome sizes are increasing but gene numbers are not going up proportionately. This interesting nugget highlights the fact that higher organisms, including plants, might be engaging in combinatorial interactions between genes and gene-products, the proteins, to achieve cellular complexity.

Living cells are exceptionally complex and may consist of more than 100,000 protein species at any given time with different physical and functional properties. The bridge between proteome and phenome is at the core of biological processes. Proteomics involves the determination of the proteome using large scale protein identification and elucidation of their function. Proteins are required not only in metabolic activities in cell, but also play a key role in integration of internal and external signals. They are subjected to a constant turnover maintaining cellular homeostasis, an essential feature of their regulation[1]. The misregulation of protein expression causes an imbalance in cell milieu, which eventually affects plant growth and development, and reduces crop yield.

Plants contribute to economic sustainability and security, being the source of food, feed, fiber, and fuel. India possesses substantial plant biodiversity. The country's agriculture contributes 8% of the world's agricultural gross domestic product and supports 18% of global population. Nevertheless, about 80% of India's land mass is highly vulnerable to external threats[2]. Therefore, conservation of biodiversity, acceleration of plant productivity and nutritional security are of paramount importance.

Designer crops

Currently plant breeders and plant biologists are focusing on the development of designer crops that are better equipped to withstand a wider range of climatic variability and have better nutrient availability. Conventional breeding approaches are handicapped because breeders require precise gene modifications with targeted traits. In the post-genomic era, the integration of proteomics into plant science will help accelerate the development of new generation of food crops.

Despite having scientific infrastructure and potential, India was not a part of the international human genome sequencing project. The country got involved in genome sequencing in June 2000 with the International Rice Genome Sequencing Project (IRGSP), and chose to sequence a part of chromosome 11. Since then plant

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genomics research in India has continued to advance. In contrast, plant proteomics has taken a back seat although it is not just complementary to the genomic information generated by genome research, but also indispensable to the country's science.

Until now, plant proteomic researchers were studying complex biological processes, defining localisation of protein species, and elucidating modification and functionality of protein complexes. Many plant proteomics laboratories in India are using high resolution mass spectrometers for systematic analysis of proteomes at the cell, tissue, and organ or organism level. The proteomics community in India has mostly followed a gel-based approach in combination with different versions of mass spectrometers. Stress proteomics is the most investigated area followed by the study of growth and development and post-translational modifications[3, 4]. It is the need of the hour to adopt and include newer gel-free, label-free approaches, advance imaging systems, high-end mass spectrometer instrumentation, data mining through multivariant analysis, proteogenomics and improvised and corrected databases for faster and accurate analysis.

Targeted proteomics

'Targeted proteomics' must be adopted to validate potentially important biomarkers for plant research using multiple reaction monitoring (MRM), selected reaction monitoring (SRM) or parallel reaction monitoring (PRM). The proteomics community should aim to provide sets of peptide markers, which are unique spatially, or temporally to give a snapshot of spatio-temporal differential proteome. Extensive genome annotations along with new genome sequence information would help tailor diverse marker peptides for broader applicability. Additionally, nano-proteomics, in combination with micro-dissection and single cell system analysis could distil the information tremendously and provide novel insights.

A systems biology approach, where integration of proteomics with genomics and phenomics would enhance the quality and meaning of the derived biological information, needs to be taken. During the past decades, an array of protein chemistry techniques have generated huge amounts of knowledge on the function and molecular properties of individual proteins. However, proteins rarely act alone, they often team up, and function as complex molecular machines. We now understand that the plant proteome is not only a static linear set of proteins, but exist as a dynamic web of informational interactions that sustain the developmental process and allow its evolutionary modification.

Recent developments in gathering large scale proteomic information pose substantial challenges to bioinformatic processing of this data[5]. The most challenging tasks of proteomics research range from sample preparation, separation of proteome complex and database processing to functional interpretation of biological significance. Therefore, inclusion of 'interaction proteomics' would help overcome such challenges, which will eventually generate new knowledge. Development of methods to systematically study protein complexes and their functional annotation opens up new avenues of plant research[6]. It is very likely that such studies will unravel new principles of how metabolic activities operate in plants, which might facilitate crop improvement.

Moulding policy

To stake India's claim to leadership in plant research, scientists and policy makers must set a goal over the next 10 years by combining traditional know-how and new proteomic technology strengths,

focusing attention on sustainable food and nutrition security. It is obvious that no single entity can effectively achieve such a goal without the active participation of academia, industry, and funding agencies. Since the birth of plant proteomics research in India[4], the country has been positioned to convene the parties and facilitate the strategies and activities crucial for the success of such endeavours.

The challenge ahead is to develop methods that would allow the generation of new testable hypothesis based on pre-existing biological information. The approach of gene discovery through proteomics is currently proving to be an effective way to speed up crop improvement programmes worldwide. India must harness the fruits of proteomics technology in collaboration with the international community, just the way the genomics research community has done. In a not too distant future, proteomics researchers might find proteomic blueprints of most crop species. This may provide plant breeders the resource to provide food security to the growing population in India and the world as a whole.

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