Tailor Made Rice Varieties for a Food Secure Future

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Rice an important staple food and the major constraints of its production:

Rice, a member of the grass family, is an important cereal and is consumed by more than 3.2 billion people worldwide as a staple food. About 90% of the world's total rice production and consumption happens in Asia. Among the Asian countries, India ranks second after China in rice production and are responsible for producing 20% of the total rice produce worldwide. In India, rice is cultivated both in Rabi (grown in winter) and Kharif (grown in summer) crop seasons and about 44 million hectares of land is utilized for this purpose. The major rice producing states in India are West Bengal, Uttar Pradesh, and Andhra Pradesh, among others.

Rice is an excellent source of carbohydrates and energy with about 23% calories. It is also rich in nutrients, vitamins, fibres, and minerals. Being diverse in its way of cultivation and usage, rice has become the most cultivable crop for all lower or lower-middle income countries.

However, the main constraint to rice cultivation lies in the fact that it requires about 35-43% of the world's total irrigation. Continuous changes in the climatic conditions, increase in population and lack of sufficient irrigation have all led to multiple global hazards. Such effects of non-living factors on living organisms like crops are known as abiotic stress conditions and 'drought' is one of them. Drought refers to the prolonged condition of dryness due to the lack/absence of rain or irrigational facilities. It has also now become a threat for rice growth, yield, and development leading to reduced productivity.

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* Ms. Mouboni Dutta, Ph.D. Scholar from University of Hyderabad, Hyderabad, is pursuing her research on "Characterization of Genes Identified through Activation Tagging in Oryza Sativa Ssp. India Cv. Samba Mahsuri for Abiotic Stress Tolerance." Her popular science story entitled "Tailor-Made Rice Varieties for a Food Secure Future" has been selected for AWSAR Award.

Reasons behind improving rice varieties:

World population is increasing continuously and is expected to reach 9.1 billion by 2050. This huge population inflation will also lead to more urbanization, adding up to the already existing food crises. Such burgeoning global population demands the rice productivity to be increased by 26% in the next 25 years. Thus, to meet up with the upcoming demand and population inflation, rice production must grow at a parallel pace, if not faster. More production will require more land, better irrigation facilities, and additional manpower which areall not feasible due to constant urbanization. Thus, rice research is the key to device improved qualities of rice which can withstand adverse climatic conditions without jeopardizing its productivity.

Genes and their manipulation to generate better quality rice:

All living organismsare made up of cells, the basic structural units of life. Each cell has a highly coiled thread-like structure called DNA (deoxyribonucleic acid) which, together with proteins form the chromosome. These chromosomes have multiple genetic information coded in the form of 'genes. Each chromosome consists of many genes, and each gene has the information to synthesize a specific protein responsible for a specific function related to the growth and development of the organism. The process by which the encoded information of the gene is used to synthesize the protein is known as 'gene expression'.

Recent developments in the techniques used in rice research have led to the provision of influencing the gene expression by introducing some beneficial DNA elements in the chromosome. These DNA elements can either increase or decrease the rate of formation of proteins, i.e. the gene expression in an organism. Thus, for example, if we have the prior knowledge of the gene and its role in imparting drought tolerance, we can increase the expression of that particular gene and develop a better quality of rice that is of more agronomic importance.

Rice Research at University of Hyderabad: Finding new tools to increase rice production with minimal resources

Effects of drought are widespread and damaging. In an Indian state, drought can cause a yield loss of about 40% which amounts to roughly $800 million. Thus, Department of Biotechnology (DBT), under the Government of India collaborated with Prof PB Kirti of University of Hyderabad and other eminent scientists all over India in 2010 to address this issue. The project aimed at identifying important genes which can be manipulated to generate improved rice varieties.

The research group used a unique method known as 'activation tagging' for identifying the uncharacterized genes in *indica* rice variety BPT 5204 (Samba Mahsuri). Activation tagging involves the introduction of some DNA elements randomly in the rice chromosome which results in increased expression of nearby genes present at the region of integration of the DNA elements, thereby 'tagging' them. Such modified plants were then grown under water-limited conditions to observe their growth and development. Those plants which showed better yield and tolerance

towards stress were studied further using various techniques to identify the tagged genes. The project continued for five years and finally, the research team successfully identified some of the important genes which might be responsible for combating abiotic stress conditions.Their manipulation can lead to the development of tailor-made rice varieties having important agronomical characters.

Rice 'helicase' was one of the genes that got tagged during the previous work from our group. Presently, we are interested in studying the detailed mechanism of rice helicases in drought tolerance. DNA has a double helical structure, i.e., it has two intertwined threads, which needs to be opened up during various functions of the cell. Helicases are the proteins which are involved in the opening of the DNA double helix so that the coded information present in the DNA can be accessed. Till now, helicases were not reported to have any role in imparting drought tolerance but, our previous findings indicated that these genes might be responsible for stress tolerance since they were identified when plants were subjected to water-limited conditions.

Our aim now is to validate this hypothesis by studying in details the underlying roles and mechanisms of the helicases in drought tolerance. For our study, we have generated customized rice plants and are investigating them under stress conditions. Preliminary results show that these plants have better root growth as compared to the normal plants (plants that were not modified) which is an important criterion for drought tolerance. The yield-related traits are yet to be analyzed.

Socio-economic importance of the research conducted:

Agriculture supports 58% of the world population. In the developing countries, close to 75% of the population resides in rural areas and earn their livelihood from agriculture. According to the global reports on food crises (2018) by Food and Agriculture Organization (FAO) in 2017 alone, about 124 million people across the world faced severe food crises. Hazards like drought reduce the crop production by 50%, thus leading to price hike, food insecurity, and malnutrition. According to FAO, food insecurity is defined as 'a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life'.

For many years, scientists have been trying to scale up the production of food grains including rice by using various measures. Although there has been some increase in the production, still it is not sufficient to eradicate food insecurity all over the world. Also, as mentioned earlier, the surge in population imposes a unique challenge wherein agricultural production must be increased to meet the rise in demand for food and other industrial uses. Thus, farmers need new tools and techniques that produce crops with sustained or increased productivity under limited resource conditions. The research work discussed in this article finds a way to identify and characterize the genes whose potential in combating abiotic stress conditions have gone undetected till now. Utilizing these newly characterized genes and creating tailor-made rice varieties will definitely help in mitigating the yield loss due to environmental factors and encourage more exports at a cheaper rate. Cost reduction wouldenable the poor to improve their nutritional and financial status.