EDITORIAL

COLUMN

Revisiting the Role of Physiology and Biochemistry in Salt Tolerant Genotype Development

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Salinization is one of the major abiotic stress problems of present day agriculture and perhaps is going to be the biggest problem in the future agrarian system. Most of the land plants, except halophytes cannot withstand saline conditions beyond 100 mμ salt concentration. The crop plants are more susceptible and exhibits productivity loss beyond 50 mμ salt concentration and succumb completely in the range of 100-300 mμ salt concentration. Presently, about 6% of world's land is affected by either salinity or sodicity, which when judged as proportion of irrigated cultivated land, (most productive soil) about 20% area is affected by salinity. It has been estimated that every three minute, we are losing 1 ha of arable land due to salinity.

Salinization of soil takes place naturally or by human intervention. A soil may turn to be saline over a long period due to release of salt (chlorides or carbonates of sodium, calcium, magnesium, etc.) from parent materials present in soil. Soils near to oceans may also become saline through continuous accumulation of salts through groundwater or moistures present in wind. However, these are natural salinity events which require many years to convert neutral soils to saline or sodic soils. The most detrimental salinization effect is imparted by human population through agriculture. Several events like irrigation water containing higher salt components, poor drainage system, clearing of native vegetation to cultivate annual crops and application of chemical fertilizers are responsible for human mediated salinity induction. Interestingly, while only 3% of rain-fed cultivated land is affected by salinity, about 20% of irrigated cultivated land suffers from salinization, which clearly demonstrates the curse of modern input intensive and excess input agriculture systems. This has tremendous impact on plant nutrition availability, growth photosynthesis and ultimately crop yield.

Soil salinization is a predominantly one way process, because recovering soil from saline condition requires tremendous efforts. Soil management systems to reduce salinity are long term practices, which are often difficult to practice in large scale in farmer's field due to low return. The farmers have to sacrifice their produce or even cultivation for a few years to recover the soil, which affects their income and survival. Thus they primarily target to get more productivity by adding more inputs which further degrades the soil. A policy decision is thus required to frame strategies for recovering such soils, so that the income loss is minimized during the recovery period and incentives in appropriate forms might be provided to these farmers to make up the losses.

Cultivation of salt tolerant crop genotypes is the most successful strategy for sustaining productivity. In the soil recovery strategies, the tolerant crop species and cultivars would play a crucial role, since their productivity would be higher than the susceptible genotypes during the soil recovery phase. For example, wheat is comparatively more salt tolerant than rice, so wheat should be considered as a part of the cropping system in the salt affected lands during recovery strategy formulation. Increasing salt tolerance in cultivated genotypes has thus been a principal target for improving crop productivity in salt affected areas. Breeding for salt tolerance is a priority in almost all crops, although only in a few crops like rice, researchers have been able to develop salt tolerant genotypes. In most crops, high yielding salt tolerant genotypes are not available.

Plant breeding efforts to develop salt tolerant varieties have been limited due to a number of reasons – i) unavailability of suitable salt tolerant genotypes, ii) difficulty in large scale phenotyping for salt tolerance creating natural soil conditions, iii) unavailability of quick and reliable screening methods for identifying salt tolerant genotypes, and most importantly iv) poor coordination in combining plant physiology, biochemistry and breeding knowledge.

Understanding physiology and biochemistry of salt movement in plat is essential for devising selection strategies. Salt uptake in crop plants is regulated in various ways; however, the basic idea is to lower the salt concentration in the cell so that the cellular growth and activities are less affected, because higher Na^+ concentration reduces enzymatic activities. Root is the primary barrier to prevent salt uptake and are affected most under saline conditions. Under high salt concentration, plant roots are most affected, since the saline water having high Na+ concentration is taken up by the plant through root cells. Understanding root physiology and biochemistry and inheritance of these characters are thus very important for selecting superior genotypes under saline conditions. Thus the constitution of root plasma membrane, the driving forces for influx of Na^+ in root cells, and methods used by plant to efflux this Na^+ to reduce Na^+ toxicity in root cells are highly important for uptake of mineral nutrients. The ratio of salt to plant solute is very important for survival of plant under saline condition. High relative growth rate of stem and leaves is a standard criterion for selection for salt tolerance, as this would lower down the Na^+ ion concentration in the solute. A second strategy is the exclusion of cellular Na^+ and compartmentalization of the salt in vacuole. This reduces salt concentration in cytoplasm and improves enzyme performance.

The most common screening methods for salt tolerance studies either involve field screening of several (often hundreds) genotypes in saline soils (or by creating artificial saline conditions using salt water) for productivity. Only a few large scale screening studies resort to study of plant characters such as root growth, root physiology, photosynthetic activities or other physio-biochemical parameters. However, most of the physiological and biochemical studies related to salt stress tend to decipher the basic mechanisms at cellular or molecular level on few genotypes. While scientific merit of these studies is invaluable and useful in manipulating the plant at genome level, they are unsuitable for large scale phenotyping. The gap between our basic understanding on salt tolerance and applying this knowledge in large scale phenotyping is very wide and gets little attraction from researchers involved in plant physiology or biochemistry. Although such methods have large scale immediate impact on breeding programmes, and have no less scientific merit than a basic study which identifies role of plasma membrane in salt tolerance, the acceptability of the basic information in high impact journals is much more than the applied component. In present day, scientific career and fame of a physiologist, biochemist or a plant breeder largely depends on his publications in high impact journals rather than devising a simple and useful method for screening large scale genotypes or to develop a good tolerant variety. However, the social contributions and impacts of the later information are obviously higher. Not comparing the basic versus applied research, the area of devising useful strategies for large scale phenotyping of abiotic stress tolerance is still largely a grey area with less importance. However, in the recent days importance of accurate phenotyping is being gradually recognized in the major plant breeding programmes related to stress tolerance.

The experiences with complex behaviour of plants under stress shows that genome and transcriptome study are not sufficient to find all the answers related to stress tolerance. Characterization of metabolome and phenome are equally important. For example, metabolic profiling and its relation to ion pool are being suggested as screening strategies for salt tolerant genotype identification in breeding programmes. Thus more intervention of plant biochemist and physiologist are required to develop crop and salt environment specific screening strategies, without which the breeders would face much more hindrance in developing salt tolerant genotypes.