EDITORIAL COLUMN

Root Responses are Indicators for Salinity and Drought Stress in Crops

Ratikanta Maiti*

[2]Vibha Seeds, Inspire, Plot#21, Sector 1, Huda Techno Enclave, High Tech City Road, Madhapur, Hyderabad, Andhra Pradesh (500 081), India
Formerly: Universidad de las Américas; Departamento de Química y Biología; Santa Catarina Martir, C.P., Puebla (72820), México

Correspondence to

**E-mail*: ratikanta.maiti@gmail.com

Degradation of cultivable lands to saline and drought prone conditions and reduced availability of water for agriculture are the two most severeproblems for modern agriculture. Development of salinity stress and drought stress tolerant crop genotypes is going to be the most daunting task for the plant breeders in the coming decades. To add to the misery of plant breeders, few effective selection indices are available that can help them to accurately identify the tolerant genotype under field conditions.

It is well established that plant root system is substantially affected from both these two stresses.Root system plays an important role throughout plant life cycle. Growth of the plant depends on root system because plant absorbs all the nutrients and water through root system from soil. Salinity and drought are major problem for sustainable agriculture. These two are major abiotic stresses that cause reduction in plant growth and yield loss. *Drought and salinity stress have direct impact on root system of the plant.* Water uptake is crucial during key stages like reproduction and grain filling, and small differences in water uptake at these stages could lead to large yield differences.*These stress factors reduce crop productivity y and quality. Salinity effects the root growth directly whereas drought has an indirect effect on root system.*

The quality of the irrigation water plays crucial role especially in arid zones affected by high evaporation rates and accumulation of salt on the soil surface. A high salt concentration present in the water and soil affect adversely the crop yield, degrade the land and pollute the ground water. The problem of soil salinity is increasing further for the use of poor saline water for irrigation and poor drainage. Several researchers worked on effects of salinity on growth and productivity of various crops. Salinity affects crop production in rice growing areas worldwide. Salt concentration causes osmotic effect, resulting in delay of water penetration into cells and dehydration of protoplasm thereby inhibiting enzyme activities, suppressing respiration, slowing the phosphorylation process, resulting inpoor seed germination and seedling growth. Salt stress affects the growth of a crop at different stages. Salinity affects germination and seedling growth in rice which might be due to osmotic stress.

The root growth response of 10-days-old seedlings of maize accessions under different concentrations suggesting the scope for enhancing salt tolerance in maize through selection and breeding on the basis of root length. Processes conferring salinity tolerance have been extensively reviewed by several workers. The role of roots in salinity tolerance is rarely documented. Recently it has been reported that increasing salinity concentration increased root length and root number as functions of osmotic adjustment in cotton, maize, rice and pearl millet.

Drought severely effects the vegetative growth and reduces the yield loss in all the field and vegetable crops. These stress factors have great impact on root system of the plant. Root system plays important role in adaptations to salinity and drought stress. Sorghum and pearl millet are adopted for growing in drought conditions and they show negligible amount of yield loss compared with maize. Maizerequires adequate water in all stages of its physiological development to attain optimum productivity. Several desert plants (cactus etc.) have deep root system. High genetic variability in maize cultivars (*Zea mays*) for resistance to drought and salinity at the seedling stage and diverse genotypes has been selected for resistance to drought and salinity stresses. Several workers made root hypothesis for drought resistance by observing different crops. In our study, genotypic variability in salt tolerance was observed in monocots such as in maize, rice and pearl millet and salt tolerant genotypes showed higher number of lateral roots with increasing salinity concentration function as osmotic adjustment.Salt tolerant dicots like cotton, sunflower, okra showed increased root length with increasing salinity concentration associated with profuse lateral roots in the upper soil profiles which function as osmotic adjustment. Therefore, it is assumed that greater root elongation could be considered as indicator of salt tolerance in dicots and greater number of lateral roots in monocots.

In cotton, sunflower, castor and okra,faster rate of root growth, deep robust root system with inclined roots are found to be drought resistant. In dicots very long tap root with inclined lateral roots are required for absorbing the available water in deeper layers of the soil under water stress.

Few studies have been undertaken on the role of biotechnology in root growth.The efficiency of the root system for absorption of water in high osmotic potential conditions should be increased which is an important character in the aspect of root system of drought resistant plants. Despite the importance given to roots in the drought scenario, few teams have undertaken breeding for root traits. Even if root QTL have been identified in certain crops such as rice, no products have appeared. There is also some doubt on the contribution of root QTL to drought tolerance in rice. In maize, where the root pulling force is well related to root length density, Bolanos and colleagues have found a negative correlation between root pulling force and grain yield under drought conditions. In fact, no relation was found between the *Root-ABA1* QTL on maize bin 2.04, and grain yield.Very limited efforts to breed for root traits have been undertaken, mostly because of the difficulties involved, the incomplete knowledge of the key parameters in the rooting characteristics that contribute to drought tolerance, and a lack of the knowledge of the range of variations available for root traits that can be used for breeding.

Research has been directed to study the root growth by several workers but few significantresearch finding have been reported. Much has been reported on the potential of roots to improve crop yield and resilience under drought. However, most studies on roots have used time consuming methods to assess rooting differences, limiting their use in breeding, and providing “static” data about roots that did not help resolve the exact role of roots.

As mentioned earlier it is observed that plants adapted to saline conditions have the root system consisting of more number of profuse, long lateral roots for osmotic adjustment and deep tap root for absorbing low concentrated soil water from lower layers of the soil as the upper layers are rich with salts (high osmotic potential of soil water due to dissolved salts).

Salinity causes physiological drought condition in plant root atmosphere (rhizosphere) by increasing osmotic potential of the soil water. Therefore the effect of Salinity and drought has common adverse effects on plants in the aspect of physiology i.e., water uptake. Research findings noted that there is correlation to some extent between salinity resistance and drought resistance in plants.

Since some of the more important physiological process, such as nutrition uptake and assimilation, stress signals, and water movement occurs in the plant root, root characteristics logically play an important role in determining the response of plants to drought.

Rice, maize, wheat, pearl millet and sorghum behaved similarly in the aspect of root growth and distribution of adventitious at seedling stage under saline condition. With increasing level of saline concentration, salinity tolerant lines were shown to havemore number of profuse adventitious roots for osmotic adjustment.

Drought resistant lines of rice, maize, sunflower and cotton have shown very less reduction in plant growth and have deep robust root system. This helps in easy establishment of plant and better absorption of water and minerals from deeper levels of the soil. Utilization deep rooted and fast growing roots in breeding for developing drought resistance in above mentioned crops is highly advisable.

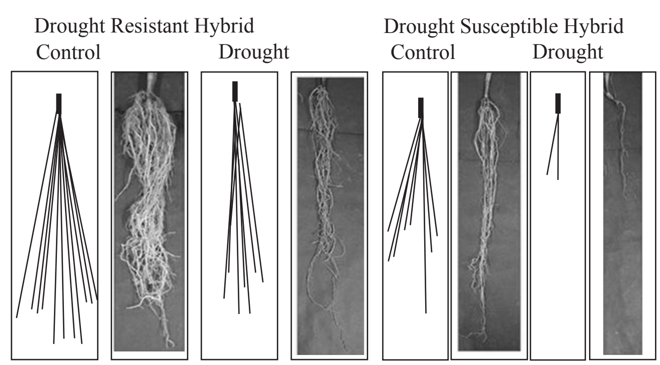


Figure 1: Root ideotype (hypothetical) for Drought resistance in Monocots- inclines deep rooting & robust root systems are the characteristics of drought resistance under water stress condition

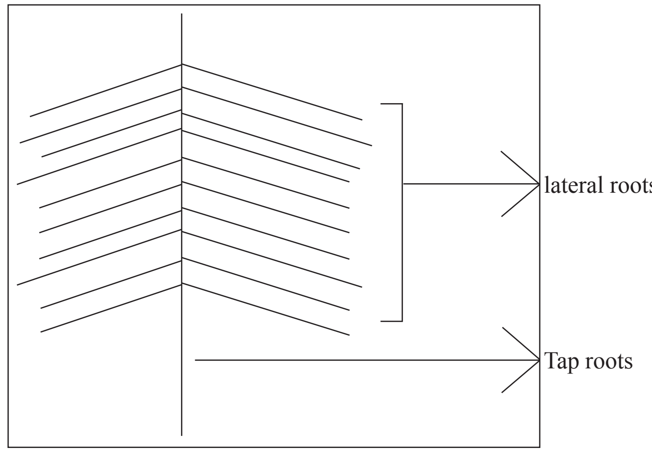
Selecting high root vigour genotypes of maize, pearl millet, sorghum, wheat and rice can be sanity and drought tolerant and helps in sustainable production. Hypothetical representation of root architecture on the basis of our research findings has been developed for drought resistance in maize as shown in Figure 1

Root length was more sensitive to salt stress than shoot length and suggested as a reliable indicator of stress tolerance. Salinity tolerant lines of dicots (cotton and sunflower)exhibit increased tap root length and more number of profuse lateral roots.

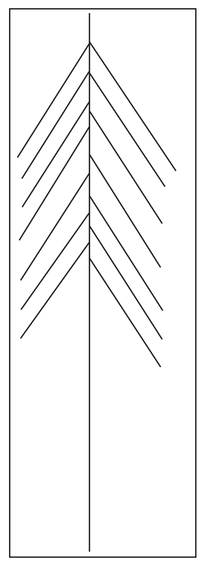
Drought resistant plants have robust inclined deep lateral roots, faster rate of root growth and very long tap root for absorbing the water available in deeper levels of the soil. The efficiency of the root system for absorption of water in high osmotic potential conditions should be increased which is an important character in the aspect of root system of drought resistant plants.

A large genotypic variability was found among lines dicots with respect to cotton and sunflower. These two crops behaved similarly in the aspect of root growth at seedling stage and adult stage. With increasing the level of saline concentration salinity tolerant hybrids were shown increase tap root length and more number of profuse lateral roots for osmotic adjustment. Therefore it is suggested that number of adventitious roots in cereals (monocots) and root length in dicot crops (cotton and sunflower) are the important selection criterion for salinity tolerance.

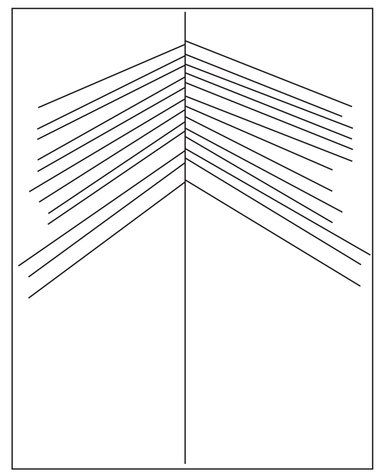
Deep robust root system may be considered for drought resistance. Hypothetical representation of root architecture for salinity and drought resistance for dicots has shown in Figure 2



Salinity tolerant: Profuse lateral roots spreading superficially



Drought tolerant: Deep root with inclined lateral roots



Salinity & Drought tolerant: Deep root with high density of lateral roots

Figure 2: Root Architecture of Dicots for drought & salinity tolerance (Hypothesis)