**A new way to engineer plant drought and salt tolerance?**

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Adverse environmental conditions such as drought, extreme temperatures and high salt content in soil can significantly limit plant growth and productivity. Since plants cannot move to avoid these conditions, they have evolved certain responses that may help to mitigate the negative impact of these stresses. One major response of plants to these stressful conditions is to turn on a large number of stress-inducible genes. The products of many of these genes could directly or indirectly enhance the tolerance of plants to the stress. For this reason, one way to engineer plant stress tolerance is to boost the expression of these stress-related genes through transgenic approaches. However, there is one little string attached to the benefit: higher expression levels of stress genes often negatively affect plant growth and result in yield reduction under normal growth conditions. This fitness cost is one of the major reasons for why genetic engineering of stress resistance has not been commercially adopted in agricultural production.

Like many other genes, these stress-inducible genes so far characterized are deemed to produce proteins from their RNA and they also function as proteins. Not surprisingly, there are also genes that are deemed not to produce proteins but rather function as RNA. Long non-coding RNA (lncRNA) are a group of such RNA that do not code for proteins yet they may perform important roles in many cellular processes including stress response. With the advancement in sequencing technology during the past decade, many lncRNA are being discovered. Nonetheless, due to the facts that most lncRNAs are expressed at low levels and their expression may be confined to specific cell types or specific conditions and that plant lncRNAs are not evolutionarily conserved, identifying and revealing the functions of these lncRNAs are still challenging.

Through sequencing the expressed genes in salt stress-treated seedlings of the model plant *Arabidopsis thaliana*, scientists from Texas A&M AgriLife Research Center at Dallas have identified dozens of putative lncRNAs that are induced by salt stress. One gene termed *DRIR* that does not seem to encode a protein was identified and studied for its possible functions in stress tolerance. The *DRIR* gene was expressed at a low level under normal conditions but can be significantly activated under drought or salt stress. Interestingly, the gene was highly expressed in leaf guard cells, a pair of cells that form the stomata through which water is lost during transpiration. To investigate the function of this lncRNA, the scientists generated transgenic plants with high expression levels of the *DRIR* gene. These engineering plants are then challenged with salt or drought stress. While these plants look fairly normal, they are more tolerant to both drought and salt stress. Under higher levels of salt, they are less damaged and have a high survival rate compared with normal plants. Under drought stress conditions (by withholding water), the engineering plants could survive longer drought treatment whereas normal plants are killed under the same conditions. The enhanced drought tolerance of transgenic plants may be partly due to a much slower rate of transpiration than the normal plants, indicating an important role of *DRIR* in controlling stomata closure under drought stress. Genome-wide gene expression analysis found that the expression of a large number of genes was altered in the transgenic plants under drought or salt stress conditions. Many of these genes are stress-related genes that may mitigate stress damaging. An interesting observation is that the enhanced expression of these stress-related genes in the transgenic plants mainly occur under stress conditions, suggesting that *DRIR* alone even at a high expression level does not turn on stress response under normal conditions but rather it strengthens the defense when plants encounter drought or salt stress. This may explain why high levels of *DRIR* do not affect the performance of plants under normal conditions.

Although how *DRIR* regulates the expression of stress-related genes is not immediately clear, the study shows the promise of regulating this lncRNA in improving plant tolerance to drought and salt stress. Exploiting lncRNA rather than proteins for enhancing plant traits is likely advantageous. lncRNA genes tend to be smaller than protein-encoding genes and thus are easier to technically manipulate. RNA molecules also are generally less stable and short-lived than proteins, which could make their negative impacts less severe to the plants or other organisms who consume the plants. It would be very interesting to see whether the *DRIR* gene could similarly improve stress tolerance of other plants.