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Interaction among different stress and their impact on crop growth and productivity.

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Introduction

- ✓ The no. of research studies on single factor stresses is far greater than that for multiple stresses.
- ✓ One of the reason for the limited no. of multiple stress experiments is the statistical complexity of the experiments
- ✓ In any environments plants will experience a no. of different resource limitations simultaneously.
- ✓ It is important to understand if one or all of these resource limitations will regulate plant performance.

Characteristic features for combination of biotic and abiotic stressors

- ✓ Environmental stress conditions such as drought, heat, salinity, cold, or pathogen infection can have a devastating impact on plant growth and yield under field conditions.
- ✓ Nevertheless, the effects of these stresses on plants are typically being studied under controlled growth conditions in the laboratory.
- ✓ The field environment is very different from the controlled conditions used in laboratory studies, and often involves the simultaneous exposure of plants to more than one abiotic and/or biotic stress condition, such as a combination of drought and heat, drought and cold, salinity and heat, or any of the major abiotic stresses combined with pathogen infection.
- ✓ Recent studies have revealed that the response of plants to combinations of two or more stress conditions is unique and cannot be directly extrapolated from the response of plants to each of the different stresses applied individually.
- ✓ Moreover, the simultaneous occurrence of different stresses results in a high degree of complexity in plant responses, as the responses to the combined stresses are largely controlled by different, and sometimes opposing, signalling pathways that may interact and inhibit each other.

Suzuki, *et al*., 2014

Effect of multiple resource limitation on plant function

- ✓ Optimization of resource allocation can be defined as a state in which any change in the resource distribution will cause a reduction in carbon gain (light and tissue nitrogen concentration).
- ✓ Plants from environments of low resource availability do not capitalize on high resource patches as effectively as do plants from regions of high resource availability.
- ✓ However, differences in environmental resource limitation coincide with differences in apparency.

Synergistic interactions between stressors

- ✓ The sensitivity of plants to light induced reduction in photosynthesis is dependent on tissue temperature.
- ✓ Metabolic process induced by cold temperature may enhance protection against photochemical damage.
- ✓ Induction of free radical scavenging proteins will help repair damage due to high light.
- ✓ The ability to accumulate nutrient is inhibited by drought and low light intensity.
- ✓ Nitrogen fixation is not a common attribute of plants under low light conditions

Antagonistic interactions between stressors

- ✓ It occurs when one stress enhances the ability of the plant to tolerate another stress
- ✓ During chilling stress there is often an increase in the conc. of cryoprotectant molecules in tissue.
- ✓ Acclimation of chilling stress will accord a certain amount of water stress tolerance in plants.
- ✓ Plants are more susceptible to the detrimental impact of water stress under high light conditions.

Anthropogenic stressors and natural resource limitation

- There are a multitude of anthropogenic stressors that affect plants as a consequence of the human population, its cultural practices and its technology.
- It depends upon the availability of resources in the natural systems
- The impact of elevated CO_2 on growth and metabolism is constrained by nitrogen availability.
- In general plant response to increased carbon dioxide thereby increasing growth, WUE and decreasing photorespiration.
- The detrimental impact of atmospheric pollutants on leaf metabolism is also modified by resource availability and climatic conditions
- Dissolution of some gaseous pollutants cause rainfall acidification and increased the accumulation of nitrogen and sulphur.

Effects of stress combination on growth, yield and physiological traits in plants and crops

1. Negative interactions of multiple stresses

- ✓ The ability of plants to recognize and respond to specific stress combinations is particularly important when those individual stresses could elicit a negative effect on plant growth and reproduction.
- ✓ Climate change models predict that the occurrence and intensity of drought and heat waves will increase in the future and lead to a reduction in agricultural production (IPCC, 2007, 2008).
- ✓ High temperature and drought are perhaps the two most major environmental factors limiting crop growth and yield worldwide, and the combination of these stresses causes many physiological changes that affect crop yield and quality (Rizhsky *et al*., 2002, 2004; Mittler, 2006; Prasad *et al*., 2011; Vile *et al*., 2012)

2. Positive interactions of multiple stresses

- ✓ Some stress combinations might have beneficial effects on plants, when compared with each of the individual stresses applied separately. Drought stress, for example, would cause a reduction in stomatal conductance, thereby enhancing the tolerance of plants to O3 stress (Pakkonen et al., 1998; Low et al., 2006).
- ✓ In addition, ROS concentrations enhanced by drought or O3 alone were decreased under the stress combination to a value comparable to the Controlled condition.
- ✓ The accumulation of these compounds under the stress combination was linked to the maintenance of a lower Na+ : K+ ratio, with a better performance of the cell water status and photosynthesis compared with salt stress alone. (Allakhverdiev et al., 2003, Cuin & Shabala, 2005).

The complexity of stress response signalling during stress combination

- ✓ When plants are exposed to a combination of stresses, their response to each of the individual stresses comprising the stress combination must be modulated to take into consideration allother factors imposed on the plant by the other individual stresses in the combination.
- ✓ In addition, novel mechanisms activated only during the stress combination were reported to be found during stress combination (Schenke et al., 2011; Atkinson et al., 2013; Prasch & Sonnewald, 2013).
- ✓ Systems biology analyses revealed a complex mode of integration of the different signaling pathways triggered in plants during stress combination (Rizhsky et al., 2004; Atkinson et al., 2013; Iyer et al., 2013; Prasch&Sonnewald, 2013; Rasmussen et al., 2013).

- ✓ The transcriptome analysis of plants subjected to drought and heat combination agrees with the physiological and metabolic analyses of this stress combination and suggests that it requires a unique acclimation response involving several transcripts that are not altered by drought or heat stress (Rizhsky et al., 2004).

- ✓ These transcripts are primarily associated with the regulation of secondary metabolism, such as IAA and phenylpropanoids (including anthocyanin), and growth regulation involving ethylene and auxin signaling.

- ✓ This may indicate that different stresses activate different secondary metabolic pathways and differentially affect growth via auxin and ethylene signaling.

Conclusions

- ✓ The major abiotic stresses that affect plants and crops in the field are being extensively studied in the laboratory in an individual manner.

- ✓ By contrast, the study of different stress combinations that mimic the field environment in a much more realistic manner has only recently been attempted by several different groups.