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Editorial

The Interdrought Conference in Perspective

A conference directed at the study of drought stress in crop plants and the mitigation of drought effect at the farm level is considered by many as timely and essential in view of present concerns about both food security and climate change. It is also a welcome fact that, due to worries about climate change, the support and sponsorships of research on drought issues in agriculture is increasing gradually. This support is common to many agencies and political platforms concerned with the future of global food security. In certain policy documents regarding this issue the mood even seems to border on panic.

However, many policy-makers, and even some in the scientific community, do not realize that both agricultural science and farmers have been addressing the issue of drought stress in crop production for a very long time. It is also not well recognized that approaches aimed at combating drought problems in dryland agriculture are constantly being developed, irrespective of the recent increasing concerns about global warming. The farmer and the agricultural scientist have always recognized that drought stress in agriculture is the rule while well-watered conditions are the exception. Thus our capacity to cope with drought and heat stress in crop production does not begin at ground zero with the emergence of global warming but is set on a solid base of knowledge and achievements that are well reflected in all the past Interdrought conferences.

The present rate of increase in crop yield potential (mainly in the cereals) is too moderate to solve the problem of increasing food demand and decreasing resources. Today, there is a call and a corresponding research effort towards increasing the genetic yield potential of our field crops. However, there are still physiological and genetic limitations to the expected breakthrough in this respect (Foulkes *et al.*, 2011; Parry *et al.*, 2011; Reynolds *et al.*, 2011);. Raising the yield ceiling will require transformational science and innovations and not just the modern tools of creating genetic modifications by genomic methods.

Breaking through the yield ceiling is urgent for raising the average cereal productivity of a country. Still, one must also consider that abiotic stresses, including drought and unfavourable temperatures pose a serious limit to actual and average global food production. Raising the yield ceiling is important but raising the floor is also crucial. Ideas and possible solutions in this direction have been discussed in Interdrought-III (2009), as reflected in the reports published here. Progress in drought research and solution delivery during the period spanning the three Interdrought conferences from Montpellier (1995), through Rome (2005) and Shanghai (2009) is represented by the following brief highlights.

Crop management: Non-tillage systems which conserve soil moisture to provide for crop production under dryland conditions has expanded globally, including the small-holder farmer in developing countries. Water-saving irrigation systems and techniques were further developed as supported by new knowledge in plant physiology as well as crop growth simulation models and decision support systems. Managing crop nutrition under limited water supply became more accurate and effective.

Plant and crop physiology: Root development and function is better understood. Root-associated biota and their impact on plant water use has been further clarified. The positive and negative roles of plant hormones such as ABA, ethylene, kinetin, and jasmonic acid in drought-stress signalling are now better resolved in the context of the whole plant and its productivity. Carbon isotope discrimination as a breakthrough method in plant science has allowed a better understanding of plant water-use efficiency (WUE) and the boundaries of its value as a criterion of plant production under drought stress. Processes controlling plant senescence and stay-green are better understood to the extent that they can be addressed in crop breeding and management. There is beginning to be an understanding of the genetic control of plant tissue growth at low water status. Legume nitrogen fixation under drought stress is almost fully resolved. Stem reserve mobilization into the grain is now recognized and implemented as an effective component of stress resistance at grain filling.

Plant breeding: The importance and use of managed stress environments in the selection and phenotyping of drought resistance is now better absorbed and applied in practice. Use of physiology-based selection criteria such as canopy temperature has become routine in phenotyping drought resistance under field conditions. Remote sensing techniques and the use of high throughput phenotyping methods in selection work are developing very fast. Specific plant breeding programmes for water-limited environments have been developed globally to an impressive scale and depth; examples are maize in Africa and in the private seed industry in the USA, the DROPS project in Europe, rice in IRRI, India, Thailand, Brazil, and China, wheat in CIMMYT and Australia, beans in CIAT and Brazil, barley in ICARDA, pearl millet in ICRISAT, India, and Africa, chickpeas in India and Australia, cowpeas in IITA in Africa, and more.

Genomics and molecular biology: Basic research succeeded in unravelling some of the gene networks leading to the control of the plant's response to drought stress. Genetic modification through transgene technology of model and crop plants

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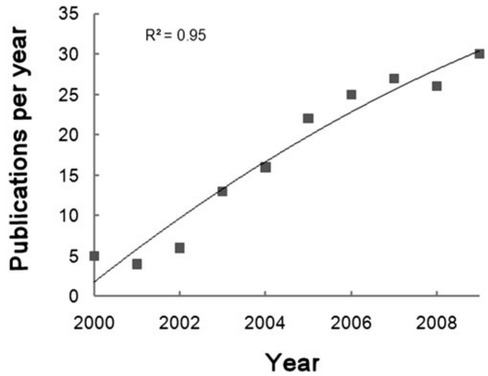

Fig. 1. The least number per year of Chinese peer-reviewed scientific reports dealing with plant drought research published internationally from 2000 to 2009.

began to explain the function of certain important genes determining drought resistance. In certain outstanding cases, genes with an established understanding of their function have become ready for, or are already under utilization in breeding. While marker-assisted selection is still grappling with its role as a tool in breeding for water-limited environments, much has been learned about the technology. In certain cases, the technology is coming of age with respect to breeding for drought resistance in the private seed sector, in certain CGIAR centres, and in several NARS.

Drought research towards sustaining crop production in water-limited environments is expanding due to innovative ideas, hard work, and increased funding. Probably the most impressive expression of this trend can be seen in China as it is driven by the realization that water crisis is a major threat to their present and future food production. The number of Chinese publications on drought research in international scientific journals has been steadily increasing since the year 2000 (Fig. 1). Beyond scientific publications, China is becoming a leader in drought research and solution delivery in upland and rainfed rice production in China and beyond.

A group of 12 distinguished scientists from MIT recently published a white paper entitled '*The third revolution: the convergence of the life sciences, physical sciences and engineering*' (http://web.mit.edu/dc/Policy/MIT%20White%20 Paper%20on%20Convergence.pdf). This paper describes a new model for scientific research known as 'convergence'. It offers the potential for revolutionary advances in biomedicine and other areas of science. This paper was driven, in part, by recognizing that the highly divided discipline of scientific research as it has evolved over many years is, in certain ways, slowing the development of solutions for improving human life and the environment. The proposed new model recommends collaboration among research groups and the integration of disciplinary approaches that have originally been viewed as separate and distinct. This merging of technologies, processes, and devices into a unified whole will create new pathways and opportunities for scientific and technological advancement. The convergence model has already proved its effectiveness, mainly in medicine where solutions have been developed by converging biological, physical, computing, and engineering sciences on a single problem.

On a smaller and more intimate scale, Interdrought can be visualized as a mechanism to enhance convergence among the different disciplines involved with drought research. While during the pre-Interdrought period the different disciplines of biology, agronomy, and environmental sciences researched the problem of drought almost independently, we now see a movement towards a convergence of disciplinary research which results in the advancement of solutions for the farmer. This trend is developing and it will develop in the future, hopefully with the continued contribution of the Interdrought conferences.

Abraham Blum*
Chair, Interdrought-II and Interdrought-III
Plantstress.com. PO Box 16246, Tel Aviv, Israel
*E-mail: ablum@plantstress.com

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