

Plant Breeding for Water-Limited Environments

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*In memory of our daughter Orly who
combined science with love for every
living thing.*

Preface

In my previous book entitled *Plant Breeding for Stress Environments* (Blum 1988) plant breeding for water-limited environments was only one chapter together with other chapters on heat, cold, mineral deficiency, mineral toxicity and salinity stress. Since that publication several major developments took place regarding plant breeding for stress environments.

Firstly, plant molecular biology emerged as a major avenue of research in plant biology and crop science. Plant molecular biology and genomics research towards plant environmental stress has grown exponentially since 1988. The number of published scientific papers specifically on the molecular biology of drought stress and drought resistance increased five-fold from about 10 per year in 1990 to at least 53 per year in 2009. The major dilemma now is how to apply molecular biology and genomics to breeding for stress conditions and specifically for water limited environments. While molecular biologists underline the potential of their discipline and whereas plant breeders underline their needs, there is too much fog lying between the two – which must be cleared up. This book offers to help.

Secondly, the plant breeding community realizes now that plant stress must be addressed in plant breeding programs in a dedicated and specific manner. Selecting for yield in diverse environments is not sufficient anymore for coping with stress problems. This approach also became too costly. There is now a growing understanding that breeding for stress conditions and specifically for water limited environments requires specific components within the general breeding program to the same extent that biotic stress resistance is approached. Qualified information on how to design and perform a breeding program component for water limited environments is in great demand.

Thirdly, concerns about the agricultural implications of climate change grew exponentially since the early 1990s to the extent that the phenomenon is now being aggressively addressed in agricultural research. Even the optimists agree that climate change cannot be completely reversed and at best it could only be slowed. The impact on crop production can already be seen by increased aridity and warmer temperatures in some regions and vicious storms and floods elsewhere. Global warming is an additional serious engine of plant stress which requires specific expertise towards breeding solutions.

Fourthly, university professors who teach plant breeding may find themselves now under increasing pressure to address abiotic stress and drought stress in their classes. It should not come as a surprise that expertise in plant stress is in demand. In a recent GCP survey among plant breeders who work towards water-limited environments (Mahalakshmi and Blum 2006), most were found to be seriously at loss on how to integrate drought resistance breeding into their program. Most were not certain about protocols for drought phenotyping and the selection methods to use. In short, many felt unqualified to deal with breeding for drought resistance and water-limited environments. Most of these breeders are the product of education in the last decade or two. Education in this plant breeding area is therefore crucial. Occasional international courses on this subject are being offered, but the basic university plant breeding curriculum still requires an upgrade in this respect.

Considering all of the above, a dedicated book on applied plant breeding for water-limited environments is deemed very timely, in demand and worth the effort. Other stresses are also important but urgency with respect to drought stress seems to be an overriding consideration. Since 2000 I have been trying to address developments in other environmental stresses (including drought) in my web site at www.plantstress.com. This is a dynamic web site with constant update of information and it should be of value to practitioners and students. In some respects it can be taken as a dynamic revision of my 1988 book, with the input of many dedicated experts.

The huge volume of information developed since 1988 on the subject of plant water-relations, drought stress and drought resistance posed a serious problem towards writing this book. This information had to be carefully scanned and sifted throughout in order to select only the relevant pieces useful for application towards plant breeding. This process was quite objective and depended on my own judgment. Furthermore, the discussion of background and basic information in plant physiology was also limited to what I considered as absolutely essential for the reader understanding of the breeding issues. This text is not the place for a comprehensive review and discussion of all information available in plant physiology as related to water in plants.

Plant breeding is a complex and costly program. Breeders are under constant pressure to deliver a new product quickly. This product must withstand competition from other programs and be accepted by the client. Rewards are not easy to come by. In public institutions the breeder often faces a situation where his/her work is evaluated by the number of publications while he/she was busy producing cultivars rather than papers. Not all public systems are enlightened enough to allow for that.

Very often the practicing breeder does not have the time or the patience for extensive reading and in these fast internet times a quick fix is what is being often sought. I am sorry to say to this reader that this book still requires time, patience and an open mind in order to achieve the gain it is intended to provide. At the same time effort is made to avoid an overload of unnecessary information which might be evident, readily available or useless to the practitioner and the student. This book also assumes that the reader already has basic knowledge in plant breeding, genetics and general plant physiology. It therefore tries to build upon that knowledge.

The reader will notice that the narrative of this book contains numerous references to “old” literature dating back as far as the 1960s. This is not a matter of nostalgia nor is it an indication that this author is not up to date on his reading. It is my deliberate intention, especially for the young generation, to point out that some hard facts that underlie much of the very contemporary knowledge in plant science and agronomy is based on very contemporary “old” literature. This might also help the emerging scientist to avoid a waste of time by re-inventing the wheel.

Plant breeding for water limited environments has been receiving increased attention in recent years as evidenced by many conferences, workshops and literature reviews cited throughout this book. Rather than being another literature review, this book can be considered as a science-based breeder’s manual. It describes detailed methods and protocols to be used in planning and executing a breeding program for water-limited environments, as supported by solid scientific evidence and discussion. However, the manual should not be used without understanding the principles, problem and pitfalls as discussed in the background chapters. Plant breeders are known to be resistant to change – for a good reason. A misguided change introduced into their program might hamper the program for years to come. Thus breeders justly tend to walk on the well-trodden path. The purpose of this book is to inspire the breeder to make changes but at the same time assume very careful evaluation before adopting change.

I close this preface with the eloquent statement by Robert Gauss, plant breeder (1910):

The dominion of climate is invincible. All who come within its range must obey its laws. It grants no pardon. It makes no compromise. Compliance with the conditions imposed is the license to exist and these conditions determine the limits of activity...Let no one look with indifference upon the possibility here outlined of acclimatizing valuable crop species to arid regions or underestimate the magnitude of the achievement suggested... So vast an achievement would rank with the discovery of new continent in its enlargement of the sources of human subsistence; and well might the hope of success quicken the activities of the most sluggish and awaken ambition in the least daring.

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Acknowledgments While this book is based on numerous literature citations it is still unavoidable that few authors may not have been appropriately or fully recognized. My apologies and acknowledgement is extended to all. I am in debt to the many excellent scientists, practitioners and farmers whom I was fortunate to associate with during my career. This work could not have been produced without these fertile interactions in the field, the laboratory and the meeting hall. Finally, I am in a loving gratitude to my wife Dvora who patiently accepted my long hours in front of the computer and long days away from home.

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Contents

1	The Moisture Environment	1
1.1	The Palmer Drought Index	2
1.2	The Crop Moisture Index	3
1.3	The Conventions of Crop Water Use	4
	References.....	8
2	Plant Water Relations, Plant Stress and Plant Production	11
2.1	The Initiation of Plant Water Deficit.....	11
2.2	The Soil-Plant-Atmosphere Continuum (SPAC)	12
2.2.1	The Albedo.....	12
2.2.2	The Water Flux.....	13
2.2.3	Root Resistance.....	16
2.2.4	Stem Resistance	19
2.2.5	Leaf Resistance (Excluding Stomata and Cuticle).....	21
2.2.6	Stomatal Resistance	21
2.2.7	Cuticular Resistance.....	23
2.3	Plant Size and the Development of Water Deficit.....	24
2.4	Plant Water Status and Plant Stress.....	24
2.4.1	Osmotic Adjustment (OA)	27
2.4.2	Absciscic Acid (ABA)	28
2.5	Growth and Water Deficit	36
2.6	Root Growth Under Drought Stress.....	38
2.7	The Formation of Yield and Drought Stress	40
	References.....	45
3	Drought Resistance and Its Improvement	53
3.1	Genetic Gains Achieved in Plant Breeding for Drought Resistance	53
3.2	Genomics and Breeding for Drought Resistance.....	56
3.2.1	Gene Expression and Gene Discovery	56
3.2.2	Marker-Assisted Selection (MAS) for Drought Resistance	57
3.2.3	Transgenic Plants	59

3.3	Drought Resistance in Terms of Yield	60
3.3.1	Drought Resistance and Yield Potential: The Crossover Interaction	60
3.3.2	The Heritability of Yield and Drought Stress	65
3.3.3	QTLs and Yield Under Drought Stress	68
3.4	Drought Resistance in Terms of Physiology	70
3.4.1	The Disease Resistance Analogy	71
3.4.2	The Components of Drought Resistance	72
3.5	Water-use Efficiency (WUE)	115
3.5.1	Effective Use of Water (EUW) and Not WUE Is the Important Driver of Yield Under Drought Stress	116
3.6	Summary of Plant Constitutive Traits Controlling Drought Resistance	128
3.7	The Drought Resistant Ideotype	129
3.7.1	The Ideotype with Respect to Drought Stress Scenarios	131
3.7.2	The Ideotype with Respect to Timing of Stress	133
	References	137
4	Phenotyping and Selection	153
4.1	The Managed Stress Environment	155
4.1.1	Site Homogeneity	155
4.1.2	Experiment Station Faults	158
4.1.3	Controlling the Water Regime	159
4.1.4	Controlling the Severity and Timing of Stress in the Field	166
4.1.5	Managed Drought in Protected Environments	171
4.2	Protocols for Drought Resistance	177
4.2.1	Plant Growth and Productivity	177
4.2.2	Plant Water Status – The Expression of Dehydration Avoidance	180
4.2.3	Dehydration Tolerance	201
4.3	High Throughput Commercial Phenotyping Service	209
	References	210
5	Genetic Resources for Drought Resistance	217
5.1	Cultivated Germplasm	218
5.2	Landraces	219
5.3	Wild Species and Crop Plant Progenitors	221
5.4	Drought Resistant Transgenic Plants	224
5.5	Resurrection Plants	230
	References	231

Contents	xiii
6 Breeding Considerations and Strategies	235
References.....	242
7 Epilogue	245
Reference	247
Index	249

