Chapter 1
Introduction to “Mitigating Environmental Stresses for Agricultural Sustainability in Egypt”

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Abstract This chapter provides a brief overview of the book, the purpose and the scope of the book. It discusses four categories of coherent topics. The first how to improve crop tolerance to abiotic stresses such as drought, heat stress, salinity and environmental pollution tolerance in crop plants. The second is about recent approaches for biotic stress tolerance. It contains varietal differences and their relation to brown rot disease resistance and effect of soil type and crop rotation on the disease in potato, advanced methods in controlling late blight in potato and importance of faba bean diseases, developing rust resistance in wheat beside the importance of faba bean diseases in Egypt. While the third is devoted to present advanced procedures in improving crop productivity include the role of He–Ne LASER, seed technology, identification of salt tolerance in peanut using molecular tools and importance of mycorrhizae in improving crop productivity. The last theme of the book is about sustainability of environmental resources from a crop production perspective and include sustainable use and optimizing inputs management for natural resources by crop rotations and bio-fertilizers in the agro-climatic zones of Egypt. The chapters under this theme concentrate on different field crops, maize productivity in the New Millennium as well as highlights on Quinoa and Cassava as promising crops to increase food security in Egypt.

Keywords Crop tolerance · Abiotic stresses · Drought · Heat stress · Salt stress · Environmental pollution · Sustainability · Management · Natural resources · Agro-climatic · Egypt · Maize productivity · Quinoa and Cassava · Food security · Biotic stresses · Varietal differences · Disease resistance · Crop rotation · Potato ·

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Faba bean · Rust resistance · Wheat · He–Ne LASER · Seed technology · Biochemical tools · Peanut · Mycorrhizae

1.1 Background

Egypt faces many challenges in the current period, namely, abiotic pressures. i.e. drought, heat stress, salt stress, and environmental pollution. Also, biotic stresses represent diseases injury the strategic crops such as wheat, maize, faba bean and potato. So, it is of importance to mitigate environmental stresses through developing tolerant cultivars with applied appropriate agronomic practices and follow recent approaches as tools in improving crop productivity under stress conditions.

Where population growth has become a threat to all aspects of economic growth in Egypt in recent years. With the estimated population of 99.38 million in the year 2018, Egypt ranks 15th in the world (http://www.fao.org/countryprofiles/index/en/?iso3=EGY). A study by the National Planning Institute predicted that the population would reach more than 114 million by 2030 and that by 2050 it would reach 125.9 million. The increase in the Egyptian population is a problem in the light of the imbalance between the population on the one hand and available resources and economic development rates on the other hand. The reports of the Food and Agriculture Organization of the United Nations (FAO), indicated that Egypt ould could not achieve self-sufficiency of food because of water scarcity, severe weather events, pests and agricultural problems. Some experts point out that drought and harsh weather conditions in food-gap-affected areas in Africa in recent decades may be due to climate change.

According to UN water deficit statistics, Egypt is currently facing this problem sharply. The average per capita water is estimated at 660 cubic meters per year. By 2030 this average will be reduced to just 500 cubic meters, making Egypt among the countries facing “absolute deficit” in water.

There are several solutions proposed to address the problem of food shortages, and these solutions attention to the development of new varieties tolerant to stress conditions and resistance to diseases and the adoption of appropriate agricultural practices in addition to modern techniques.

Thus, agricultural development plays a key role in generating the income needed to ensure food security; between half and two-thirds of the world’s poor live in rural areas, where agriculture is the dominant sector.

However, agriculture and food experts stress that priority must be given to improving agricultural land productivity. In this regard, over the past 15 years, researchers at Agriculture Research Center have produced more than 300 new agricultural varieties, and hybrids tolerate to drought, high temperatures, and soil salinity levels. These new agricultural varieties succeeded in increasing the productivity of agricultural crops.

1.2 Purpose of the Book

This book concentrated on the earth and environmental resources and how to exploit and deal with them for sustainable agriculture under the Egyptian conditions. Topics such as crop science, plant breeding and biotechnology for tolerance to environmental abiotic stresses are treated. Also, drought, heat, salt, pollutants, as well as biotic stresses such as disease resistance, ways to increase productivity, improving the quality of field crops and reducing the food gap are included. The main reasons behind this approach results from the potential of horizontal expansion in the newly reclaimed lands in Egypt depend on the development of crop varieties high tolerant to stress environmental conditions, and mitigate the impact of climate changes on their productivity. Besides that, the use of modern technologies is an essential tool in the scientific research system to improve crops production through the use of Laser, seed technology, mycorrhiza, and biotechnology to increase the yield of genotypes in sustainable farming systems. Therefore, this volume discusses the ways to increase the productivity of field crops under different environmental circumstances.

The purpose of this book is to broaden the knowledge of the nature of the environmental pressures to which crop plants are exposed in the light of climate change. Also, this scientific work aims to analyse the possible scenarios of the impact of environmental stress on crop plants and the strategies to be followed to avoid the negative effects on the productivity and quality of agricultural crops. Besides, the possibility of entering new crops to the agricultural arena in the desert lands, as well as interest in improving the productivity of cultivated crops in order to narrow the food gap and ensuring food requirements. Where, Egypt is one of the arid regions with a very low rainfall rate of 133 mm per year in the coastal areas, half in the delta and a quarter in central Egypt and is almost absent in Upper Egypt. Crop plants suffer from the effects of environmental stresses such as drought, high temperature, salinity and environmental pollutants, as well as the biotic pressures of plant diseases, which negatively affect crop production. Such environmental stresses affect crop outcome in many regions of the world, especially arid, semi-arid and hot regions such as the Arab region. The areas of horizontal expansion in the Egyptian deserts are one of these areas. Thus, horizontal expansion in the desert outside the cultivated area in the Nile Delta and valley is necessary. The new lands are located mainly on both the east and west sides of the Delta and valley. It scattered over various areas in the country where it covers 1.05 million ha (http://www.fao.org/docrep/008/y5863e/y5863e06.htm). These lands are viewed as an opportunity for increasing agricultural production and ensuring food security in the country. The performance of crop germplasm suffers from abiotic and biotic stresses and its effects on various plant traits. Crop genotypes varied in their response to stress conditions and showed various degrees of tolerance to stresses (Mensah et al. 2006; Awaad 2009; Doaa et al. 2015; Ali and Abdul-Hamid 2017 and Abdel-Motagally and Manal El-Zohri 2018). So, the food security problem is one of the most important challenges facing the achievement of the objectives of the policies and sustainable development in Egypt, which can be overcome through an integrated system in which different sectors of the state cooperate.

1.3 Themes of the Book and Contribution of the Chapters

In addition to the introduction (this chapter) and the conclusions (the last chapter), the volume consists of 4 themes. The first is titled "Improve Crop Tolerance for Abiotic Stresses" which is covered in 7 chapters. The second theme is written in 5 chapters and is titled "Recent approaches for biotic stress tolerance." While the third theme is titled "Advanced procedures in improving crop productivity" is covered in 4 chapters and the last theme is covered in 3 chapters under the title "Sustainability of environmental resources from a crop production perspective."

In the subsections, the main technical elements of the chapters under each theme are presented.

1.3.1 Improve Crop Tolerance for Abiotic Stresses

Chapter 2 highlights the drought tolerance in some important field crops, including rice, barley, maize and sunflower from the following aspects, (a) performance and genetic diversity, (b) related traits to drought tolerance, (c) genetic behavior beside breeding efforts and (d) biotechnology. Previous results concluded that there is a strong relationship between highest mean performances for morpho-physiological and biochemical characters and grain yield/plant under drought conditions, referring to the importance of such traits in improving drought tolerance (Moussa and Abdel-Aziz 2008; Farid et al. 2016). Several statistical parameters were utilized as genetic correlations and path coefficient analysis to identify the most selection criteria associated with water stress tolerance. Researchers have focused on the importance of employing Molecular markers RAPD and ISSR to detect the genetic diversity between various genotypes and to speed up the cycle of the breeding program (Abdel-Ghany 2012).

In integration with Chaps. 2, and 3 is presented to review drought tolerance in a strategically important crop in the world and Egypt i.e., wheat. The chapter discusses how to increase wheat productivity either through vertical expansion by increasing the productivity of the unit area or by horizontal expansion by increasing the area cultivated by drought tolerant cultivars in the new lands. This chapter addresses the critical stages of wheat growth that are affected by water stress (Salter and Goode 1967; Gupta 1997), and grain yield reductions percentage due to water stress. Many researchers explained the plant reaction to water stress through escape, avoidance, and tolerance mechanisms, where mechanisms of water stress resistance differ in different plant species (Foulkes et al. 2007). They also mention the importance of measuring and assessing drought tolerance through some indices such as stress sensitivity index as a useful measurement of comparing yield performance of genotypes between stressful and non-stressful environments (Fischer and Maurer 1978). Interrelationships and relative importance between grain yield and relevant physiological and component characters under both normal and drought conditions have been computed by many investigators (Abd El-Mohsen Dina 2015; Saleh 2011; Ata et al. 2014). This chapter also crippled the possibility of using molecular markers in breeding programs to differentiate between different wheat genotypes (Al-Naggar et al. 2015), also many efforts of transgenic wheat lines have been incorporated in the national wheat-breeding program of Agriculture Research Center, Egypt for further field testing and seed multiplication (Wally 2016). Lastly, the author suggested the possibility of mitigating the effects of water stress hazard through specific agricultural practices with tolerant varieties.

Chapter 4 is proposed to highlight an important factor of environmental stress affecting crop productivity, which is high temperature. This chapter brings to the reader's attention of some concepts related to heat stress, direct and indirect impact of heat stress on the Egyptian Agriculture Sector. Also, this chapter exposure to how crop plants can deal with high temperature through heat resistance mechanisms such as avoidance and thermotolerance. And addresses the capabilities of crop plants that help them to adapt with heat stress whether they are phenological, morpho-physiological or biochemical characteristics of molecular structure (Singh and Ahmad 2003; Awaad 2009; Farooq et al. 2009; Kumari et al. 2012; El Basyoni et al. 2017) are the key for heat stress tolerance. The authors surveyed many genes responsible for the production of heat shock proteins are closely associated with heat stress resistance in several crops. This chapter also concentrates on breeding achievements and biotechnology from aspects of molecular markers, gene transfer, and tissue culture technology. Finally, the authors explained the role of agricultural processes in reducing the impact of heat stress on different crop plants.

From the perspective of assessing the impact of pollutants and their effect on the quality of the environment, crop productivity and how to deal with sources of pollution (Awaad et al. 2013; Pal 2016) suggest Chap. 5. Chapter 5 focuses on the various aspects of the effect of environmental pollutants on crop plants, the role of plant breeding and biotechnology as well as procedures to mitigate the impact of the pollutants. Where, recently, the decrease in wheat yield due to heavy metals pollution is more than 20% besides the effect on quality (EL-Gharbawy 2015). The Codex Alimentarius Commission of the Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) determined maximum allowable levels of cadmium and inorganic arsenic in crop plants. Testing and evaluation of the water quality of 24 sites between Aswan and Cairo along the Nile, the water quality variations were mainly related to inorganic nutrients and heavy metals (Abdel-Satar et al. 2017). Review on the main research findings on crop adaptation mechanisms revealed the importance of selection, hybridization with molecular genetics using DNA-markers method in improving tolerance of crop plants to environmental pollutants. There are many suggestions to reduce the impact of contaminants on crop plants and the application of laws and compliance with the provisions of international conventions.

Chapter 6 was suggested to integrate with Chap. 5 and comprises detailed information about the effect of heavy metals and their mixture on germination and growth characters of wheat genotypes. This study will help to understand the level of tolerance and sensitivity of wheat genotypes under heavy metals stress conditions for establishing a breeding program for heavy metals tolerance in wheat. The use of tolerance measurements such as seedling phytotoxicity (Chou and Lin 1976) and seedling tolerance index (Iqbal and Rahmati 1992) helps to recognize tolerate or sensitive genotypes. They suggested the importance of recommending the cultivation of tolerant cultivars or could be exploited in a breeding program for high-yielding and tolerance for heavy metals.

On the light of climate change in the world, especially in the Mediterranean region, the aims of Chap. 7 are to identify adaptability and stability of wheat genotypes for earliness, quality and grain yield under diverse environmental combinations. Among the various parameters joint regression (Eberhart and Russell 1966) and additive main effects and multiplicative interaction, AMMI (Gauch 1992) have been reported to measure the adaptability and stability of new cultivars. The author showed that highly significant differences among environments reflect the wide differences in climatic conditions prevailing during the growing seasons. Exploit Stress Tolerance index (TOL) provides a measure of yield stability based on yield loss under stress as compared to non-stressed condition (Rosielle and Hamblin 1981), it identifies tolerant genotypes to environmental stress and confirmed with those previous results by Ali and Abdul-Hamid (2017). Both methodologies of Eberhart and Russell (1966) and AMMI (Gauch 1992) are consistent in describing the stability of Line 1 and Line 5 for grain yield. These genotypes could be useful in wheat breeding programs for improving stability.

Chapter 8 aims to highlight the African locust bean, as known to grow in a diversity of agro-ecological zones ranging from tropical rain forests to arid zones (Millogo-Kone et al. 2008). This chapter stressed the effects of salinity stress on some physiological and biochemical parameters of *Parkia biglobosa* cell suspension culture, at the application of NaCl concentration levels. Also, the establishment of an application protocol for cell suspension culture production from callus under salt stress. They applied protein electrophoresis technique in order to determine the molecular weight of protein, sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) under denaturing conditions (Laemmli 1970), also isozymes electrophoresis as suggested by Larkindale and Huang (2004). The researcher recommended by using the HPLC technique to separate the phenolic constituents that responsible for *P. biglobosa* to tolerate salinity such as gallic, caffeic, vanillic, ferulic, p-coumaric and salicylic acids.

1.3.2 Recent Approaches to Biotic Stress Tolerance

Chapter 9 comes from the point of view that the bacterial wilt problem is a major constraint for vegetable growers, especially potato and tomato farmers in many regions of the world and Egypt. So this manuscript was carried out in an attempt to study the transmission of *Ralstonia solanacearum*, the causal agent of potato brown rot, through field weeds, survey, isolation, identification and varietal differences in their relation to brown rot disease resistance in potato under Egyptian condition. The problem lies in the greater number of weed varieties as hosts for *R. solanacearum*; it causes disease at least 200 different plant species. For these reasons, isolates of *R. solanacearum* from weeds and other plant species must be identified using morphological, physiological and biochemical tests. Also, advanced Immunofluorescence Antibody Stains (IFAs), Polymerase Chain Reaction (PCR) and Real-time PCR (TaqMan) techniques could be applied (Hamad 2016). Researchers have been able to divided potato varieties according to tolerance levels and varied from more sensitive to resistant to the pathogen. They also determined some plant extracts from *Corchorus olitorius*, *Solanum nigrum*, *Ricinus communis* and *Portulaca oleracea* against *R. solanacearum.*

Chapter 10 focuses on the biotic abilities of *R. solanacearum* in relation to dispersion, survival, and effects which might be important in designing effective management against the pathogen. This study included the importance of soil type, soil pH and crop rotation, as the most important factors affecting on the causal agent of potato brown rot disease *R. solanacearum.* Application of suitable agronomic practices which led to decreasing pH value might be useful for controlling the causal agent. Crop rotation is considered an important agricultural procedure to reduce the number of weed varieties as hosts for *R. solanacearum.* There is increasing evidence of hosts which under certain condition act as latent or symptomless carriers of infection. Hamad, (2008) have reached that some rotations were more effective in decline the population density.

The purpose of Chap. 11 is to introduce recent information about the late blight disease in potatoes (*Solanum tuberosum* L.) which is arguably one of the most infamous diseases in agriculture. This chapter also focuses on assessment the economic importance of the disease. Also, identification of the fungus using the most vital methods differentiates between the new isolates of the pathogen by numerous techniques, a- the traditional method b- using DNA markers and c- bioinformatics and then control fungus by the best practices. Meanwhile, some chemicals are toxic and dangerous for both the environment and human health. Therefore, the research studies indicate that cultivation of resistant varieties and the application of another methods such as treatment with plant oils, natural extracts as well as the use of nanotechnology and biological control as an alternative to chemical fungicides will reduce environmental problems on plants and animals and then humans.

Based on the destructive effect of rust diseases on the productivity and quality of wheat, the current Chap. 12 is proposed to integrate the system of biological stresses in the light of modern trends in plant breeding. This chapter is divided into three main categories to explain the Egyptian case of wheat rusts, *i.e.*, yellow rust, leaf rust, and stem rust. This chapter provides detailed information about genetic variability, seeking for new sources of resistance, genetic system, and genes conferring resistance, breeding efforts and biotechnology along with yield losses caused by the rust diseases. They emphasized that breeding for resistance is a continuous procedure, and plant breeders need to increase new effective resources in breeding materials (Draz et al. 2015). The authors have suggested that the previous information's will serve as a foundation for developing durable rust-resistant wheat cultivars.

Chapter 13 provides some knowledge about the impact of the major plant diseases as a factor affecting faba bean yield production. This section limps on the most important diseases attacked faba bean plants, i.e. fungal diseases (chocolate spot, rust, root rot, and wilt) and viral diseases (Faba Bean Necrotic Yellow Virus, Bean Yellow Mosaic Virus, and Bean Leaf Roll Virus). These pathogens considered as a main constrains affected growth of the plant and contributed significantly to causing great yield loss both in quantity and quality, herby led to importing considerable amounts of faba bean seeds to fulfill the requirements and demands of the consumers (El-Metwally et al. 2013). Reference studies have suggested the possibility of recommending some measures to reduce the pathogenic effects involve breeding for disease resistance, fungicides treatments, plant extracts, agricultural practices, and others.

1.3.3 Advanced Procedures in Improving Crop Productivity

Chapter 14 focus on the helium-neon laser and its advantages and applications on crop plants, especially wheat in improving yield and quality characteristics. This manuscript is exposed to focuses on the mode of action of biostimulation, advantages, and disadvantages of helium-neon laser and objectives of using the helium-neon laser in agriculture. Also, applications of helium-neon laser in improving crop plants, quality, tolerance to environmental stresses and increasing water use efficiency. Where Chen and Han (2014) and Abaza Ghada et al. (2017) suggest applied Helium-neon laser to improve morphological parameters and the yield of wheat crop.

Chapter 15 highlights the application of the new technology of seed production of field crops. Also, exposed to seed as a basis for development, seed processing, seed treatments, the role of seed storage in agricultural development. High seed quality with genetical purity, high vigor, free from weed seeds and infested or borne diseases needs should be used for planting seed crops. It focuses on the importance of perfect harvesting, seed processing, and suitable storage facilitates for saving and protect the seed for next seed sowing (Ali 2017). It is important to perform seed multiplying of improved varieties to keep the new varieties from mixture or losses their pure genetical. Finally, this chapter emphasizes the need seed inspection and testing must be occurred before sowing in order to obtain high seed quality.

The objectives of Chapter 16 are to screen peanut genotypes from Egypt and Nigeria for salt stress in terms of morphological, biochemical and molecular genetic level. Also, to design specific primers for identifying and sequencing the salt tolerance gene in peanut genotypes. They also emphasized to compare between tolerant and susceptible genotype for salinity tolerance based on SNPs level. Negrao et al. [2017] discuss how to quantify the impact of salinity on different traits, such as relative growth rate, water relations, transpiration, ionic relations, photosynthesis, senescence, yield and yield components. The results of this chapter recommend that

Ismailia1 and Samnut 22 varieties could be involved in peanut salt tolerance breeding programs

Chapter 17 deal with the importance of mycorrhizae in crop productivity from the perspectives of various sides i.e. effects of organic and inorganic fertilizers on the activity of arbuscular mycorrhizal fungi in the rhizosphere, role of arbuscular mycorrhizal fungi on phosphorus and nitrogen uptake by host plants, role of arbuscular mycorrhizal fungi on plants grown under drought and salinity stress. Also, the chapter deliberates the role of arbuscular mycorrhizal fungi on the quality and productivity of crop plants. Reacharch results found that the manipulation of arbuscular mycorrhizal fungi in sustainable agricultural systems will be of marvelous vital for soil fertility and crop yield under severe edapho-climatic conditions (Lal 2009).

1.3.4 Sustainability of Environmental Resources from a Crop Production Perspective

Chapter 18 focuses on how to optimizing inputs management for sustainable agricultural development. In the current chapter, the authors discuss the importance of sustainable agriculture for protecting environment and humans from potential risks of some agricultural practices such as using excessive synthetic fertilizer as well as using toxic chemical pesticides or herbicides in crop productivity. This chapter also exposed to the importance of organic (biochar) and bio-fertilizers and their significance in the agricultural system. The attention will also be paid into the advantages of cropping rotation systems for better health of soil, environment, and human. The research studies suggest that use of modern agricultural technology such as productivity of new seeds, fertilizers, modern irrigation systems and suitable management strategies has saved such serious expectations (Abou El Hassan et al. 2014).

Chapter 19 deals with climate change and environmental degradation that threaten cereal production and global food security. In Egypt, the expected changes, according to the climate change scenarios will cause harmful effect in crop production. So this chapter focuses on the strategic crop maize: consumption and gap, distribution, ecology and growth requirements (air temperature, soil temperature, soil moisture, precipitation, and water requirements). Also concentrate on maize production under Egyptian conditions and challenges to face maize production such as abiotic stresses (drought, heat, poor soil fertility, low soil nitrogen tolerance and soil acidity/aluminum toxicity tolerance) and biotic stresses (insects and diseases). This besides milestones in maize breeding advances and Biotech Interventions. Studies suggest that crop productivity could be increased on both old lands and in the newly reclaimed areas using improved varieties, optimum cultivation practices, high seed-quality and the efficient use of land and water inputs. In addition, with better extension, the gaps between yields obtained by farmers and those obtained by researchers could be narrowed or even closed (FAO 2005).

Finally, Chap. 20 displays on quinoa and cassava crops to increase food security in Egypt. There is a large gap between production and consumption of wheat estimated by 55%, which negatively affects the production of bread in Egypt. This work is exposed to previous research by the Crop Intensification Research Department; Agricultural Research Center in Egypt which indicated that 40% of quinoa flour could be mixed with wheat flour in bread making. Furthermore, their research also indicated that 30% of cassava flour could be mixed with wheat flour (Shams 2011). Thus, the objective of this chapter was to review the studies that was done on quinoa and cassava internationally and nationally to help researchers in Egypt to expand and improve their work with these two important crops from the following aspects, salinity, water stress, insects and diseases, uses internationally as well as introduction of quinoa and cassava in Egypt

The last part consists of one chapter which is the conclusions chapter. It presents an update, the most important conclusions and a set of key recommendations.

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