Genetic and biotechnological studies on drought tolerance in tomato

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This research was conducted at the experimental farm and laboratory of Maryout Research Station; Desert Research Center, in addition to the Genetic and Cytological Laboratory of Desert Research Center, Matarya, Egypt and Germplasm Preservation Laboratory, Department of Horticulture, Faculty of Agriculture, Benha University;during summer seasons of 1999 to 2004.Several tomato genotypes which have differential reaction to drought tolerance and belong to different species; i.e., esculentum, pennellii, and chilense were used in the present study. Plants of all tomato genotypes were selfed for two generations before making somecrosses.The experimental design used in conducting this experiment was randomized complete block design with four replicates. Individual plants of the different tomato genotypes were maintained under water stress conditions and used for the following purposes :5.1 - Screening for Drought ToleranceThe individual plants of the different tomato genotypes were kept under close observations to determine their drought tolerance according to the scale which ranged from 10 (most tolerant) to I (most susceptible).Sllllmary 1035.2. Measuring Fruit CharacteristicsThe following characters related to fruits were recorded for th individuals plants of the different tomato genotypes:1.Fruit weight.2.Fruit diameter.3.Fruit length.4.Fruit flesh thickness.5.Number of locales.6.Number of fruits/plant. 7.Fruit set percentage. 8.Total yield/plant.5.3. Conducting Chemical AnalysisLeaf and fruit samples were collected in the proper time from the plants of the different tomato genotypes to determine the followingchemical characteristics:1.Leaf total photosynthetic pigments2.Leaf total cholophyll3.Fruit total titrable acidity4.Ascorbic acid (vitamin C) content of fruit5.Leaf free proline6.Percentage of fruit total soluble solids(TSS)7.Leaf dry weight8.Leaf total sugars content5.4.Conducting Leaf AnatomySample of young, fully expanded leaves from the top of some plants of the tomato genotypes were collected for the purpose of leaf anatomy. Determination of volume fractions of epidermal cells, palisade mesophyll cells, spongy mesophyll cells in addition to internal air space, and vascular tissue were made and presented as percentages.5.5.Conducting Molecular Analysis: a — SDS — Protein Electrophoresis.b-Esterase Isozymes Electrophoresis.c-Phylogenetic Relationships.The results could be summarized as follows:1- Screening for Drought Tolerance1-Tomato genotypes LA 1963 (L. chilense), LA 716 (L. pennellii), UC82B (L. esculentum), LA 1953 and LA 1673 (L. esculentum var. cerasiforme) and Edkawi (L. esculentum) can be considered as good sources for genes controlling drought tolerance in tomato.2-The potence ratio (PR) indicated overdominance for high tolerance to drought in the crosses Peto 82 X LA 716 (PR= 1.26), Peto 82 X Edkawi (PR=1.77), and UCT5 X Edkawi (PR=1.5).3-The previously mentioned crosses showed different values of better parent heterosis for drought tolerance due to the presences of overdominance Peto 82 X LA 716 (8.33%), Peto 82 X Edkawi(19.23%) and UCT5 X Edkawi (11.54%) . Such F1 hybrids wil perform well in arid areas whereas drought stress is likely to happen.4-The F1 hybrid UCT5 X LA 716 gave slight partial dominance towarc high drought tolerance (PR = 0.18) while the F1 hybrid Super Marmande X Edkawi showed intermediate partial dominance towardhigh drought tolerance (0.51).2-Some Aspects Related To Fruits Under Drought Stress1-The highest fruit set percentage values were associated with thegenotypes LA 716, (L. pennellii) (79.75%), LA 1953 ,(L. esculentumvar. cerasiforme) (65.55%), and Edkawi, L. esculentum (61.75%).The high percentage of fruit set under water stress conditions can beconsidered as an indication for drought tolerance,

which had thehighest levels of drought tolerance.2- The results indicated that tomato genotypes LA 1673 and LA 1953 (L. esculentum var. cerasiforme) and LA 716 (L. pennellii) can be considered as good sources for genes controlling high number of fruits/plant under drought conditions. The results indicated the potentiality of LA 716 (L. pennellii) in forming hybrids with high superiority concerning high number of fruits/plant under waterstress conditions.3- The tomato genotype LA 1953 (L. esculentum var. cerasiforme) had the highest total yield/plant under water stress conditions (3443.55g). This result indicates that line LA 1953 carries genes controlling highyield per plant under water stress conditions. Furthermore, the F1 hybrid Peto 82 X Edkawi had relatively high yield per plant under drought stress conditions (2320.02g).4-The plants of tomato genotype LA 1963 (L. chilense) which had the highest degree of drought tolerance (10.0) gave the smallest value of total yield per plant (54.40g). This can be explained by the presence of self incompatibility among the plants of L. chilense, which might have resulted in reducing fruit set and consequently total yield/perplant became very low.3-Some Aspects Related To Chemical Compositions UnderDrought Stress:1-The line LA 1963 (L. chilense) which had the highest degree of drought tolerance (10.0), had very high percentage of leaf dry mater content (36.29%). Dry matter content can be used as an indication for productivity of tomato plants under water stress conditions.2-Based on the results obtained in the present study it can be suggested that tomato genotypes LA 716 and LA 1953 were good sources for genes controlling high level of leaf chlorophyll under drought stress conditions. The high value of leaf chlorophyll was a sign for high biological efficiency under water stress conditions.4-Leaf Anatomy :1- The results indicated that the line LA 716 (L.pennellii), which is considered a source for drought resistance in tomato, had the lowestleaf area comparing to other tomato genotypes evaluated under watt stress conditions. It is well known that small leaf area is one of th important components for drought resistance.2- The highest values of epidermis percentage under drought conditioj were recorded for the leaves of the tolerant F1 hybrid Peto 82 3 Edkawi (9.97%) and the tolerant genotype LA 716(L. pennelli),(9.33%). Epidermis cells act as a protective layer for leaves and car reduce water loss through leaves under drought stress conditions.3- The highest values of palisade mesophyll percentage were thoseassociated with drought tolerant of tomato genotypes, i.e., F1 UCT5 XLA 716 (38.17%), followed by LA 716 (26.37%), F1 Peto 82 XEdkawi (22.3%) and F1 Peto 82 X LA 716 (21.50%).4-The lowest value was that associated with Super Marrnande (9.53%) which showed susceptibility to drought.5-These results indicated that the high percentage of palisade mesophyll tissue can be considered a desirable trait because it will improve photosynthesis and consequently increase the biological efficiency ofthe plants under such stress condition.6-The highest percentage of spongy mesophyll (81.30%) was associated with the drought tolerant genotype UC82B, which was not significantly different from the value associated with the susceptible genotype UCT5 while, line LA 716 (L. pennellii), which showed high tolerance to drought, had a value of 51.53%..7- Significant differences were observed among the different tomato genotypes evaluated under water stress condition concerning percentage of vascular tissue relative to other components of leaf tissue. The highest percentages of vascular tissue were associated with the tomato genotypes Castle Rock (21.46 %), LA1673 (19.80%) and Peto 82 (19.46%).8-The differences observed among the evaluated tomato genotypes under water stress conditions concerning the different aspects of leaf anatomy measurements can be very useful in tomato breeding programs for improving drought tolerance.5-Molecular Analysis5.5.1. SDS-Protein Electrophoresis1- An unique band of 16.34 KDa was associated with the tolerant genotype Edkawi and one of the Fis which involved this parental tolerant genotype, i.e., Peto 82 X Edkawi. This band of 16.34 KDa can be considered a distinguished marker for the tolerant parental genotype Edkawi under water stress conditions. However, the appearance of this band in only one of the Pi s which showed tolerance under water stress conditions, i.e., Peto 82 X Edkawi, while it disappeared in the other tolerant F1 hybrids which involved the same tolerant parent Edkawi, i.e., Super Marmande X Edkawi and UCT5 X Edkawi and UCT5 X Edkawi, can be attributed to carryingSummary 109different mechanisms by these genotypes for resistance or toleranc to drought conditions.2-An unique band of 68.36 KDa was found to be exclusively associate(with tomato genotype LA 1673 (L. esculentum var. cerasiforme).3-A band of molecular weight 63.08 KDa was found to be useful ir positive identification of tomato germplasm which are tolerant tc drought. Moreover, one band of

molecular weight 52.42 KDa was present in SDS-PAGE samples of the cultivar Castle Rock which was classified as susceptible to drought while this band was absent in samples of the other tolerant tomato germplasm.4-The results indicated that the presence of bands of 77.56 KDa and8.98 KDa will be an indication for absence of reasonable degree of drought tolerance.5. 5.2. Esterase Isozymes Electrophoresis1- Tomato genotypes LA1963(L. chilense) and LA716 (L. pennellii) had two activity zones for the esterase enzyme, i.e., Est-1 (very faint band) and Est-2 (very faint band) for LA 1963 (L. chilense), and Est-1 (faint band) and Est-3 (very faint band) for LA716 (L. pennellii). In addition, the parental genotype Edkawi which was classified astolerant had three bands Est-1(faint), Est-3 (faint), and Est-4 (very faint).2- It was found that the two susceptible parental genotypes UCT5 and Super Marmande had more and darker bands than that expressed by the evaluated resistant tomato genotypes, i. e., line LA1963 (L. chilense), LA716 (L. pennellii), and Edkawi (L. esculentum).3- It was found that isozyme electrophoresis for esterase enzyme can be used in making biotechnological studies on drought tolerance in tomato to distinguish between tolerant and susceptible genotypes, as well as better understanding for expression of genes controllingdrought tolerance or susceptibility.5. 5. 3. Phylogenetic Relationships1.It was found that one of the clusters included Edkawi (tolerant) in a sub-cluster, while UCT5 (susceptible) and Peto 82 (susceptible) were included in another sub-cluster. In addition, each of the genotypes Edkawi, (tolerant), Super Marmande (susceptible) and Castle Rock (susceptible) occupied separate clusters.2.It was found that another cluster, included line L. esculentum var. cerasiforme LA 1953 (tolerant) in a sub-cluster while, L. esculentum var. cerasiforme LA 1673 var. cerasiforme(tolerant) occupied the other sub-cluster. Furthermore, line LA 1963, L. chilense (resistant)occupied separate clusters.3-The highest similarity value (72.4%) was recorded between Peto 82 (susceptible) and UCT5 (susceptible), followed by value (63.7%) which were recorded between LA 1953 L. esculentum var. cerasiforme (tolerant) and UC82B (tolerant).4-The lowest similarity value (11.6%) was recorded between Castle Rock, L. esculentum (susceptible) and line LA 1953, L. chilense (tolerant) followed by the value (14.4%) which was recorded between Super Marmande, L. esculentum (susceptible) and line LA 1963, L.chilense (tolerant).Summary 1115-These results are of great value for studying genetic diversity amon tomato genotypes concerning drought resistance which will help idesigning successful breeding programs for drought resistance throng selecting the suitable parental genotypes.6-Correlation Between Some Traits Evaluated Under Drough Stress1-Negative correlation was observed between degree tolerance and percentage of dry matter content of leaves.2-The results indicated significant negative relationship between degree of tolerance to drought and leaf sugars content.3-Significant positive relationship between proline accumulation in leaves under water stress and degree of tolerance to drought in case of the involvement of L. esculentum germplasm in forming intraspecific hybrids (r = 0.63), while this significant relationship was negative (r = -0.47) in case of using L. pennellii in making interspecific hybrids.4-The results revealed positive correlation coefficients between degreeof tolerance to drought and fruit acidity. However, the positive correlation coefficients was only significantintraspecific F1 hybrids, i.e, crosses between genotypes.5-Based on these results, selecting tomato plants for high tolerance todrought will be indirectly accompanied by selection for high fruit acidity and/or low fruit vitamin C.of droughin case of the L. esculennunSummary 1126-The results showed positive correlation between degree of drought tolerance and leaf area. However, the correlation coefficient was only significant in case of the intraspecific hybrids whereas r = 0.38 and r=0.19.7-Significant positive correlation coefficients (r=0.48) were observed between degree of drought tolerance and number of fruits per plant in case of the correlation study which was performed on intraspecific F1 hybrids and related L. esculentum parents and in case of the study performed on interspecific crosses and related L. esculentum and L. pennellii parents r was equal to 0.53. These results indicated that number of fruits per plant under water stress conditions can be considered as an indication for drought tolerance and it should be included in any selection index for drought tolerance in tomato.8-The data indicated significant negative correlation coefficient between degree of drought tolerance and each of fruit total soluble solids, flesh thickness, and number of locules in case of the correlation study performed on interspecific hybrids and related L. esculentum and L. pennellii parental genotypes evaluated under stress conditions.9-It was found that tomato

plants with high total pigments and total chlorophyll under water stress conditions will have high degree of drought tolerance. The high leaf total pigments and total chlorophyll contents under stress conditions indicate high biological efficiency under water stress, i.e., high drought tolerance.10-The results showed significant positive correlation coefficient between yield of tomato plants under drought stress conditions andSummary 113each of fruit number and fruit weight. These results indicated importance of including fruit weight in any selection index used btomato breeder in breeding programs to improve total yield per plar under drought conditions.11- The correlation study which was performed on interspecific crosseand related L. esculentwn parental genotypes evaluated under watestress conditions showed significant positive correlation coefficient:between degree of drought tolerance and each of leaf epidermispercentage (r = 0.41) and palisade mesophyll percentage includinginternal air space (r = 0.50). Same trend of results were observed incase of the correlation study performed on the interspecific crossesand related L. esculentum and L. pennellii parental.