5- SUMMARY

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 some crosses.

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 Tolerance

The 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 1 (most susceptible).

5.2. Measuring Fruit Characteristics

The following characters related to fruits were recorded for the individuals plants of the different tomato genotypes:

1. Fruit weight.
2. Fruit diameter.
3. Fruit length.
4. Fruit flesh thickness.
5. Number of locules.
6. Number of fruits/plant.
7. Fruit set percentage.
8. Total yield/plant.

5.3. Conducting Chemical Analysis

Leaf and fruit samples were collected in the proper time from the plants of the different tomato genotypes to determine the following chemical characteristics:

1. Leaf total chlorophyll
2. Percentage of fruit total soluble solids (TSS)
3. Fruit total titrable acidity
4. Ascorbic acid (vitamin C) content of fruit
5. Leaf free proline
6. Leaf total photosynthetic pigments
7. Leaf dry weight
8. Leaf total sugars content

5.4. Conducting Leaf Anatomy

Sample 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:

I - Screening for Drought Tolerance

1- 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 potency 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, i.e., Peto 82 X LA 716 
(8.33%), Peto 82 X Edkawi (19.23%) and UCT5 X Edkawi 
(11.54%) . Such F₁ hybrids will perform well in arid areas
whereas drought stress is likely to happen.

4- The F₁ hybrid UCT5 X LA 716 gave slight partial
dominance toward high drought tolerance (PR = 0.18) while
the F₁ hybrid Super Marmande X Edkawi showed
intermediate partial dominance toward high drought
tolerance (0.51).

II. Some Aspects Related To Fruits Under Drought Stress

1- The highest fruit set percentage values were associated with
the genotypes LA 716, (L. pennellii) (79.75%), LA 1953,
(L. esculentum var. cerasiforme) (65.55%), and Edkawi,
L. esculentum (61.75%). The high percentage of fruit set
under water stress conditions can be considered as an
indication for drought tolerance, which had the highest 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 water stress 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 high yield 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/per plant became very low.
III. Some Aspects Related To Chemical Compositions Under Drought 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 (51.67%). 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 LA1953 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.

IV. 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 lowest leaf area comparing to other tomato genotypes evaluated under water stress conditions. It is well known that small leaf area is one of the important components for drought resistance.

2- The highest values of epidermis percentage under drought condition were recorded for the leaves of the tolerant F₁
hybrid Peto 82 x Edkawi (9.97%) and the tolerant genotype LA 716 (L. pennellii), (9.33%). Epidermis cells act as a protective layer for leaves and can reduce water loss through leaves under drought stress conditions.

3- The highest values of palisade mesophyll percentage were those associated with drought tolerant of tomato genotypes, i.e., F$_1$ UCT5 X LA 716 (38.17%), followed by LA 716 (26.37%), F$_1$ Peto 82 X Edkawi (22.3%) and F$_1$ Peto 82 X LA 716 (21.50%).

4- The lowest value was that associated with Super Marmande (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 of the 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.

V. Molecular Analysis
VI.a. SDS-Protein Electrophoresis

1- An unique band of 16.34 KDa was associated with the tolerant genotype Edkawi and one of the F1s 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 F1s 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 carrying different mechanisms by these genotypes for resistance or tolerance to drought conditions.

2- An unique band of 68.36 KDa was found to be exclusively associated with tomato genotype LA 1673 (*L. esculentum var. cerasiforme*).

3- A band of molecular weight 63.08 KDa was found to be useful in positive identification of tomato germplasm which are tolerant to 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 and 8.98 KDa will be an indication for absence of reasonable degree of drought tolerance.

**V.b. Esterase Isozymes Electrophoresis**

1- 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 as tolerant 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 controlling drought tolerance or susceptibility.

c. Phylogenetic Relationships

1. 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 LA1963, *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).

5- These results are of great value for studying genetic diversity among tomato genotypes concerning drought resistance which will help in designing successful breeding programs for drought resistance through selecting the suitable parental genotypes.
VI. Correlation Between Some Traits Evaluated Under Drought Stress

1- Negative correlation was observed between degree of drought 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 degree of tolerance to drought and fruit acidity. However, the positive correlation coefficients was only significant in case of the intraspecific F\(_1\) hybrids, i.e, crosses between *L. esculentum* genotypes.

5- Based on these results, selecting tomato plants for high tolerance to drought will be indirectly accompanied by selection for high fruit acidity and/or low fruit vitamin C.
6- 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 F\(_1\) hybrids and related \textit{L. esculentum} parents and in case of the study performed on interspecific crosses and related \textit{L. esculentum} and \textit{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 \textit{L. esculentum} and \textit{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 and each of fruit number and fruit weight. These results indicated the importance of including fruit weight in any selection index used by tomato breeder in breeding programs to improve total yield per plant under drought conditions.

11- The correlation study which was performed on interspecific crosses and related *L. esculentum* parental genotypes evaluated under water stress conditions showed significant positive correlation coefficients between degree of drought tolerance and each of leaf epidermis percentage (*r* = 0.41) and palisade mesophyll percentage including internal air space (*r* = 0.50). Same trend of results were observed in case of the correlation study performed on the interspecific crosses and related *L. esculentum* and *L. pennellii* parental.