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# GENETIC STUDIES ON DROUGHT RESISTANCE IN WATERMELON (*Citrullus lanatus*)

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**ABSTRACT: The parental, $F_1$, $F_2$, $Bc_1$ and $Bc_2$ generations of the two crosses Charleston Gray X Giza-1 and Charleston Gray X Sugar Baby as well as their reciprocal crosses were evaluated in field and pot experiments to study the inheritance and nature of drought resistance and some component characteristics in watermelon (*Citrullus lanatus*). There were highly significant root length increase percentages under drought condition compared with that under normal irrigation for $P_1$, $P_2$ and $F_1$ population. On the other hand, there were highly significant decrease percentages between $P_1$, $P_2$ and $F_1$ populations of each cross concerning root size, fresh and dry weights under drought condition compared with those under normal irrigation. The drought resistance, leaf water loss ratio, total yield/plant and leaf proline content were found to be inherited quantitatively. Partial dominance for the highest levels of drought resistance and leaf proline content over the low levels were detected. Whereas, partial dominance for the lowest leaf area and total yield/plant over the highest leaf area and total yield/plant were found. Broad and narrow sense heritability for drought resistance, leaf area, total yield/plant and leaf proline content ranged from intermediate to high percentages. The number of effective gene pairs controlling drought resistance, leaf area, total yield/plant and leaf proline content ranged from 1 to 3, 2 to 4, 1 to 7 and 2 to 3, respectively. Significant positive correlation was found between drought resistance and each of fruit weight and total yield/plant. Whereas, there was highly significant negative correlation between drought resistance and each of fruit set percentage, leaf water loss ratio, rind thickness and leaf area. Leaf proline content was positively correlated with each of drought resistance, fruit length and**

**diameter, and total yield/plant. Furthermore, there was significant linear relationship between resistance to drought and the combined effects of number of branches/plant, number of days from sowing date to the first flower anthesis, fruit set percentage, fruit weight, leaf water loss ratio, total yield/plant and leaf area.**

## INTRODUCTION

Water shortage in the middle east is expecting to be the limiting factor for agriculture in the near future. The demand for drought-resistant cultivars is increasing due to the limiting water sources, which are not going to be enough for irrigation of crops, especially with the continuous increase of population. Obtaining new watermelon cultivars possessing resistance to drought will be of great importance in water conservation. Such drought-resistant cultivars will be very suitable for the new reclaimed lands. Watanabe *et al.* (2001 and 2003) found that fruit weight was closely related to total leaf area per plant. Also, Orta *et al.* (2003) showed that the yield was directly correlated with mean of crop water stress index values.AL-Gosaibi (2001) illustrated that roots did not grow deeper in the ground especially at high rate of drip irrigation regime and under high soil moisture content in the root zone.

Meanwhile, Rajan *et al.* (2002) showed that various watermelon hybrids exhibited both positive and negative heterosis of varying magnitudes for many economic characters. Moreover, significant genetic differences were detected among watermelon germplasm concerning drought resistance (Zhang *et al.*, 2002 a; Zhang-Ming *et al.*, 2002; Zhang *et al.*, 2002 b).

The present research aims to study the inheritance mode of resistance to water stress in watermelon plants and to examine the nature of this resistance as well as the correlation between drought-resistant and some economic characters. Such information is important when designing a breeding program for developing local watermelon cultivars which are susceptible to drought.

## MATERIALS AND METHODS

This research was conducted at the Agricultural-Experimental farm, Department of Horticulture, College of Agriculture-Moshtohor, Zagazig

University, Benha Branch, during the summer seasons of 2001 to 2003.

The watermelon (*Citrullus lanatus*) cultivars "Giza-1" and "Sugar Baby", which are known for their susceptibility to drought, and "Charleston Gray", which is known for its high resistance to drought, were used as the parental genotypes for the crosses made in this research. Seeds of these cultivars were obtained from the germplasm preservation laboratory, Faculty of Agriculture-Moshtohor, Department of Horticulture, Moshtohor, Kalubia, Egypt. Individual plants of those cultivars were selfed for two generations before initiation of this research

Seeds of the three cultivars were planted in the field and crosses between plants of the three cultivars were made in the summer season of 2001 to obtain $F_1$ seeds of the crosses; Charleston Gray X Giza-1, Charleston Gray X Sugar Baby, and/also their reciprocals were obtained. Seeds of the parents and $F_1$' s were planted in the summer season of 2002, to obtain seeds of the $F_2$ and backcross populations and to obtain $F_1$ seeds of the crosses made in the first season. The backcrosses populations were obtained by crossing each $F_1$ hybrid with its respective parents.

**I. Pots Experiment**

On March 28, 2003, seeds of the different watermelon parental cultivars in addition to their $F_1$ seeds were planted separately in pots, 30 cm in diameter, containing sandy clay soil(1:1, *V : V*). Ten seeds were planted in every pot. The seedlings were thinned later to five plants/pot. Ten pots were devoted for each population. When the seedlings reached the two true leaf stage, the pots were divided into two groups, each group consisted of five pots for each population. The first group was irrigated regularly and the second one was not irrigated. Every week, one pot from each population within each one of the two groups was taken. The roots of the individual plants within each pot were washed with water and the following data were recorded:

(1) Root length (cm), (2) Root size ($cm^3$), (3) Root fresh weight, and (4) Root dry weight.

Representative soil samples were taken on regular basis from each pot, directly after taking the sample plants for evaluation. Moisture of soil in the pot was determined as percentage of field capacity.

**II. Field Experiment**

On March 28, 2003, seeds of the parents, $F_1$ , $F_2$, $Bc_1$ and $Bc_2$ were planted in the field on one side of ridges spaced 2m apart, with two seeds per hill and 40 cm apart. The experimental design used for evaluating the populations in this experiment was randomized complete block design with three replicates. Plants of all populations were two irrigations after sowing irrigation. The first irrigation was after two weeks from sowing date and the second irrigation was at the full blooming stage. All other agriculture practices; *i.e.*, fertilization, weed, diseases and pest control, were followed as recommended for watermelon.

**Data recorded**

The individual plants of the different populations were evaluated under water stress conditions in the field experiment by recording the morphological traits and yield as follows.

The percentage of healthy leaves compared with total leaves/ plant, number of branches/ plant, number of days from sowing date to the first flower anthesis, fruit set percentage, fruit length, diameter and weight, leaf water loss ratio(by weighting the detached leaf every two hours and calculate the ratio of water loss in the laboratory), rind thickness (It was measured by caliper), average of leaf area ($cm^2$) using five leaves/plant (on the base of fresh weight) and total yield (kg) / plant.

Free proline was estimated calorimetrically in dry plant leaves using the method described by Bates *et al.* (1973). Samples were taken from the fourth and fifth fully expanded leaf (from the top of the plant) at the flowering stage.

**Genetic Statistical Analysis:**

1. Analysis of variance was performed, on recorded data, according to the method described by Gomez and Gomez (1984).

2. Mid-parent heterosis percentage was calculated, using the following equation described by Bhatt (1971).

$$\text{Heterosis} = \frac{F_1 - MP}{MP} \times 100$$

where: $F_1$ and MP are the means of $F_1$ and mid-parent values= ½($P_1$+$P_2$), respectively.

3. The nature of dominance was determined by calculating the potence ratio (P), using the following equation suggested by Smith(1952):

$$\text{Potence ratio (P)} = \frac{F_1 - MP}{\frac{1}{2}(P_2 - P_1)}$$

where:

$F_1$ = $F_1$ mean
$P_1$ = smaller parent mean
$P_2$ = larger parent mean

MP = mid-parent value = ½($P_1 + P_2$)

4. The minimum number of gene pairs differentiating the two parental genotypes was estimated using the following method, which described by Castle and Wright (1921):

$$N = \frac{D^2}{8(VF_2 - VF_1)}$$

where:

N = minimum number of gene pairs by which the parental genotypes differ.

D = mean of larger parent – mean of smaller parent.

$VF_1$ = variance of $F_1$ population.

$VF_2$ = variance of $F_2$ population.

5. Heritability in the broad sense (BSH) was estimated using the following method described by Allard (1960):

$$BSH = \frac{VF_2 - (VF_1 + VP_1 + VP_2)/3}{VF_2} \times 100$$

6. Narrow sense heritability (NSH) was estimated after Mather and Jinkes (1971):

$$NSH = \frac{2VF_2 - (VBC_1 + VBC_2)}{VF_2} \times 100$$

whereas:

$VF_1$ = variance of the first filial generation, $VF_2$ = variance of the second generation, $VP_1$ = variance of the first parent, $VP_2$ = variance of the seeond parent, $VBC_1$ = variance of the first backcross, and $VBC_2$ = variance of the second backcross.

7. Estimates of the mean and its standard deviation and total variance of the studied characters for all populations were calculated using, the methods described by Briggs and Knowles (1977).

8. Coefficients of correlation between different characters in $F_2$ populations and multiple regression analysis were performed using, the methods described by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

### I. Pots Experiment

Data presented in Table 1 show that, there were highly significant differences between $P_1$, $P_2$ and $F_1$ plants in all crosses under study for root traits; *i.e.*, length, size, fresh and dry weight, under normal irrigation or drought, except that for root length in the crosses of Charleston Gray X Giza-1 and Giza-1 X Charleston Gray, and for root DW in cross Giza-1 X Charleston Gray which was significant. In this respect, the parental cultivar Charleston Gray had the highest values of root length, size, fresh and dry weights, whereas these values reached to 39.00 cm, 18.00 $cm^3$,

**Table 1 Means of root characteristics and the percentage of increase or decrease of different watermelon cultivars and their $F_1$ hybrids, under normal irrigation and water stress conditions in pots experiment**

| Cross | Popula | Normal | | | | Stress | | | | Root length Increase (%) | Decrease (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Root length (cm) | Root size (m3) | Root F. W. (g) | Root D.W. (g) | Root length (cm) | Root size (cm3) | Root F.W. (g) | Root D.W. (g) | | Root size (cm3) | Root F.W. (g) | Root D.W. (g) |
| Charleston Gray | $P_1$ | 39.00 | 18.00 | 23.80 | 4.31 | 45.50 | 11.00 | 9.12 | 2.22 | 15.64 | 38.89 | 61.68 | 48.49 |
| X | $P_2$ | 31.00 | 8.25 | 5.92 | 1.07 | 35.10 | 6.50 | 4.33 | 0.99 | 13.23 | 21.21 | 26,86 | 7.48 |
| Giza-1 | $F_1$ | 33.00 | 11.75 | 10.16 | 2.31 | 40.75 | 9.25 | 7.05 | 1.79 | 23.48 | 21.28 | 30.61 | 22.51 |
| L.S.D. 0.05 | | 6.06 | 1.44 | 4.19 | 0.75 | 3.50 | 1.09 | 2.88 | 0.61 | N.S. | 10.35 | 11.31 | 10.14 |
| 0.01 | | N.S. | 2.09 | 6.09 | 1.09 | 5.09 | 1.58 | 4.19 | 0.89 | N.S. | 15.02 | 16.42 | 14.72 |
| Giza-1 | $P_1$ | 31.00 | 8.25 | 5.92 | 1.07 | 35.10 | 6.50 | 4.33 | 0.99 | 13.23 | 21.21 | 26.86 | 7.48 |
| X | $P_2$ | 39.00 | 18.00 | 23.80 | 4.31 | 45.50 | 11.00 | 9.12 | 2.22 | 15.64 | 38.89 | 61.68 | 48.49 |
| Charleston Gray | $F_1$ | 34.20 | 12.39 | 11.56 | 2.43 | 41.00 | 9.16 | 7.91 | 1.87 | 19.88 | 26.07 | 31.57 | 23.05 |
| LS.D. 0.05 | | 5.87 | 1.41 | 4.13 | 0.71 | 3.43 | 2.18 | 2.63 | 0.98 | N.S. | 10.77 | 11.50 | 10.27 |
| 0.01 | | N.S. | 2.05 | 6.01 | 1.03 | 4.99 | 3.17 | 3.83 | N.S. | N.S. | 16.63 | 16.69 | 14.91 |
| Charleston Gray | $P_1$ | 39.00 | 18.00 | 23.80 | 4.31 | 45.50 | 11.00 | 9.12 | 2.22 | 15.64 | 38.89 | 61.68 | 48.49 |
| X | $P_2$ | 27.00 | 7.05 | 3.89 | 0.93 | 30.00 | 6.25 | 3.76 | 0.79 | 11.11 | 11.35 | 3.34 | 15.05 |
| Sugar Baby | $F_1$ | 32.00 | 11.50 | 9.82 | 2.01 | 38.50 | 9.00 | 7.03 | 1.55 | 20.31 | 21.74 | 28.41 | 22.89 |
| L.S.D. 0.05 | | 8.22 | 1.33 | 1.36 | 0.83 | 7.89 | 1.23 | 1.20 | 0.98 | N.S. | 10.10 | 10.16 | 10.15 |
| 0.01 | | 11.96 | 1.93 | 1.98 | 1.21 | 11.48 | 1.79 | 1.75 | 1.42 | N.S. | 14.66 | 14.75 | 14.73 |
| Sugar Baby | $P_1$ | 27.00 | 7.05 | 3.89 | 0.93 | 30.00 | 6.25 | 3.76 | 0.79 | 11.11 | 11.35 | 3.34 | 15.05 |
| X | $P_2$ | 39.00 | 18.00 | 23.80 | 4.31 | 45.50 | 11.00 | 9.12 | 2.22 | 15.64 | 38.89 | 61.68 | 48.49 |
| Charleston Gray | $F_1$ | 33.40 | 11.67 | 10.90 | 2.05 | 40.20 | 9.21 | 6.96 | 1.53 | 20.36 | 21.08 | 36.15 | 25.37 |
| L.S.D. 0.05 | | 7.94 | 1.64 | 3.64 | 1.46 | 7.56 | 1.97 | 1.77 | 0.72 | N.S. | 10.33 | 11.87 | 10.74 |
| 0.01 | | 11.55 | 2.39 | 5.30 | 2.13 | 11.00 | 2.87 | 2.58 | 1.05 | N.S. | 14.99 | 17.23 | 15.59 |
| Field capacity (%) | | 83.94 | | | | 22.15 | | | | | | | |

23.80 g and 4.31 g, respectively under normal irrigation, while these values were 45.50 cm, 11.00 $cm^3$, 9.12 g and 2.22 g, respectively under drought condition, followed by *cv* Giza-1(31.00 cm, 8.25 $cm^3$, 5.92 g and 1.07 g, respectively under normal irrigation and 35.10 cm, 6.50 $cm^3$, 4.33 g and o.99 g, respectively under drought conditions) and *cv* Sugar Baby (27.00 cm, 7.05 $cm^3$, 3.89 g and 0.93 g, respectively under normal irrigation and 30.00 cm, 6.25 $cm^3$, 3.76 g and 0.79 g, respectively under drought conditions). These results indicated that, cultivar Charleston Gray can be considered as a good source for drought resistance. The $F_1$ hybrids of all crosses under study (Table 1) had intermediate values between the two parents of each cross under normal irrigation or drought conditions. The results (Table 1) illustrate that, root length of all crosses population was longer under stress than that under normal conditions. It also interest to note that those trait had no maternal effect, as shown from reciprocal. Obtained results were supported by those of AL-Gosaibi (2001), who mentioned that roots did not grow deeper in the ground at high rate of drip irrigation regime and under high soil moisture content in the root zone.

With regard to the effect drought conditions of root behaviour (Table 1), the cultivar Charleston Gray gave the highest increase percentage in root length (15.64%) followed by *cv* Giza-1 (13.23%) and *cv* Sugar Baby (11.11%). The increase of $F_1$ root length percentage values was higher than the two parents for each cross. However, such increment did not reach to the significant level. On the other hand, there were highly significant decrease percentages in the root size, and both fresh and dry weights for $P_1$, $P_2$ and $F_1$ for each cross, under drought condition compared with normal irrigation condition. The cultivar Charleston Gray gave the highest decreases in the previously mentioned characters, followed by *cv* Giza-1 and *cv* Sugar Baby, respectively. The decrease percentage of $F_1$ root size, fresh weight and dry weight values were intermediate between the two parents of each cross under study (Table 1).

Data in Table 2 reveal that the potence ratio (P-ratio) calculated for root length, size, fresh and dry weight under water stress in pots experiment showed partial dominance toward low parent value in different crosses. Concerning heterosis, the data in Table 2 showed that, there were slight mid-parent heterosis for root length, size,

**Table 2 Potance ratio and heterosis of some root characteristics for the plants of different watermelon crosses evaluated under water stress conditions in pots experiment**

| Cross | Parameter | Root character | | | |
|---|---|---|---|---|---|
| | | Length (cm) | Size ($cm^3$) | Fresh weight (g) | Dry weight (g) |
| Charleston Gray X Giza-1 | P. ratio | 0.09 | 0.22 | 0.14 | 0.31 |
| | Heterosis | 1.12 | 5.71 | 4.75 | 11.18 |
| Giza-1 X Charleston Gray | P. ratio | 0.13 | 0.18 | 0.50 | 0.44 |
| | Heterosis | 1.74 | 4.69 | 17.53 | 16.15 |
| Charleston Gray X Sugar Baby | P. ratio | 0.10 | 0.16 | 0.22 | 0.07 |
| | Heterosis | 1.99 | 4.29 | 9.16 | 2.65 |
| Sugar Baby X Charleston Gray | P. ratio | 0.32 | 0.25 | 0.19 | 0.04 |
| | Heterosis | 6.49 | 6.72 | 8.07 | 1.32 |

fresh and dry weight in all crosses under study. The highest values of heterosis for root length and size (6.49% and 6.72%, respectively) were obtained from the cross Sugar Baby X Charleston Gray. Meanwhile, the lowest heterosis value (1.12%) was obtained from the cross Charleston Gray X Giza-1 for root length and (4.29%) from the cross Charleston Gray X Sugar Baby for root size. On the other hand, the highest values of heterosis for root fresh and dry weight were obtained from the plants of the cross Giza-1 X Charleston Gray, whereas, the lowest value (4.75%) was obtained from the plants of the cross Charleston Gray X Giza-1 for root fresh weight and (1.32%) from the cross Sugar Baby X Charleston Gray for root dry weight (Table 2). Similar findings were obtained by Rajan *et al.* (2002) who mentioned that various watermelon hybrids exhibited both positive and negative heterosis of varying magnitudes for all the economic characters.

**II. Field Experiment**

***1. Drought Resistance***

Results presented in Table 3 indicate highly significant differences between the parents; *i.e.*, *cvs* Charleston Gray, Giza-1, and Sugar Baby, concerning drought resistance. The average drought resistance ratio was 94.97% in case of the *cv* Charleston Gray, while it was 20.70% in case of the cultivar Giza-1 and 15.30% in case of the cultivar Sugar Baby. These results indicated that *cv* Charleston Gray was more resistant to drought than the other cultivars. High resistance of such cultivar may be due to high values of root length and root size (Table 1) and some other traits compared with other cultivars. Obtained results were supported by those of Zhang *et al.* (2002a), Zhang- Ming *et al.* (2002) and Zhang *et al.* (2002b) who mentioned that significant genetic differences were detected among watermelon germplasm concerning drought resistance.

The frequency distribution for drought resistance in the $F_1$,$F_2$, $BC_1$ and $BC_2$ populations of all crosses under study were contentious which indicated quantitative inheritance segregation pattern for this character (Table 3).

The $F_1$ means of all crosses were intermediate between the two parents for each cross. In addition, the potence ratio (P) values ranged from 0.14 to 0.82 (Table 4). These results indicated partial dominance for the high level of resistance over the low level. The frequency distribution for this character in the different populations of all crosses supported the partial dominance of high level of resistance.

The broad sense heritability estimates for drought resistance were 94.17%, 87.60%, 98.17% and 94.51%., while, the narrow sense heritability estimates were 62.24%, 55.91%, 50.34% and 62.65% for the crosses Charleston Gray X Giza-1, Giza-1 X Charleston Gray, Charleston Gray X Sugar Baby and Sugar Baby X Charleston Gray, respectively (Table 4). These results indicate that the additive genetic variation associated with drought resistance was more than the non-additive and environmental variation. Based on these results, selection for high resistance to drought can be made based on the performance of individual plants in the segregating generations. The number of effective gene pairs controlling drought resistance ranged from one to three in all crosses under study (Table 4).

**Table 3 Frequency distributions for plant reaction to drought resistance in parents, $F_1$, $F_2$, $Bc_1$ and $Bc_2$ segregations derived from some watermelon crosses.**

| Cross | Population | Upper class limits (% of healthy leaves/plant under water stress) | | | | | | | | | | Total No.of plants | Mean±SE | Variance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | | | |
| Charleston Gray X Giza-1 | $P_1$ | - | - | - | - | - | - | - | - | 5 | 25 | 30 | 94.77±3.86 | 19.71 |
| | $P_2$ | - | 20 | 10 | - | - | - | - | - | - | - | 30 | 20.70±3.86 | 15.76 |
| | $F_1$ | - | - | - | - | - | - | - | 10 | 20 | - | 30 | 88.10±3.86 | 35.64 |
| | $F_2$ | - | 1 | 4 | 6 | 16 | 16 | 22 | 25 | 16 | 14 | 120 | 68.65±1.93 | 506.83 |
| | $Bc_1(F_1XP_1)$ | - | - | 9 | 16 | 7 | 6 | 9 | 13 | - | - | 60 | 59.33±2.73 | 381.20 |
| | $Bc_2(F_1XP_2)$ | - | 19 | 13 | 3 | 9 | 8 | 8 | - | - | - | 60 | 44.75±2.73 | 316.24 |
| L.S.D. | 0.05 | | | | | | | | | | | | 29.86 | |
| | 0.01 | | | | | | | | | | | | 45.23 | |
| Giza-1 X Charleston Gray | $P_1$ | - | 20 | 10 | - | - | - | - | - | - | - | 30 | 20.70±3.48 | 15.76 |
| | $P_2$ | - | - | - | - | - | - | - | - | 5 | 25 | 30 | 94.77±3.48 | 19.71 |
| | $F_1$ | - | - | - | 4 | 5 | 13 | 8 | - | - | - | 30 | 63.07±3.48 | 127.46 |
| | $F_2$ | 5 | 7 | 7 | 8 | 9 | 10 | 14 | 28 | 23 | 9 | 120 | 62.46±1.74 | 438.07 |
| | $Bc_1(F_1XP_1)$ | - | - | - | 8 | 8 | 12 | 8 | 7 | 17 | - | 60 | 66.50±2.46 | 330.88 |
| | $Bc_2(F_1XP_2)$ | - | - | - | - | 7 | 9 | 4 | 8 | 18 | 14 | 60 | 75.60±2.46 | 300.33 |
| L.S.D. | 0.05 | | | | | | | | | | | | 26.95 | |
| | 0.01 | | | | | | | | | | | | 40.83 | |
| Charleston Gray X Sugar Baby | $P_1$ | - | - | - | - | - | - | - | - | 5 | 25 | 30 | 94.77±4.01 | 19.71 |
| | $P_2$ | 4 | 26 | - | - | - | - | - | - | - | - | 30 | 15.30±4.01 | 15.60 |
| | $F_1$ | - | - | - | - | - | - | 15 | 15 | - | - | 30 | 70.30±4.01 | 19.80 |
| | $F_2$ | 6 | 8 | 12 | 11 | 28 | 12 | 16 | 11 | 10 | 6 | 120 | 54.53±2.01 | 1003.62 |
| | $Bc_1(F_1XP_1)$ | - | - | - | 2 | 7 | 8 | 15 | 10 | 18 | - | 60 | 65.82±2.84 | 811.28 |
| | $Bc_2(F_1XP_2)$ | - | - | - | 6 | 11 | 16 | 15 | 12 | - | - | 60 | 57.78±2.84 | 690.72 |
| L.S.D | 0.05 | | | | | | | | | | | | 31.05 | |
| | 0.01 | | | | | | | | | | | | 47.05 | |
| Sugar Baby X Charleston Gray | $P_1$ | 4 | 26 | - | - | - | - | - | - | - | - | 30 | 15.30±4.04 | 15.60 |
| | $P_2$ | - | - | - | - | - | - | - | - | 5 | 25 | 30 | 94.77±4.04 | 19.71 |
| | $F_1$ | - | - | - | - | 7 | 18 | 5 | - | - | - | 30 | 67.70±4.04 | 92.16 |
| | $F_2$ | 6 | 4 | 5 | 4 | 12 | 12 | 19 | 26 | 25 | 7 | 120 | 60.98±2.02 | 774.51 |
| | $Bc_1(F_1XP_1)$ | - | - | 16 | 8 | 11 | 13 | 10 | 2 | - | - | 60 | 61.73±2.86 | 466.99 |
| | $Bc_2(F_1XP_2)$ | | - | 9 | 10 | 6 | 10 | 13 | 7 | 5 | - | 60 | 69.47±2.86 | 596.82 |
| L.S.D. | 0.05 | | | | | | | | | | | | 31.26 | |
| | 0.01 | | | | | | | | | | | | 47.35 | |

Table 4 Potance ratio, broad and narrow sense heritability and minimum number of effective gene pairs estimates for the studied characteristics in some watermelon crosses

| Cross | Character / Parameter | Drought resistance | Leaf area | Total yield/ plant | Leaf praline content |
|---|---|---|---|---|---|
| Charleston Gray X Giza-1 | P. ratio | 0.82 | 0.42 | -0.14 | - |
| | BSH | 94.17 | 70.57 | 59.82 | - |
| | NSH | 62.24 | 53.00 | 25.20 | - |
| | No. of genes | 2 | 3 | 1 | - |
| Giza-1 X Charleston Gray | P. ratio | 0.14 | -0.15 | -0.33 | 0.24 |
| | BSH | 87.60 | 70.38 | 66.86 | 81.26 |
| | NSH | 55.91 | 49.59 | 25.74 | 76.72 |
| | No. of genes | 3 | 3 | 1 | 3 |
| Charleston Gray X Sugar Baby | P. ratio | 0.38 | -0.41 | 0.01 | - |
| | BSH | 98.17 | 79.46 | 75.79 | - |
| | NSH | 50.34 | 56.49 | 29.81 | - |
| | No. of genes | 1 | 2 | 2 | - |
| Sugar Baby X Charleston Gray | P. ratio | 0.32 | -0.13 | -0.05 | 0.11 |
| | BSH | 94.51 | 98.64 | 62.47 | 92.20 |
| | NSH | 62.65 | 67.27 | 29.03 | 80.89 |
| | No. of genes | 2 | 4 | 7 | 2 |

***2. Leaf Area***

Data presented in Table 5 indicate that the cultivar Charleston Gray had the lowest area of the leaf (16.79 $cm^2$) comparing to the other parental genotypes, *cv* Giza-1 (55.02 $cm^2$) and *cv* Sugar Baby (76.57 $cm^2$).

The potence ratio (P) calculated for the different crosses (Table 4) indicated partial dominance towards low leaf area in all crosses. There were highly significant differences between $F_1$ and the two parents in all crosses under study.

The frequency distribution for leaf area of plants in $F_2$, $Bc_1$ and $Bc_2$ populations for all crosses indicated quantitative inheritance pattern for this character. Leaf area may be one of several factors responsible for drought resistance. Leaves with small area will have smaller water loss ratio (Fig. 1). Leaf area can be considered as one of the components for drought resistance, which may have direct or indirect effect on resistance to drought (Turner and Kramer, 1980).

With regard to broad and narrow sense heritability, all crosses had values above 70.38% and 49.59%, respectively, (Table 4). These indicated that the greater portion of phenotypic variance was due to additive genetic variance while smaller part was due to non-additive and environmental components. Accordingly, selection for this component of resistance to drought in segregating generations of crosses between watermelon germplasm would be effective.

Concerning number of the gene pairs, data in Table 4 showed that the minimum number of gene pairs differentiating the two parental cultivars for leaf area ranged from two to four.

### *3. Leaf water loss ratio*

Data illustrated in Fig. 1 show that there were highly significant differences between $P_1$, $P_2$, $F_1$, $F_2$, $Bc_1$ and $Bc_2$ populations of all crosses under study concerning leaf water loss ratio after different times from leaf detachment from the plant under laboratory condition. The cultivar Charleston Gray had the lowest leaf water loss ratio (6.15%, 6.01%, 5.81%, 5.56% and 5.23% after two, four, six, eight and ten hours, from leaf detachment from the plant, respectively); while the cultivar Sugar Baby had the highest leaf water loss ratio (9.60%, 8.81%, 7.80%, 7.72% and 7.38% after two, four, six, eight and ten hours, from leaf separation from the plant, respectively) (Fig. 1), followed by the cultivar Giza-1 which had leaf water loss ratio of 7.64%, 7.43%, 7.24%, 7.23% and 6.76% after two, four, six, eight and ten, hours from leaf detachment from the plant, respectively. These results indicated that the parental cultivar Charleston Gray was the best source for genes controlling the low leaf water loss ratio which can be considered as a component for drought resistance. On the other hand, leaf water loss ratio of the $F_1$ plants was intermediate between the two parental cultivars for each cross (Fig. 1).

With regard to backcrosses, leaves of $BC_1$ plants had the low values of leaf water loss ratio compared with the plants of $Bc_2$ in the crosses Charleston Gray X Giza-1 and Charleston Gray X Sugar Baby, on the other hand, leaves of $BC_1$ plants had the high values of leaf water loss ratio compared with the plants of $BC_2$ in their reciprocal crosses under different times in laboratory conditions.

Table 5 frequency distributions. for leaf area in different populations for some watermelon crosses

| Cross | Population | Range of leaf area (cm²) 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | Total No.of plants | Mean ± SE | Variance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Charleston Gray X Giza-1 | $P_1$ | 20 | 10 | - | - | - | - | - | - | 30 | 16.79±1.68 | 25.00 |
| | $P_2$ | - | - | - | 12 | 18 | - | - | - | 30 | 55.02±1.68 | 37.09 |
| | $F_1$ | - | 30 | - | - | - | - | - | - | 30 | 27.91±1.68 | 110.46 |
| | $F_2$ | 16 | 19 | 27 | 23 | 17 | 8 | 9 | 1 | 120 | 31.00±0.84 | 195.45 |
| | $Bc_1(F_1XP_1)$ | 25 | 12 | 23 | - | - | - | - | - | 60 | 25.60±1.19 | 103.23 |
| | $Bc_2(F_1XP_2)$ | - | 20 | 26 | 14 | - | - | - | - | 60 | 32.55±1.19 | 184.09 |
| L.S.D. 0.05 | | | | | | | | | | | 12.98 | |
| 0.01 | | | | | | | | | | | 19.67 | |
| Giza-1 X Charleston Gray | $P_1$ | - | - | - | 12 | 18 | - | - | - | 30 | 55.02±2.27 | 37.09 |
| | $P_2$ | 20 | 10 | - | - | - | - | - | - | 30 | 16.79±2.27 | 25.00 |
| | $F_1$ | - | 11 | 19 | - | - | - | - | - | 30 | 33.07±2.27 | 31.81 |
| | $F_2$ | 7 | 14 | 26 | 23 | 16 | 14 | 19 | 1 | 120 | 39.69±1.13 | 105.68 |
| | $Bc_1(F_1XP_1)$ | - | - | 13 | 16 | 13 | 18 | - | - | 60 | 39.22±1.60 | 53.69 |
| | $Bc2(F_1XP_2)$ | 8 | 15 | 17 | 20 | - | - | - | - | 60 | 34.07±1.60 | 105.26 |
| L.S.D. 0.05 | | | | | | | | | | | 17.56 | |
| 0.01 | | | | | | | | | | | 26.61 | |
| Charleston Gray X Sugar Baby | $P_1$ | 20 | 10 | - | - | - | - | - | - | 30 | 16.79±2.46 | 25.00 |
| | $P_2$ | - | - | - | - | - | 8 | 9 | 13 | 30 | 76.57±2.46 | 103.23 |
| | $F_1$ | - | 16 | 8 | 6 | - | - | - | - | 30 | 34.51±2.46 | 167.70 |
| | $F_2$ | 14 | 27 | 29 | 23 | 11 | 12 | 2 | 2 | 120 | 36.61±1.23 | 480.23 |
| | $Bc_1(F_1XP_1)$ | - | 22 | 18 | 8 | 12 | - | - | - | 60 | 36.61±1.74 | 343.52 |
| | $Bc_2(F_1XP_2)$ | - | - | 1 | 35 | 16 | 8 | - | - | 60 | 43.09±1.74 | 345.68 |
| L.S.D. 0.05 | | | | | | | | | | | 19.07 | |
| 0.01 | | | | | | | | | | | 28.88 | |
| Sugar Baby X Charleston Gray | $P_1$ | - | - | - | - | - | 8 | 9 | 13 | 30 | 76.57±2.52 | 103.23 |
| | $P_2$ | 20 | 10 | - | - | - | - | - | - | 30 | 16.79±2.52 | 25.00 |
| | $F_1$ | - | - | 16 | 14 | - | - | - | - | 30 | 42.91±2.52 | 126.56 |
| | $F_2$ | 18 | 20 | 31 | 19 | 14 | 16 | 2 | - | 120 | 43.52±1.26 | 6244.30 |
| | $Bc_1(F_1XP_1)$ | - | - | 18 | 23 | 19 | - | - | - | 60 | 41.29±1.78 | 158.89 |
| | $Bc_2(F_1XP_2)$ | - | 17 | 12 | 28 | 3 | - | - | - | 60 | 35.13±1.78 | 165.38 |
| L.S.D. 0.05 | | | | | | | | | | | 19.47 | |
| 0.01 | | | | | | | | | | | 29.49 | |

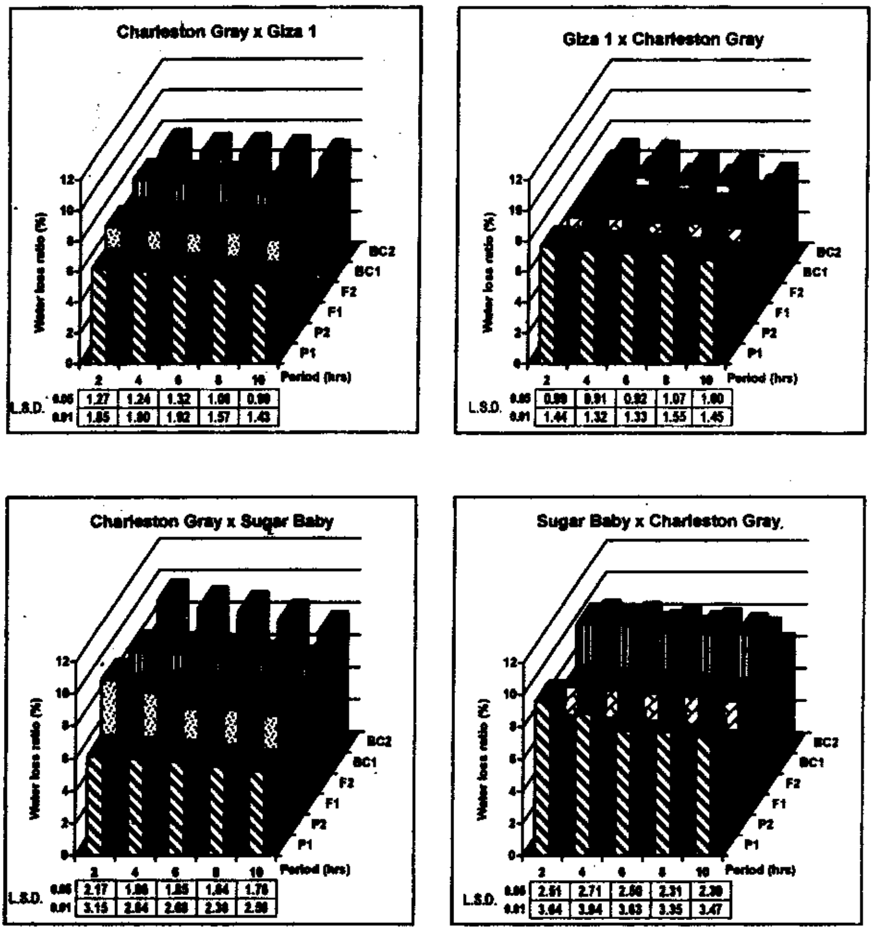


**Fig. 1** Leaf water loss ratio in parents, $F_1$, $F_2$, $Bc_1$ and $Bc_2$ segregation derived from some watermelon crosses under water stress in laboratory conditions

***4. Total yield per plant***

Results illustrated in Table 6 indicate that the parental cultivar Charleston Gray had highest total yield/plant under water stress (11.57 kg), followed in descending order by Giza-1 (6.95 kg) and Sugar Baby (3.83 kg). These results indicated that the cultivar Charleston Gray can be a source for genes controlling high total yield per plant under water stress. The total yield/plant of the $F_1$ populations of all crosses under study was intermediate between the two parents for each cross. These results are supported by the relative potence ratio of gene set ratios calculated for this character in the present study, which were -0.14, -0.33 and -0.05(partial dominance toward low yielding parent) and 0.01 (slightly partial dominance toward high yielding parent), for the crosses Charleston Gray X Giza-1, Giza-1 X Charleston Gray, Sugar Baby X Charleston Gray and Charleston Gray X Sugar Baby, respectively (Table 4).

In all crosses, frequency distribution for total yield/plant in the $P_1$, $P_2$, $F_1$, $F_2$, $Bc_1$ and $Bc_2$ populations indicated quantitative inheritance pattern for this character (Table 6).

The broad sense heritability estimates for total yield per plant were 59.82%, 66.86%, 75.79% and 62.47% in the crosses Charleston Gray X Giza-1, Giza-1 X Charleston Gray, Charleston Gray X Sugar Baby and Sugar Baby X Charleston Gray, respectively (Table 4). On the other hand, the narrow sense heritability estimates ranged from 25.20% in the cross Charleston Gray X Giza-1, to 29.03%, in the cross Sugar Baby X Charleston Gray (Table 4). These results indicated that the effects of environment and non-additive type of gene action had a great influence on the variation observed for this character. Based on these results, selection for high total yield/plant in the segregating generations should be performed based on family mean basis in replicated experiments.

Numbers of minimum genes controlling total yield/plant ranged from one to seven gene pairs.

***5. Leaf proline content***

Significant differences were observed between each of Giza-1, Charleston Gray and Sugar Baby cultivars in their leaf proline content (Table 7). The cultivar Charleston Gray had high leaf proline content (35.94 mg/100g D.W.), while the cultivar Sugar Baby had lower amount (16.55 mg/100g D.W.). Obtaining a verity with high leaf proline content and resistance to water stress (Table 3) will be of

Table 6 Frequency distributions for total yield/plant in different populations for some watermelon crosses

| Cross | Popula. | Range of total yield/plant(kg) 4 | 6 | 8 | 10 | 12 | 14 | 16 | Total No.of plants | Mean±SE | Variance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Charleston Gray X Giza-1 | $P_1$ | - | 3 | 27 | - | - | - | - | 30 | 11.57±0.44 | 0.16 |
| | $P_2$ | - | - | - | - | 22 | 8 | - | 30 | 6.95±0.44 | 9.92 |
| | $F_1$ | - | - | 8 | 13 | 9 | - | - | 30 | 8.93±0.44 | 8.24 |
| | $F_2$ | 1 | 19 | 39 | 30 | 16 | 11 | 4 | 120 | 7.80±0.22 | 15.20 |
| | $Bc_1$ | 10 | 24 | 13 | 13 | - | - | - | 60 | 7.91±0.31 | 12.76 |
| | $Bc_2$ | - | 15 | 13 | 13 | 19 | - | - | 60 | 8.16±0.31 | 13.81 |
| L.S.D. | 0.05 | | | | | | | | | 3.41 | |
| | 0.01 | | | | | | | | | 5.17 | |
| Giza-1 X Charleston Gray | $P_1$ | - | - | - | - | 22 | 8 | - | 30 | 6.95±0.44 | 9.92 |
| | $P_2$ | - | 3 | 27 | - | - | - | - | 30 | 11.57±0.44 | 0.16 |
| | $F_1$ | - | - | 18 | 12 | - | - | - | 30 | 8.49±0.44 | 14.06 |
| | $F_2$ | 15 | 19 | 40 | 40 | 2 | 2 | 2 | 120 | 7.40±0.22 | 24.28 |
| | $Bc_1$ | - | 19 | 20 | 21 | - | - | - | 60 | 8.86±0.31 | 19.41 |
| | $Bc_2$ | 4 | 15 | 13 | 20 | 8 | - | - | 60 | 7.57±0.31 | 22.90 |
| L.S.D. | 0.05 | | | | | | | | | 3.39 | |
| | 0.01 | | | | | | | | | 5.14 | |
| Charleston Gray X Sugar Baby | $P_1$ | - | 3 | 27 | - | - | - | - | 30 | 11.57±0.43 | 0.16 |
| | $P_2$ | 21 | 9 | - | - | - | - | - | 30 | 3.83±0.43 | 2.13 |
| | $F_1$ | 8 | 11 | 11 | - | - | - | - | 30 | 7.68±0.43 | 1.56 |
| | $F_2$ | 15 | 21 | 30 | 32 | 11 | 6 | 5 | 120 | 6.09±0.22 | 5.30 |
| | $Bc_1$ | - | 20 | 24 | 16 | - | - | - | 60 | 6.38±0.30 | 4.16 |
| | $Bc_2$ | 35 | 4 | 18 | 3 | - | - | - | 60 | 5.75±0.30 | 4.86 |
| L.S.D. | 0.05 | | | | | | | | | 3.34 | |
| | 0.01 | | | | | | | | | 5.06 | |
| Sugar Baby X Charleston Gray | P1 | 21 | 9 | - | - | - | - | - | 30 | 3.83±0.46 | 2.13 |
| | $P_2$ | - | 3 | 27 | - | - | - | - | 30 | 11.57±0.46 | 0.16 |
| | $F_1$ | 3 | 9 | 18 | - | - | - | - | 30 | 7.51±0.46 | 8.18 |
| | $F_2$ | 15 | 20 | 25 | 25 | 16 | 12 | 7 | 120 | 6.73±0.23 | 9.30 |
| | $Bc_1$ | 25 | 9 | 13 | 13 | - | - | - | 60 | 5.46±0.33 | 8.02 |
| | $Bc_2$ | - | 30 | 17 | 13 | - | - | - | 60 | 6.50±0.33 | 7.88 |
| L.S.D. | 0.05 | | | | | | | | | 3.57 | |
| | 0.01 | | | | | | | | | 5.41 | |

Table 7 Frequency distributions for leaf proline content in different populations for some watermelon crosses under drought conditions

| Cross | Population | Upper class limits (mg/100g D.W.) 15 | 20 | 25 | 30 | 35 | 40 | 45 | Total No. of plants | Mean ±SE | Variance |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Giza-1 X Charleston Gray | $P_1$ | 8 | 22 | - | - | - | - | - | 30 | 18.15±1.10 | 1.97 |
| | $P_2$ | - | - | - | - | - | 25 | 5 | 30 | 35.94±1.10 | 1.41 |
| | $F_1$ | - | - | - | 23 | 7 | - | - | 30 | 29.17±1.10 | 19.49 |
| | $F_2$ | 1 | 19 | 18 | 32 | 21 | 20 | 9 | 120 | 26.86±0.55 | 39.22 |
| | $BC_1(F_1XP_1)$ | - | - | 25 | 10 | 25 | - | - | 60 | 32.93±0.78 | 25.60 |
| | $BC_2(F_1XP_2)$ | - | - | - | - | 21 | 39 | - | 60 | 35.12±0.78 | 22.75 |
| LSD 0.05 | | | | | | | | | | 8.50 | |
| 0.01 | | | | | | | | | | 12.89 | |
| Sugar Baby X Charleston Gray | $P_1$ | 11 | 19 | - | - | - | - | - | 30 | 16.55±1.17 | 0.49 |
| | $P_2$ | - | - | - | - | - | 25 | 5 | 30 | 35.94±1.17 | 1.41 |
| | $F_1$ | - | - | - | 24 | 6 | - | - | 30 | 27.35±1.17 | 7.41 |
| | $F_2$ | 4 | 8 | 15 | 15 | 49 | 24 | 5 | 120 | 25.11±0.58 | 39.72 |
| | $BC_1(F_1XP_1)$ | - | - | 24 | 22 | 14 | - | - | 60 | 28.64±0.83 | 20.91 |
| | $BC_2(F_1XP_2)$ | - | - | - | 21 | 13 | 26 | - | 60 | 31.15±0.83 | 26.40 |
| LSD 0.05 | | | | | | | | | | 9.05 | |
| 0.01 | | | | | | | | | | 13.71 | |

great importance especially when selecting for drought resistance in segregating populations.

The potence ratio values in the crosses Giza-1 X Charleston Gray and Sugar Baby X Charleston Gray were 0.24 and 0.11 which indicated slight partial dominance for high leaf proline content (Table 4). The average leaf proline content of $F_1$ plants (29.17 and 27.35 mg/100g D.W.) were much higher than that of the low leaf proline content cultivars, Sugar Baby (16.55 mg/100g D.W.) and Giza-1 (18.15 mg/100g D.W.), (Table 7). These results indicate the possibility of improving the selection for drought resistance by using leaf proline content as a selection criteria. These result was supported by backcrosses results where leaf proline content of $BC_2$ populations in the crosses Giza-1 X Charleston Gray and Sugar Baby X Charleston Gray were higher than that of $BC_1$ populations (Table 7).

The frequency distribution for leaf proline content in the $F_2$ populations of the crosses Giza-1 X Charleston Gray and Sugar Baby X Charleston Gray (Table 7) indicated that this character was inherited quantitatively.

High estimate of broad sense heritability (81.26% and 92.20%) and narrow sense heritability (76.72% and 80.89%) in the crosses Giza-1 X Charleston Gray and Sugar Baby X Charleston Gray for leaf proline content, respectively (Table 4) which indicated that selection individual watermelon plants with high leaf proline content in the segregating generations will be effective in improving the leaf proline content of watermelon plants.

The minimum number of effective genes controlling leaf proline content in the crosses Giza-1 X Charleston Gray and Sugar Baby X Charleston Gray were ranged from two to three gene pairs.

### *6. Simple correlation*

Significant positive correlation was found between drought resistance and each of fruit weight and total yield/plant in the $F_2$ populations of the all crosses under this study (Table 8). Whereas, there was highly significant negative correlation between drought resistance and each of fruit set percentage, leaf water loss ratio, rind thickness and leaf area. These results confirmed those obtained by Orta *et al.* (2003) who showed that the yield was directly correlated with mean of crop water stress index values

Fruit weight was significantly and positively correlated with total yield/ plant. On the other hand, there were significant negative correlation between fruit weight and each of leaf water loss ratio and rind thickness in the $F_2$ plants of all crosses. Many investigators working on this character as Watanabe *et al.* (2001, 2003) who found that fruit weight was closely related to total leaf area per plant.

Highly significant positive correlation was found between leaf water loss ratio and each of rind thickness and leaf area. Meanwhile, significant negative correlation was detected between leaf water loss ratio and total yield/plant in all crosses under this study (Table 8).

Leaf proline content was positively correlated with each of drought resistance, fruit length and diameter, and total yield/plant. Meanwhile, significant negative correlation was found between leaf proline content and each of fruit set percentage, leaf water loss ratio, rind thickness and leaf area in the $F_2$ plants of the crosses Giza-1X Charleston Gray and Sugar Baby X Charleston Gray (Table 8). The relationship will ease the process of selection for drought resistance.

**Table 8 Correlation coefficients between some measurements of drought resistance in the $F_2$ of some watermelon crosses**

| Cross | Characters | No. of branches | Earliness | Fruit set percentage | Fruit length | Fruit diameter | Fruit weight | Leaf water loss ratio | Rind thickness | Total yield/plant | Leaf area | Proline content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Charleston Gray x Giza-1 | Drought resistance | 0.193* | -0.039 | -0.266** | 0.029 | 0.026 | 0.297** | -0.935** | 0.259** | 0.412** | -0.230** | |
| | No. of branches | | 0.021 | -0.230** | 0.105 | 0.040 | -0.217* | -0.126 | 0.361** | -0.186* | 0.469** | |
| | Earliness | | | -0.116 | 0.28** | 0.240** | 0.157 | 0.060 | 0.200* | -0.018 | 0.178* | |
| | Fruit set percentage | | | | -0.221* | -0.050 | 0.032 | 0.208* | -0.306** | 0.187* | -0.216* | |
| | Fruit length | | | | | 0.848** | 0.736** | 0.003 | -0.164 | 0.261** | 0.358** | |
| | Fruit diameter | | | | | | 0.717** | 0.016 | -0.256** | 0.326** | 0.266** | |
| | Fruit weight | | | | | | | -0.400** | -0.543** | 0.649** | 0.139 | |
| | Leaf water loss ratio | | | | | | | | 0.239** | -0.680** | 0.632** | |
| | Rind thickness | | | | | | | | | -0.393** | 0.197* | |
| | Total yield/plant | | | | | | | | | | -0.290 | |
| Giza-1 X Charleston Gary | Drought resistance | 0.011 | -0.066 | -0.264** | 0.342** | 0.216* | 0.382** | -0.957** | -0.254** | 0.467** | -0.246** | 0.961** |
| | No. of branches | | -0.447** | -0.543** | 0.033 | 0.080 | -0.101 | -0.062 | 0.042 | 0.259** | 0.580** | -0.038 |
| | Earliness | | | 0.408** | -0.151 | -0.132 | 0.097 | 0.075 | -0.003 | -0.138 | -0.510** | -0.046 |
| | Fruit set percentage | | | | -0.217* | -0.200* | -0.117 | 0.094 | 0.098 | -0.080 | -0.440** | -0.331** |
| | Fruit length | | | | | 0.764** | 0.806** | -0.365** | -0.380** | 0.387** | 0.027 | 0.318** |
| | Fruit diameter | | | | | | 0.476** | -0.257** | -0.412** | 0.386** | 0.100 | 0.216* |
| | Fruit weight | | | | | | | -0.261** | -0.679** | 0.461** | -0.103 | 0.146 |
| | Leaf water loss ratio | | | | | | | | 0.234** | -0.675** | 0.410** | -0.926** |
| | Rind thickness | | | | | | | | | -0.375** | 0.098 | -0.198* |
| | Total yield/plant | | | | | | | | | | -0.313** | 0.261** |
| | Leaf area | | | | | | | | | | | -0.268** |
| Charleston Gray X Baby Sugar | Drought resistance | 0.102 | 0.095 | -0.238** | 0.162 | 0.014 | 0.269** | -0.967** | -0.262** | o.436** | -0.276** | |
| | No. of branches | | -0.505** | -0.518** | -0.426** | -0.303** | -0.467** | -0.142 | 0.344** | -0.426** | -0.328** | |
| | Earliness | | | 0.421** | 0.105 | o.127 | 0.346** | -0.065 | -0.236** | 0.119 | 0.565** | |
| | Fruit set percentage | | | | 0.109 | 0.053 | 0.111 | 0.170 | 0.107 | 0.234** | 0.297** | |
| | Fruit length | | | | | 0.653** | 0.931** | -0.127 | -0.748** | 0.486** | -0.200* | |
| | Fruit diameter | | | | | | 0.675** | 0.017 | -0.305** | 0.451** | -0.025 | |
| | Fruit weight | | | | | | | -0.269** | -0.710** | 0.574** | 0.007 | |
| | Leaf water loss ratio | | | | | | | | 0.258** | -0.282** | 0.269** | |
| | Rind thickness | | | | | | | | | -0.229** | 0.022 | |
| | Total yield/plant | | | | | | | | | | -0.400** | |
| Sugar Baby X Charleston Gray | Drought resistance | 0.247** | -0.162 | -0.295** | 0.122 | -0.124 | 0.315** | -0.970** | -0.296** | 0.463** | -0.227** | 0.987** |
| | No. of branches | | 0.217* | -0.310** | -0.122 | -0.160 | -0.159 | -0.244** | 0.021 | 0.084 | 0.209* | 0.251** |
| | Earliness | | | -0.199* | 0.045 | 0.091 | 0.088 | 0.154 | -0.086 | 0.186* | 0.106 | -0.163 |
| | Fruit set percentage | | | | -0.196* | -0.096 | -0.226** | 0.281** | 0.252** | -0.138 | 0.063 | -0.269** |
| | Fruit length | | | | | 0.803** | 0.812** | -0.106 | -0.731** | 0.518** | -0.255** | 0.230** |
| | Fruit diameter | | | | | | 0.762** | 0.162 | -0.471** | 0.441** | -0.213* | 0.304** |
| | Fruit weight | | | | | | | -0.309** | -0.801** | 0.591** | -0.053 | 0.131 |
| | Leaf water loss ratio | | | | | | | | 0.329** | -0.272** | 0.231** | -0.962** |
| | Rind thickness | | | | | | | | | -0.450** | 0.060 | -0.309** |
| | Total yield/plant | | | | | | | | | | 0.699** | 0.197* |
| | Leaf area | | | | | | | | | | | -0.236** |

* Significant at 5% level of significance **Significant at 1% level of significance

**Table 9 Multiple regression coefficients between drought resistance and its studies components in the $F_2$ of some watermelon crosses**

| Cross | Involved indepent variables | $R^2$ | Multiple -R | Significance |
|---|---|---|---|---|
| Charleston Gray X Giza-1 | No. of branches<br>Earliness<br>Fruit set percentage<br>Fruit weight<br>Leaf water loss ratio<br>Total yield/plant<br>Leaf area | 0.882 | 0.939 | ** |
| Giza- 1 X Charleston Gray | No. of branches<br>Earliness<br>Fruit set percentage<br>Fruit weight<br>Leaf water loss ratio<br>Total yield/plant<br>Leaf area | 0.919 | 0.959 | ** |
| Charleston Gray X Sugar Baby | No. of branches<br>Earliness<br>Fruit set percentage<br>Fruit weight<br>Leaf water loss ratio<br>Total yield/plant<br>Leaf area | 0.978 | 0.989 | ** |
| Sugar Baby X Charleston Gray | No. of branches<br>Earliness<br>Fruit set percentage<br>Fruit weight<br>Leaf water loss ratio<br>Total yield/plant<br>Leaf area | 0.941 | 0.970 | ** |

**Significant at 1% level of significance

### *7. Selection Index For Drought Resistance*

Data presented in Table 9 show the results of the multiple regression analysis which indicated that there was significant linear relationship between resistance to drought and the combined effect of number of branches/plant, number of days from sowing date to the first flower anthesis, fruit set percentage, fruit weight, leaf water loss ratio, total yield/plant and leaf area, in the crosses Charleston Gray X Giza-1 and Charleston Gray X Sugar Baby as well as their reciprocal crosses. These results indicated that 88.2%, 91.9%, 97.8% and 94.1% of the variation in resistance to drought observed in the $F_2$ populations of the four crosses under study were attributed to the genetic factor in the plant. It means that there is a real relationship between drought resistance and the combined effect of number of branches/plant, number of days from planting date to the first flower anthesis, fruit set percentage, fruit weight, leaf water loss ratio, total yield/plant and leaf area. Therefore, based on the results of the multiple regression analysis Table 9, the above mentioned characters should be considered together as a selection index when selecting for high resistance to drought.

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# دراسات وراثية على مقاومة الجفاف فى البطيخ

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تم تقييم نباتات الآباء والجيل الأول والجيل الثاني والتهجين الرجعى لنباتات الجيل الأول مع الأب الأول ، والتهجين الرجعى لنباتات الجيل الأول مع الأب الثاني وذلك في الهجينين شارلستون جراى x جيزه-١ و شارلستون جراى x شوجر بيبى وكذلك أيضا الهجينين العكسيين لهذين الهجينين وذلك في تجربه بالحقل وأخرى بالأصص وذلك لدراسة توريث وطبيعة المقاومة للجفاف وبعض الصفات المكونة للمقاومة في نباتات البطيخ. وجدت اختلافات معنوية في النسبة المئوية للزيادة في طول الجذر تحت ظروف الجفاف بالمقارنة بطول الجذر تحت ظروف الري المنتظم وذلك في نباتات الأب الأول والأب الثاني ونباتات الجيل الأول لكل هجين. وعلى العكس من ذلك وجدت اختلافات معنوية في النسبة المئوية للنقص في حجم الجذر ووزن الجذر الطازج ، وزن الجذر الجاف في نباتات الأب الأول والأب الثاني ، ونباتات الجيل الأول لكل هجين وذلك تحت ظروف الجفاف بالمقارنة بالري المنتظم. وجد أن صفات المقاومة للجفاف ومساحة الورقة ومحصول النبات الكلي ومحتوى أوراق النبات من الحامض الامينى برولين تورث كمياً. كما وجد أن هناك سيادة جزئيه للمستوى العالي للمقاومة للجفاف ، محتوى أوراق النبات من الحامض الامينى برولين على المستوى المنخفض من المقاومة والحامض الامينى ، بينما كان هناك سيادة جزئيه للمستوى المنخفض من مساحة الورقة ومحصول النبات الكلي على المستوى العالي من مساحة الورقة ومحصول النبات الكلي ، وجد أن طبيعة التوريث بمعناها الواسع والضيق بالنسبة لصفات المقاومة للجفاف ، مساحة الورقة ومحصول النبات الكلى ، محتوى أوراق النبات من الحامض الاميني برولين تراوحت ما بين متوسطه إلى عالية ، كذلك فان عدد أزواج العوامل الوراثية التي تتحكم في توريث صفات المقاومة للجفاف ، ومساحة الورقة ، محصول النبات الكلى ، محتوى أوراق النبات من الحامض الامينى برولين تراوح بين ١-٣ و٢-٤ و١-٧ و٢-٣ أزواج على التوالي. هناك ارتباط معنوي موجب بين المقاومة للجفاف وكل من وزن الثمرة ، محصول النبات الكلى، بينما هناك ارتباط معنوي سالب بين المقاومة للجفاف وكل من النسبة المئوية للعقد ، معدل فقد الورقة للماء ، سمك قشرة الثمرة ، مساحة الورقة ، ووجد أن محتوى الأوراق من البرولين يرتبط ارتباطاً معنوياً موجباً مع كل من المقاومة للجفاف ، طول وقطر الثمرة ، محصول النبات الكلى. وهناك علاقة خطيه معنوية موجبه بين التأثير المشترك للصفات الآتيه على المقاومة للجفاف وهى عدد أفرع النبات ، عدد الأيام من الزراعة حتى تفتح أول زهره على النبات ، النسبة المئوية لعقد الثمار، وزن الثمرة ، معدل فقد الورقة للماء ، محصول النبات الكلى ، المساحة الورقية مما يدل على إمكانية استخدام هذه الصفات في عمل دليل انتخاب ذو كفاءة للوصول إلى درجات عالية من المقاومة للعطش في البطيخ.