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# SELECTION FOR DROUGHT TOLERANCE IN SOME TEMPERATE AND SUBTROPICAL MAIZE POPULATIONS

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## ABSTRACT

Nine temperate and subtropical maize populations had undergone one cycle of S1-family selection for drought tolerance. The original (C0) and improved (C1) populations were evaluated under normal (flooding) and stress irrigation conditions at Sids and Nubaria Agric. Res. Stations in 2000.

Results showed that the behavior of C0 and C1 populations under the two irrigation levels differed from one population to another, moreover, response of different traits to selection for drought tolerance varied considerably among populations and between the two irrigation levels. Reduction in yield under drought stress was less for C1 (29.6%) of Giza 2 C6, Giza 2 C8, DTP.1 C7 (Y), and DTP.2 C5 (W) populations when compared with yield reduction of C0 (48.5%) of these populations, which reflects the success of selection to improve performance of the four populations under drought stress conditions. Average gain/cycle for grain yield under drought stress was 10%. Improved performance under drought stress of the four populations was mainly due to an improvement in number of ears/plant and/or 100-kernels weight. For most of the studied populations, selection succeeded to reduce the silk-tassel interval under drought stress by 1-3.5 days. It was concluded that Giza 2 C8 is the best population for the development of drought tolerant inbred lines.

Key Words: ***Maize, Corn, Zea mays, Drought, Water stress.***

## INTRODUCTION

Considerable attention is currently being given to the effect of limited irrigation water supply on crop growth and production. Maize production in the new reclaimed lands at Nubaria and some parts of Western Delta is facing irrigation problems due to either insufficient amounts of water reaching these areas or distant irrigation shifts amounting to 3 weeks during hot summer.

Either of the two reasons could impose severe drought impact on maize growth specially when it occurs during the critical periods of crop growth, i.e. flowering period. Yield losses due to drought stress varies from one area or one season to another and can reach 50% or more (Denmead and Shaw 1960, Mc Pherson and Boyer 1977). Reduction in maize production due to drought stress depends upon level of tolerance of the grown plants, durability of drought period, and the growth stage at which plants were exposed to drought.

Improved tolerance of maize hybrids and populations to drought stress has contributed significantly to grain yield improvement of maize in areas apt to moisture stress during growing season (Tollenaar *et al* 1994a). Recently, there are increasing efforts in the National Maize Program towards developing drought tolerant hybrids. The basis for developing these hybrids is to have drought tolerant populations (local or exotic) or to improve the existing population (s) for drought tolerance.

The objectives of this investigation are, (1) to study the effect of timing and duration of drought stress periods on growth and yield of nine maize populations; (2) to search if any of these populations can be used as a direct source for developing drought tolerant inbred lines; and (3) to evaluate the response of these populations to one cycle of S1 recurrent selection for drought tolerance.

## MATERIALS AND METHODS

Nine maize populations had undergone one cycle of S1-family selection for drought tolerance. Out of the 9 populations, 5 were white i.e. Giza 2 cycles 6, 7 and 8; Drought Tolerant Population # 2 C5-W (DTP.2 C5-W); and Drought Tolerant Population # 1 C7-W (DTP.1 C7-W). The other four populations were yellow, i.e. Population 45 C1 and C2; Drought Tolerant Population #2 C5-Y; and Drought Tolerant Population #1 C7-Y). Both Giza 2 and Population 45 were developed by the National Maize Program. The drought tolerant populations were developed by the International Center for Maize and Wheat Improvement (CIMMYT). The germplasm background of these populations is given in Table (1).

In 1997, the 9 populations were grown in the breeding nursery at Sids Station under regular irrigation. At flowering, about 500 plants were selected and selfed based on good morphological attributes. At harvest, 250-300 ears were selected (based on good ear characters) and shelled separately. In 1998, S1 families were evaluated at two locations under regular irrigation and stress irrigation conditions. Under stress irrigation (drought conditions), water was withheld for 3 consequent irrigations (about 35 days) starting from about 10-15 days before flowering. Selection intensity of 20-25% was used based on good yield performance under both irrigation levels, short tassel-silk interval, and resistance to late wilt disease. In 1999, remnant seed of selected S1 families from each population were planted in the breeding nursery and crossed in all possible combinations in a half-sib manner to form C1 population. At the same time, selected S1 families were advanced to S2 generation. In year 2000, both original C0 and improved C1 populations were evaluated at Sids and Nubaria Agric.

**Table 1. Germplasm constitution of the populations used in the study.**

| Population | Grain color type | Genetic background |
|---|---|---|
| Giza 2 (C6-C7-C8) | White Dent | A composite population consisted of 10 genotypes (Tepalsingo No.5, Tepalsingo No.6, Tuxpeno, Mexican June, Laposta, Kitale Syn.2, Blanco Comune, American Early Dent, Composite C, and Local 14). It was developed by the National Maize Breeding Program and had undergone 8 cycles of H.S.recurrent selection for yield and disease resistance. |
| Composite 45 (C1-C2) | Yellow Dent | Originally a CIMMYT population named AMARILLO (BAJIO), a subtropical-temperate population with good adaptaion to Egyptian environment and had undergone two cycles of H.S.recurrent selection for yield and disease resistance. |
| DTP.1 C7 | White Dent | A CIMMYT white population consisted of drought tolerant sources and subjected to 7 cycles of S1 recurrent selection for yield and drought tolerance. |
| DTP.1 C7 | Yellow Dent | Same genetic constitution as white population DTP.1 C7 but converted to yellow population. |
| DTP.2 C5 | White Dent | A CIMMYT white population consisted of DTP.1 white population in addition to some other drought tolerant sources. It was subjected to 5 cycles of S1 recurrent selection for yield and drought tolerance. |
| DTP.2 C5 | Yellow Dent | Same genetic constitution of DTP.2 white population but converted to yellow population. |

Res. Stations under normal irrigation and drought stress as descried for 1998 evaluation trials. Meanwhile, selected S2 families were advanced to S3 generation. The experimental design was split - plot with 4 replicates. The irrigation levels were assigned to the main plots, while the populations were assigned to the sub-plots. Two replicates were for normal irrigation and the other two were for the stress irrigation. The experimental plot consisted of two rows, each of 6 m length and 70 cm width. Planting was performed in hills evenly distributed at 25 cm along the row, at the rate of 2 seeds per hill.

Plants were thinned later to one plant per hill, providing for a population density of 24000 plants/fad.

Fertilizers were applied at the rate of 120:30:24kg N:P:K per faddan. Other agricultural practices were followed as recommended. At Sids, day temperatures during the growing season ranged between 30 and 42°C, while night temperatures ranged between 18 and 25°C. At Nubaria, day temperatures were 28-35°C and night temperatures were 15-22°C. Depth of soil water table was about 80 cm at Sids, while at Nubaria it was about 150 cm. Data were collected for number of days to 50% silking and tasselling, plant height (measured on 5 plants/plot), grain yield, and ear length and diameter.

Test of homogeneity of error variances at both locations was performed according to Snedecor and Cochran (1967). Error variances were found to be heterogenious, therefore, combined analysis was not applicable.

## RESULTS AND DISCUSSION

Mean squares for grain yield, number of ears per plant, 100-kernels weight, ear diameter, ear length, silk-tassel interval, and plant height are given in Table (2) for Nubaria and Sakha Research Stations. Significant differences were found between the two stress levels for grain yield (at both locations), 100-kernels weight and ear diameter at Nubaria, and number of ears/plant, silk-tassel interval, and plant height at Sids. Moreover, significant differences were found among populations for all traits at both locations except for ear length at Sids and silk-tassel interval at Nubaria. Populations x stress interaction was significant for grain yield, ears/plant, and silk-tassel interval at Sids only.

### A- Performance of populations under normal irrigation

### 1- Giza 2 population (C6, C7 and C8)

After one cycle of selection for drought tolerance in the three Giza-2 populations, grain yield of C1 at Sids was less than C0 for Giza-2C6 and Giza 2 C7, while C1 was slightly higher than C0 for Giza 2 C8 (Table 3). At Nubaria, yield of C0 for Giza-2 C6 was significantly higher than C1, while the opposite trend was found for Giza-2 C8. The highest response to selection was achieved for Giza 2 C8 where yield of C1 (29.4 ard /fad) was significantly higher than C0 (25.3 ard/fad) by 16% at Nubaria, while at Sids, there was a slight increase in yield of C0 when compared with C1. Grain yield of C1 of Giza 2 C8 at both locations was the highest among the 3 Giza 2 populations. It was concluded that, generally, no remarkable yield

Table 2. Mean squares for yield and six agronomic traits of 18 maize populations grown under normal and stress irrigation at Nubaria and Sids Research Stations in 1999.

| S.O.V | d.f. | Grain yield (ard/fad) | | Ears /plant (no) | | 100 kernels wt. (g) | | Ear diameter (cm) | | Ear length (cm) | | S-T interval † (d) | | Plant height (cm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nubaria | Sids | Nubaria | Sids | Nubaria | Sids | Nubaria | Sids | Nubaria | Sids | Nubaria | Sids | Nubaria | Sids |
| Replicates | 1 | 0.38 | 1.06 | 0.003 | 0.002 | 12.17 | 91.35 | 0.257 | 0.180 | 9.46 | 1.40 | 0.01 | 0.89 | 159.01 | 8.68 |
| Stress | 1 | 501.60* | 2330.96* | 0.047 | 1.220* | 141.68* | 43.71 | 0.740* | 0.109 | 23.01 | 3.02 | 0.35 | 102.72** | 4065.01 | 10296.13* |
| Rep. x Stress | 1 | 3.05 | 7.30 | 0.011 | 0.001 | 0.85 | 16.15 | 0.003 | 0.036 | 0.59 | 4.94 | 0.13 | 0.01 | 268.35 | 51.68 |
| Entry | 17 | 31.13** | 47.03** | 0.029** | 0.016** | 20.07** | 30.83* | 0.294** | 0.219* | 3.06** | 4.08 | 0.56 | 7.12** | 569.80** | 727.90 |
| Entry x Stress | 17 | 5.60 | 18.10** | 0.007 | 0.014** | 2.28 | 15.49 | 0.024 | 0.092 | 0.34 | 4.26 | 0.23 | 3.93** | 80.93 | 200.65 |
| Pooled error | 34 | 3.08 | 3.15 | 0.004 | 0.004 | 1.34 | 13.52 | 0.028 | 0.111 | 0.30 | 4.61 | 0.42 | 1.31 | 72.41 | 199.09 |
| C.V.(0.05) | | 7.64 | 9.25 | 6.08 | 7.38 | 3.08 | 13.71 | 3.51 | 7.90 | 3.26 | 13.27 | 14.50 | 14.7 | 4.24 | 8.30 |

*, ** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.Silk-tassel interval.

Table 3. Means for yield and six other agronomic traits for nine populations at Nubaria and Sids Res. Stations under normal irrigation in 1999.

| Population | Cycle | Grain yield (ard/fad) | | Ears/plant (no) | | 100-Kernel wt. (g) | | Ear diameter (cm) | | Ear length (cm) | | S-T interval* (d) | | Plant height (cm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids |
| Giza 2 C6 | C0 | 28.95 | 27.03 | 1.12 | 0.99 | 41.7 | 28.9 | 5.3 | 4.5 | 17.4 | 16.8 | 2.5 | 3.0 | 218 | 203 |
| | C1 | 25.70 | 23.54 | 0.96 | 0.93 | 37.4 | 30.1 | 5.3 | 4.6 | 18.3 | 18.0 | 2.5 | 2.0 | 220 | 194 |
| Giza 2 C7 | C0 | 23.10 | 28.20 | 0.98 | 0.97 | 40.4 | 31.6 | 5.1 | 4.7 | 17.1 | 16.7 | 2.5 | 2.0 | 222 | 191 |
| | C1 | 24.14 | 25.96 | 1.00 | 0.95 | 41.2 | 23.8 | 4.8 | 4.2 | 17.4 | 17.4 | 2.0 | 1.5 | 211 | 190 |
| Giza 2 C8 | C0 | 25.34 | 30.59 | 1.00 | 0.98 | 40.2 | 33.9 | 4.9 | 4.4 | 18.9 | 17.3 | 2.5 | 2.0 | 219 | 179 |
| | C1 | 29.26 | 29.08 | 1.18 | 1.04 | 41.6 | 27.4 | 4.6 | 4.2 | 17.9 | 17.8 | 2.0 | 1.5 | 213 | 192 |
| POP. 45 C1 | C0 | 24.07 | 26.31 | 1.03 | 0.98 | 37.8 | 34.6 | 5.1 | 4.3 | 16.0 | 14.8 | 2.5 | 2.5 | 207 | 184 |
| | C1 | 22.58 | 23.06 | 1.03 | 0.99 | 33.9 | 29.3 | 4.9 | 4.5 | 17.0 | 16.5 | 2.0 | 2.0 | 195 | 157 |
| POP. 45 C2 | C0 | 23.40 | 25.82 | 1.02 | 0.98 | 40.2 | 31.6 | 5.2 | 4.8 | 17.5 | 18.1 | 2.5 | 2.5 | 197 | 185 |
| | C1 | 17.40 | 19.18 | 1.04 | 0.99 | 35.7 | 24.9 | 4.6 | 4.1 | 16.5 | 16.1 | 2.0 | 2.5 | 188 | 174 |
| DTP. 1 C7 W | C0 | 29.11 | 25.05 | 1.22 | 1.10 | 37.5 | 29.4 | 4.5 | 4.2 | 18.0 | 17.7 | 3.5 | 2.0 | 230 | 188 |
| | C1 | 26.12 | 19.45 | 1.09 | 1.01 | 38.4 | 30.9 | 4.3 | 4.1 | 17.2 | 16.7 | 3.0 | 1.0 | 212 | 158 |
| DTP. 1 C7 Y | C0 | 26.47 | 22.57 | 1.16 | 1.01 | 38.4 | 28.5 | 4.8 | 4.2 | 17.7 | 15.8 | 3.0 | 3.0 | 219 | 201 |
| | C1 | 26.95 | 21.52 | 1.19 | 1.07 | 39.2 | 27.1 | 4.9 | 3.9 | 16.0 | 16.6 | 2.5 | 2.0 | 196 | 168 |
| DTP. 2 C5 W | C0 | 27.79 | 22.03 | 1.13 | 1.02 | 32.8 | 25.0 | 4.7 | 4.1 | 15.8 | 16.2 | 3.0 | 2.5 | 209 | 204 |
| | C1 | 29.35 | 25.19 | 1.10 | 1.00 | 37.0 | 28.5 | 5.3 | 4.4 | 17.0 | 15.9 | 3.0 | 2.5 | 197 | 172 |
| DTP. 2 C5 Y | C0 | 23.13 | 19.05 | 1.15 | 1.08 | 37.9 | 24.8 | 4.7 | 4.0 | 18.5 | 15.0 | 2.5 | 2.0 | 215 | 190 |
| | C1 | 23.88 | 17.35 | 1.18 | 0.99 | 38.3 | 22.2 | 4.3 | 3.5 | 16.2 | 15.6 | 2.5 | 2.0 | 185 | 149 |
| LSD (0.05) | | 2.66 | 4.47 | 0.12 | NS | 2.1 | 6.2 | 0.3 | 0.6 | 1.1 | NS | NS | 1.4 | 17 | 28 |
| CV % | | 4.9 | 8.5 | 5.0 | 6.6 | 2.5 | 10.7 | 3.3 | 6.2 | 3.1 | 17.3 | 19.9 | 28.8 | 3.8 | 7.2 |

* S-T interval : silk-tassel interval

improvement due to selection was noticed for the 3 Giza 2 populations with the exception of Giza 2 C8 at Nubaria only. Higher yields were mainly due to higher number of ears/plant and/or higher kernels weight. Direction of response to selection for ear length, ear diameter, and plant height was not constant. There was a slight response to selection for reduced silk-tassel interval where selection reduced the interval by 0.5-1 day.

**2- Population 45 (C 1 - C 2)**

Grain yield of C1 for both populations was less than C0. Yield reduction ranged from 6.2-25.7%, The reduction was significant for Pop.45 C2 at both locations. Yield reduction was mainly due to less kernels weight. Ear length and diameter were slightly less in C1 populations. However, selection led also to a noticeable reduction in plant height, which resulted in less vigorous plants, smaller ears and consequently less kernels weight. Little change was noticed in S-T interval between C0 and C1 under normal irrigation, but there was evident change under drought stress.

**3- Population DTP. 1 C7 (W) and DTP.1 C7 (Y)**

Response to selection of the two populations was different. Selection for drought tolerance in the white population resulted in significant decrease in grain yield at both locations. At Nubaria, yield of C1 was 10.3% less than C0, while at Sids the yield reduction was 22.4%. Yield decrease was mainly due to significant reduction in plant height and less ears / plant. In addition, ear diameter and length tended to be less in C1 compared with C0 population. For DTP.1 C7 yellow population, no significant differences were found between C0 and C1 for grain yield and all other traits except for plant height at both locations where C1 plants were significantly shorter than C0 plants. A noticeable improvement due to selection was found for S-T interval between C0 and C1 plants under stress conditions.

**4- Population DTP.2 C5 (W) and DTP.2 C5 (Y)**

Yield of C1 was greater than that of C0 for DTP.2C5 white population at both locations. Yield increase at Nubaria was due to significant increase in kernels weight, ear diameter and length, while at Sids it was due to kernels weight and ear diameter only. C1 plants were shorter than C0 plants, where at Sids, C1 plants were 32 cm shorter than C0 plants. No change occurred in S-T interval between C0 and C1 at both locations. For DTP.2C5 yellow population, no significant differences in yield were found between C0 and C1 at both locations. Little or no change due to selection was observed for the other traits except for plant height at both locations where significant reduction occurred. C1 plants were 30 (41%)

and 41cm (21.6%) shorter than C0 plants at Nubaria and Sids, respectively. *No change occurred in S-T interval between C1 and C0 plants.*

**B- Performance of populations under drought stress**

**1- Giza 2 population (C6, C7 and C8)**

Response of Giza-2 populations to selection for drought tolerance was much clear when these populations were evaluated under drought stress conditions. Grain yield of C1 populations was much better than that of C0 at both locations (Table 4). At Sids, the difference in grain yield between C0 and C1 was significant for G.2 C6 and G.2 C8. The increase in yield of C1 for the two populations reached 41.8 and 28.8%, respectively. As under normal irrigation, C1 of G.2 C8 yielded the best of all Giza-2 populations. From results under normal and stress irrigation, it is clear that one cycle of selection for drought tolerance in Giza-2 population has reasonably improved performance of these populations under drought stress conditions. The high yield of C1 for Giza-2 C6 and Giza-2 C8 was mainly due to improved ability of plants to carry more ears under drought stress. Plants of C1 under drought stress were exceptionally taller than those of C0. Taller and vigrous C1 plants of Giza-2 populations under drought conditions could be the main reason of having better yield of C1 population. These characters enable plants to store bigger amounts of dry matter in stems and leaves to be used during drought stress period and consequently enabling production of relatively good yield under drought conditions. It was noticed from the results that yield under drought conditions at Sids was much less than that at Nubaria for all populations. The reason was that, water witholding at Nubaria started ten days before tassel emergence due to the system of irrigation shifts, while at Sids, water witholding started three weeks before tasselling. As a result, drought effect at Sids covered an important period of the plant vegetative growth, flowering period, and early filling period, which resulted in more drought stress and consequently more yield reduction. The effects of higher temperature at Sids relative to that at Nubaria can not be ruled out .

Differences between C1 and C0 of the above two populations for kernels weight and ear length and diameter were insignificant. The effect of selection on S-T interval was more noticeable under drought than under normal irrigation. S-T interval for C0 of Giza-2 populations at Sids ranged from 4.5 – 6.5 days while for C1 plants it was 2-3.5 days which reflects gain from selection for this trait.

Table 4. Means for yield and six other agronomic traits for nine populations at Nubaria and Sids Res. Stations under drought stress in 1999.

| Pop. | Cycle | Grain yield (ard/fad) | | Ears/plant (no) | | 100-Kernels wt. (g) | | Ear diameter (cm) | | Ear length (cm) | | S-T interval* (d) | | Plant height (cm) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids | Nub. | Sids |
| Giza 2 C6 | C0 | 19.53 | 10.79 | 0.96 | 0.55 | 35.7 | 25.1 | 5.0 | 4.5 | 15.7 | 16.8 | 3.5 | 6.0 | 198 | 169 |
| | C1 | 19.68 | 15.30 | 0.98 | 0.79 | 36.1 | 26.2 | 5.1 | 4.1 | 17.5 | 17.3 | 3.0 | 3.0 | 212 | 179 |
| Giza 2 C7 | C0 | 18.24 | 11.97 | 0.96 | 0.59 | 38.9 | 22.8 | 4.9 | 4.3 | 15.1 | 16.0 | 2.5 | 6.5 | 187 | 159 |
| | C1 | 19.75 | 12.38 | 0.89 | 0.73 | 38.3 | 28.6 | 4.6 | 4.6 | 16.7 | 16.6 | 2.0 | 4.5 | 202 | 167 |
| Giza 2 C8 | C0 | 19.95 | 17.80 | 1.01 | 0.55 | 38.1 | 22.2 | 4.8 | 4.3 | 17.0 | 16.6 | 2.5 | 4.5 | 197 | 161 |
| | C1 | 22.14 | 22.93 | 1.04 | 0.85 | 38.3 | 25.4 | 4.6 | 4.0 | 16.4 | 15.3 | 2.0 | 3.0 | 201 | 176 |
| POP. 45 C1 | C0 | 17.92 | 14.77 | 1.01 | 0.88 | 32.6 | 26.8 | 4.5 | 4.3 | 15.1 | 16.4 | 3.0 | 4.5 | 182 | 162 |
| | C1 | 19.60 | 11.21 | 0.96 | 0.82 | 33.4 | 22.6 | 4.6 | 4.0 | 16.2 | 14.1 | 3.0 | 3.5 | 188 | 163 |
| POP. 45 C2 | C0 | 19.46 | 16.77 | 0.97 | 0.84 | 36.9 | 26.1 | 5.0 | 4.1 | 15.6 | 14.4 | 3.0 | 7.0 | 194 | 155 |
| | C1 | 14.76 | 12.09 | 0.95 | 0.71 | 33.4 | 24.2 | 4.5 | 4.1 | 16.0 | 16.1 | 2.5 | 3.5 | 172 | 136 |
| DTP. 1 C7 W | C0 | 23.95 | 12.82 | 1.07 | 0.73 | 35.4 | 31.8 | 4.5 | 4.3 | 17.3 | 16.4 | 3.0 | 5.0 | 220 | 161 |
| | C1 | 23.41 | 12.44 | 1.09 | 0.74 | 36.1 | 30.9 | 4.7 | 4.1 | 15.7 | 17.0 | 3.0 | 2.5 | 195 | 142 |
| DTP. 1 C7 Y | C0 | 23.00 | 11.36 | 1.10 | 0.71 | 36.0 | 28.1 | 4.5 | 4.3 | 15.9 | 16.1 | 3.5 | 4.5 | 210 | 152 |
| | C1 | 24.14 | 15.89 | 1.19 | 0.84 | 37.6 | 32.8 | 4.4 | 4.1 | 15.8 | 16.1 | 3.0 | 2.5 | 187 | 153 |
| DTP. 2 C5 W | C0 | 19.09 | 12.89 | 1.01 | 0.81 | 31.6 | 21.5 | 4.6 | 3.9 | 14.5 | 16.0 | 2.5 | 2.5 | 188 | 168 |
| | C1 | 19.79 | 16.57 | 1.05 | 0.86 | 32.8 | 25.4 | 5.1 | 4.7 | 16.3 | 14.8 | 2.0 | 1.5 | 194 | 179 |
| DTP. 2 C5 Y | C0 | 21.69 | 12.25 | 1.01 | 0.76 | 34.7 | 22.0 | 4.6 | 3.9 | 18.1 | 15.4 | 3.5 | 4.0 | 184 | 166 |
| | C1 | 17.13 | 8.90 | 0.92 | 0.69 | 35.3 | 22.8 | 4.1 | 3.9 | 15.0 | 16.2 | 2.0 | 3.5 | 171 | 151 |
| LSD | | 4.51 | 2.83 | 0.15 | 0.13 | 2.8 | NS | 0.4 | NS | 1.2 | NS | NS | 3.1 | 19 | NS |
| CV % | | 10.5 | 9.9 | 7.0 | 8.4 | 3.6 | 16.4 | 3.8 | 9.3 | 3.4 | 6.9 | 28.0 | 29.1 | 4.7 | 10 |

* S-T interval : silk-tassel interval

### 2- Population 45 (C1 – C2)

Significant reduction in grain yield under drought was observed for C1 of the two populations, except for Pop. 45 C1 at Nubaria, where yield of C1 was slightly higher than that of C0 but not significant. The reduction in yield was mainly due to reduction in number of ears/plant, kernels weight, and plant height. This was more obvious in Pop.45 C2. Reductions in kernels weight and plant height for Pop-45 C2 were significant at Nubaria, while at Sids only reduction in ears/plant was significant. Reduction in S-T interval was not significant and was noticed only under Sids environment.

### 3- Population DTP. 1 C7 (W) and DTP.1 C7 (Y)

No significant differences were found for yield between C1 and C0 of DTP.1 C7 white population at both locations. For the yellow population DTP.1 C7 no significant differences were obtained for yield between C1 and C0 at Nubaria, however, yield of C1 was slightly higher than that of C0. At Sids, significant difference for yield was found between C1 and C0, where C1 yielded 40% more than C0. This increase was due to more ears/plant and higher kernel weight.

For both populations, at Nubaria, C1 plants were significantly shorter than C0 plants. At Sids, C0 and C1 plants of DTP.1 C7 yellow population were of the same height, while for population DTP.1 C7 white population, C1 plants were shorter than C0 plants. For the two populations, the difference between C0 and C1 for S-T interval at Nubaria was small, while at Sids the interval was reduced by 2 days for C1 plants which reflects the efficiency of selection.

### 4- Population DTP.2 C5 (W) and DTP.2 C5 (Y)

For DTP.2C5 white population, grain yield of C1 at Sids was significantly higher than that of C0 by 3.7 ard/fad (28.5%). This increase was mainly due to more ears/plant, higher kernel weight, and increased ear diameter. At Nubaria, yield of C1 and C0 was nearly the same. It was noticed that C1 plants were slightly taller than C0 plants. Slight reduction was found in S-T interval between C1 and C0 plants.

On the contrary to DTP.2 C5 (W) population, selection for drought tolerance in DTP.2 C5 yellow population caused significant reduction in grain yield of C0 plants. Yield reduction reached 4.6 (21%) and 3.4 (27%) ard/fad at Nubaria and Sakha, respectively. Yield decrease was mainly due to less ears/plant, smaller ear diameter and length, and reduced plant height. Reduction in S-T interval of C0 due to selection was 0.5-1.5 days.

From the results of evaluation under regular irrigation and drought stress we can notice that the behavior of C0 and C1 differed from one population to another. Also, response of different traits to selection for drought tolerance varied a lot among populations and between the two irrigation levels. There was a clear and distinct reduction in yield for all populations when they were subjected to drought stress. However, the magnitude of reduction differed from one population to another depending on the response of each population to selection. The effect of the two irrigation levels on the other 6 studied traits was not the same at both locations since this effect was significant only at one location or the other.

The real value of selection for drought tolerance is to have good performance under both normal and stress irrigation for the same population (or hybrid). As mentioned earlier, the response of different traits to selection varied from one population to another as follows:

**1- Grain yield**

The results obtained showed that, under normal irrigation, selection for drought tolerance either reduced or had no effect on grain yield for 7 of the 9 populations. Only for Giza 2 C8 (at Nubaria) and DTP.2 C5 (W) populations, yield of C1 was higher than C0 population. Under drought stress, which is more important and reflects efficiency of selection, C1 of populations Giza 2 C6, Giza 2 C8, DTP.1 C7(Y), and DTP.2 C5(W) had significantly higher yield than C0 populations. The increase in yield of C1 over C0 was 41.8, 28.8, 40.0, and 28.5%, respectively. It should be noticed that C1 of Giza 2 C8 and DTP.2 C5 (W) were also supperior to C0 under normal irrigation. Under drought stress, the reduction in grain yield of original populations (C0) ranged from 6.2-32.5% (average 20.3%) at Nubaria, and from 35.1-60.5% (average 46%) at Sids. Similar results were reported by Denmead and Shaw (1960), McPherson and Boyer (1977), Jurgens *et al* (1978), Perro and Cassel (1986), Eck (1986), and Lorens *et al* (1987). They indicated that yield reduction due to drought stress ranged from 10-54% depending on the stage of growth subjected to drought and duration of drought stress period. Jurgens *et al* (1978) indicated that drought stress imposed 10 days after flowering until maturity reduced grain yield by 54% and yield reduction was mainly due to reduction in kernels weight. They have also indicated that photosynthesis was more inhibited than dry matter translocation. Eck (1986) found that water stress imposed for 4 weeks starting from 41 and 55 days from planting reduced grain yield by 23-46% and 10-36%, respectively. He reported that grain yield reductions were proportional to reductions in kernels weight.

Performance of C1 populations ( improved cycles) under drought stress showed that grain yield of C1 was better than C0 for populations, Giza 2 C6, Giza 2 C8, DTP.1 C7 (Y), and DPT.2 C5 (W). The reduction in yield under drought was less for C1 of these populations as compared with yield reduction of C0 populations which reflects the success of selection in improving performance of these 4 populations under drought stress conditions. Reduction in C1 yield of the four populations when tested under drought at Sids (severe stress) was 29.6%, while it was 48.5% for C0 of same populations when tested under the same stress conditions, which means an average gain of 18.9% from one cycle of S1 family selection in these 4 populations. At Nubaria, where relatively mild stress was imposed, average gain from selection for the 4 populations was 1.1%. Accordingly, average gain for grain yield under drought stress across the two locations was 10%. However, taking into consideration population yield *per se* under normal and stress irrigation, we can conclude that Giza-2 population especially C8 is the best population to be used in a breeding program aiming at developing drought tolerant inbred lines. Similar results were obtained by Edmeades *et al* (1999), Chapman *et al* (1999) and Bryne *et al* (1995). After 3 cycles of S1 recurrent selection and 8 cycles of half-sib recurrent selection for drought tolerance in three tropical maize populations, Edmeades *et al* (1999) obtained yield gain/cycle of 12.6 and 3.8% for S1 and half-sib selection methods, respectively. Bryne *et al* (1995) found that 8 cycles of full-sib recurrent selection for drought tolerance at one site in Tuxpeno sequia population resulted in 1.68% gain/cycle for grain yield.

**2- Number of ears per plant and 100-kernels weight**

Improved performance of C1 population of Giza 2 C6, Giza 2 C8, DPT.1 C7(Y), and DPT.2 C5(W) under drought stress was, in most cases, due to better ability of plants to carry more ears and/or increased kernel weight. The increase in ears/plant ranged from 6-54%, while for 100-kernels weight it was from 14.4-18.6%. Chapman and Edmeades (1999) obtained 8.9% increase in ears/plant/cycle under drought in S1recurrent selection program for drought tolerance. Bryne *et al* (1995) obtained 1.26% gain/cycle for ears/plant in a full-sib recurrent selection program for drought tolerance in 2 tropical populations.

**3- Ear diameter and ear length**

No significant increase due to selection was obtained, in most cases, for ear length and diameter. However, in few cases, high yield of C1 plants under drought was partially due an increase in ear diameter.

#### 4- Silk-tassel interval

During selection in the 9 studied populations, silk-tassel interval was the main selection criterion used for drought tolerance. For different cycles of Giza 2 and Pop.45, the S-T interval for C0 plants under drought stress ranged from 4.5-7 days, and one cycle of selection was successful to reduce the interval by 1-3.5 days. Because DTP.1 C7 and DTP.2 C5 were developed for drought tolerance, the S-T interval under drought was not as big as S-T interval for Giza 2 and Pop.45, therefore, the reduction due to selection in DPT.1 and DPT.2 populations was less. Champan *et al* (1999) obtained a reduction of 22% per cycle of selection for drought tolerance in some tropical maize populations using S1 family recurrent selection. In a different study, Bryne *et al* (1995) obtained 8.59% reduction in S-T interval per cycle of selection using full-sib family recurrent selection.

#### 5- Plant height

For the 3 Giza 2 populations and DTP.2 C5(W) population selection has resulted in taller C1 plants than C0 plants. For the other 5 populations, C1 plants were nearly equal or shorter than C0 plants. Among the 4 populations that had good performance of C1 plants under drought conditions, three of them, i.e. Giza-2C6, Giza 2 C8, and DTP.2 C5 (W) had taller C1. The fourth population, i.e. DTP.1C7(Y) had significantly shorter C1 plants than C0 plants. Bryne *et al* (1995) obtained slight decrease (-0.83% per cycle) in plant height during a recurrent selection program for drought tolerance. Similar results were found by Chapman *et al* (1999) where they obtained a plant height reduction of 2.0% per cycle of selection for drought tolerance in some tropical maize populations.

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# الانتخاب لتحمل الجفاف في بعض عشائر الذرة الشامية التي تنتمي إلى المناطق المداريه وشبه الاستوائية

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تم عمل دورة واحدة من الانتخاب المتوالى المتكرر لتحمل الجفاف باستخدام طريقة عائلات الجيل الذاتى الأول في تسعـــة عشائر من الذرة الشامية التى تنتمى الى المناطق المداريه وشبه الاستوائية وهى :

١- عشيره جيزه ٢ (بيضاء الحبوب) ويمثلها الحلقات الانتخابيه السادسه(C6) والســابعه (C7) والثامنـــه (C8).

٢- عشيره ٤٥ (صفراء الحبوب) ويمثلها الحلقات الانتخابيه الاولى (C1) والثانيه (C2)

٣- عشيره تتحمل الجفاف DTP.1 (بيضاء الحبوب) ويمثلها الحلقه الانتخابيه السابعه (C7) (احد عشائر الـCIMMYT )

٤- عشيره تتحمل الجفاف DTP.1 (صفراء الحبوب) ويمثلها الحلقه الانتخابيـــه الســابعه (C7) (احـــد عشائر ال CIMMYT )

٥- عشيره تتحمل الجفاف DTP.2 (بيضاء الحبوب) ويمثلها الحلقه الانتخابيه الخامسه (C5) (احد عشائر ال CIMMYT )

٦- عشيره تتحمل الجفاف DTP.2 (صفراء الحبوب) ويمثلها الحلقه الانتخابيـه الخامسـه (C5) (احـد عشائر الـ CIMMYT )

تم تقيم الحلقة الاصلية الغير محسنة (C0) والحلقة الاولى (C1) ناتج التحسين لهذه العشائر تحت مستويين مـن مياه الرى ، الاول يتمثل فى اعطاء كميات المياه المطلوبه بدون تعرض العشائر لأى اجهاد مائى ، اما الثانى فيتمثل فى تعريض هذه العشائر لفتره من الاجهاد المائى لمدة ثلاث ريات متتاليه (٣٥ يوم) تبدأ بعد الريه الثالثه (١٠ – ١٥ يوم قبل بدء التزهير) وتمتد حتى المرحله المبكره من امتلاء الحبوب وذلك بمحطتى البحـوث الزراعيـة بسـدس والنوبارية خلال عام ٢٠٠٠ ٠ تم استخدام تصميم القطع المنشقه في أربعة مكررات في تنفيذ التجربة ٠
أظهرت النتائج أن سلوك الحلقة الأصلية والحلقة الاولى للتحسين تحت نظامي الرى قد اختلف من عشيرة لأخـرى ، كما اختلفت العشائر أيضاً في استجابة الصفات النباتية المختلفة للانتخاب لتحمل الجفاف أضافه إلى اختلاف سـلوك هذه الصفات تحت نظامى الرى المستخدمين بالتجربة٠ لقد كان انخفاض المحصول تحت ظروف الجفاف (الاجـهاد المائى) لحلقة التحسين الأولى (C1) للعشائر جيزة ٢ C6 ، جيزة ٢ C8 ، DTP.1C7(Y)، DTP.2C5 (W) أقل من الانخفاض الذى حدث للعشائر الأصلية الغير محسنه (C0) حيث بلـغ متوسـط الانخفـاض فـي المحصول فى حلقة التحسين الاولى ٢٩,٦ % ، بينما كان الانخفاض فى الحلقه الاصليه ٤٨,٥ % مما يعكس نجاح عملية الانتخاب في تقليل الفقد فى محصول هذه العشائر الاربعه عند تعرضها لظروف الجفاف ٠
لقد بلغ متوسط نسبة الزيادة في محصول الحبوب نتيجة الحلقة الانتخابية الأولى ١٠ % عند تقييمها تحت ظـروف الجفاف مقارنة بالحلقه الاصليه٠ كان التحسن فى إنتاجية العشائر الأربعة تحت ظروف الجفاف كان يرجع أساسا الى التحسن في عدد الكيزان للنبات أو وزن الـ ١٠٠ بذرة أو كلاهما٠ لقد نجح الانتخاب في معظم العشائر في خفـض الفترة ما بين ظهور السنابل والحرائر بمقدار يتراوح ما بين يوم إلي ثلاثة أيام ونصف ٠ يمكـن الاسـتنتاج بـأن العشيرة جيزة ٢ C8هى أفضل عشيرة يمكن استخدامها لاستنباط سلالات تتحمل الجفاف.

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