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## SUMMARY

Ten maintainer B-lines and six fertility restorer lines (RF-lines) were evaluated at Shandaweel Res. Station, A. R. C. during the early summer season of 2000 to study the performance of these lines under three levels of irrigation i.e., 1.0, 0.8 and 0.6 cumulative pan evaporation (CPE). Five A-lines and three restorer lines tolerant to drought and high yielding, were identified after evaluation and crossed in late summer season of 2000. The resultant 15 hybrids and its parents along with a check hybrid (Euroflor) were evaluated in 2001 and 2002 season at levels of 1.0, 0.8 and 0.6 CPE to identify the high yielding hybrids tolerant to drought.

A split-plot design with three replicates was used in early summer season to evaluate maintainer and restorer lines. The hybrids (15 hybrids) and their parents with a check hybrid were evaluated under three levels of irrigation in a split-plot design experiment during 2001 and 2002 seasons, Line x Tester analysis was performed.

**The obtained results could be summarized as follows:**

**I-Evaluation of lines:**

**1-Analysis of variance:**

The combined analysis of variance over the levels of irrigation in 2000 season showed significant or highly significant differences between levels of irrigation for all studied traits. Also, highly significant differences among genotypes were found for all the studied traits. The interaction effect between irrigations and genotypes was significant on all the studied traits, except for stem and head diameters.

## 2-Means and drought tolerance index:

- A- Increasing water stress from 1.0 to 0.6 CPE caused earliness in flowering and maturity for all tested lines. The drought tolerance index was slightly decreased with increasing water stress for days to flowering and maturity, indicating that all studied genotypes were markedly earliness in flowering and maturity at 0.6 CPE.
- B- The overall mean of plant height, stem and head diameters for genotypes were decreased from 171.91 to 161.18 cm, 2.05 to 1.20 cm and from 17.95 to 16.55 cm with increasing water stress from 1.0 to 0.6 CPE. The wide variability obtained among genotypes in drought tolerance index for these traits at levels of 0.8 and 0.6 CPE, indicating the large differences among genotypes in respect to water requirement.
- C- Mean of 100-seed weight of genotypes was decreased from 5.91 to 5.41g with increasing water stress from 1.0 to 0.6 CPE. On the basis of drought tolerance index for 100-seed weight, the best tolerant and yielding lines were selected and crossed to produce the hybrids.
- D- The overall mean of seed yield / plant for the lines was decreased from 39.93 to 36.10 g with increasing water stress from 1.0 to 0.6 CPE. The best five maintainer lines in seed yield / plant were B20 (58.99g), B19 (58.50g), B9 (55.79g), B5 (53.68g) and B18 (50.90g), while the best restorer lines were RF<sub>7</sub> (43.57g), RF<sub>2</sub> (15.63g) and RF<sub>6</sub> (14.50g), since these lines were high yielding and having high values of drought tolerance index and low values of drought susceptibility index. So, these lines were selected and crossed to produce 15 hybrids.
- E- The overall mean of seed yield /feddan for genotypes was decreased with increasing water stress. Seed yield /feddan were 1.20, 1.13 and 1.09 ton / fed. at 1.0, 0.8 and 0.6 CPE, respectively. The results of

drought tolerance index indicated the differences among genotypes in their water requirements.

F- The overall mean of seed oil percentage was affected by water stress and increased from 39.36 to 41.26% with decreasing irrigation rate from 1.0 to 0.6 CPE. Drought tolerance index values showed that high lines to drought tolerance were higher in seed oil percentage.

### **3-Water relations:**

#### **A- Water consumptive use (CU):**

Applying irrigation at 1.0 CPE recorded the highest water consumptive use for genotypes, while water consumptive was decreased when applying irrigation at irrigation levels of 0.8 and 0.6 CPE. Five lines recorded the lowest water consumptive use at high water stress level of 0.6 CPE which were B9, B5, B19, B20 and RF<sub>6</sub>, they were selected for crossing.

#### **B- Water use efficiency (WUE):**

The results showed that the highest value of WUE for mean of genotypes (0.785 Kg seeds/m<sup>3</sup> water) was obtained when irrigation was applied at level of 0.6 CPE, whereas the lowest WUE was obtained when irrigation was applied at level 1.0 CPE (0.503 Kg seeds / m<sup>3</sup> water). The best lines for WUE were B20 (0.934), B19 (0.875), B9 (0.821), B18 (0.735), B5 (0.718) and RF<sub>7</sub> (0.618 Kg seeds / m<sup>3</sup> water).

## II- Line x Tester analysis:

### 1-Days to 50% flowering:

A- The combined analysis of variance of days to 50% flowering showed significant and highly significant differences between the two seasons and among irrigation levels, respectively. Mean squares for genotypes and its components (parents, parents vs. crosses and crosses) and their interactions with irrigations in 2001 and 2002 seasons were highly significant. The interaction between genotypes and each of seasons and irrigations were highly significant. Also, years x irrigations and years x irrigations x genotypes interactions possessed significant and highly significant effect on this trait. Males, females and males x females lines and their interactions with irrigation were significant and highly significant in the two seasons except for males x females x irrigations interaction in 2002 season.

B- Overall mean of days to 50% flowering of the hybrids and its parents was decreased by increasing water stress from 1.0 to 0.6 CPE. All hybrids were earlier than the check hybrid (Euroflor) at the three levels of irrigation. Overall means of drought tolerance index of parental lines, crosses and check hybrid was decreased with increasing water stress from 1.0 to 0.6 CPE in both seasons. Also, all genotypes drought tolerance index was decreased with increasing water stress. The highest drought tolerance index values recorded for B20 and RF<sub>2</sub> lines and for A19 x RF<sub>6</sub> and A19 x RF<sub>7</sub> crosses in 2001 and 2002 seasons, respectively.

C- Most of early flowering lines had negative GCA effects. Moreover, all the crosses had negative significant SCA were early in their flowering and crosses had positive significant SCA were late in their

flowering in most irrigation levels in both seasons. Both additive and non-additive effects were important in the inheritance of days to flowering.

D- In the most cases, all earlier crosses in their flowering possessed negative significant heterosis at different irrigation levels in both seasons. Many of hybrids were early in their flowering compared to earlier parents at the three levels of irrigation in the two seasons.

## **2- Days to maturity:**

A- The combined analysis of variance of days to maturity showed highly significant differences among irrigation levels. Years x irrigations interaction exhibited highly significant effect on this trait. Mean squares for genotypes and its components (parents, parents vs. crosses and crosses) and their interactions with irrigations were highly significant in both seasons except for parents vs. crosses x irrigations interaction in 2001 season. The interaction between genotypes with seasons and / or irrigations were highly significant. Mean squares for males, females and males x females and their interactions with irrigation were significant or highly significant in the two seasons.

B- Overall mean days to maturity of the hybrids and its parents was decreased with increasing water stress from 1.0 and 0.6 CPE in both seasons. Most hybrids were earlier for maturity than the check hybrid (Euroflor) at the three levels of irrigation. Drought tolerance index of parents, crosses and check hybrid was decreased with increasing water stress in both seasons. The highest tolerant lines were B20 and RF6, while the most tolerant crosses were A20 x RF<sub>7</sub> and A9 x RF<sub>6</sub> in 2001 and 2002 seasons, respectively.



- C- Four parental lines (B19, B20, RF<sub>2</sub> and RF<sub>7</sub>) had negative GCA effects. Moreover, all the crosses had negative significant SCA were early in their maturity and the crosses had positive significant SCA were late in their maturity. Both additive and non-additive effects were important in the inheritance of days to maturity.
- D- Many of hybrids were earlier in their maturity than earlier parent at the three levels in the two seasons. All earlier crosses in their maturity possessed negative significant heterosis at different levels of irrigation in both seasons.

### 3- Plant height:

- A- The combined analysis of variance of plant height showed highly significant mean squares for seasons, irrigations, genotypes, in addition to seasons x irrigations, seasons x genotypes, irrigation x genotypes and seasons x irrigations x genotypes interactions. However, parents, parents vs. crosses and crosses and their interactions with irrigations were significant or highly significant in both seasons except irrigation x parents interaction in 2001 season. Moreover, mean squares of males, females, males x females and their interactions with irrigation were significant or highly significant except for females x irrigations interaction in 2002 season.
- B- Overall mean for plant height of each hybrids and parental lines was decreased with increasing water stress in the two seasons. Mean plant height of parents was lower than mean of hybrids at the three levels of irrigation in the two seasons. Also, drought tolerance index for means of parents, crosses and check hybrids was decreased with increasing water stress. Drought tolerance index of each genotype at 0.8 CPE was higher than those of 0.6 CPE in both seasons.



- C- Plant height of the crosses was more affected by the female (tall) than the restorer one (short). Some hybrids showed over-dominance towards tallness at the three levels of irrigation in both seasons. Therefore, the female lines must selected to be short. Most of taller crosses showed positive significant SCA effects at different irrigation levels in both seasons.
- D- Significant positive heterosis were obtained for 2, 4 and 3 hybrids in 2001 season and for 2, 2 and 4 in 2002 season, respectively.

#### **4- Stem diameter:**

- A- The combined analysis of variance of stem diameter exhibited significant and highly significant differences between the two seasons and among irrigation levels. Mean squares for genotypes and its components over irrigations in both seasons (parents, parents vs. crosses and crosses) were significant or highly significant. Also, the interaction of genotypes with seasons and/or irrigations were significant or highly significant. Crosses x irrigations interaction was significant in both seasons. Moreover, males, females, males x females and their interactions with irrigations except for females x irrigations were significant or highly significant in both seasons.
- B- Mean stem diameter of the parental lines and hybrids was decreased with increasing water stress in the two seasons. Drought tolerance index of parental lines and its crosses was decreased with increasing water stress from 0.8 to 0.6 CPE in both seasons. However, hybrids surpassed either parental lines or hybrid check in drought tolerance index at the three levels of irrigation in both seasons.

C- General and specific combining ability were low for this trait. Some hybrids showed positive significant SCA for stem diameter at the three levels of irrigation in both seasons.

D- Some hybrids showed significant or highly significant heterosis for stem diameter at the three levels of irrigation in both seasons.

### **5- Head diameter, cm:**

A- The combined analysis of variance of head diameter showed significant or highly significant differences between seasons and among irrigation levels. Seasons x irrigation interaction had significant effect on this trait. Mean squares for genotypes, parents, parents vs. crosses and crosses over years and irrigations or over irrigations in both seasons were significant or highly significant. Also, genotypes x seasons or irrigations interactions were highly significant. Moreover, mean squares for males, females, males x females and their interactions with irrigation were significant or highly significant in both seasons except for males x irrigation in 2001 season.

B- Mean head diameter of the parental lines and hybrids was decreased with increasing water stress from 1.0 to 0.6 CPE. Overall means of hybrids exceeded both parental lines and check hybrid at different irrigation levels in both seasons. At high level of water stress (0.6 CPE), RF<sub>6</sub> line recorded the highest drought tolerance index in both seasons, while the highest values for crosses were 97.77% (A9 x RF<sub>2</sub>) and 97.88% (A20 x RF<sub>6</sub>) in 2001 and 2002 seasons, respectively.

C- General and specific combining ability for most parents or hybrids were negative or positive significant in most cases for GCA in both seasons and for SCA in the first season at different irrigation levels. Also, the hybrids which had positive SCA effects either significant or

not significant showed a good performance concerning head diameter. Non-additive effects was important in inheritance for head diameter.

D- Some hybrids showed significant or highly significant heterosis either positive or negative for head diameter on the basis of high parent at the three levels of irrigation in the two seasons.

#### **6- 100-seed weight, g:**

A- The combined analysis of variance of 100-seed weight showed significant or highly significant differences between seasons, irrigation, genotypes and components of the genotypes (parents, parents vs. crosses and crosses). Also, mean squares of the genotypes x seasons and genotypes x irrigations interactions were highly significant. Moreover, the mean squares of males, females, males x females and their interactions with irrigations were significant or highly significant in both seasons.

B- Mean 100-seed weight of the parents and hybrids was decreased with increasing water stress in the two seasons. Mean 100-seed weight of the hybrids was heavier than that of the parents at all levels of irrigation in the two seasons. Moreover, the parents were markedly affected by severe drought stress (0.6 CPE) than the hybrids in the two seasons. Drought tolerance index was decreased with increasing water stress for all genotypes in both seasons. Both parents and hybrids recorded higher values for drought tolerance index than check hybrid at 0.8 and 0.6 CPE in both seasons.

C- General combining ability was positive and significant for B20 and RF<sub>7</sub> parental lines at different irrigation levels in both seasons, however, specific combining ability was positive significant for some hybrids. Both the additive and non-additive effects were affected in

inheritance of 100-seed weight, and the non-additive were important than additive. However, this relations differed with water stress.

D- Some hybrids exhibited significant or highly significant heterosis for 100-seed weight over the better parents at the three levels of irrigation in the two seasons.

### **7- Seed yield / plant, g:**

A- The combined analysis of variance of seed yield per plant showed that both of the seasons and irrigations mean squares were significant or highly significant. Years x irrigation interaction had significant effect on this trait. Also, mean squares of the genotypes and its components (parents, parents vs. crosses and crosses) were significant or highly significant. Moreover, the genotypes x irrigations, genotypes x seasons, seasons x irrigation and genotypes x seasons x irrigations interactions were significant or highly significant. Mean squares of males, females, males x females and their interactions with irrigations were significant or highly significant except for males x females x irrigations interaction in 2002 season.

B- Mean seed yield / plant for parents and hybrids was decreased as increasing water stress. The female lines was in general higher than the restorer lines in yielding ability in 2001 and 2002 seasons. Most hybrids outyielded the overall means of parental lines or the check hybrid (Eurdflor) at the three levels of irrigations in the two seasons. Among parental lines, B20 recorded higher seed yield / plant and drought tolerance index with lower values for drought susceptibility index in both seasons, while A20 x RF7 hybrid surpassed all hybrids in seed yield and showed higher value of drought tolerance index with lower value of drought susceptibility index in both seasons. So, it is be

recommended to cultivate this hybrid under water stress for increasing sunflower production.

- C- The female lines played the important role in the expression of seed yield / plant rather than the restorer lines. Positive significant SCA effects were found in A20 x RF<sub>7</sub> hybrid at different irrigation levels in both seasons. Both additive and non-additive effects were involved in the inheritance of seed yield / plant at the three levels of irrigations in the two seasons.
- D- Some of the hybrids showed significant or highly significant heterosis under the three levels of irrigation. Variable amounts of heterosis were found from level of irrigation to another and from season to season. Therefore, it is better to identify the best hybrids in seed yield / plant in the two seasons and for levels of water stress. These hybrids were A20 x RF<sub>7</sub>, A19 x RF<sub>7</sub>, A19 RF<sub>2</sub>, A9 x RF<sub>2</sub>, A9 x RF<sub>7</sub> and A18 x RF<sub>2</sub>. The respective superiority of these hybrids was from the check hybrid (Euroflor).

#### **8- Seed yield ton/feddan:**

- A- The combined analysis of variance of seed yield /fed. showed that both of seasons and irrigations mean squares were significant or highly significant. Also mean squares of the genotypes and its components (parents, parents vs. crosses and crosses) and their interactions with seasons and irrigations were significant or highly significant. Mean squares of males, female, males x females and their interactions with irrigations were significant or highly significant in both seasons except for males x irrigations in 2001 seasons.
- B- Mean seed yield /fed., for parents and hybrids was decreased with increasing water stress. The female lines were higher than the male

lines in yielding ability. Most of hybrids outyielded the overall means of parental lines and check hybrid (Euroflor) at three levels of irrigation in the two seasons.

C- The female lines played the important role in the expression of seed yield / fed., rather than the male lines. Many of hybrids showed positive significant SCA for this trait at the three levels of irrigation in the two seasons. Both additive and non-additive effects were involved in the inheritance of seed yield / feddan.

D- Many of hybrids showed significant or highly significant heterosis at the three levels of irrigation in the two seasons. The best hybrid having high seed yield / fed. at the levels of water stress in the two seasons were A20 x RF<sub>7</sub>, A18 RF<sub>2</sub>, A9 x RF<sub>7</sub>, A19 x RF<sub>7</sub> and A5 x RF<sub>7</sub>. The respective superiority of these of these hybrids was from the check hybrid (Euroflor).

#### **9- Seed oil percentage:**

A- The combined analysis of variance of seed oil percentage showed highly significant differences among irrigation levels. Years x irrigations interaction had significant effect on this trait. Mean squares for genotypes (parents, parents vs. crosses and crosses) were highly significant. Also, the genotypes interactions with seasons and / or irrigations were highly significant. Mean squares for males, females, males x females and their interactions with irrigations were highly significant.

B- Mean seed oil percentage of the hybrids and its parents was increased by increasing water stress. Most hybrids were higher than the check hybrid (Euroflor) at the three levels of irrigation in the two

seasons. Drought tolerance index of oil percentage was increased with increasing water stress from 0.8 to 0.6 CPE.

- C- General combining ability of three parental lines (B18, B19 and B20) were positive significant. However, specific combining ability for hybrids having the highest seed oil percentage were positive and significant, indicating that heterotic effect in these hybrids, non-additive effect was important in inheritance of seed oil percentage.
- D- Some hybrids showed positive significant or highly significant heterosis at the three levels of irrigation. The hybrids showed positive highly significant heterosis recorded highest seed oil percentage. The best hybrids compared to the check hybrid (Euoflor) at the three levels of irrigation were A18 x RF<sub>2</sub>, A18 x RF<sub>6</sub>, A18 RF<sub>7</sub>, A9 x RF<sub>2</sub> and A5 x RF<sub>2</sub>.



### III – Water relations:

#### A-water consumptive use (CU):

- 1- The results showed that applying irrigation at 1.0 CPE recorded the highest water consumptive use for parents and hybrids. Increasing water stress to 0.8 and 0.6 decreased CU for all genotypes (parents, crosses and check hybrid) in both seasons. The hybrids consumed quantity of water lower than both parents and check hybrid at different levels of irrigation in both seasons.
- 2- The lowest hybrids in water consumptive use at the three levels of irrigation were A20 x RF<sub>7</sub>, A19 x RF<sub>7</sub>, A20 x RF<sub>2</sub>, A18 x RF<sub>2</sub> and A19 x RF<sub>6</sub>.

#### B- Water use efficiency (WUE):

- 1- The results showed that the highest values of WUE for parents, hybrids and check hybrid were at level 0.6 CPE, while the hybrids possessed higher values for WUE than parental lines or check hybrid (Euroflor) in both seasons.
- 2- Water use efficiency for parents and hybrids was decreased with increasing the level of irrigation from 0.8 to 1.0 CPE in the two seasons, respectively.
- 3- The hybrids recorded the highest WUE over the three levels of irrigation were A20 x RF<sub>7</sub>, A19 x RF<sub>7</sub> and A20 x RF<sub>2</sub> in both seasons.