



**PERFORMANCE AND STABILITY OF SOME GRAIN  
SORGHUM CROSSES AND THEIR PARENTS  
UNDER DROUGHT CONDITION**

**By**

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## **SUMMARY**

This investigation was carried out through two experiments, first experiment to study the drought tolerance of ten maintainer lines (B-lines) and fourteen restorer lines (R-lines) under two irrigation levels (100% as optimum and 40% from the optimum) to identify the best and high yielded tolerant and susceptible genotypes from both B and R lines under severe water stress in order to use them for releasing new crosses. This experiment was conducted at Shandaweel Agric. Res. Station, Sohag, in 2009 season.

Five B-lines (BSH-6, BSH-10, BSH-11, BTX-37 and ICSB-88003) and three R-lines (ICSR-92003, ICSV-273 and Kymoun) were selected as drought tolerance genotypes and three B-lines (BSH-8, BSH -12 and BSH-13) and two R- lines (Adv-6 and ICSR-89028) were selected as susceptible genotypes. The selected A-lines and R-lines were crossed to obtain forty crosses.

The second experiment was conducted in two season at Shandaweel Agric. Res. Station, Sohag in 2011, 2012 seasons. This experiment included the forty crosses and their parental lines (eight B-lines and five R-lines) plus the check hybrid H-306.

In this study, RCBD design were used in the three experiments one for each the irrigation levels (100% optimum, 70% and 40% from the optimum). The line  $\times$  tester analysis were used to compute the genetic parameters.

The obtained data in the two experiments were illustrated as following:-

### **A- First experiment (lines evaluation)**

#### **1- Analysis of variance**

The combined analysis of variance showed highly significant differences among lines, irrigation treatments, and interactions between lines  $\times$  irrigation for all the studied traits, except number of green leaves  $\times$  irrigation was significant, reflecting the differential genotypes and water requirements of genotypes.

### **2- Lines performance**

Data indicated that days to 50% flowering under 40% irrigation water for the B-lines ranged from 68.17 (BSH- 8) to 74.00 (BSH-13) with an average of 70.40 days and it ranged from 62.34 (BSH-6) to 67.50 (BSH-8) with an average of 64.84 days under 100% of irrigation water. Also, for the R-lines, it ranged from 68.50 (F8-8001) to 77.50 (ICSR-89028) and it ranged from 61.00 (Indian-5) to 70.50 days (ICSV-273), respectively. The days to 50% flowering increased by 5 to 6 days under 40% of irrigation water for both B and R lines, respectively.

Plant height, under 40% and 100% of irrigation water for the B-lines ranged from 103.33 (ICSB-88003) to 130 cm (BSH-12) and 124.33 (ICSB-88003) to 144.00 cm (BSH-8), respectively. Also, for the R-lines, the plant height ranged from 126.00 (ICSR-92003) to 206.67 cm (Indian-5) and it ranged from 145.33 (F<sub>9</sub>-9005) to 232.33 cm (Indian-18) under 40 and 100% of irrigation water, respectively. The plant height decreased by 15 and 20.4 cm under 40% of irrigation water for both B and R-lines, respectively.

Panicle length, under 40% and 100% of irrigation water for the B-lines ranged from 19.42 (BTX-631) to 24.97 cm (BSH-10) and from 26.15 (BTX-631) to 30.00 cm (BTX-37), respectively. Also, for the R-lines, panicle length ranged from 22.17 (Indian-5) to 27.83 cm (ICSR-92003) and it ranged from 26.33 (Indian-18) to 35.67 cm (Indian-25) under 40 and 100% of irrigation water, respectively. The average

## *Summary*

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reductions for panicle length of both B and R-lines under severe water stress were 4.88 cm.

Panicle width, under 40% of irrigation water for the B-lines ranged from 4.17 (BTX-631) to 5.83 cm (BSH-6) and it ranged from 5.00 (BTX-631) to 6.83 cm (BSH-13) under 100% of irrigation water. Also, for the R-lines, it ranged from 4.17 (Adv.6, Indian-5 and Indian-25) to 6.17 cm (ICSV-273 and Kymoun) and it ranged from 5.50 (Indian-25) to 7.50 cm (ICSV-273) under 40 and 100% of irrigation water, respectively. The reductions for panicle width of both B and R-lines under severe water stress was 1.37 cm, respectively.

Number of green leaves, under 40% of irrigation water for the B-lines ranged from 4.33 (BSH-13) to 7.33 leaves (BSH-6, BSH-10 and ICSB-88003) and it ranged from 7.00 (BSH-13) to 9.67 leaves (ICSB-88003) under 100% of irrigation water. Also, for the R-lines, it ranged from 4.33 (Adv-6, F<sub>8</sub>-8001 and ICSR-89028) to 9.00 leaves (ICSV-273) and from 7.33 (F<sub>8</sub>-8001) to 10.67 leaves (ICSV-273) under 40 and 100% of irrigation water, respectively. The reductions in both B and R-lines under severe water stress in no. of green leaves were 2.20 and 2.67 leaves, respectively.

1000-grain weight, under 40% of irrigation water for the B-lines ranged from 20.23 (BSH-8) to 25.67 g (BSH-17) and it ranged from 24.20 (BTX-631) to 28.57 g (ICSB-88003) under 100% of irrigation water. Also for the R-lines, 1000-grain weight ranged from 19.77 (ICSR-89028) to 27.26 g (ICSR-92003) and it ranged from 22.05 (F<sub>8</sub>-8001) to 30.20 g (ICSR-92003) under 40 and 100% of irrigation water, respectively. The reductions in the average of 1000-grain weight for both B and R-lines under severe water stress were 5.10 and 4.15 g, respectively.

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The grain yield/plant for the B-lines under 40% of irrigation water ranged from 32.97 (BSH-13) to 53.60 g (ICSB-88003) while, under 100% of irrigation water, it ranged from 49.13 (BTX-631) to 62.59 g (BSH-10). Also, for the R-lines, it ranged from 33.18 (F<sub>8</sub>-8001) to 68.83 g (ICSV-273) and it ranged from 48.33 (Indian-25) to 77.63 g (ICSV-273) under 40 and 100% of irrigation water, respectively. The reductions in grain yield for both B and R-lines under severe water stress were 13.19 and 14.82 g, respectively.

The drought susceptibility index (DSI) values for B-lines ranged from 0.35 (ICSB-88003) to 1.62 (BSH-13), while, it ranged from 0.46 (ICSV-273) to 1.68 (Adv-6) for the R-lines. These highest values mean those lines are considered as susceptible lines (DSI >1), comparing with 1.06 the check-2 (Dorado). The selected B-lines as drought tolerance were BSH-6, BSH-10, BSH-11, BTX-37 and ICSB-88003 and the selected R-lines were ICSR-92003 and Kymoun, ICSV-273 these lines have high value of drought tolerance index (DTI) and low value of DSI. While, the selected B-lines as susceptible were BSH-8, BSH-12 and BSH-13 and the selected R-lines Adv-6 and ICSR-89028 gave low value of DTI and high value of DSI.

### **B- Evaluation of crosses obtained by line × tester**

#### **I- Means and variance**

The combined analysis of variance over the two years showed highly significant differences between years, irrigation treatments and among genotypes for all the studied traits, indicating the response of these traits with years and drought stress. The interactions between years × genotypes, irrigation levels × genotypes and year × irrigation × genotype were highly significant for all the studied traits, except for days to 50% flowering, reflecting the differential response of genotypes to water stress

## *Summary*

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from year to another. Moreover, parents and crosses had significant differences for most studied traits.

The combined over years indicated that days to 50% flowering under 40% irrigation for the female lines ranged from 68.84 (ICSB-88003) to 74.17 (BSH-17) with an average of 71.96 days, while for the R-lines, it ranged from 71.67 (ICSR-92003) to 75.00 (Adv-6) with an average of 73.40 days. Moreover, for the crosses, it ranged from 65.83 (ASH-6 × ICSR-92003) to 73.33 (ICSA-37 × Kymoun) with an average of 69.92 days. Whereas, the average of days to 50% flowering under 70% irrigation levels, were 69.23 for female lines, 70.93 days for R-lines and 67.59 days for the crosses. While, the days of 50% flowering under 100% irrigation for the female lines ranged from 66.00 days (ICSB-88003) to 70.34 (BSH-10) with an average of 67.54 days, for the R-lines, it ranged from 66.50 (ICSR-92003) to 71.17 (Kymoun) with an average of 69.00 days and for the crosses, it ranged from 62.00 (ASH-6 × ICSR-92003) to 69.50 (ASH-11 × ICSV-273) with an average of 65.47 days. The results indicated that the increase in the average of days to 50% heading for the female, male lines and crosses under severe water stress was 4.42, 4.00 and 4.45 days, respectively.

Plant height over seasons for the female lines under 40% irrigation ranged from 95.00 (BSH-13) to 114.00 (ICSB-37) with an average of 107.82 cm, while for the R-lines, it ranged from 132.17 (Adv-6) to 196.00 (ICSV-273) with an average of 148.94 cm. Moreover, for the crosses, it ranged from 148.50 (ASH-6 × ICSR-89028) to 245.50 (ASH-6 × ICSV-273) with an average of 203.53 cm. Whereas, under level of 70% irrigation for the female lines it varied from 108.00 (BSH-13) to 127.5 (ICSB-37) with an average of 121.73cm. While, for the R-lines it ranged from 145.00 (Adv-6) to 209.67 (ICSV-273) with an average of 163.37

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cm. Moreover, for the crosses it ranged from 161.17 (ASH-6 × ICSR-89028) to 263.67 (ASH-6 × ICSV-273) with an average of 220.52 cm. While, the mean of plant height under 100% irrigation for the female lines ranged from 121.17 (ICSB-88003) to 141.17 (BSH-8) with an average of 130.65 cm. While for the R-lines, it ranged from 158.00 (Kymoun) to 217.00 (ICSV-273) with an average of 173.50 cm. Moreover, for the crosses, it ranged from 185.34 (ASH-6 × ICSR-89028) to 284.17 (ICSA-37 × Adv-6) with an average of 234.86 cm. Mean of plant height for the parents and hybrids decreased by drought stress in the two seasons.

Panicle length over the two seasons under 40% irrigation level for the female lines varied from 20.25 (SHB-17) to 26.42 (ICSB-88003) with an average of 23.26 cm, for R-lines under 40% irrigation ranged from 21.47 (Adv-6) to 27.17 (ICSV-273) with an average of 23.80 cm, while, for the crosses varied from 23.75 (ASH-10 × Kymoun) to 30.83 (ICSA-37 × ICSR-92003) with an average of 27.26 cm. Whereas, the average of panicle length of genotypes (females, males and crosses) under 70% irrigation over the two seasons were 26.51, 27.79 and 30.84 cm. respectively. On the other hand, panicle length under 100% irrigation for the female lines varied from 27.34 (BSH-8) to 31.50 (ICSB-88003) with an average of 29.21cm and for R-lines ranged from 29.50 (ICSR-92003) to 32.84 (ICSV-273) with an average of 30.80 cm. While, for the crosses, it varied from 30.08 (ASH-10 × ICSR-89028) to 39.25 (ASH-6 × Adv-6) with an average of 34.57cm. The reduction in the average of panicle length for the female, males and crosses under severe water stress 40% irrigation was 5.95, 7.00 and 7.30 cm, respectively.

Panicle width over the two seasons under 40% irrigation showed that the female lines varied from 3.67 (BSH-8) to 5.67 (ICSB-88003)

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with an average of 4.60 cm, for males ranged from 4.42 (ICSR-89028) to 5.79 (ICSV-273) with an average of 5.09 cm, for the crosses, it varied from 4.42 (ASH-8 × Kymoun) to 7.73 (ICSA-88003 × ICSV-273) with an average of 6.00 cm. Whereas, the average of panicle width of females, males and crosses under 70% irrigation over the two season were 5.83, 5.79 and 7.25 cm, respectively. Panicle width under 100% irrigation for the female lines it varied from 5.09 (SHB-13) to 6.75 (ICSB-88003) with an average of 5.95 cm, panicle width for the male lines ranged from 5.75 (Adv-6) to 7.09 (ICSV-273) with an average of 6.37 cm. While, for the crosses varied from 6.50 (ASH-8 × Kymoun) to 10.58 (ASH-11 × Adv-6) with an average of 8.24 cm. The reduction in the average of panicle width for the female, R-lines and crosses under severe water stress 40% irrigation was 1.35, 1.28 and 2.24 cm, respectively.

The 1000-grain weight average over the two seasons under 40% showed that for the female lines ranged from 21.55 (BSH-8) to 25.45 (ICSB-88003) with an average of 23.20 g, while for the male lines it ranged from 24.70 (Adv-6/2009) to 28.54 (ICSR-92003) with an average of 26.07 g. For the crosses it ranged from 22.11 (ASH-6 × ICSR-98028) to 30.74 (ICSA-37 × ICSR-92003) with an average of 26.67 g. The results indicated that the reductions in the average of 1000-grain weight for the female, male lines and crosses under severe water stress 40% irrigation level were 3.16, 3.30 and 4.13 g, respectively. Mean of 1000-grain weight significantly decreased with increasing drought stress for both of the parents and hybrids over the two seasons.

The grain yield/plant over the two seasons under sever water stress 70% and 40% irrigation level showed that crosses no. 1, 4, 13, 16, 18, 19, 33, 34, 38 and 39 significantly out yielded of the check H-306. Moreover, these crosses also, gave significantly higher yield under 100% irrigation

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level over the two seasons. These crosses have males ICSV-273 and ICSR-92003 and female lines ASH-6, ASH-11, ICSA-37 and ICSA-88003 which are tolerant to water stress. The crosses no. (4, 16, 19 and 33) gave the highest yield over the two seasons and combined under three levels of irrigation showed that the combined average were 90.89, 93.64, 95.39 and 96.52 g respectively. While, the combined average of the check H-306 were 77.20 g.

Over the two seasons, the estimated of drought tolerance index (DTI) values for the female lines ranged from 58.60 (BSH-17) to 82.27% (BSH-11), also, for the male lines, it ranged from 60.39 (ICSR-89028) to 85.02% (ICSR-273). For the crosses, it ranged from 49.58 (ASH-17 × ICSR-89028) to 83.54% (ASH-6 × Adv6).

The combined data over the two years showed that twenty-two crosses had lowest DSI values, that means these crosses are considered as a drought tolerant genotypes. The other two methods stress tolerance of irrigation index (STI) and relative performance (P) gave similar results of DTI and DSI of the genotypes to evaluate the drought tolerance.

In general, the best crosses; ASHA-6 × Adv-6, ASHA-6 × ICSV-273, ASH-10 × ICSR-92003, ASHA-11 × ICSV-273, ICSA-37 × ICSR-92003, ICSA-37 × ICSV-273, ICSA-88003 × ICSR-92003 and ICSA-88003 × ICSV-273 gave the highest yield over the two seasons under 40% and 100% irrigation levels. Also, these crosses are drought tolerant and significantly outyielded the check H-306. These crosses can be used in sorghum production under drought stress condition after testing them in a large scale. Also, the male lines ICSV-273 and ICSR-92003 which were used in these crosses can be considered the best tolerant restorer lines and it can be used in crossing with more female lines.

### **II- Heterosis**

The combined data over the two seasons, heterosis values for days to 50% flowering over the two seasons under the three levels of irrigation treatments showed that eighteen crosses were negative and highly significant heterosis values that means these genotypes had favorable gene action for earliness.

Heterosis values for plant height over the two seasons under 40% of irrigation level ranged from 4.95 to 80.08%. Under 70% of irrigation level, it ranged from 3.76 to 81.38%. While, under 100% of irrigation level, it ranged from 9.66 to 72.19%. All crosses were positive and highly significant heterosis values that means these crosses had favorable gene action for tallness.

For panicle length, the heterosis values over the two season showed that seventeen crosses (no. 1, 3, 4, 5, 6, 8, 10, 13, 16, 17, 18, 20, 21, 23, 26, 28, 30, 31, 32, 33, 35, 38 and 39) had highly significant heterosis values under three levels of irrigation in the two seasons and over the two seasons. Positive and highly significant heterosis values means that these crosses had longer panicle length than the better parent.

Heterosis values for panicle width over two seasons indicated that twenty seven crosses (no. 1, 2, 3, 4, 5, 6, 7, 11, 13, 16, 17, 18, 19, 20, 21, 22, 24, 26, 31, 32, 33, 34, 35, 36, 37, 38 and 39) had Positive and highly significant heterosis values under three levels of irrigation, means that these crosses had higher panicle width than the better parent.

Heterosis values for 1000-grain weight over the two season showed that twenty crosses (no. 6, 7, 9, 11, 16, 17, 18, 19, 20, 21, 31, 32, 33, 34, 35, 36, 37, 38, 39 and 40) had positive and significant or highly

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significant heterosis under the three levels of irrigation that means these crosses had heaviest grain weight than the better parent.

Heterosis values of the combined over the two seasons for grain yield under 40% of irrigation level, ranged from -18.93 to 87.06% under 70% of irrigation level, it varied from -3.52 to 92.52% and under 100% of irrigation level, it ranged from 2.85 to 89.13%. Twenty five crosses gave the highest heterosis for grain yield/plant than the better parent under the three levels of irrigation at each and over the two seasons.

### **III- Combining ability**

The combined analysis of variance over irrigation levels at each season showed highly significant differences among the crosses and their partitions (females, males and females  $\times$  males) for all the studied traits. These results indicated that the additive (GCA) and non-additive (SCA) were important in the inheritance of these traits. Also, the interactions between irrigations and these components were significant at both seasons for all the studied traits.

For days to 50% flowering, two female lines (ASH-6 and ICSA-88003) and two male lines (Adv.6/2009 and ICSR-92003) had negative and highly significant GCA effects under three irrigation levels at each season and combined over the two seasons. These lines had favorable genes and would be good combiners for earliness. Moreover, the crosses no.16 and 27 had negative significant SCA effects under 40% of irrigation level over the two seasons. This means that these crosses could be considered as good combinations for earliness under stress condition.

For plant height, the female lines ICSA-37 and ICSA- 88003 and the male lines Adv.6/2009 and ICSV-273 had positive and highly significant general combining ability under three irrigation levels at both

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seasons and combined over the two seasons, these lines had favorable gene action for tallness. While, the crosses no. 4, 13, 16, 19, 27, 32 and 38 had positive and highly significant SCA effect under three levels of irrigation over the two seasons. These crosses could be considered as good combinations for tallness.

For panicle length, the female line ICSA-37 and the male lines ICSR-92003 and ICSV-273 had positive and significant GCA effects under irrigation levels at both and combined over the two seasons. These lines would be considered as a best combiners for panicle length. While, the cross no. 14 had positive and highly significant SCA effects under three irrigation levels over the two seasons.

For panicle width, the female lines ASH-11, ICSA-37 and ICSA-88003 and the male lines Adv.6 and ICSV-273 had positive and highly significant GCA under irrigation levels at both and over the two seasons. These lines had favorable gene action for panicle width. The crosses no. 16 and 39 had positive and significant SCA effects for panicle width and would be considered a good combinations for this trait under water stress conditions.

1000- grain weight showed that, the female lines ASH-8, ASH-11, ICSA-37 and ICSA-88003 and the male lines Adv.6, ICSR-92003 and ICSV-273 had positive and highly significant general combining ability effects under three irrigation levels over the two seasons. These lines had favorable genes and would be considered good combiners for heavy 1000-grain weight. The crosses no. 9 and 29 had positive and highly significant SCA effects for 1000-grain weight over seasons and over three irrigation levels. These crosses were considered the best combinations for increasing the 1000-grain weight.

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For grain yield, the female lines ASH-6, ASH-11, ICSA-37 and ICSA-88003 and the male lines ICSR-92003 and ICSV-273 had positive and highly significant general combining ability effects under three irrigation levels in both and over the two seasons. These lines had favorable genes and would be considered good combiners for high yielding ability. The crosses no. 7, 13, 16 and 33 had positive and highly significant SCA effects at each and combined over the two seasons under the three of irrigation levels and would be considered the best combinations for grain yield/plant.

### **IV- Stability**

The stability performance of the fifty four genotypes were studied over six environments i.e.; two years and three irrigation levels. The joint regression analysis of variance indicated that mean squares due to crosses and environments (Linear) were highly significant for days to 50% flowering, plant height, panicle length, panicle width, 1000-grain weight and grain yield/plant. The genotypes  $\times$  environment interaction including environmental linear were also highly significant for all the studied traits. In addition, the linear component of genotypes  $\times$  environment interaction were highly significant for all studied traits except for days to 50% flowering was insignificant. The significant of pooled deviation for plant height, panicle length, panicle width, 1000-grain weight and grain yield indicate that these genotypes differed considerably with respect to their stability for these traits.

The crosses considered to be superior and stable were ASH-13  $\times$  Kymoun, ASH-17  $\times$  Kymoun for 50% flowering, the crosses ASH-6  $\times$  Adv-6, ASH-6  $\times$  ICSV-273, ASH-10  $\times$  Adv-6, ASH-10  $\times$  ICSR-92003, ASH-11  $\times$  ICSV-273, and ICSA-37  $\times$  Kymoun considered to be superior because the regression coefficient of these genotypes equal one ( $b_i=1$ )

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and a high mean of plant height when compared with the mean over all genotypes.

The crosses ASH-10 × ICSV-273, ASH-11 × ICSR-92003 for panicle length considered to be stable. Also, the crosses ASH-6 × Adv-6, ASH-10 × ICSV-273, ASH-13 × Adv-6, ICSA-88003 × ICSR-89028 and ICSA-88003 × ICSR-92003 considered to be superior and stable for panicle width.

For 1000-grain weight the crosses ASH-8×Adv-6, ASH-11 × ICSV-273, ICSA-88003 × Adv-6 and ICSA-88003 × ICSR-92003 considered to be stable for 1000-grain weight because the regression coefficient of these genotypes equal one ( $b_i=1$ ) and had high 1000-grain weight when compared with the mean over all genotypes,. Also, the crosses ASH-6 × ICSV-273, ICSA-37 × ICSR-92003 and ICSA-37 × Kymoun considered to be superior for grain yield/plant.

Some crosses were stable for grain yield and other traits for all environments; also the crosses ASH-6 × ICSV-273 and ICSA-37 × Kymoun were stable in favorable environment. While, the crosses ASH-6 × Adv-6 and ASH-8 × ICSV-273 were relatively better and stable in less favorable environments for grain yield and some other traits, these crosses had highly grain yield and highly significant and positive heterosis values and SCA effects.