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SUMMARY

Heterosis and combining ability in grain sorghum [*Sorghum bicolor* (L.) Moench] under optimum and low level of nitrogen.

The experiment was conducted in two seasons 2006, 2007 in Shandaweel Agric. Res. Station, Sohag. This experiment included the thirty-two crosses and their parental lines (four B and eight R lines) plus the check hybrid Shandaweel-2.

In this study the RCBD design were used in the experiment for the each nitrogen levels (100 and 50 kg N/fed.,) to evaluate the genotypes. Line x tester analysis were used to compute the genetic parameters.

The obtained data in the experiment were illustrated as following:-

I-Mean performance:-

The combined analysis of variance over nitrogen levels at each season showed highly significant differences between genotypes and nitrogens for all studied traits. Also, significant or highly significant differences between seasons for days to 50% flowering, plant height, panicle length and 1000 grain weight .The interactions between genotypes x seasons was highly significant for all studied traits. The interactions between genotypes x nitrogens was highly significant for all studied traits except for both panicle width and no. of green leaves the interaction was insignificant. While, the interactions between seasons x nitrogens was insignificant for all studied traits except for plant height, panicle length and grain yield/ plant, also, the interactions between genotypes x nitrogen x seasons were highly significant for days to 50% flowering, plant height, panicle length, 1000 grain weight and grain yield/plant.

1- The combined data over two seasons indicate that days to 50% flowering for the female lines under 50 kg N level ranged from

69.83(SPDM-94021-B) to 75.50 (SPAN-94037-B), while for the R-lines it ranged from 73.17 (ICSR-89036) to 78.33 (ICSR-90012). Moreover, for the crosses it ranged from 64.00 (SPAN-94037-A x ICSR-89028) to 77.33 (SPAN-94037-A x ICSR-90012). Also, for the female lines under 100 kg N level it ranged from 65.00 (SPDM-94021-B) to 70.50 (SPAN-94037-B), while for the R-lines it ranged from 68.83 (ICSR-89036) to 73.00 (ICSR-90012). While, for the crosses it ranged from 59.67 (SPAN-94037-A x ICSR-94007) to 70.00 (SPAN-94037-A x ICSR-90012). The results indicated that the increase in the average of days to 50% flowering for the female, male lines and crosses under 50 kg N level was 5.33, 4.92 and 5.88 days, respectively. It can be concluded that the average of days to 50% flowering for all studied genotypes increase under low nitrogen, which means that low nitrogen delays days to 50% flowering.

2- Plant height for the female lines over two seasons under 50 kg N level ranged from 123.33 (SPDM-94021-B) to 178.33 (SPAN-94037-B), while for the male lines it ranged from 110.00 (ICSR-94007) to 204.17 (ICSV-273). Moreover, for the crosses it ranged from 155.83 (SPDM-94021-A x ICSR-89028) to 223.33 (SPST-94009-A x ICSV-273). Under 100 kg N level for the female lines it ranged from 134.17 (SPDM-94021-B) to 199.17 (SPAN-94037-B), while for the R-lines it ranged from 116.67 (ICSR-94007) to 217.50 (ICSV-273). While, plant height for the crosses ranged from 170.00 (SPDM-94021-A x ZSV-14) to 279.17 (SPAN-94037-Ax ICSV-273). The average of crosses was significantly higher than those of the female and male lines at each and over two seasons under the two nitrogen levels indicating the heterotic effect. Whereas, the male line ICSV-273 gave the tallest plant height of its crosses. The reduction in the

average of plant height for the female, male lines and crosses under 50 kg N level was 13.54, 16.36 and 20.78 cm, respectively.

3- Panicle length over two seasons for the female lines under 50 kg N level ranged from 21.33 (SPST-94009-B) to 24.33 (SPAN-94037-B), while for the male lines it ranged from 20.67(ICSR-94007) to 27.17(ICSR-89036). Moreover, it ranged for the crosses from 21.33 (SPST-94009-A x ICSR-91022) to 29.33 (SPDM-94021-A x ICSR-90012). Under 100 kg N level it ranged for the female lines from 26.67(SPST-94009-B) to 30.67 (SPAN-94037-B), while for the male lines it ranged from 25.50 (ICSR-94007) to 31.50 (ICSR-89036). However, for the crosses it ranged from 27.00 (SPST-94009-A x ICSR-91022) to 35.50 (SPDM-94021-A x ICSR-90012). The average of panicle length of crosses significantly exceeded those of female and male lines reflecting the heterotic effect. There results showed that the reduction in the average of panicle length for the female, male lines and crosses under 50kg N level was 4.92, 5.06 and 5.45cm.

4- Panicle width over two seasons showed that for the female lines under 50 kg N level ranged from 3.50 (SPDM-94021-B) to 6.33 (SPAN-94037-B), while for the male lines it ranged from 3.67 (ICSR-91022) to 7.83 (ICSV-273). While, for the crosses it ranged from 3.50 (SPAN-94037-A x ICSR-89036) to 7.17 (SPAN-94037-A x ICSV-273). Moreover, for the female lines under 100 kg N level it ranged from 5.50 (SPDM-94021-B) to 8.33 (SPAN-94037-B), while for the male lines it ranged from 5.67 (ICSR-91022) to 9.67 (ICSV-273). Also, panicle width for the crosses ranged from 5.00 (SPAN-94037-A x ICSR-89036) to 9.83 (SPAN-94037-A x ICSR-89066). The results indicated that the reduction in the average of panicle

width for the female, male lines and crosses under 50kg N level were 1.75, 1.89 and 2.12 cm.

5- Number of green leaves/plant over two seasons under 50 kg N level for the female lines ranged from 5.17 (SPDM-94021-B) to 6.00(SPAN-94037-B), while for the male lines it ranged from 3.67 (ZSV-14) to 7.33 (ICSV-273). Whereas, for the crosses it ranged from 4.67 (SPDM-94021-A x ICSR-90012) to 9.00 (SPDM-94002-A x ICSR-89066). However, under 100 kg N level number of green leaves/plant for the female lines ranged from 7.50 (SPDM-94021-B) to 8.67 (SPAN-94037-B), while, it ranged for the male lines from 6.00 (ZSV-14) to 10.17 (ICSV-273). For the crosses it ranged from 6.83 (SPDM-94021-Ax ICSR-91022) to 12.00 (SPDM-94002-Ax ICSR-89066). The results showed that the reductions in the average of no. of green leaves/plant for the female, male lines and crosses under 50kg N level were 2.41, 2.44 and 2.81, respectively.

6- The 1000-grain weight over two seasons under 50 kg N level for the female lines ranged from 20.67 (SPDM-94002-B) to 23.31 (SPDM-94021-B), while for the male lines it ranged from 21.85 (ICSR-89036) to 28.55 (ICSR-94007). Whereas, for the crosses it ranged from 19.77 (SPAN-94037-A x ICSR-89036) to 27.28 (SPDM-94021-Ax ZSV-14). Moreover, 1000-grain weight under 100 kg N level for the female lines it ranged from 24.90 (SPDM-94002-B) to 29.08 (SPAN-94037-B), while for the male lines it ranged from 25.40 (ICSR-89028) to 30.57 (ICSR-94007). For the crosses it ranged from 22.53 (SPST-94009-A x ICSR-89028) to 31.36 (SPDM-94002-Ax ICSR-89028). The reductions in the average of 1000-grain weight for the female, male lines and crosses under 50 kg N level were 4.87, 3.71 and 3.38 g, respectively.

7- The grain yield/plant over two seasons for the female lines under 50 kg N level ranged from 39.13 (SPDM-94021-B) to 41.76(SPDM -94002-B), while for the male lines it ranged from 44.39 (ICSR-89028) to 65.88 (ICSV-273). Also, for the crosses it ranged from 44.42 (SPAN-94037-Ax ICSR-89028) to 75.83 (SPAN-94037-Ax ICSV-273). Moreover, grain yield/plant for the female lines under 100 kg N level it ranged from 47.31 (SPDM-94021-B) to 55.72 (SPST-94009-B), while for the male lines it ranged from 57.51 (ICSR-89028) to 72.02 (ICSV-273). Also, for the crosses it ranged from 63.55 (SPDM-94021-A x ICSR-89028) to 94.88 (SPDM-94002-A x ICSV-273). The crosses significantly out yielded their parents at each and over two seasons under two nitrogen levels indicating the presence of heterosis. The reductions in the average of grain yield/plant for the female, male lines and crosses under 50kg N level were 12.53, 10.54 and 17.80 g, respectively.

Generally, under low nitrogen level, the crosses number (4, 5, 19 and 28) significantly out yielded the hybrid Shandaweel-2 in 2006, 2007 and over two seasons. Moreover, these crosses, also, gave significantly higher yield under 100 kg N level at each season and over all seasons.

Economic nitrogen use efficiency values NUE_e over two seasons for the female lines under 50 kg N level ranged from 34.48 (SPDM-94021-B) to 36.80 (SPDM -94002-B), while for the male lines it ranged from 39.11 (ICSR-89028) to 58.05 (ICSV-273). Also, for the crosses it ranged from 39.14 (SPAN-94037-Ax ICSR-89028) to 66.82 (SPAN-94037-Ax ICSV-273). Moreover, economic nitrogen use efficiency values NUE_e for the female lines under 100 kg N level ranged from 26.66 (SPDM-94021-B) to 31.40 (SPST-94009-B), while for the male lines it ranged from 32.41 (ICSR-89028) to 40.59 (ICSV-273). Also, for the

crosses it ranged from 35.81 (SPDM-94021-A x ICSR-89028) to 53.47 (SPDM-94002-A x ICSV-273).

Nitrogen use efficiency values NUE over two seasons for the female lines under 50 kg N level ranged from 71.15 (SPDM-94021-B) to 75.93 (SPDM -94002-B), while for the male lines it ranged from 80.71 (ICSR-89028) to 119.78 (ICSV-273). Also, for the crosses it ranged from 80.76 (SPAN-94037-Ax ICSR-89028) to 137.87 (SPAN-94037-Ax ICSV-273). Moreover, nitrogen use efficiency values NUE for the female lines under 100 kg N level it ranged from 43.01 (SPDM-94021-B) to 50.65 (SPST-94009-B), while for the male lines it ranged from 52.28 (ICSR-89028) to 65.47 (ICSV-273). Also, for the crosses it ranged from 57.77 (SPDM-94021-A x ICSR-89028) to 86.25 (SPDM-94002-A x ICSV-273).

Generally, the best crosses; SPDM-94002-A x ICSV-273, SPDM-94002-A x ZSV-14, SPDM-94021-A x ICSR-90012 and SPAN-94037-A x ICSV-273 gave the highest yield in 2006, 2007 and over two seasons under both nitrogen levels. Also, these crosses are nitrogen tolerant and significantly out yielded the check Shandaweel-2. These crosses can be used in sorghum production under low nitrogen levels after testing them in a large scale. Also, the male lines ICSV-273, ZSV-14 and ICSR-90012 which was used in these crosses can be considered the best tolerant restorer line and it can be used in crossing with more female lines.

II- Heterosis: -

1- The combined data over two seasons under 50 kg N level showed that heterosis values for days to 50 % flowering ranged from –15.23 to 9.79% and twenty crosses had negative significantly heterosis. Under 100 kg N level heterosis values for days to 50 % flowering ranged from –14.66 to 6.67% and twenty three crosses had negative significantly heterosis. The heterosis of days to 50 % flowering for

twenty crosses were negative and significant under two nitrogen levels.

2- For plant height, under 50 kg N level heterosis values ranged from –0.46 to 29.75% and twenty-five crosses had positive significantly. Also, under 100 kg N level the heterosis ranged from -5.12 to 35.4%. The most of the crosses were significantly taller than the better parent and the heterosis of thirteen crosses were highly significant under the two nitrogen levels at both seasons and over the two seasons.

3- For panicle length, under 50 kg N level heterosis values ranged from –5.52 to 21.38% and twenty-two crosses had positive significantly heterosis. Also, under 100 kg N level it ranged from – 4.65 to 22.41% and twenty-three crosses had positive significantly heterosis. The heterosis for seventeen crosses was positive highly significant under two nitrogen levels.

4- Heterosis values for panicle width under 50 kg N level, varied from –44.74 to 69.57%. Twelve crosses out of thirty-two crosses had positive significantly heterosis. Under 100 kg N level heterosis values for panicle width ranged from –40.00 to 45.71% and eighteen crosses had positive significantly heterosis. The heterosis for ten crosses were positive highly significant under the two levels of nitrogen.

5- Data over the two seasons under 50 kg N level, heterosis values for number of green leaves ranged from –16.67 to 60.61%, seventeen crosses had positive significantly heterosis. Under 100 kg N level heterosis values for number of green leaves ranged from –8.89 to 54.35% and twenty-two crosses had positive significantly heterosis.

6- For 1000-grain weight, under 50 kg N level heterosis values varied from –27.94 to 17.02%, the crosses no. 2, 6, 7, 13 and 21 had positive significantly or highly significant heterosis. Under 100 kg N level

heterosis values ranged from –25.03 to 23.46% and three crosses had positive highly significant heterosis under the two levels of nitrogen.

7- Heterosis values of the combined data for grain yield / plant over the two seasons under 50 kg N level ranged from –14.29 to 51.09 %. Under 100% of nitrogen level varied from 3.00 to 55.14 % and twenty four crosses had positive highly significant heterosis for grain yield/plant under the two levels of nitrogen. Twenty four crosses gave the highest heterosis for grain yield/plant than the best parent under the two levels of nitrogen in both and over the two seasons.

III- Combining ability: -

The combined analysis of variance over nitrogen levels at each season showed highly significant differences among the crosses and their partitions (females, males and females x 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 nitrogens and these components were significant at both seasons for all the studied traits, except for days to 50% flowering and panicle length, the interaction between males x nitrogens was insignificant in 2006 season. While, for the panicle width the interactions between nitrogens and these components were insignificant at both seasons except the interaction between males x nitrogens was significant in 2006 season. Also, for no. of green leaves the interaction between nitrogens and these components were insignificant at both seasons.

III- A- General combining ability effect (gca):-

1- For days to 50% flowering, the general combining ability effect of female line SPAN-94037-B was negative and highly significant under two nitrogen levels in 2006, 2007 and over two seasons. The gca effect of the male line ICSV-273 was negative highly significant under the two nitrogen levels at both studied seasons and combined

over N levels except under 100 Kg N level in 2007 season. These lines had favorable genes and would be consider of good combiners for earliness.

2- For plant height, the general combining ability effect of female lines SPST-94009-B and SPAN-94037-B had positive highly significantly under the two nitrogen levels in 2006, 2007 seasons and over the two studied seasons. Also, the male lines ICSV-273 had positive highly significantly general combining ability effect under the two nitrogen levels at both seasons and combined over the two seasons. These lines had favorable gene action for tallness.

3- For panicle length, the female line SPAN-94037-B had positive highly significantly gca effect under the two nitrogen levels at each season and over the two seasons. This line had favorable genes and would be considered good combiner for panicle length.

4- For panicle width, the general combining ability effect of male lines ICSR-89066 and ICSV-273 had positive highly significantly under the two nitrogen levels at both season and combined over seasons. These lines had favorable gene action for panicle width. The gca effect for female line SPDM-94021-B positive highly significant under the two nitrogen levels in 2007season and combined over seasons. This line had favorable gene and would be considered a good combiner for this trait under stress conditions.

5- For number of green leaves, the general combining ability effect of the female lines SPDM-94002-B, SPST-94009-B and the male line ICSV-273 was positive and highly significant under the two nitrogen levels at each season and combined over the two seasons. Therefore, means these lines had favorable gene action for no. of green leaves.

6- For 1000- grain weight, the general combining ability of male line ZSV-14 was positive highly significant under the two nitrogen levels

in 2006,2007 and over the two seasons. Also, the male line ICSR-91022 had positive highly significantly general combining ability under the two nitrogen levels in both and over the two seasons except under 50 kg N level in 2007 season that was insignificant. These lines had favorable genes and would be considered good combiners for heavy 1000-grain weight and may contribute to grain yield.

7- For grain yield / plant, the general combining ability effect of female line SPDM-94002-B was positive and highly significant under the two nitrogen levels at both seasons and combined over the two seasons. Also, the male lines ICSR-89066, ICSV-273 and ZSV-14 had positive highly significantly general combining ability effect under the two nitrogen levels in 2006, 2007 and over seasons. These lines had favorable genes and would be considered good combiners for high yielding ability.

III- B- Specific combining ability (sca):-

1- The crosses number 1, 2, 3, 12, 15, 20, 21, 30, 31 and 32 had negative significantly sca effects under two nitrogen levels and combined over two seasons. Means these crosses would be considered a good combination for earliness.

2- The crosses number 16, 19 and 30 had positive significantly sca effect for plant height under the two levels of nitrogen in each and over the two seasons.

3- The crosses number 2, 9, 10, 19 and 30 had positive significantly sca effect for panicle length over the two seasons under both nitrogen levels. These crosses are considered the best combinations for panicle length.

4- The crosses number 8, 12, 14, 18 and 24 had positive significantly sca effect for panicle width under both nitrogen levels and over two

seasons. That means these crosses were the best combinations for panicle width. While, crosses number 8 and 18 had the favorable gene and would be considered agood combinations for this trait under optimum conditions.

5- The crosses number 1, 2, 6, 11, 14, 15, 20 and 32 had positive significantly sca effect for no. of green leaves in combined over the two seasons under the two nitrogen levels.

6- The crosses number 7, 16 and 21 had positive significantly sca effect for 1000-grain weight at each season and over the two seasons under both nitrogen levels. These crosses were considered the best combinations for increasing the 1000-grain weight.

7- The crosses number 7, 9, 14, 15, 17, 18, 19, 21, 26, 28, 30 and 32 had positive significantly sca effect for grain yield/plant in combined over the two seasons under the two nitrogen levels. The crosses number 9, 19, 30 and 32 had positive significantly sca effect in each and combined over the two seasons under both nitrogen treatments and would be considered the best combinations for grain yield/plant. On the other hand, crosses SPDM-94002-A x ICSR-89028, SPST-94009-A x ICSR-89066, SPST-94009-A x ICSR-91022, SPST-94009-A x ICSR-94007, SPDM-94021-A x ICSR-90012, SPAN-94037-A x ICSR-89036, SPAN-94037-A x ICSV-273, SPAN-94037-A x ICSR-91022 and SPAN-94037-A x ICSR-94007 had significantly positive SCA effect under 50 kg N level and were considered good combinations under low nitrogen.

IV- Phenotypic correlations: -

The correlation between grain yield/plant and each of plant height, panicle length, panicle width and no. of green leaves were positive and significant under both nitrogen levels, while, the correlation between

grain yield/plant and days to 50% flowering was negative and significant. The correlation between grain yield/plant and 1000-grain weight was insignificant. Also, the correlation between days to 50% flowering and each of plant height and panicle length were negative and significant under 50 kg N level, while, the correlation between days to 50% flowering and each of panicle width and no. of green leaves was negative and insignificant indicating that the delay in the days to 50% flowering under low nitrogen level.