Evaluation of Egyptian cotton cultivars under water stress conditions using line × tester analysis

by

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CONTENTS

SUMMARY

Evaluation of Egyptian cotton cultivars under water stress conditions using line × tester analysis

The experiments of the present study were carried out at Shandaweel Research Station, Sohag, Agricultural Research Center (A.R.C), Egypt during the three-summer successive growing seasons of 2018, 2019 and 2020. Fourteen cotton varieties (*Gossypium barbadense* L.) and promising lines were evaluated under water stress and normal irrigation conditions. Ten genotypes were crossed as lines with three as testers in a line–tester method to give 30 F_1-hybrids. Furthermore, two cycles of selection were achieved for different traits on a population in the F_2-generation.

Results could be summarized in the following five main topics:

A - Tolerance of Egyptian cotton genotypes to drought stress condition.

B - Drought tolerance indices.

C- phenotypic correlations among traits and path analysis of seed cotton yield and its components in Egyptian cotton.

D - Line × tester analysis.

E- Two cycles of pedigree selection.

A-Tolerance of Egyptian cotton genotypes to drought stress condition

1- Mean squares of all the studied traits under normal and stressed conditions in year 1 and year 2 and their combined indicated significant ($p \leq 0.01$) differences among genotypes in separate and combined analysis.
2- The effect of years showed significant ($p \leq 0.05$ to $p \leq 0.01$) differences between the two seasons for all traits except NB/P, NS/B, DFF and Micronaire reading under normal irrigation, and for all traits except for LY/P and lint% under stressed condition.

3- The results showed that the stability of cotton characters differ from year to year. Furthermore, the interaction of genotypes by years were significant for all traits except for staple length and strength under normal irrigation, and for all traits except for lint% under drought stress. Except for fiber length and strength, most of the variability was caused by genotypes rather than years and their interactions with genotypes. These results indicate differential response of most cotton traits to soil moisture and seasons.
4- The reduction% caused by drought stress in SCY/P ranged from 31.44 (D- genotype) to 39.39 (karashinki) with an average of 33.93.
5- Giza 95 showed the best performance under both environments for SCY/P, LY/P, Lint%, LI and BW, while Giza 90 was the best for fiber length (upper half mean length), and the Australian genotype was the best in fiber strength as measured in Pressley index.
6- The reduction% in LY/P caused by drought stress was slightly higher than in SCY/P indicating that lint was more affected than seeds. In consequence, lint index was more affected by drought than seed index.
7- Lint% was slightly affected due to that drought stress affected both of lint and seeds.

B - Drought Tolerance Indices

1- The drought tolerance indices (SSI, STI, MP, GMP, TOL, YSI, HM, SDI, DI and SDI) were calculated based on the combined mean of SCY/P under irrigation and SCY/P under drought stress and ranked.
2- The low rank indicates tolerance and the high indicates susceptibility to drought.
3- The ranks mean was the lowest for Giza 95 followed by Giza 90 and (Giza 90 × Aust.) indicating tolerance to drought stress. These genotypes rank the first, second, and the third for drought tolerance

indicators STI, MP, GMP, HM and DI. Conversely, the highest ranks mean (towards susceptibility) was for Dandara, Ashmouni and Karashinki, their ranks ranged from 9 to 14 for SSI, STI, MP, GMP, YSI, HM, DI and RDI drought indices.

4- The STI, MP, GMP, HM and DI detected both of tolerant and susceptible genotypes and could be considered the best tolerant indices. Furthermore, for the 14 studied genotypes, the simple correlation between the ranks of Yp and Ys with ranks mean were 0.999 and 0.993, respectively indicating that the information respect to drought tolerance could be derived from the performance of a genotype under normal and stress environments.

C.1-Phenotypic correlations among traits

1- The correlation of SCY/P under normal irrigation was high with LY/P, Lint%, NB/P, BW and LI moderate with NS/B and upper half mean length, and low with DFF, Pressley index and negative with Micronaire reading. However, the picture was different under drought stress in which drought affect lint rather than seeds.

2- Under drought stress the correlation of SCY/P was moderate with lint% (0.5897), fiber length (0.7248), low and negative with LI (-0.1488) and Micronaire reading (- 0.4090) indicating that drought affected deposition of cellulose which slightly lowered Micronaire and increase fiber strength.

3- Under normal irrigation LY/P showed correlations with other traits as SCY/P did. While under drought stress the correlation of LY/P was high with lint%, moderate with NB/P, BW and LI and negative with DFF.

4- The correlation of lint% under irrigation was high with NB/P, BW and LI, moderate with NS/B and fiber length, and low with the other traits. However, under stress it was moderate only with LI and low with NB/P (0.3010), BW (0.3788) and NS/B (0.3229).

5- Under irrigation the correlation of NB/P was high with LI (0.8123) and moderate with BW (0.6978) and fiber length (0.5401). While under drought NB/P gave negative correlations with BW, LI, NS/B, and Micronaire reading, and positive moderate with DFF, fiber length and strength. The increase in BW under both environments increased NS/B and LI.

6- Respect to fiber length it was increased under irrigation and decreased under drought with increasing BW. It is known that drought stress decrease fiber length.

C.2- Path - coefficient analysis

1- Seed cotton yield/plant is a result of lint yield/plant, bolls/plant, number of seeds/boll and seed index.

2- The correlation coefficient of lint yield/plant with seed cotton yield/ plant was positive and very large in magnitude (0.9970) under normal irrigation, and (0.7517) under drought stress. However, the direct effect of LY/P on SCY/P was high (0.6540) under normal irrigation, and low (0.0891) under drought stress. The analysis indicated that under normal irrigation selection should be paid on LY/P, NB/P and NS/B, and for NB/P and NS/B under drought stress. The indirect effect of LY/P via SI was low and negligible.

3- Partitioning the correlation coefficient NB/P with seed cotton yield to their direct and indirect effects indicated that the direct effect of NB/P was the highest (0.9991) under stress rather than under normal irrigation (0.2376). The indirect effect of NB/P on SCY/P was high under irrigation via LY/P (0.5991) and low under drought (0.0365). The indirect effects of NB/P via NS/B and SI were low. Therefore, selection for NB/P under stress and for LY/P under irrigation should be considered.

4- Partitioning correlation of NS/B and SI with SCY/P indicated that the direct and indict effects differed greatly under both environments. The direct effect of NS/B and SI were high under drought and low under irrigation, and vice versa respect LY/P.

5- It could be concluded that the direct and indirect effects of SCY/P components varied greatly under both environments, and LY/P, NB/P and NS/B should be considered as selection indices under normal irrigation, NB/P and NS/B under stress when selection practiced for SCY/P.

D- Line × tester analysis

1- Mean squares (Table 10) was significant ($p \leq 0.01$) for genotypes of all investigated traits under both environments, indicating the presence of variability among hybrids and their parents.

2- Mean squares of parents, crosses, parent's *vs* crosses, lines, testers, and lines × testers for all studied traits under both environments was significant ($p \leq 0.01$) except lint% under drought stress and lint index under irrigation. The significant mean squares of lines, testers and crosses means that both additive and non-additive effects of genes control the characters.

3- The significant ($p \leq 0.01$) mean squares of parent's *vs* crosses reflect the high level of heterozygosity, in other words non-additive gene actions in the inheritance of these traits, in consequence heterosis.

4- The lines mean of SCY/P was 91.44 g and the males mean was 96.52 g with hybrid mean of 103.44 g indicating the non-additive effects and heterosis under normal irrigation. The same trend was observed under drought stress, and for LY/P, lint%, BW, SI, LI, DFF, Micronaire reading, fiber length and strength under both environments. Whereas NB/P did not show hybrid vigor.

5- The line (G. 90 × Aus.) showed the highest GCA effects for SY/P, LY/P, lint%, NB/P, BW, SI, LI, NS/B, and fiber length under both environments. However, its crosses were not the best for all traits. This could be due to the predominant of non-additive effects.

6- The SCA effects was positive and significant for the hybrids of two parents or at least one parent has positive GCA effect on most cases under normal irrigation and drought stress, indicating that additive and non-additive effects of genes control this trait. This relation was lost for LY/P under stress.

7- The hybrid of the highest performance was G95 × (G.90 × Aust.), in which the two parents showed positive GCA effects. The hybrid performance was not in accordance with SCA effect in all traits under both environments.

8- Results of correlation between SCA effect and hybrid performance ranged from high in SCY/P to very weak or negative in some cases, indicating predominant of non-additive effects of genes in all traits.

9- Mean reduction% caused by drought stress of the parents varied greatly from - 4.05 for NS/B to 33.85 for LY/P, while it varied for the hybrids from 5.11 for fiber strength to 34.92 for LY/P. The most tolerant parent was C-genotype and the most susceptible was Karashinki for both of SCY/P and LY/P. The tolerance of the parents varied from trait to another. Likewise, none of the hybrids was tolerant for all traits. But Aust × Ashmouni hybrid showed the lowest reduction% for LY/P, lint%, NB/P, and LI.

D-2.The role of additive and non-additive gene effects in the inheritance of different traits

1- The additive variance (σ^2A) was larger under normal irrigation than under water stress conditions for seed cotton yield, lint yield, lint percentage, boll weight, number of seeds /bolls, days to first flowers, fiber fineness and fiber strength, however, it was larger under water stress for number of bolls/plants, seed index, lint index and fiber length.

2- The dominance variance (σ^2D) was larger at normal irrigation than water stress conditions for seed cotton yield, lint yield, number of bolls/plants, fiber fineness, fiber length and fiber strength however, it was larger under drought stress for boll weight, seed index, lint index, number of seed/ boll and days to first flowers.

3- The ratio σ^2A/σ^2D was less than unity for all traits indicating that the role of dominance was more important than additive effects in the inheritance of these traits.

D-3. Contribution of lines, testers, and their interaction to total variance

1- The proportional contribution of lines was larger than that of testers for all traits except for seed index, DFF, and fiber length at both environments, and for Micronaire reading under drought stress.

2- The contribution of lines was larger than that of lines × testers interaction in all characters except for NB/P and seed index at both environments indicating the importance of selection of lines for hybridization.

3- The contribution of line × tester was about 40% for yields and NB/P and NS/B depicting the importance of non-additive type of gene action.

E- selection

Two cycles of single trait selection and independent culling levels were achieved for six traits: seed cotton yield/plant (SCY/P), lint yield/plant (LY/P), lint%, number of boll/plant (NB/P), boll weight (BW), and lint index (LI) on a population in the F_2-generation stemmed from the cross Giza 90 × Giza 95. The results could be summarized as:

1. Description of the base population; F_2 - generation

1.1. Mean seed cotton yield/plant (SCY/P) of the parents Giza 90 and Giza 95 was 83.38 and 82.31g under normal irrigation, and 56.82 and 62.47 under drought stress with reduction of 31.85 and 24.11%, respectively. Mean SCY/P of the F_2 was 42.83 and 33.13 under normal irrigation and drought stress; respectively, with reduction of 22.65%.

1.2. The F_2 mean was less than the two parents with under dominance towards the low yielding parent. Phenotypic (PCV%) and genotypic (GCV%) coefficients of variability were high in the F_2 and accounted for 63.91 and 34.80% under normal irrigation, and 51.40 and 14.79% under drought stress; respectively, indicating sufficient variability for selection for SCY/P.

1.3. Lint yield/ plant showed the same trend. Likewise, NB/P showed wide variability and PCV%, in consequence high expected genetic advance of 16.18 of the mean under irrigation, but low (4.74%) under drought stress.

1.4. The results indicated that except for BW, NS/B, and technological properties the PCV% was high under normal irrigation than under drought stress.

2. Phenotypic correlation among traits

2.1. The correlation of SCY/P with the other traits was higher under normal irrigation than under drought stress except for lint% and NS/B. SCY/P was mainly depended on NB/P, BW and SI, and moderately by LI.

2.2. The correlation of LY/P showed the same trend, but its correlation with LI was higher than that with SCY/P.

2.3. Lint% was more correlated with LY/P than SCY/P and higher under irrigation than under drought stress.

2.4. Lint index showed the same trend and gave high correlation with lint%. Days to first flower showed negative correlation with all traits and was higher under normal irrigation than under drought stress.

3. Variances and Means

3.1. Mean squares of all selection criteria after the second cycle was significant ($p \leq 0.05$ - $p \leq 0.01$) when selection practiced under normal irrigation either evaluation was done under normal irrigation or under stress, except for three out of 168 cases (in boldface).

3.2. selection under drought stress, mean squares was significant for the selection criteria except for BW under drought stress. Few cases (19 out of 168) were not significant.

4. Coefficients of variation and heritability

4.1. Genotypic coefficient of variation under normal irrigation in SCY/P decreased from 34.80% in the F_2 to 4.24% in $F_{4,}$ and for LY/P decreased from 37.39 to 9.75%. Such decrease was observed for the other selection criteria.

4.2. the PCV and GCV in selection criteria were higher in evaluation under drought stress than under normal irrigation when selection practiced under both environments.

4.3. The PCV% and GVC% were slightly higher in magnitude in ICL method than those in single trait selection for SCY/P, Lint%, BW and LI when selection practiced under normal irrigation. However, selection under drought stress the coefficients of variation were higher for BW and NB/P. Generally, in multiple traits selection preserve genetic variability more than single trait selection.

4.4. Heritability in broad sense for all selection criteria was higher except for selection for BW under stress, and for lint% in ICL under stress when selection practiced under stress.

4.5. Heritability in narrow sense as estimated by regression of offspring on parents ranged from 0.0385 for LI to 0.9733 for LY/P when selection practiced and evaluated under normal irrigation, but evaluation under stress h^2 was very low for the same traits.

4.6. selection under drought stress, h^2 was higher for SCY/P, LY/P, lint%, and NB/P at evaluation under drought stress than under normal irrigation. In other words, h^2 was high under normal evaluation if selection was done under normal irrigation, and vice versa.

4.7. h^2 in ICL method it was mostly higher under normal irrigation evaluation either selection was under normal irrigation or under drought stress.

5. Mean, direct observed genetic gain for single trait selection

5.1. Selection for SCY/P, LY/P, BW and LI under normal irrigation showed the best performance under normal irrigation, and selection under stress gave the best performance under drought stress.

6. Independent culling levels method of selection (ICL)

6.1. The results indicated that ICL method of selection under drought stress was better than under normal irrigation, Seed cotton yield/ plant, LY/P, lint%, NB/P, BW and LI performed well under drought stress than under normal irrigation.

6.2. Finally, it could be concluded that the results of single trait selection proved that selection under optimum environment performed well under optimum, and selection under drought stress was better under stress. Otherwise, ICL method of selection did well under drought stress.