Genetic variations among several Egyptian cotton cultivars under saline soil conditions

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CONTENTS

Summary

The materials of this study were fifteen long-staple cultivated, cottons and obsolete cultivars, F_2-segrgating population, 27 hybrids, their lines and testers were grown under clay and saline soils at El-Maragha, Sohag, Egypt.

Results could be summarized in the following five main topics

- Tolerance of Egyptian cotton genotypes to salinity condition.
- Study of the salinity tolerance indices.
- A study of phenotypic and genotypic correlations among traits and path analysis of seed cotton yield and its components in Egyptian cotton.
- Line by tester analysis under saline and normal soils.
- Two cycles of pedigree selection under saline and normal soils.

1- Tolerance of Egyptian cotton genotypes to salinity

1.1. The analysis of variance indicated insignificant differences between years for all traits under saline and normal soils, indicating the stability of the studied genotypes over years.

1.2. Under saline soil, the differences among genotypes were significant ($P \leq 0.05$ or $P \leq 0.01$) in one year and in the combined analysis for SCY/P, LY/P, SI, NS/B, PH, and Pressley index. While the BW, the genotypes differed significantly in both years and combined analysis. Otherwise, the other traits showed insignificant differences among genotypes.

1.3. Under normal soil, the genotypes expressed their potential and differed significantly ($P \leq 0.05$ or $P \leq 0.01$) in all traits except for Micronaire reading, NS/B in one year and Pressley index in both years.

1.4. The effect of soil salinity expressed as Red% was maximum on yield. The deleterious effect was observed for PH (55.92%), LY/P (52.21%),

SCY/P (48 75%) and NB/P (32.47%), while LI (5.68%), Micronaire reading (11.22%), Pressley index (6.63%) and UHM length (0.89%) showed little effect of salinity. Salinity affected lint yield rather than seed.

1.5. Micronaire reading measures fineness between cultivars and maturity within a cultivar. Therefore, the soil salinity affected the deposition of cellulose. Hence, the strength was affected to some extent, while the length of the fibers was not affected. It is noticed that the Pressley index was less affected than the Micronaire reading, due to the increase in the number of hairs per unit weight.

1.6. The combined mean over years indicated that the cultivars "G 90 × Aus", G95, G 90, G 80, and G 83 showed the highest performance in SCY/P, LY/P, Lint%, NB/P and NS/B either under normal or saline soil.

1.7. Concerning DFF, the salinity enhanced flowering. The mean DFF was decreased under normal soil from 76.51 to 59.82 under saline soil. The earliest cultivars were G90 under normal soil, and G95 under saline soil. The results indicated awide range in DFF under normal soil (67.83 to 80.00), while it was narrow under saline soil (58.17 to 60.67).

1.8. The Micronaire reading was decreased for all cultivars by salinity. The reduction% ranged from 7.30 to 15.92% with an average of 11.20%. It should be noted that the Egyptian cotton cultivars could be considered pure lines, and the intrinsic fineness (hair perimeter and diameter) of each cultivar is constant and least affected by environment. Therefore, the reduction in Micronaire reading caused by salinity for a cultivar reflect the low deposition of cellulose, in other words decrease in maturity which caused low depression in strength.

2. Salinity Tolerance Indices

2.1. The stress tolerance indices (SSI, STI, MO, GMP, TOL, YSI, HM, SDI, DI and SDI) were calculated based on the combined mean of SCY/P under normal soil and SCY/P under stress of saline soil.

2.2. The low rank indicates tolerance and the high indicates susceptibility to salinity.

2.3. The rank of mean was the lowest for Giz90 × Aus followed by Giza 90 indicating tolerance to salinity stress.

2.4. The indices STI, MP, GMP, HM and DI detected both of tolerant and susceptible genotypes and could be considered the best tolerant indices.

3. A-Genotypic correlations among traits were summarized as follow.

1- Under both environments the correlations among SCY/P, LY/P, NB/P, BW, and lint% were positive except for NB/P and BW under saline soil.

2- Negative correlation was found between LI and SI under both environments.

3- Positive correlation was observed between LI and NS/B.

4- Positive correlations between BW and NS/B, lint%, SI and LI.

5- DFF gave negative correlations with all traits except SI under saline soil, and LI, NS/B, lint%, and Micronaire reading at normal soil.

6- Micronaire reading showed positive correlations with all traits except PI and UHM length under normal soil, and lint%, SI and DFF under saline soil.

7- The correlations of UHM length were positive except for SI, DFF under saline soil and negative with all except for PI under normal soil.

8- Pressley index showed positive correlations with all traits except for DFF and SI under saline soil, and LI, Micronaire reading and DFF at normal soil.

3.B. Path coefficient analysis

3.1. The correlation coefficient of lint yield / plant with seed cotton yield / plant was positive and very high in magnitude (0.9970) under normal soil, and 0.998 under salinity stress. However, the direct effect of LY/P on SCY/P was moderate (0.401) under normal soil, and high (0.802) under salinity stress. NB/P showed indirect effect of 0.484 under normal soil and low and negligible under salinity stress (0.101). Furthermore, NS/B and SI had negligible indirect effects under both environments. Therefore, LY/P and NB/P should be considered in selection for SCY/P under normal soil, and for LY/P only under salinity stress.

3.2. The correlation coefficient of NB / plant with seed cotton yield / plant was 0.961 under the non-stressed environment and 0.646 under the stressed one. The direct effect of BW was 0.507 under good and 0.178 under salinity stress. However, LY/P indirectly play an important role under both environments. The other indirect effects of NS/B and SI were very low or negative. This confirms that selection for SCY/P should depend on LY/P and NB/P under non-stressed and on LY/P under the stressed environments.

3.3. Partitioning the correlation of NS/B with SCY/P (0.136) indicated that the direct effect of NS/B was 0.147 under normal soil conditions, while the other indirect effects of LY/P, NB/P and SI on SCY/P via NS/B were low and negligible. Otherwise, the indirect effect of LY/P on SCY/P via NS/B was high (0.506). The other indirect effects of NB/P and SI on SCY/P via NS/B were low and negative.

3.4. Partitioning the correlation of SI with SCY/P (0.603) under the normal soil, the direct effect was 0.153, while the indirect effects of LY/P and NB/P on SCY/P via SI were 0.229 and 0.262, respectively. Under saline soil, the direct effect of SI was0.050 and the indirect effects of

LY/P , NB/P and NS/B on SCY/P via SI were 0.085 and 0.-0.24 and -0.006, respectively.

3.5. It could be concluded that the direct and indirect effects of SCY/P components varied greatly under both environments. The direct effects of the SCY/P components under normal soil were 0.504, 0.401, 0.153 and 0.147 for NB/P, LY/P, SI, and NS/b, respectively. However, under saline soil the direct effects were 0.802, 0.178, 0.128 and 0.050 for LY/P, NB/P, NS/B and SI, respectively. Therefore, under both environments, selection should be mainly paid to NB/P and LY/P.

4. Line × tester analysis

4.1. Nine cultivars were crossed as lines to three testers to study the mode of gene action controlling the traits in these materials. Mean squares was significant ($p \leq 0.05$ or $p \leq 0.01$) for genotypes of all investigated traits under normal soil except for Micronaire reading and PI, indicating the presence of variability among hybrids and their parents. However, under saline soil the genotypes mean squares were significant only for five out of the 13 traits. The analysis of combining ability was performed only on the traits showed significant differences among genotypes.

4.2. There were significant differences among lines and/or testers, reflecting the presence of additive gene effects in the inheritance of SCY/P, LY/P, NB/P, NS/B, BW and UHM length under the two environments, and for lint%, SI, DFF and PH under the non-stressed environment.

4.3. The significant mean squares of L×T for SCY/P, LY/P, Lint%, NB/P, BW, and NS/B under the non-stressed environment indicated the presence of dominance variance. 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.

4.4. The lines mean of SCY/P was 81.9 g and the males mean was 113.36 g with hybrid mean of 91.12 g, indicating the absence of heterosis under normal soil. The same trend was observed under saline soil. The GCA effects were significant positive ($p \leq 0.05$ or $p \leq 0.01$) for the lines Giza 80, Giza 83, and Giza 85 and negative for Ashmouni and Dandara and Giza 90 (tester). Only four crosses, i.e. (G91 × G90 × G 80) × G 95, Ashmouni × (G90 × Aus), (G 90 × Aus × G85) × G90 and Ashmouni × (G90 × Aus) × G95 showed positive significant SCA. None of the parents of these crosses had positive significant GCA effects indicating the presence of non-additive effects. Furthermore, non-significant SCA effects was found under saline soil.

4.5. Concerning LY/P under normal soil the lines G 80, G 85 and G 83 had significant positive GCA, while Ashmouni and Dandara gave significant negative GCA effects. One cross ((G90 × Aus) × G85) × G95 had positive SCA effects, and other three had negative significant SCA. The four crosses shared the male parent G95 which had positive significant GCA, the lines of the four crosses showed insignificant GCA, indicating non-additive effects. Under saline soil none of the crosses showed significant SCA.

4.6. For lint%, only two crosses had significant SCA, in consequence the performance of the crosses could not be predicted from GCA effects of the parents.

4.7. Under normal soil and NB/P, the GCA of lines G 80, G 83 and G 85 was positive and significant ($p \leq 0.05$ or $p \leq 0.01$), while the lines (G 90×Aus), Ashmouni and Dandara their GCA was negative and significant. The GCA of the testers was not significant. Only two crosses showed significant SCA. The crosses (G90×Aus×G85) ×G95

(3.981) and Dandara × G 95 (3.372) gave significant SCA (3.981), their lines had negative GCA and shared one tester G95 which positive insignificant GCA. Therefore, the crosses could not be expected from their parents GCA. Under saline soil the SCA of the crosses showed the same trend.

4.8. Under normal soil the best performance of BW was for the tester Giza 90 (2.90g) and the lowest for the line (G90 × Aus) (G80 × G83 × Dandara). Giza80, giza 83 and Giza 85 gave positive and significant ($p \leq 0.01$) GCA, while ((G90 × Aus) × G85), Ashmouni and Dandara had negative significant ($p \leq 0.01$) GCA effects. Twenty-five crosses showed significant ($p \leq 0.01$) SCA effects. The crosses which gave positive significant SCA effects had one parent, or both showed significant GCA except few cases. Ashmouni × Giza 90 gave positive significant SCA, its parents had negative GCA. These results indicate the presence of additive and non-additive in the inheritance of BW in these materials. The best combiners for BW were Giza 80 followed by Giza 83 and Giza 85 as lines, and Giza 95 as tester.

Under saline soil Giza 80 had negative GCA for SI, the other parents and crosses didn't show significant GCA or SCA. Results of LI indicated insignificant GCA of the parents and SCA of the crosses irrespective of the significant mean squares the genotypes, parents and vs crosses obtained.

4.9. Results of NS/B under normal soil only Ashmouni and Giza 90 had significant negative GCA, and none of the crosses had significant SCA effects.

4.10. Results of DFF showed that the parents Giza 83 had negative GCA and Ashmouni had positive significant GCA effects. The other males and female parents and crosses gave insignificant GCA and SCA effects. The high positive GCA effects are preferable for all traits except DFF and Micronaire reading in which negative GCA and SCA are preferable.

4.11. Results of PH, the lines Giza 80 and Ashmouni had significant positive and negative GCA effects, respectively. Three crosses, (G90× Aus) ×G85) × (G90 × Aus),(G91 × G90 × G80) × G95,and (G91 × G90 × G80) × (G90 × Aus) gave significant negative SCA for the first two crosses, and significant positive for the third cross. It could be noticed that positive GCA of female and male gave negative SCA, negative GCA of female with negative GCA of male gave negative SCA, and negative female with positive male gave positive SCA. This confirmed that in the presence of non-additive the performance of the crosses could not expected from the GCA of the parents.

4.12. The results of UHM length indicated that line Giza 85 and line (G90 × Aus) (G83 × G80 × Dad) gave positive GCA effects, and lines (G90 × Aus) × G85), and Ashmouni showed negative GCA. None of the crosses gave significant SCA effects.

It could be concluded that in all traits studied under good and bad environments the GCA effects of the parents were not indicative to the SCA effects of their crosses and their perfirmace. Therefore, the non-additive effects were predominant in the inheritance of these traits, in consequence, the best combiner could not be assessed.

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

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 all traits except for NB/P under saline soil. Therefore, the performance of the hybrids could not be expected from their GCA effects of the parents. Furthermore, σ^2A was not significant in many cases indicating the importance of dominance or non-additive in the inheritance of these traits in these materials.

4.14. The sum of squares of the crosses was divided to sum of squares due to lines, testers, and their interaction. The proportional contribution of lines was larger than that of testers for all traits at normal soil, and for SCY/P, LY/P, NB/P, SI and LI under saline soil. Furthermore, the contribution of lines was larger than that of lines × testers interaction in all characters except for LI under both environments and SI under saline soil indicating the importance of selection of lines for hybridization. The contribution of line × tester was about 30% for most traits depicting the importance of non-additive type of gene action.

4.15. **Reduction% caused by salinity effects**

4.15.1. Salinity severely affected yield, its components and plant height, and mild affected BW, DFF, NS/B, SI and Micronaire reading, while PI and UHM length were low affected. The Red% of the parents for SCY/P ranged from 36.50 to % 62.94% with an average of 49.2% indicating wide range of parental sensitivity to salinity. The highest yielding parent in normal soil (G90 × Aus) was not the highest yielding parent in saline soil (G90). Generally, the best three parents under saline soil were (G90 × Aus), G90 and G80. The reduction in crosses ranged from 35.71 to 57.67% with an average of 48.21%, and the best yielding crosses in saline soil were G.80× (G.90*Asu), G.85×G.95, and G.80×G.90.

4.15.2. Concerning LY/P, it ranged under normal soil from 24.77 (Ashmouni) to 50.68g (G90 × Aus) with an average of 53.65g. The best three yielding parents under saline soil were the same for SCY/P, (G90 × Aus), G90 and G80.

4.15.3. The effect of salinity on lint% was moderate. The Red% drops from more than 50% for yields to 8.82% for the parents, and 6.0% for the crosses. This attributed that the salinity affects both of lint and seeds.

4.15.4. The Red% in NB/P showed wide variation, it ranged from 10.16 to 46.47 with an average of 33.30% for the parents, and from 22.04 to 42.44 with an average of 34.0% for the crosses.

4.15.5. Respect to BW the Red% ranged for the parents from 13.70 to 30.40 with an average of 23.82%, while the crosses ranged from 5.9 to 29.63 with an average of 21.0%. The best parents in BW under saline soil were G95, G90 and (G90 × Aus), and the crosses were (G91 × G90 × G80) × G90, (G90 × Aus × G83)(G83 × G80 × Dandara) × G90, and (G90 × Aus) × G85) × G90.

4.15.6. The salinity effect on SI was slight, the mean Red% of the parents was 7.80% and 9.59% for the crosses.

4.15.7. The salinity effect on LI was slight, the mean Red% of the parents was 6.41% and -0.80% for the crosses, thirteen crosses gave negative Red%.

4.15.8. The Red% in NS/B of the parents ranged from -5.09 to 20.19% with an average of 12.80, and from -2.13 to 18.49% with an average of 9.62%.

4.15.9. Salinity enhanced Flowering by about two weeks, Red% of the parents ranged from 13.72 to 24.13% with an average of 20.57%, and for the crosses from 7.5 to 14.22% with an average of 9.96**%.**

4.15.10. Plant height was severely affected by salinity. The Red% in the parents ranged from 51.99 to 58.45% with an average of 55.39%, and the crosses ranged from 51.37 to 55.27% with an average of 53.18%.

4.15.11. Micronaire apparatus measure fineness and maturity in combined. Therefore, deposition of cellulose affect Micronaire reading. The effect of salinity on Micronaire reading was mild, the average Red%

in the parents was 11 48% and in crosses 9.49%. Likewise, the strength as measured by PI is a varietal characteristic and genetic makeup, but the deposition of cellulose affects it. The average Red% in the parents was 6.51% and in crosses 7.88%. Likewise, the fiber length is a genetic makeup characteristic and least affected be environmental fluctuations. The average Red% in the parents was 1.25% and in crosses 1.99%.

4.15.12. It could be noticed that the Red% in the crosses were slightly lower than in the parents in nine out of the thirteen traits studied, furthermore, in most cases the range of the parents was wider than in the crosses because of the hybrid always more hemostatic and elastic to environmental fluctuations.

5. Selection

5.1. Description of the base population; F_2 -generation

5.1.1. Mean seed cotton yield/plant (SCY/P) of the parents Giza90 and Giza86 was 104.67 and 94.06 g under normal soil, and 46.16 and 45.92 under salinity stress with reduction% 55.90 and 51.18, respectively. Mean SCY/P of the F_2 was 69.47 and 41.36 under normal soil and salinity stress; respectively, with reduction% of 40.46. The F_2 mean was less than the two parents showing under dominance towards the low yielding parent.

5.1.2. The phenotypic (PCV%) and genotypic (GCV%) coefficients of variability were high in the F_2 and accounted for 19.723 and 13.909% under normal soil and 10.28 and 8.86% under salinity stress; respectively, indicating possibility of selection for SCY/P. Furthermore, the variation expressed as the minimum and maximum values for all traits in the F_2-generation nearly covered the range of the parents for yield and yield components under both environments indicating feasibility of selection. The variability was high in yields and NB/P and low for the other traits.

5.1.3. The broad sense heritability of ranged from 0.٧0 for BW to 66.49% for UHM length under normal soil, and from 20.64% for BW to 90.52% for PH under saline soil. This variability resulted in expected genetic advance in percentage of the mean of 0.0١ for BW and 11.99% for SCY/P under normal soil, and 0.98 for DFF and 15.99% for PH.

5.1.4. In general, the results indicated that the measurements under normal soil were better than under salinity stress.

5.2. Phenotypic correlation among traits

5.2.1. The correlations of SCY/P with the other traits were positive and significant ($p \leq 0.01$) and depended in descending order on LY/P, NB/P, PH, SI, and BW under normal soil, and LY/P, PH, BW, NB/P, SI, and NS/B under saline soil. Seed cotton yield showed negative and significant ($p \leq 0.01$) correlation with the DFF under both environments, indicating that the yield depended on early plants. The high yields negatively correlated with Micronaire reading under normal soil, vice versa under saline soil and positive with UHM length and PI under both environments. The correlations of LY/P behaved the same as SCY/P. Results indicated that the high yielding plants were early, fine (negative Micronaire reading) and high in fiber length and strength under both environments except Micronaire reading.

5.2.2. Lint% and LI were more correlated with LY/P than SCY/P and higher under salinity than under normal soil. Lint index showed positive high correlation with lint%.

5.2.3. Days to first flower showed negative correlation with all traits except PI under both environments. This may be caused by low deposition of cellulose in later mature plants, which slightly increased flat bundle strength because of the number of fibers increased per unit weight.

5.3. Variances and means after two cycles of selection

5.3.1. Selection for SCY/P under normal soil showed significant ($p \leq 0.01$) differences among the selected families for SCY/P, LY/P, lint%, DFF, and UHM length when evaluation was done under the normal soil, while evaluation under saline soil the differences among families were significant for all traits except NS/B, Mic, and UHM length. Nearly the same trend was observed when selection practiced for LY/P. These results indicates that the salinity stress more efficient to detect the differences among selected families.

5.3.2. Mean squares of the selection criteria was significant either selection practiced under normal or saline soils indicating the presence of remained variability after two cycles of selection. Most of the correlated traits were significant under both environments, except for the technological properties which were least affected by environments in most cases.

5.4. Coefficients of variation and heritability

5.4.1. Genotypic and phenotypic coefficients of variability (**Tables 20 and 21**) were greatly depleted by selection from F_2 to F_4- generation. Genotypic coefficient of variation under normal soil in SCY/P decreased from 13.91% in the F_2 to 4.90% in $F_{4,}$ and for LY/P decreased from 13.91 to 5.91%. Such decrease was observed for the other selection criteria either selection practiced at normal or saline soils except for BW at both environments and LI at saline oil.

5.4.2. It is of interest to demonstrate that the GCV in selection criteria were higher in the F_4-generation under salinity stress than under normal soil in four out of six criteria (Lint%, BW, NB/P, and LI).

5.4.3. Concern selection by the ICL method of the same six traits, the PCV and GCV depressed greatly after two cycles of selection as in single trait selection.

5.4.4. Heritability in broad sense after two cycles of selection was slightly higher when the selected families evaluated at normal than saline soil irrespective of selection environment.

5.4.5. Heritability in broad sense ranged from 68.75% for NB/P to 81.70% for lint% (selection and evaluation at normal soil), and from 65,26% for SCY/P to 91.31% for NB/P (selection at N and Evaluation at S). Selection at saline soil, the estimates ranged from 68.87% for SCY/P to 88.75% for lint% (evaluation at N), and from63.68% for LY/P to 89.73% for LI (evaluation at salinity stress).

5.4.6. Heritability in narrow sense as estimated by regression of offspring on parents was low compared to heritability in broad sense. It ranged from 0.012 for BW (selection and evaluation at normal soil) to 2.32 for lint% (selection saline and evaluation at normal soli). Generally, h^2 was higher at stress than at normal soil when selection practiced at normal soil, and vice- versa for selection at saline soil.

5.4.7. Concern h^2 in the ICL method, it was higher at normal soil evaluation than at saline soil for selection at both environments.

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

5.5.1. The direct observed genetic gain after two cycles of selection for SCY/P at normal soil (**Table 22**) was positive and significant ($p \leq 0.01$) from the mid-parent (11.68%) and better parent (10.74%) when evaluation was at normal soil, but evaluation under salinity stress showed significant gain from the mid-parent (7.03%) and insignificant from the better parent (6.69%).

5.5.2. selection under salinity stress gave significant gain ($p \leq 0.05$) from mid-parent of 8.8% and 8.24% at normal and salinity stress evaluation, respectively. Selection for LY/P showed the same trend.

5.5.3. Generally, for all selection criteria, the performance at normal soil was better than at saline soil irrespective of selection environment, and selection at saline soil was better in performance at saline soil.

5.6. Independent culling levels method of selection (ICL)

5.6.1. The ICL method of section (**Table 23**) included six traits: SCY/P, LY/P, lint%, NB/P, BW, and lint index. The observed genetic gain indicated that ICL method of selection at salinity stress was better than at normal soil. Seed cotton yield/ plant, LY/P, lint%, NB/P, BW and LI performed well at salinity stress than at normal soil.

5.6.2. 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 stress was better under stress. Otherwise, ICL method of selection did well under salinity stress.