

## **CORRELATION BETWEEN SUSCEPTIBILITY TO FUSARIUM WILT AND AGRONOMIC AND TECHNOLOGICAL TRAITS IN SOME COTTON GENOTYPES**

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### **ABSTRACT**

Field trials were carried out at Giza Agricultural Research Station in 2012 and 2013 growing seasons. In 2012, 50 cotton genotypes were self-pollinated. In 2013, the genotypes were grown in a randomized complete block design with three replications. A random sample of four guarded plants of each genotype was randomly chosen from each plot to determine some agronomic and technological traits. The agronomic traits were boll weight (g), seedcotton yield (g/plant), lint yield (g/plant), and lint percentage. The technological traits were fiber length at 2.5 % (mm), fiber length uniformity ratio (%), micronaire reading and fiber strength (g/tex). The genotypes were screened, under greenhouse conditions, in 2014 against a mixture of 50 isolates (race 3) of the wilt fungus. Incidence of Fusarium wilt was used as criterion to evaluate the reactions of the tested genotypes to the disease. The genotypes showed a narrow range of reactions to Fusarium wilt incidence ranging from 0 to 19.99 %. Of the tested genotypes, 54, 40 and 6 % were classified as highly resistant (wilt incidence was 0 %) resistant (wilt incidence ranged from 3.33 to 6.66 %), and susceptible (wilt incidence ranged from 13.33 to 19.99 %), respectively. Linear correlation coefficient was calculated to measure the degree of association between wilt incidence and each of agronomic and technological traits. Cluster analysis was used for grouping the genotypes based on the profiles of their agronomic and technological traits. Correlation and cluster analysis showed a lack of correlation between wilt incidence and each of agronomic and technological traits. This result suggests that breeding for Fusarium wilt resistance in cotton will not negatively affect the quality of agronomic or technological traits.

**Keywords:** Egyptian cotton, Fusarium wilt resistance, agronomic, and technological traits.

### **INTRODUCTION**

Fusarium wilt of cotton is a serious fungal disease responsible for significant losses throughout the world. The causal organism *Fusarium oxysporum* Schlecht. f.sp. *vasinfectum* (ATK.) Syd and Hans. (FOV) invades the host through the taproots behind the root tip. The combined effect of fungal metabolites and the production of lipodial substances by the host in response to infection may lead to occlusion of the vascular tissue, resulting in wilt of the cotton plant (Hillocks, 1984). FOV can survive for several decades in soil and cannot be eradicated from infested fields. The pathogen can infect cotton at all stages of growth and produces symptoms, which include seedling death, wilting, vascular discoloration and plant death (Watkins, 1981).

Outside Egypt, it is commonly associated with nematode infection [root knot- *Fusarium* wilt complex (McFadden *et al.*, 2004)], particularly in acidic, sandy soils. In Egypt, where cotton is grown in alkaline clay soils, there is no evidence for the involvement of nematodes in *Fusarium* wilt disease (A.A. Aly, *personal observation*).

Currently, up to eight races of FOV, most of which are geographically separated, are recognized worldwide. The basis for determining races of FOV depends on their virulence to a differential set of cotton (*Gossypium*) lines and species and up to 5 non-cotton hosts (Watkins, 1981).

The Egyptian race (race 3) of FOV, has long been known in the Nile Valley, where it remains one of the most damaging pathogens on Egyptian Cottons (*G. barbadense* L.). This race also attacks *G. barbadense* in the former, Soviet Union (Watkins, 1981) and Israel (Netzer *et al.*, 1985).

FOV caused serious losses in the commercial Egyptian cottons (*G. barbadense* L.) in the late fifties (Bakry *et al.*, 1958). Since then, an extensive cotton-breeding program was initiated to develop cultivars resistant to the disease. In this program, breeding materials submitted by cotton breeders (Cotton Research Institute) have been screened for *Fusarium* wilt resistance under greenhouse conditions in soil artificially infested with FOV. This test has been conducted annually for the past 60 years in the greenhouses of Cotton and Fiber Crops Dis. Res. Section, Plant Pathology Research Institute. The program has been so successful in developing highly resistant commercial cultivars that the disease no longer occurs in the commercial fields (Aly *et al.*, 2000).

*Fusarium* wilt remains a potential threat to cotton production in Egypt because FOV is still well established in the Egyptian soil (Aly *et al.*, 2000), thus, increasing the probability that new races other than race 3 or new biotypes of this race may arise to confound cotton breeders.

Cotton fiber is defined by a suite of traits, which have a major impact on fiber selling price. Several fiber quality parameters such as fiber length, length uniformity, strength, and elongation are genetically controlled, mainly but other traits like micronaire, though genetically controlled, are impacted, to a greater degree by environmental conditions (Baxevanos *et al.*, 2013).

Outside Egypt, few attempts have been made to evaluate the correlation between incidence of *Fusarium* wilt and each of agronomic and technological traits. For example, in China, Wu *et al.* (2004) found that incidence grade of *Fusarium* wilt was negatively correlated with fiber strength, micronaire value, and the fiber span length, and reached significant and highly significant levels. In USA, Ulloa *et al.* (2006) reported that foliar damage and vascular discoloration caused by FOV were negatively correlated with node number and plant height. In China, Guo *et al.* (2013) found that oil content in cottonseed kernels was weakly negatively correlated with *Fusarium* wilt resistance. Thus, the improvement of the oil content of cottonseed kernels will weakly affect disease resistance.

In Egypt, as far as we know, no attempts have been made to study the correlation between incidence of *Fusarium* wilt and each of agronomic and technological traits. Therefore, the objectives of the present study were to evaluate a collection of cotton germplasm against *Fusarium* wilt race 3 and

to evaluate the correlation between wilt incidence on the tested genotypes and their agronomic and technological traits.

## **MATERIALS AND METHODS**

### **Cotton genotypes:**

The genotypes used in the present study were randomly selected from the collection of germplasm available at the Department of Cotton Breeding, Cytology and Genetics Unit, Cotton Research Institute (Table 1).

### **Field traits:**

Field traits were carried out at Giza Agricultural Research Station in 2012 and 2013 growing seasons. In 2012 growing season, cotton genotypes were self-pollinated. In 2013 growing season, they were grown in a randomized complete block design with three replications. Each plot consisted of two rows, the row was six meter long, 60 cm apart and interhill spacing was 20 cm. Seedlings were thinned to one seedling per hill. The recommended cultural practices were adopted throughout the growing season. A random sample of four guarded plants of each genotype was chosen from each plot to determine the following traits (Said *et al.*, 2013).

#### **a. Agronomic traits:**

1. Boll weight (BW): The average weight in grams of a boll calculated from a random sample of five harvested bolls / plant.
  2. Seedcotton yield (SCY): The expression of seedcotton weight in grams / plant.
  3. Lint yield (LY): The expression of lint weight in grams / plant.
  4. Lint percentage (L %): The ratio by weight of lint to seedcotton.
- Agronomic traits of the tested genotypes are shown in Table 2.

#### **b. Technological traits:**

1. Fiber length at 2.5 % (mm): The upper half mean length. It was measured by a fibrograph according to ASTM: D 1447-83 (1984).
2. Fiber length uniformity ratio (%): The expression of the ratio of upper-half fiber length and the mean length. It was determined according to Sundaram (1979).
3. Micronaire reading: The measurement of fiber fineness and maturity. It was determined according to ASTM: D 1448 – 59 (1984).
4. Fiber strength (g /tex): The necessary force to break a beard of fibers that are clamped between two sets of jaws. It was determined according to ASTM: D 1448- 59 (1984).

All fiber test were carried out in the Laboratories of Cotton Research Institute, Agric. Res. Center, Giza at constant relative humidity of  $65 \pm 2$  % and temperature of  $70 \pm 20^{\circ}\text{f}$ . Technological traits of the tested genotypes are shown in Table 3.

Table 1. Cotton genotypes used in the present study.

| Genotype Number | Pedigree                                       |
|-----------------|--|
| 1               | Giza 69 / 92                                   |
| 2               | Giza 70 / 93                                   |
| 3               | Giza 81/ 94                                    |
| 4               | Giza 85 / 96                                   |
| 5               | Giza 86 / 98                                   |
| 6               | Australian 10229 / 101                         |
| 7               | (Giza 81 x Giza 86) / 106                      |
| 8               | (Giza 85 x Giza 89) / 107                      |
| 9               | (Giza 86 x Giza 85 x Giza 89) / 115            |
| 10              | (Pima S) 2 / 127                               |
| 11              | Giza 67 / 128                                  |
| 12              | (Pima S x Giza 85) / 129                       |
| 13              | (Aamon x Giza 89) / 130                        |
| 14              | (Pima S <sub>7</sub> x Giza 67) / 131          |
| 15              | Bahteem / 142                                  |
| 16              | Giza 84 / 144                                  |
| 17              | Giza 70 / 145                                  |
| 18              | Giza 87 / 146                                  |
| 19              | Giza 74 / 148                                  |
| 20              | Giza 45 / 149                                  |
| 21              | (Giza 77 x Giza 81) / 150                      |
| 22              | (Giza 70 x Giza 77 x Giza 87) / 153            |
| 23              | (Giza 70 x Giza 84) / 155                      |
| 24              | (Pima S <sub>8</sub> x Giza 77) / 162          |
| 25              | (Giza 74 x Giza 71) / 163                      |
| 26              | (Giza 70 x Giza 77) / 164                      |
| 27              | (Giza 45 x Giza 68) / 165                      |
| 28              | Giza 88 / 167                                  |
| 29              | Giza 45 / 169                                  |
| 30              | Giza 68 / 171                                  |
| 31              | Giza 71 / 172                                  |
| 32              | Karnak / 175                                   |
| 33              | (Giza 86 x Giza 84) / 176                      |
| 34              | (Giza 45 x Giza 70) / 177                      |
| 35              | (Giza 77 x Giza 76) / 178                      |
| 36              | (Giza 77 x Giza 45) / 179                      |
| 37              | (Giza 81 x Giza 87) / 180                      |
| 38              | Pima S <sub>8</sub> x Giza 45) / 181           |
| 39              | (Giza 77 x Giza 74) / 182                      |
| 40              | Pima S <sub>8</sub> x Giza 70) / 183           |
| 41              | Giza 84 x (Giza 45 x Giza 84) / 184            |
| 42              | Giza 77 x (Giza 77 x Giza 84) / 185            |
| 43              | (Giza 86 x Giza 74) x Giza 84 / 187            |
| 44              | (Giza 45xGiza 77)x(Giza 51 B x Giza 70) / 189  |
| 45              | (Pima S x Giza 45) x (Giza 45 x Giza 68) / 190 |
| 46              | Giza 45 (Radiated) / 192                       |
| 47              | Giza 76 / 193                                  |
| 48              | (Giza 77 x Giza 84) / 193                      |
| 49              | (Pima S <sub>8</sub> x Giza 87) / 199          |
| 50              | (Giza 74 x Giza 71) x Giza 77 / 202            |

**Table 2. Agronomic traits of genotypes used in the present study.**

| Genotype Number. | Boll weight (g) | Seedcotton yield (g / plant) | Lint yield (g / plant) | Lint percentage |
|------------------|-----------------|------------------------------|------------------------|-----------------|
| 1                | 2.80            | 27.83                        | 7.73                   | 34.15           |
| 2                | 2.63            | 25.10                        | 8.80                   | 34.08           |
| 3                | 2.08            | 13.93                        | 4.80                   | 35.88           |
| 4                | 2.43            | 13.70                        | 4.60                   | 34.25           |
| 5                | 2.33            | 32.05                        | 11.35                  | 36.35           |
| 6                | 2.28            | 9.48                         | 3.63                   | 37.15           |
| 7                | 2.30            | 7.53                         | 2.85                   | 38.15           |
| 8                | 2.43            | 11.08                        | 4.25                   | 38.43           |
| 9                | 2.58            | 20.55                        | 6.73                   | 35.65           |
| 10               | 2.43            | 30.40                        | 10.33                  | 34.73           |
| 11               | 2.88            | 26.40                        | 9.53                   | 36.58           |
| 12               | 2.98            | 19.50                        | 6.93                   | 35.80           |
| 13               | 2.80            | 15.25                        | 5.63                   | 36.93           |
| 14               | 2.75            | 16.43                        | 6.05                   | 37.10           |
| 15               | 2.65            | 34.00                        | 11.43                  | 33.15           |
| 16               | 2.33            | 8.53                         | 2.65                   | 31.40           |
| 17               | 2.45            | 11.70                        | 3.55                   | 30.60           |
| 18               | 2.25            | 10.40                        | 3.10                   | 30.00           |
| 19               | 2.80            | 11.23                        | 3.63                   | 32.33           |
| 20               | 2.55            | 22.88                        | 7.48                   | 32.45           |
| 21               | 2.33            | 16.80                        | 5.48                   | 32.48           |
| 22               | 2.48            | 65.80                        | 6.63                   | 31.53           |
| 23               | 2.43            | 13.33                        | 4.55                   | 34.25           |
| 24               | 2.43            | 12.80                        | 4.05                   | 31.88           |
| 25               | 2.73            | 7.60                         | 2.53                   | 33.70           |

**Evaluation of cotton germplasm against Fusarium wilt race 3 under greenhouse conditions:**

The fungal inoculum used in the greenhouse test was a mixture of equal parts (w / w) of 50 isolates of FOV race 3. These isolates were obtained from the fungal collection of Cotton Pathology Lab., Plant Pathology Res. Inst., Agric. Res. Center., Giza. Autoclaved clay loam soil was infested with the mixture of the isolates at a rate of 10 g / Kg of soil. Substrate for growth of each isolate was prepared in 500-ml glass bottles, each bottle contained 50 g of Sorghum grains and 40 ml of tap water. Contents of the bottle were autoclaved for 30 minutes. Isolate inoculum, taken from one-week old culture on PDA, was aseptically introduced into the bottle and allowed to colonize sorghum for 3 weeks. Infested soil was dispensed in 10-cm-diameter clay pots and these were planted with 10 seeds per pot. There were five replications (pots) for each genotype. Pots were distributed on a greenhouse bench in a randomized complete block design of five replications. The greenhouse was equipped with a heating system assuring that the minimum temperature in the greenhouse was maintained at 28° C; however, due to the lack of a cooling system, the maximum temperature was out of control fluctuating from 30 to 35°C depending on the prevailing temperature during the day (the test was conducted in January and February, 2014).

Table 2. Cont..

| Genotype Number. | Boll weight (g) | Seedcotton yield (g / plant) | Lint yield (g / plant) | Lint percentage |
|------------------|-----------------|------------------------------|------------------------|-----------------|
| 26               | 2.60            | 15.35                        | 5.25                   | 33.85           |
| 27               | 2.30            | 9.20                         | 3.25                   | 35.45           |
| 28               | 2.48            | 13.23                        | 4.43                   | 34.35           |
| 29               | 2.50            | 15.00                        | 5.10                   | 33.51           |
| 30               | 2.25            | 7.25                         | 2.85                   | 39.30           |
| 31               | 2.25            | 6.05                         | 2.03                   | 36.90           |
| 32               | 2.83            | 14.63                        | 5.05                   | 34.50           |
| 33               | 2.90            | 13.50                        | 4.73                   | 35.13           |
| 34               | 2.73            | 16.90                        | 5.70                   | 33.90           |
| 35               | 2.48            | 11.33                        | 4.23                   | 37.35           |
| 36               | 2.43            | 12.83                        | 3.25                   | 34.13           |
| 37               | 2.48            | 17.68                        | 6.38                   | 37.25           |
| 38               | 2.43            | 12.50                        | 4.50                   | 36.05           |
| 39               | 2.60            | 11.63                        | 4.30                   | 37.25           |
| 40               | 2.53            | 15.68                        | 5.85                   | 37.10           |
| 41               | 2.68            | 19.78                        | 7.25                   | 36.43           |
| 42               | 2.68            | 16.63                        | 5.98                   | 35.83           |
| 43               | 2.60            | 19.30                        | 6.03                   | 30.93           |
| 44               | 2.20            | 12.10                        | 4.15                   | 34.90           |
| 45               | 2.48            | 14.53                        | 4.55                   | 31.28           |
| 46               | 2.63            | 14.98                        | 4.80                   | 32.45           |
| 47               | 3.10            | 17.63                        | 6.05                   | 33.05           |
| 48               | 2.60            | 25.08                        | 8.20                   | 32.43           |
| 49               | 2.70            | 11.48                        | 4.23                   | 36.88           |
| 50               | 2.93            | 8.63                         | 2.83                   | 33.20           |

**Assessment of Fusarium wilt incidence:**

Percentages of infected seedlings were recorded 45 days from planting date. The infected seedlings included the dead seedlings and the surviving seedlings, which showed external or internal symptoms. The external symptoms usually began at the margin of cotyledons as yellowing along the veins (vein clearing), eventually, the entire cotyledons turned yellow and dropped from the seedlings. Seedlings that remained apparently healthy 45 days after planting were cut diagonally across the root and stem to examine the internal symptoms. If discolouration of xylem vessels was observed, they were considered infected. If seedlings were free of such a discolouration, they were considered healthy. Thus, the seedlings of each genotype were placed in two distinct classes: healthy if they were free of any external or internal symptoms, or infected if the seedlings died or survived showing any external or internal symptoms (Aly *et al.*, 2007 and Abd-Elsalam *et al.*, 2009).

Wilt incidence on the tested genotypes is shown in Table 4.

**Statistical analysis of the data:**

Linear correlation coefficient was calculated to measure the degree of association between wilt incidence and each of agronomic and technological traits. Genotypes were clustered by the average linked technique (unweighted pair-group method) based on the profiles of their agronomic and technological traits. Correlation and cluster analyses were performed with the software package SPSS 6.0.

**Table 3. Technological traits of genotypes used in the present study.**

| Genotype Number. | Fiber length at 2.5 % (mm) | Fiber length uniformity ratio (%) | Micronaire reading | Fiber strength (g / tex) |
|------------------|----------------------------|-----------------------------------|--------------------|--------------------------|
| 1                | 30.85                      | 84.95                             | 4.28               | 9.75                     |
| 2                | 32.45                      | 85.60                             | 4.28               | 10.50                    |
| 3                | 32.43                      | 85.95                             | 4.23               | 10.18                    |
| 4                | 32.15                      | 85.95                             | 4.05               | 10.23                    |
| 5                | 32.88                      | 86.03                             | 3.75               | 10.15                    |
| 6                | 33.25                      | 86.68                             | 3.98               | 10.48                    |
| 7                | 31.45                      | 86.23                             | 3.98               | 9.60                     |
| 8                | 32.23                      | 85.95                             | 4.05               | 10.08                    |
| 9                | 32.55                      | 86.38                             | 4.33               | 9.63                     |
| 10               | 30.28                      | 84.33                             | 3.95               | 9.20                     |
| 11               | 30.40                      | 84.83                             | 4.13               | 9.53                     |
| 12               | 31.73                      | 85.23                             | 3.88               | 10.45                    |
| 13               | 33.20                      | 86.15                             | 4.45               | 10.45                    |
| 14               | 31.93                      | 85.85                             | 4.25               | 10.05                    |
| 15               | 31.13                      | 85.15                             | 4.00               | 9.85                     |
| 16               | 32.73                      | 85.50                             | 3.75               | 10.50                    |
| 17               | 33.00                      | 86.05                             | 4.05               | 10.75                    |
| 18               | 33.00                      | 86.13                             | 4.20               | 10.33                    |
| 19               | 32.50                      | 85.55                             | 4.20               | 10.35                    |
| 20               | 33.00                      | 85.75                             | 3.93               | 10.43                    |
| 21               | 31.70                      | 84.88                             | 4.15               | 10.03                    |
| 22               | 32.53                      | 85.30                             | 4.00               | 10.13                    |
| 23               | 31.93                      | 85.28                             | 4.30               | 9.73                     |
| 24               | 32.45                      | 85.93                             | 3.48               | 10.73                    |
| 25               | 33.93                      | 87.08                             | 3.63               | 10.58                    |
| 26               | 34.68                      | 86.95                             | 3.75               | 10.65                    |
| 27               | 32.88                      | 85.60                             | 3.75               | 10.48                    |
| 28               | 33.50                      | 85.75                             | 3.88               | 10.78                    |
| 29               | 32.58                      | 86.60                             | 3.85               | 10.28                    |
| 30               | 33.20                      | 86.70                             | 4.03               | 10.03                    |
| 31               | 33.80                      | 85.78                             | 4.08               | 10.65                    |
| 32               | 32.80                      | 85.35                             | 4.25               | 10.38                    |
| 33               | 30.03                      | 85.53                             | 4.35               | 9.48                     |
| 34               | 32.63                      | 85.58                             | 3.98               | 10.45                    |
| 35               | 33.25                      | 85.80                             | 3.65               | 10.75                    |
| 36               | 33.45                      | 85.50                             | 3.98               | 10.58                    |
| 37               | 32.05                      | 86.63                             | 4.18               | 10.00                    |
| 38               | 30.70                      | 85.93                             | 4.00               | 9.50                     |
| 39               | 31.40                      | 85.45                             | 3.90               | 10.68                    |
| 40               | 32.93                      | 86.35                             | 4.08               | 10.58                    |
| 41               | 33.50                      | 85.98                             | 3.60               | 10.60                    |
| 42               | 33.33                      | 86.48                             | 3.98               | 10.48                    |
| 43               | 33.80                      | 87.20                             | 3.45               | 10.83                    |
| 44               | 32.98                      | 86.70                             | 3.30               | 10.80                    |
| 45               | 33.30                      | 85.55                             | 4.10               | 10.15                    |
| 46               | 35.18                      | 87.30                             | 3.55               | 11.20                    |
| 47               | 35.03                      | 87.43                             | 3.88               | 10.50                    |
| 48               | 33.53                      | 86.68                             | 4.00               | 10.78                    |
| 49               | 31.95                      | 86.33                             | 3.70               | 10.48                    |
| 50               | 34.05                      | 86.80                             | 3.60               | 10.68                    |

## RESULTS

### Screening of genotypes for Fusarium wilt resistance:

Incidence of Fusarium wilt was used as criterion to evaluate the reactions of the tested genotypes to Fusarium wilt. The tested genotypes showed a narrow range of reaction to Fusarium wilt incidence ranging from 0 to 19.99 % (Table 4). Of the tested genotypes, 54, 40 and 6 % were classified as highly resistant (wilt incidence was 0 %), resistant (wilt incidence ranged from 3.33 to 6.66 %), and susceptible (wilt incidence ranged from 13.33 to 19.99 %), respectively (Table 4).

### Correlation analysis:

Correlation analysis of Fusarium wilt incidence and each of agronomic and technological traits is shown in Table 5. All correlation coefficients were nonsignificant ( $P > 0.05$ ).

**Table 4. Evaluation of some cotton genotypes against Fusarium wilt (race 3) under greenhouse conditions.**

| Genotype Number. | Wilt incidence <sup>a</sup> (%) | Disease Category <sup>b</sup> |
|------------------|---------------------------------|-------------------------------|
| 1                | 0.00                            | HR                            |
| 2                | 0.00                            | HR                            |
| 3                | 0.00                            | HR                            |
| 4                | 3.33                            | R                             |
| 5                | 0.00                            | HR                            |
| 6                | 19.99                           | S                             |
| 7                | 0.00                            | HR                            |
| 8                | 0.00                            | HR                            |
| 9                | 3.33                            | R                             |
| 10               | 3.33                            | R                             |
| 11               | 3.33                            | R                             |
| 12               | 6.66                            | R                             |
| 13               | 3.33                            | R                             |
| 14               | 0.00                            | HR                            |
| 15               | 3.33                            | R                             |
| 16               | 3.33                            | R                             |
| 17               | 3.33                            | R                             |
| 18               | 0.00                            | HR                            |
| 19               | 19.99                           | S                             |
| 20               | 6.66                            | R                             |
| 21               | 0.00                            | HR                            |
| 22               | 0.00                            | HR                            |
| 23               | 0.00                            | HR                            |
| 24               | 0.00                            | HR                            |
| 25               | 0.00                            | HR                            |



**Table 4. Cont.**

| Genotype Number. | Wilt incidence <sup>a</sup> | (%) | Disease Category <sup>b</sup> |
|------------------|-----------------------------|-----|-------------------------------|
| 26               | 0.00                        |     | HR                            |
| 27               | 0.00                        |     | HR                            |
| 28               | 0.00                        |     | HR                            |
| 29               | 0.00                        |     | HR                            |
| 30               | 0.00                        |     | HR                            |
| 31               | 13.33                       |     | S                             |
| 32               | 3.33                        |     | R                             |
| 33               | 0.00                        |     | HR                            |
| 34               | 3.33                        |     | R                             |
| 35               | 0.00                        |     | HR                            |
| 36               | 0.00                        |     | HR                            |
| 37               | 3.33                        |     | R                             |
| 38               | 0.00                        |     | HR                            |
| 39               | 6.66                        |     | R                             |
| 40               | 0.00                        |     | HR                            |
| 41               | 0.00                        |     | HR                            |
| 42               | 0.00                        |     | HR                            |
| 43               | 3.33                        |     | R                             |
| 44               | 6.66                        |     | R                             |
| 45               | 3.33                        |     | R                             |
| 46               | 3.33                        |     | R                             |
| 47               | 0.00                        |     | HR                            |
| 48               | 3.33                        |     | R                             |
| 49               | 3.33                        |     | R                             |
| 50               | 0.00                        |     | HR                            |

a Wilt incidence is the percentage of infected seedlings, which showed external or internal symptoms.

b Disease category is highly resistant (HR), resistant (R), and susceptible (S).

**Table 5. Correlation between wilt incidence (%) and each of agronomic and technological traits of a collection of cotton germplasm.**

| Traits                        | Correlation                              |
|-------------------------------|--|
| Agronomic traits              |  |
| Boll weight                   | -0.019 <sup>a</sup> (0.896) <sup>b</sup> |
| Seedscotton yield             | -0.149 (0.302)                           |
| Lint yield                    | -0.128 (0.374)                           |
| Lint percentage               | 0.016 (0.914)                            |
| Technological traits          |  |
| Fiber length at 2.5 %         | 0.038 (0.793)                            |
| Fiber length uniformity ratio | -0.027 (0.851)                           |
| Micronaire reading            | 0.049 (0.736)                            |
| Fiber strength                | 0.152 (0.292)                            |

a Linear correlation coefficient, which measures the degree of association between wilt incidence and the tested traits.

b Probability level, all linear correlation coefficients were nonsignificant, n = 50.

**Cluster analysis:**

A phenolgram based on dissimilarity distance (DD) generated from cluster analysis of the profiles of agronomic and technological traits of the tested genotypes are presented in Fig. 1. The smaller the DD, the more

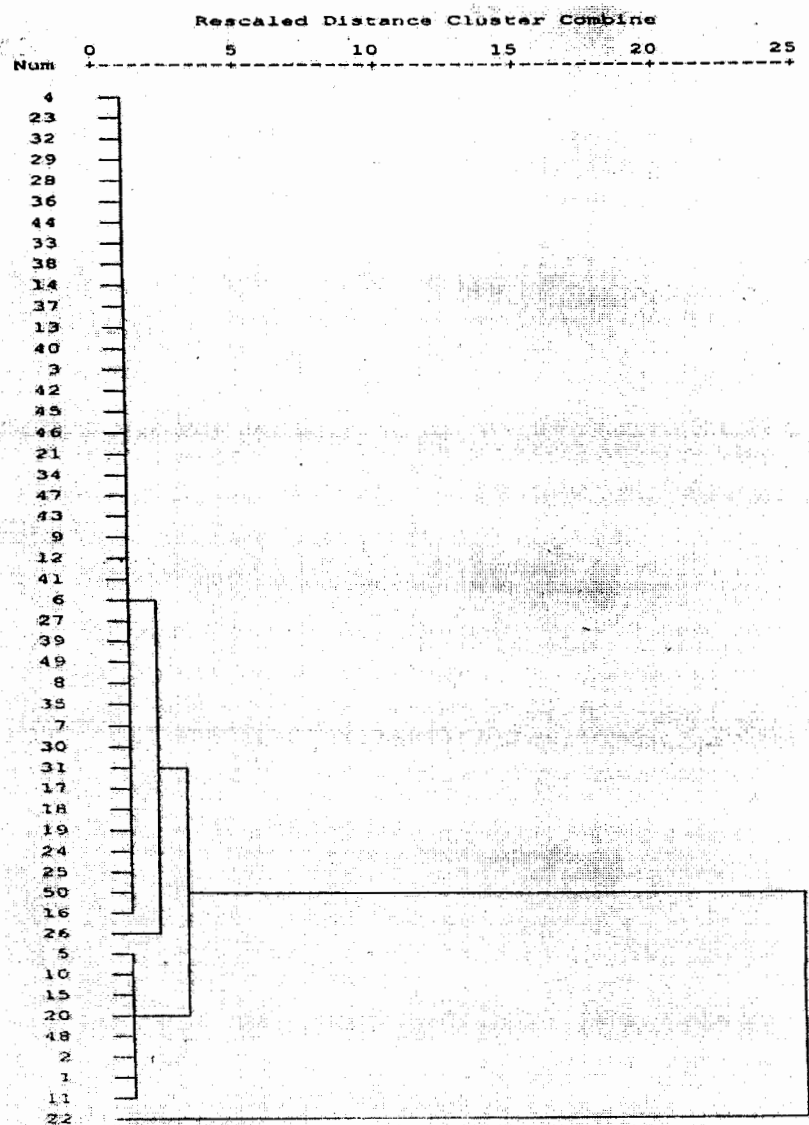
closely the genotypes were related in the profiles of their traits. Four genotypes of cotton genotypes were identified by cluster analysis. The first group (the largest group) included 40 genotypes. The 2<sup>nd</sup> group included the genotype no. 26. The 3<sup>rd</sup> group included eight genotypes. Genotypes no. 22 was placed alone in a separate group unrelated to the other groups. The genotypes of the first group were identical in the profiles of their agronomic and technological traits (DD= 0); however, they showed all the disease categories from highly resistant to susceptible. Therefore, grouping the isolates by cluster analysis based on their traits profiles was not related to their resistance levels.

## DISCUSSION

In the present study, genotypes were screened against 50 FOV isolates from almost all cotton growing areas in Egypt. The use of such a large number of isolates is a strategy to maximize the probability that resistant genotypes identified under greenhouse conditions will maintain their resistance levels under field conditions in distinct geographic locations. On the contrary, if genotypes were screened against a limited number of isolates, they may not perform as expected due to potential presence of isolates differing in their virulence profile from those used in the greenhouse tests.

A distinctive characteristic of Fusarium wilt is the olive brown discolouration of the root and stem xylem. However, there is no consensus regarding the diagnostic importance of this vascular discolouration for evaluation of the host germplasm reaction to Fusarium wilt. For example, Armstrong and Armstrong (1978) stated that vascular discolouration is a questionable standard for judging susceptibility to wilt in seedling tests. Zink *et al.* (1983) found no clear relationship between the severity of external symptoms in surviving muskmelon seedlings and the extent and degree of internal vascular discolouration. On the other hand, Salgado *et al.* (1994) used vascular discolouration as a criterion for judging susceptibility of tepary bean (*Phaseolus acutifolius* Gray) seedlings to Fusarium-wilt. Osman (1996) found a highly significant correlation ( $r = 0.98$ ,  $P < 0.01$ ) between external wilt symptoms and vascular discolouration of cotton seedlings (cultivar Giza 74). In the present study, we used more rigorous criteria for disease rating. According to these criteria, the seedlings were considered slightly susceptible if they showed internal discolouration even though they were free of external symptoms. Thus, the seedlings were considered resistant only if they were completely free of any internal and external symptoms. In our study, cotton genotypes were screened under very favorable conditions for FOV development. The soil was sterile, temperature was optimal most of the time, and the inoculum density was relatively high. Under these conditions, it is unlikely that any susceptible genotypes would have escaped from infection. However, one should keep in mind that evaluation in the greenhouse precludes identifying genotypes that may possess useful levels of field resistance to wilt. The soil infestation method, which we used for seedling inoculation, had several advantages. Assays were simple, did not damage

the seedlings, and provided discriminating and reproducible disease reactions.



**Fig. 1:** Phenogram based on average linkage cluster analysis of agronomic and technological traits profiles of 50 cotton genotypes.

Since no cotton wilt nurseries have been established in Egypt, greenhouse tests will continue to be the only reliable method for screening cotton breeding materials for *Fusarium*-wilt resistance. The current absence of *Fusarium* wilt in commercial cotton field using cultivars derived from our breeding program demonstrates the reliability of these screening procedures, which we have adopted in testing cotton genotypes for *Fusarium*-wilt resistance. In addition, the present work provides new and useful sources of resistance that might be employed in breeding programs aiming to develop cotton cultivars with resistance to FOV race 3 isolates.

It is well known that the type and degree of correlation between characters may facilitate or complicate selection process in breeding programs. Selection for character may result in an improvement or deterioration in other characters according to the type and degree of correlation. Hence, it was desirable to assess the type and degree of association between incidence of *Fusarium* wilt and some major agronomic and technological traits. The lack of correlation between wilt incidence and agronomic or technological traits, as we have demonstrated herein, indicates that breeding for *Fusarium*-wilt resistance will not negatively affect the quality of agronomic or technological traits of the resistant genotypes.

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## الإرتباط بين القابلية للإصابة بذبول الفيوزاريوم والصفات المحصولية والتكنولوجية فى بعض التراكيب الوراثية للقطن

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أجريت تجربة حقليّة بمحطة البحوث الزراعيّة بالجيزة خلال موسمي ٢٠١٢، ٢٠١٣. خلال موسم ٢٠١٢ أجرى تلقيح ذاتى لخمسين تركيباً وراثياً من القطن المصرى. وخلال موسم ٢٠١٣ زرعت هذه التراكيب الوراثية فى تصميم يتكون من ثلاثة قطاعات كاملة العشوائية. أختيرت أربعة نباتات ممثلة لكل تركيب وراثى بطريقة عشوائية من كل قطعة تجريبية. استعملت النباتات المتحصل عليها لقياس بعض الصفات المحصولية (متوسط وزن اللوزة ومحصول القطن الزهر/ نبات ومحصول القطن الشعر / نبات وتصافى الطليج) ، وكذلك بعض الصفات التكنولوجية (طول التيلة عند نسبة ٢٥% ودرجة إنتظام الطول وقراءة الميكرونير والمتانة). فى عام ٢٠١٤، قيمت التراكيب الوراثية - تحت ظروف الصوبة - من حيث المقاومة أو القابلية للإصابة بمرض ذبول الفيوزاريوم ، باستعمال خليط يتكون من ٥٠ عزلة للسلاطة رقم ٣ من فطر الذبول. إستعمل حدوث المرض كمعيار لتقييم أداء التراكيب الوراثية المختبرة. أظهرت التراكيب الوراثية قدراً محدوداً من التباين فى حدوث المرض تراوح ما بين صفر إلى ١٩,٩٩%. أمكن تصنيف التراكيب الوراثية - بناء على حدوث المرض - إلى ثلاثة مجموعات هى على النحو التالى: مجموعة عالية المقاومة (حدوث المرض كان صفر) ومجموعة مقاومة (حدوث المرض من ٣,٢٣ إلى ٦,٦٦%) ومجموعة قابلة للإصابة (حدوث المرض من ١٣,٣٣ إلى ١٩,٩٩%). مثلت المجموعات الثلاث ٥٤ و ٤٠ و ٦% - على الترتيب - من إجمالى التراكيب المختبرة. إستعمل معامل الإرتباط الخطى لتقييم درجة الإرتباط بين حدوث مرض الذبول للتراكيب الوراثية وصفاتها المحصولية أو التكنولوجية. كما إستعمل التحليل العنقودى لتصنيف التراكيب الوراثية إلى مجموعات بناءً على ما بينها من تباين فى أنماط الصفات المحصولية أو التكنولوجية. أظهر كل من تحليل الإرتباط والتحليل العنقودى عدم وجود علاقة بين حدوث مرض ذبول الفيوزاريوم وكل من الصفات المحصولية و التكنولوجية. تدل نتائج الدراسة الحالية على أن إستنباط أصناف من القطن مقاومة لمرض ذبول الفيوزاريوم لن يترتب عليه حدوث تأثيرات سلبية على مستويات الجودة للصفات المحصولية أو التكنولوجية.