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Genetic variation among cotton (*G. hirsutum* L.) cultivars for motes, seed-coat fragments and loading force

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Abstract

Seed quality is one of the important objectives in cotton production and breeding. Seed-coat fragments (SCFs) and motes are the main impurities in lint cotton and are major concerns in the textile industry. A 2-year study was conducted to compare 10 cotton (*Gossypium hirsutum* L.) cultivars for the number of SCFs, motes, and resistance to loading force (RL).

Although cultivars were not significantly different for the number of SCFs in both years, mean values changed among cultivars and between years. Heritability for the number of SCFs was 0.52 indicating almost equal genotypic and environmental effects on phenotype. There was no correlation between the number of SCFs and RL. Cultivars were different for number of motes. Genotypic and environmental effects on the number of motes were 0.71 and 0.29, respectively. No significant correlation was detected between number of SCFs and RL.

Keywords: Cotton; Mote; Resistance; Seed coat; Seed quality

1. Introduction

Although yield is an important factor in cotton production, higher demand is being placed on the quality of the seed cotton or lint. For this reason, the textile industry puts greater importance on fiber properties requiring finer, stronger, longer cotton with greater uniformity (Deussen, 1992). Also, improved cleaning equipment and methods to lessen foreign matter content of cotton lint is preferred. Problems due to SCF and mote contamination in ginned cotton lint occur in textile mills during spinning and dying. These particles are generated when the fiber is separated from the seed cotton during ginning. Most seed coats have substantial amount of fibers attached, which can make them difficult to remove during processing. Seed coats that remain in the sliver after cleaning and carding can cause yarn faults and breaks and generally reduce the quality of the final product.

Mote frequency in seed cotton is affected both genotype and environment (Davidonis et al., 2000; Stewart, 1986). Motes are ovules that have not been fertilized or fail to ripen into mature seeds but develop into aborted structures and cause imperfections in yarn and cloth quality by causing neps (Davidonis et al., 2002; Hughes, 1968; Pearson, 1944). Motes from unfertilized ovules and short fiber motes can be easily eliminated during cotton processing (Baker and Griffin, 1984). Since long and middle length fiber motes have immature fibers that can easily form neps with each other or seed coats, it is difficult to remove them during ginning. Neps, entanglements or clumps of immature fibers are imperfections that severely decrease textile quality at the consumer level since they take up dye poorly and appear as light spots or white specks scattered throughout dyed fabrics (Berger et al., 1997; Jacobsen et al., 2000; Watson and Jones, 1985).

Immature fibers are finer in structure, and have a higher tendency to form neps than more mature fibers do (Hebert et al., 1988). On the other hand it has been shown that during the processes to remove long fiber motes the gin turnout was lessened 6–12% (Cabrera and LePori, 1994). Intensification of lint cleaning processing decreases yarn evenness and resistance during spinning (Newton et al., 1966).

Cotton genotypes can have a potential for large numbers of undesirable seed coat fragments (SCFs) and brittle seed coats, which are an obvious problem in the textile industry. Funiculus, motes and seed coat fragments (having fiber or not) are

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collectively called SCFs and are the main source of neps (Krifa et al., 1999), yarn imperfections, decreasing strength and poor dyeability (Frydrych et al., 1999; Pearson, 1944; Towler and Rogers, 1997). Removal of relatively larger SCFs in the cleaning systems is easier than removing SCFs that are small; the latter have variable sizes of seed coats and different amounts of fiber (Novick et al., 1991).

Two of the most important factors contributing to the occurrence of SCFs have been shown to be both the variety of cotton grown and timing of the harvest. The SCFs in ginned cotton can vary by 50% due to cotton variety (Mangialardi and Meredith, 1990) so it is important to know cultivar characteristics for this trait. Another study showed that SCFs in lint may vary by 50% due to the variety, crop year or timing of harvest (Anthony et al., 1988). Mechanical processing procedures apparently contribute to the presence of defects in cotton fibers (Pearson, 1933). Neps or fiber clusters caused by SCFs are primarily formed during cotton processing (Mangialardi, 1992), but the prime origin of many neps is thought to be in the biology of cotton-seed development. When the number of motes per boll is increased, number of motes in the seed cotton and thus neps in the lint cotton will increase (Saranga et al., 1998). Thirteen percent (Hebert et al., 1988) and 30–40% (Gupta and Vijayshankar, 1985) of all neps are due to SCFs.

In attempting to increase lint yield, cotton breeders have noticed that genotypes with high lint percent generally have poor seed coat quality characterized by small seed with brittle seed coats (Bowman, 1996). In addition to breakage or cracks on the seed, seed moisture content and, most importantly, seed coat resistance to pressure are the factors affecting the number of SCFs (Bowman, 1996). Neps and SCFs account for about 27% of yarn defects (Saranga et al., 1998).

Developing cultivars with stronger seed coats is favoured in breeding programs. This experiment was conducted using 10 cotton cultivars (three were developed in the USA, two in Australia and five in Turkey) grown in Mediterranean conditions. The objectives were to compare cotton cultivars with respect to: (i) number of motes per boll; (ii) number of seed coat fragments in lint cotton; (iii) seed coat resistance to pressure applied; and (iv) to examine correlations and calculate heritabilities among these characters.

2. Materials and methods

Ten upland cotton (*Gossypium hirsutum* L.) cultivars were field tested in 2003 and 2004 under Mediterranean climatic conditions in a silt loam soil. Of the 10 cultivars, three (Stoneville 453, Suregrow 125 and Tex) were developed in the USA, two (Carmen and Deltaopal) in Australia and the five (Çukurova 1518, Gürelbey, Maraş 92, Nazilli 84S, Sayar 314) in Turkey. All the cultivars are registered and have been released in Turkey and they are also grown in the USA. Deltaopal was derived from Deltapine 5816 × Sicala 34 (Aydin, 2001). Stoneville 453, Suregrow 125 and Tex were derived from crosses of Stoneville 213 × Stoneville 603, Des 119 × Deltapine 50, and Acala SJ-2 × GWS-1, respectively (Calhoun et al., 1997; Aydin, 2001). Çukurova 1518 and Nazilli 84S selected from Caroline Queen 201 and Nazilli 84, respectively. Parents of Gürelbey, Maraş 92, and Sayar 314 are Nazilli M-503 × Stoneville 825, Caroline Queen × Taşkent-1 and Deltapine 15 × Acala 314, respectively (Aydin, 2001).

The experiment was a randomized block design with four replications. Plots were two rows, 12 m in length and spaced 0.70 m apart.

Acid-delinted cotton seed (20 g) was planted in each plot in early to mid-May. Plants were thinned to give a stand of approximately 50–60 plants/plot (five to six plants per meter). Standard production practices were applied each year. Seed-cotton was standardized for relative humidity and ginned using a rollergin.

SCFs are generally black or dark brown in color and have fibers attached (Brown and Ware, 1958). Visual counts for the number of SCFs were made on four replicates of 3 g samples (American Society for Testing and Materials, 1985) picked randomly from the ginned plots for each cultivar.

The number of motes per boll was determined on bolls sampled randomly from 10 plants in each block for each cultivar. Open bolls were sampled with their shift from the first positions of the 1st, 6th, and 11th sympodial branches. Visual counts were made in the laboratory and recorded as mote counts per boll.

Undamaged seeds were taken from the lots for each cultivar and kept in laboratory storage until testing. An ''Electronic Tensile Testing Machine'' was used to crush individual seed and measure resistance to load (peak force at break point) in two ways: from ends (chalazal to micropil) and sides. The machine was made by the Hounsfield Company. It has a digital load display, test speed display and can be used to test various materials from wire to seed. The values were recorded at the time of breakage of the seed. Four replicates (10 seeds/replicate) of seeds for each cultivar were used to test loading.

Data were analyzed using analysis of variance statistical procedures (SAS Institute Inc., 1989). Means were separated using Fisher's Protected LSD test at the 0.05 significance level of probability. Heritability was calculated by the method outlined by Comstock and Moll (1963).

3. Results and discussion

3.1. Number of seed coat fragments (SCFs)

The number of SCFs, excluding funiculus, of cotton cultivars is given in Table 1. Analysis of variance for SCFs in both years showed that cultivars were not significantly ($P = 0.05$) different from each other though they were different for the average of both years (Tables 1 and 2). The number of SCFs (counts/3 g lint) in lint cotton were ranged from 50.38 (Nazilli 84S) to 111.94 (Maraş 92) and averaging 71.55 for 2003; from 36.31 (Carmen) to 69.94 (Maraş 92) and averaging 53.11 (Table 1) in 2004. Changes in the number of SCFs due to years and cultivars were also reported by Anthony et al. (1988).

There was no significant interaction between cultivars and years (environment) (Table 2). All cultivars (except Çukurova 1518) had higher SCFs in 2003 than in 2004. On the other hand, cultivars Carmen and Nazilli 84S had less SCFs than the