The Effect of Sowing Date and Plant Density on Cotton Yield

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Abstract: This study was conducted to determine the interaction of sowing date and plant density in Naziilli 84 cotton cultivar in Aegean Region. It was found that delaying sowing date significantly decreased seed cotton yield but the differences among plant densities were non-significant in both cultivars. The correlation coefficients and path analysis results among yield components, fiber technological characteristics and dry matter accumulation at first true leaf-boll retention showed that the ginning turnout had the highest positive direct effect on seed cotton yield. It was concluded that when the plant has less boll retention, dry matter accumulations between flowering-boll retention had adverse effect on seed cotton yield.

Key words: Cotton, sowing date, plant density, correlation and path analysis

INTRODUCTION

The genetic potential of produced cultivar, environmental conditions and applied cultural practices affected crop yield. The sowing date and plant density are the most important management factors in cotton as well as other crops. The crop yield and quality are maximized by suitable sowing date. High level of CO₂ and environment have affected negatively on the cotton plant height. At the same time, these factors have increased early maturity and crop-weed competition. Hall and Ziska (2000) proposed that plant density should be increased in order to minimize yield losses. Aegean Region is one of the most important cotton growing areas of Turkey. In this region, adverse meteorological conditions such as low soil temperature and late precipitation at April and May delayed cotton sowing date or replanting should be needed. Thus, studies manipulating plant spacing and sowing date were needed for the regional development of grower guidelines for cotton planting and replant decisions (Munk, 2001).

There are many researches on suitable sowing date and plant density in cotton. Kittuck et al. (1981) demonstrated that early sowing date for Pima cotton is more important than that of Upland cotton. The air and soil temperature have determinant factors on sowing date. Especially low soil temperature and slow emergence decreased seed cotton yield (Norfleet et al., 1997). Delaney et al. (1999) explained that cotton sowing date varied between April 15 and May 30 and sowing after these dates had lower seed cotton yield in Alabama-USA. They found that sowing date x plant density interaction for seed cotton yield was significant and proposed that early sowing date should be having high plant densities. Unay and Inan (1994) determined that plant density not affected lint yield, but there were significant differences for number of boll/plant, boll weight, seed and boll lint yield, ginning percentage, seed index and fiber length.

Recent studies evaluated dry matter accumulation in the determination of sowing date and plant density. The dry matters at the stages of squaring, flowering and boll opening had higher values in high plant densities (Kirby et al., 1990). In addition, decreasing of space row resulted in increasing the leaf area index, dry matter accumulation and number of bolls/unit area (Samani et al., 1999). In the other studies, optimum dry matter accumulation before flowering and high dry matter accumulation after flowering increased seed cotton yield (Chen et al., 2001).

Some season cotton growers faced the problem of plant density deciding in late sowing dates in Aegean Region as well as other cotton growing areas. The objectives of this study are determine the effects of different plant densities on seed cotton yield and dry matter accumulation and relationships among seed cotton yield, yield components and dry matter accumulations.

MATERIALS AND METHODS

This study was conducted at Naziilli Cotton Research Institute (latitude 37°44′-37°49′ N and longitude 27°44′-27°50′ E) in 1999 and 2000. Aegean Region standard cotton cultivar, Naziilli 84, was used as material. Experimental design was Split Block Design with three replications. Three different sowing dates
Table 1: The maximum, minimum and daily mean temperatures and relative humidity in 1999 and 2000

<table>
<thead>
<tr>
<th>Months</th>
<th>1999 Max. Temp. (°C)</th>
<th>1999 Mean Temp. (°C)</th>
<th>1999 Min. Temp. (°C)</th>
<th>Relative Humidity (%)</th>
<th>2000 Max. Temp. (°C)</th>
<th>2000 Mean Temp. (°C)</th>
<th>2000 Min. Temp. (°C)</th>
<th>Relative Humidity (%)</th>
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</thead>
<tbody>
<tr>
<td>May</td>
<td>30.4</td>
<td>24.2</td>
<td>23.0</td>
<td>47.9</td>
<td>28.4</td>
<td>13.7</td>
<td>20.5</td>
<td>50.4</td>
</tr>
<tr>
<td>June</td>
<td>33.6</td>
<td>21.8</td>
<td>27.1</td>
<td>44.0</td>
<td>34.3</td>
<td>19.2</td>
<td>27.3</td>
<td>40.8</td>
</tr>
<tr>
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<td>36.6</td>
<td>21.4</td>
<td>29.0</td>
<td>46.8</td>
<td>38.2</td>
<td>20.5</td>
<td>30.0</td>
<td>41.0</td>
</tr>
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<td>36.4</td>
<td>21.1</td>
<td>29.0</td>
<td>47.6</td>
<td>36.1</td>
<td>21.2</td>
<td>28.5</td>
<td>47.9</td>
</tr>
<tr>
<td>September</td>
<td>32.5</td>
<td>15.8</td>
<td>23.8</td>
<td>52.8</td>
<td>32.5</td>
<td>15.2</td>
<td>23.8</td>
<td>52.8</td>
</tr>
<tr>
<td>October</td>
<td>27.0</td>
<td>12.9</td>
<td>15.7</td>
<td>57.0</td>
<td>25.6</td>
<td>11.3</td>
<td>17.6</td>
<td>58.2</td>
</tr>
</tbody>
</table>

Meteorological data regarding to cotton growing seasons of 1999 and 2000 years were given in Table 1.

The highest mean temperature in 1999 were recorded at July and August and in 2000 was recorded at August. It was seen that squaring and flowering periods at July and August in 2000 had higher mean and maximum temperatures. Minimum temperatures and the values of relative humidity in both years were similar.

The number bolls per plant and, boll weight (g) were determined with randomly chosen 10 plants from each plot. The first picking percentages (%) as earliness, ginning percentage (%) and seed index (g) were determined in harvest. For fiber technological properties such as fiber length (mm), fiber fineness (mic.) and fiber strength (Presley) were used High Volume Instruments. In addition to agronomic and technological characters, dry matter accumulations at the stages of first true leaf, squaring, flowering and boll opening were determined with randomly chosen 10 plants from each plot. These plant samples were dried at 70°C in 72 h (Wells and Meredith, 1986).

The observed values of seed cotton yields were tested statistically and means were compared with LSD at 0.05 probability level. Correlation coefficients among characters and path analysis were estimated.

RESULTS AND DISCUSSION

In the variance analysis of seed cotton yield, it was seen that differences among sowing dates was significant (Table 2).

The highest seed cotton yield was obtained from May 1 sowing date (4196 kg ha⁻¹) and differences between this sowing date and other sowing dates were significant (Table 2). Seed cotton yield decreased 8.34% in May 15 and 34.13% in May 30. Also, the differences between May 15 and May 30 sowing date for seed cotton yield was significant and seed cotton yield decreasing was found to be 28.13%. Although differences for seed cotton yield among plant densities were non-significant, the highest values were obtained from 9523 plants m⁻² (70 x 15) and 14285 plants m⁻² (70 x 10). Similar to Norfleet et al. (1997), the earliest sowing date having optimum environment conditions was considered the most suitable sowing date. On the other hand, non-significant sowing date x plant density interaction shown that the chance of plant density in late sowing dates not affected seed cotton yield. On the contrary, Delaney et al. (1999) found that high plant density in early sowing date increased seed cotton yield. These contradict conclusions resulted from different material, sowing dates and applied cultural managements.

When the dry matter accumulations at the stages of first true leaf (FTLDM), squaring (SDM), flowering (FDM) and boll opening were evaluated, the all-dry matter accumulations had higher values in higher plant densities. On the other hand, dry matter accumulations at all development stages were higher in the high plant densities and these accumulations decreased in the low plant densities. Furthermore, the late sowing dates had

Table 2: Seed cotton yields and dry matter accumulations at four different development periods of different sowing dates and plant densities

<table>
<thead>
<tr>
<th>Sowing date Density (SCY (kg ha⁻¹))</th>
<th>FTLDM</th>
<th>SDM</th>
<th>FDM</th>
<th>BDM</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 1</td>
<td>3967</td>
<td>48.6</td>
<td>91.43</td>
<td>4057.1</td>
</tr>
<tr>
<td>May 10</td>
<td>4066</td>
<td>24.3</td>
<td>51.43</td>
<td>2357.2</td>
</tr>
<tr>
<td>May 15</td>
<td>4479</td>
<td>16.2</td>
<td>318.0</td>
<td>2257.2</td>
</tr>
<tr>
<td>May 20</td>
<td>4273</td>
<td>12.9</td>
<td>321.4</td>
<td>1828.6</td>
</tr>
<tr>
<td>Mean</td>
<td>4196</td>
<td>25.5</td>
<td>532.8</td>
<td>2625.0</td>
</tr>
<tr>
<td>May 1</td>
<td>3677</td>
<td>51.4</td>
<td>971.4</td>
<td>4771.4</td>
</tr>
<tr>
<td>May 10</td>
<td>3940</td>
<td>27.1</td>
<td>585.7</td>
<td>3328.6</td>
</tr>
<tr>
<td>May 15</td>
<td>3978</td>
<td>17.1</td>
<td>361.9</td>
<td>2542.9</td>
</tr>
<tr>
<td>May 20</td>
<td>3787</td>
<td>12.1</td>
<td>321.4</td>
<td>2721.5</td>
</tr>
<tr>
<td>Mean</td>
<td>3846</td>
<td>26.9</td>
<td>560.1</td>
<td>3341.1</td>
</tr>
<tr>
<td>May 1</td>
<td>2523</td>
<td>45.7</td>
<td>1942.8</td>
<td>5228.5</td>
</tr>
<tr>
<td>May 10</td>
<td>2914</td>
<td>22.8</td>
<td>1142.9</td>
<td>3828.6</td>
</tr>
<tr>
<td>May 15</td>
<td>2818</td>
<td>15.2</td>
<td>1085.7</td>
<td>2866.7</td>
</tr>
<tr>
<td>May 20</td>
<td>2802</td>
<td>12.1</td>
<td>928.6</td>
<td>2757.2</td>
</tr>
<tr>
<td>Mean</td>
<td>2764</td>
<td>24.0</td>
<td>1275.0</td>
<td>3670.3</td>
</tr>
</tbody>
</table>

FTLDM: Dry matter/first true leaf, SDM: Dry matter/squaring, FDM: Dry matter/flowering BDM: Dry matter/boll opening, **: Significant at 0.01 probability level
low dry matter accumulations. Also, Kerby et al. (1990) explained that dry matter accumulations increased as number of plant per unit area decreased. Dry matter accumulations of boll opening stage were 8.0% higher in the high plant density according to Kerby et al. (1990). In this study, this amount was determined as 37.1%. Also, Samani et al. (1999) stated that decreasing the plant spacing resulted in increasing the leaf area index, number of boll per unit area and dry matter accumulation.

The positive and significant correlation coefficients between SCY and NB; LP and FF, the negative and significant correlation coefficient between SCY and SI, FL, SMD, FDM, BDM were determined. The positive and significant correlation coefficients between NB and FL, FF; the negative and significant correlation coefficients between NB and dry matter accumulations at four development stages were estimated (Table 3). The increasing dry matter accumulations of development stages negatively affected seed cotton yield. Therefore, it can be said that low boll retention and increasing dry matter accumulation was directed the non-productive organs. The seed cotton yield was increased by the optimum dry matter accumulation before flowering and high dry matter accumulation after flowering (Chen et al., 2001). In this respect, the ratio of seed cotton yield/biologic yield or harvest index was considerable character in cotton growing and breeding.

LP and FF were positively and significantly correlated with seed cotton yield. The correlation coefficients between SCY and SI, FL were negative and significant. Fiber length (FL) increased but Fiber Fineness (FF) decreased as the number of fiber per unit area, number of seed per boll and seed area increased. Therefore, the increasing seed cotton yield resulted from LP and FF (Unay and Inan, 1994).

The path analysis for seed cotton yield was applied especially in order to determine the direct effects of dry matter accumulations at four developmental stages and results direct effect of LP on seed cotton yield was the highest and positive value (50.94%). Other positive indicative characters were FS (21.38%), BW (18.75%), FTLD (15.48%) and NB (13.50%), respectively (Table 4). Recent studies shown that the highest direct effects on seed cotton yield were NB (Kowsalya and Raveendran, 1996; and Larik et al., 1999), BW (Tyagi, 1994); NB and BW (Rao and Mary, 1996). Although positive and direct effect of FTLD was very high, indirect effect via NB was negatively 14.75%.

There were negative and significant direct effects on seed cotton yield. These characters were SI (27.63%), BKM (25.27%) and FDM (20.03%). The dry matter accumulations at squaring, flowering and boll opening had negative direct effects. Therefore, it can be said that increasing the dry matter at these development stages

### Table 3: Correlation coefficients between measured characteristics

<table>
<thead>
<tr>
<th></th>
<th>SCY</th>
<th>BW</th>
<th>NB</th>
<th>SI</th>
<th>LP</th>
<th>FL</th>
<th>FF</th>
<th>FS</th>
<th>SMD</th>
<th>FDM</th>
<th>BDM</th>
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<tbody>
<tr>
<td>SCY</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>NB</td>
<td>0.475**</td>
<td>-0.289</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td>-0.525**</td>
<td>0.200</td>
<td>0.055</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LP</td>
<td>0.515**</td>
<td>0.134</td>
<td></td>
<td>-0.245</td>
<td>-0.213</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FL</td>
<td>-0.522**</td>
<td>0.506**</td>
<td>0.378*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FF</td>
<td>0.571**</td>
<td>-0.429**</td>
<td>0.661**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FS</td>
<td>-0.022</td>
<td>-0.244</td>
<td>0.123</td>
<td>0.047</td>
<td>-0.576**</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>FTLD</td>
<td>-0.122</td>
<td>0.314</td>
<td>-0.797**</td>
<td>-0.306</td>
<td>0.572**</td>
<td>0.297</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>SMD</td>
<td>-0.835**</td>
<td>0.179</td>
<td>-0.754**</td>
<td>0.234</td>
<td>-0.174</td>
<td>0.421**</td>
<td>-0.525**</td>
<td>0.014</td>
<td></td>
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<tr>
<td>FDM</td>
<td>-0.525**</td>
<td>0.417*</td>
<td>-0.888**</td>
<td>0.113</td>
<td>0.334*</td>
<td>0.490**</td>
<td>-0.657**</td>
<td>-0.271</td>
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<tr>
<td>BDM</td>
<td>-0.690**</td>
<td>0.490**</td>
<td>-0.797**</td>
<td>0.233</td>
<td>0.167</td>
<td>0.520**</td>
<td>-0.674**</td>
<td>-0.311</td>
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</table>


### Table 4: The percentage values of direct and indirect effects of measured characteristics on seed cotton yield (%)

<table>
<thead>
<tr>
<th></th>
<th>BW</th>
<th>NB</th>
<th>SI</th>
<th>LP</th>
<th>FL</th>
<th>FF</th>
<th>FS</th>
<th>SMD</th>
<th>FDM</th>
<th>BDM</th>
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<tbody>
<tr>
<td>BW</td>
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<td>-6.1</td>
<td>-4.0</td>
<td>9.4</td>
<td>2.4</td>
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<td>-19.1</td>
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<td>NB</td>
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<td>-11.0</td>
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<td>2.3</td>
<td>1.8</td>
<td>-14.7</td>
<td>-4.5</td>
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<td>5.1</td>
<td>12.7</td>
<td>-2.6</td>
<td>-20.4</td>
<td>4.6</td>
<td>-3.4</td>
<td>1.5</td>
<td>-12.1</td>
<td>3.0</td>
<td>-7.1</td>
</tr>
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<td>LP</td>
<td>1.8</td>
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<td>5.1</td>
<td>59.9</td>
<td>0.1</td>
<td>-0.7</td>
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<td>11.9</td>
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<td>-11.1</td>
</tr>
<tr>
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<td>-7.8</td>
<td>-14.0</td>
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<td>3.9</td>
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<td>-1.0</td>
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<td>-8.1</td>
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<td>-36.3</td>
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<td>21.3</td>
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<td>0.1</td>
<td>11.1</td>
</tr>
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<td>FTLD</td>
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<td>-1.1</td>
<td>-4.3</td>
<td>15.4</td>
<td>2.8</td>
<td>-21.3</td>
</tr>
<tr>
<td>SMD</td>
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<td>-3.2</td>
<td>-8.4</td>
<td>1.4</td>
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<td>0.2</td>
<td>11.5</td>
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<td>-1.9</td>
<td>-3.5</td>
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<td>12.4</td>
<td>4.8</td>
<td>-25.0</td>
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</table>

were non-productive portion. Thus, the indirect effects of NB via FDM (24.61%) and via BDM (22.28%) were positive, but indirect effects of FDM (-9.64%) and BDM (-9.75%) via NB were negative. In addition, the direct effects BW, SI, LP and FL via FDM and BDM were negative and high values. On the other hand, NB had positive direct effect on seed cotton yield, positive indirect effects via FDM and BDM, but indirect effects of all dry matter accumulation via NB were negative. It can be concluded that dry matter accumulations having optimum number of boll per unit area positively affected seed cotton yield whereas dry matter accumulations having low boll retention was defined as excessive vegetative development.

REFERENCES


