Turk J Agric For
29 (2005) 401-407


# Effects of Reduced Tillage and Planting Systems on Seed Cotton Yield and Quality*

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Received: 07.10.2004

**Abstract:** There is increasing scientific and practical interest in the importance of reduced tillage systems for increasing yield, and obtaining it more economically, in cotton production. Reduced tillage systems which involve lesser field applications have several advantages when compared to conventional systems. Field trials were conducted over 2 years. The aim was to establish the greatest applicability of reduced tillage systems. The 4 types of tillage compared were conventional, precision, strip and ridge tillage. In each of these plots, seeds were planted in 8 rows. A mechanical seed drill was used in 4 rows of each plot at a seed rate of 50 kg $ha^{-1}$. In the other 4 rows planting was done at 0.05 m seed spacings using a pneumatic spacing drill. Planting was performed in 0.7 m row spaces. Tillage and planting treatments were evaluated for 8 different criteria. The emergence degree, plant height, number of bolls/plant, seed cotton yield, first picking percentage and fibre quality parameters such as fineness, length and strength were measured. Analysis of variance revealed, no significant differences among the systems in terms of seed cotton yield, number of bolls/plant or fibre quality parameters. The height of the plants in the ridge planting applications was 10% greater than that in the conventional planting applications. However, 10.6% greater first picking percentage was observed in the ridge planting applications. Finally, it was concluded that reduced tillage systems were more advantageous than conventional tillage systems.

Key Words: Cotton, reduced tillage systems, planting, mechanisation

## Pamukta Azaltılmış Toprak İşleme ve Ekim Sistemlerinin Verim ve Lif Kalite Özelliklerine Etkisi

**Özet:** Pamukta verimin arttırılması ve ürünün daha az masrafla elde edilmesi düşüncesi azaltılmış toprak işleme yöntemlerinin önemini arttırmıştır. Dolayısıyla uygulanan geleneksel yönteme karşılık, tarlada daha az trafiği amaçlayan toprak işleme yöntemlerinin kullanılması gerekmektedir. Araştırmada, tarla çalışmaları iki yıl süreyle yürütülmüştür. Uygulanabilir nitelikte olan azaltılmış toprak işleme sistemlerinin araştırılması amaçlanmıştır. Dört farklı toprak işleme yöntemi olarak, geleneksel, hassas, şeritvari ve sırta ekim yöntemleri karşılaştırılmıştır. Her bir parselde, sekiz sıra ekim yapılmıştır. Her parselin dört sırasına 50 kg $ha^{-1}$ ekim normuna ayarlanmış normal sıravari mekanik pamuk ekim makinası ile ekim yapılmıştır. Diğer dört sıranın ekimleri 0.05 m ekim mesafesinde çalışan pnömatik hassas ekim makinası ile yapılmıştır. Ekimlerde 0.7 m sıra arası mesafesi uygulanmıştır. Toprak işleme ve ekim uygulamaları sekiz farklı kritere göre değerlendirilmiştir. Tarla filiz çıkış derecesi, bitki boyu, koza sayısı, kütlü pamuk verimi, erkencilik ve lif inceliği, lif uzunluğu ve lif mukavemeti gibi lif kalite değerleri incelenmiştir Varyans analizi sonuçlarına gore, sistemlerin kütlü pamuk verimleri, koza sayıları ve lif kalite özellikleri arasında fark ortaya çıkmamıştır. Sırta ekim sisteminden elde edilen bitki boyu değerleri geleneksel toprak işleme sisteminden elde edilen değerlere gore %10 daha fazla olmuştur. Aynı şekilde sırta ekim sisteminin uygulandığı parsellerde %10.6 erkencilik elde edilmiştir.

Anahtar Sözcükler: Pamuk, azaltılmış toprak işleme yöntemleri, ekim, mekanizasyon

* This study was funded by TÜBİTAK, Project No: TOGTAG/TARP-2562.
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## Introduction

The main goal in agricultural production is to improve the yield and quality of the harvest and to increase profits. Another way to increase profits is to reduce the use of agricultural inputs. Among the agricultural inputs, the effect of agricultural mechanisation is important in increasing agricultural production. When the use of agricultural machinery is considered, the importance of the soil tillage and seed bed preparation processes cannot be ignored (Yalçın et al., 2002).

Due to the high cost of production, average cotton production in Turkey has been declining. Therefore, reduced tillage systems providing farmers with the opportunity to harvest an equal amount and equal quality of cotton with reduced inputs in comparison with the conventional tillage system have been used. Moreover, reduced tillage systems are associated with reduced soil compaction, especially because they restrict wheeled traffic to set paths in the field, a system known as controlled traffic farming. Reduced tillage systems also reduce field work time requirements and costs because they require fewer passes over the field. In addition, reduced tillage systems can reduce soil erosion and leaching of nutrients into groundwater. According to Brown et al. (1985), cotton yields can decline by as much as 4% for each centimetre of topsoil lost. Considering all these facts, it is essential that farmers apply reduced tillage systems in cotton farming (Coates and Thacker, 1993; Yalçın and Uçucu, 1999; Kennedy and Hutchinson, 2001; Nyakatawa and Reddy, 2001).

The objectives of this study were to examine different tillage systems and to compare these systems in cotton farming. Systems were therefore analysed in terms of plant characteristics (emergence degree, plant height and number of bolls/plant), seed cotton yield and fibre quality parameters.

## Materials and Methods

The study was conducted in the 2000 and 2001 growing seasons at the Research and Production Farm of the Agriculture Faculty, Adnan Menderes University in Aydın, Turkey. The texture of the soil at the study site is sandy-loam (clay, 12%; silt, 23%; and sand, 65%). The hourly total values of maximum temperatures above 32 $^{o}$C (high temperature threshold for cotton) in July and August, 2000 and 2001, are given in Table 1 according to meteorological data.

Table 1. The hourly total values of maximum temperatures above 32 °C in July and August.

| Month | 2000 (h) | 2001 (h) | Change (%) |
|---|---|---|---|
| July | 239 | 312 | +30.54 |
| August | 188 | 236 | +27.12 |
| Total | 427 | 548 | +28.34 |

The delinted and bare seeds of the cotton (*Gossypium hisutum* L.) cultivar Nazilli 84 S, produced by the Nazilli Cotton Research Institute, was used (Özarslan, 2002).

This study was intended to determine the effects of 4 soil tillage and seed bed preparations and 2 planting techniques. The experimental design was a randomised split-plot design with 3 replications. The tillage systems were applied in split plots. Plots were 25 m long and 8 rows were sown in each plot within the 3 m plot space, which resulted in 4 rows of cotton, 5 m apart. Planting was performed in 0.7 m row spacings which is the system most commonly followed in this region. In all the plots, a plant population of 70,000 plants ha$^{-1}$ was the objective (Wanjura, 1990; Williford, 1992): 300 kg ha$^{-1}$ of fertiliser (20-20-0) was applied pre-planting and 250 kg ha$^{-1}$ of fertiliser (ammonium nitrate, 33%) before the first irrigation. For weed control 2000 cc ha$^{-1}$ of trifluralin was applied in pre-planting periods. All data were evaluated using LSD. Details of the equipment and machines used in the tillage and seed bed preparations are given in Table 2.

Seeds were planted in 8 rows after tillage and seedbed preparation. Planting was conducted using a mechanical seed drill in 4 rows in each plot with a seed rate of 50 kg ha$^{-1}$. In the other 4 rows planting was performed at 0.05 m seed spacing using a pneumatic spacing drill. Eight different systems resulting from tillage and seed bed preparation, planting and other operations were compared. Evaluations and comparisons related to the analysed characteristics were performed according to these 8 systems (Table 3).

Table 2. The equipment and machines used in the tillage and seedbed preparation operations for the 4 tillage systems.

| Conventional Tillage | Strip Tillage | Precision Tillage | Ridge Tillage |
|---|---|---|---|
| Mouldboard Plough | Mouldboard Plough | Mouldboard Plough | Mouldboard Plough |
| Chisel | Chisel | Precision tillage equipment | Chisel |
| Disc Harrow (x6) | Broadcaster | Broadcaster | Ridger |
| Broadcaster | Field sprayer | Field sprayer | Broadcaster |
| Field sprayer | Disc Harrow | Ridger | Field sprayer |
| Disc Harrow | Rotary row tiller | Ridge scrubber | Ridger |
| Scrubber | | | Ridge scrubber |

Table 3. Soil tillage, seedbed and planting applications.

| Soil Tillage and Seedbed Applications | Planting Applications | Other Applications | Systems |
|---|---|---|---|
| A1 - Conventional Tillage | MSD (Application B1) | Application C | 1 |
| Method | PSD (Application B2) | Application C | 2 |
| A2 - Precision Tillage | MSD (Application B3) | Application C | 3 |
| Method | PSD (Application B4) | Application C | 4 |
| A3 - Strip Tillage | MSD (Application B5) | Application C | 5 |
| Method | PSD (Application B6) | Application C | 6 |
| A4 - Ridge Tillage | MSD (Application B7) | Application C | 7 |
| Method | PSD (Application B8) | Application C | 8 |
| APPLICATION A | APPLICATION B | APPLICATION C | |

MSD: Mechanical seed drill PSD: Pneumatic spacing drill

In plots where conventional planting was performed, the seed bed was prepared using conventional and strip tillage methods. In the plots where ridge planting was performed, the seed bed was prepared using the precision and ridge tillage systems (Carter et al., 1965; Kolstad et al., 1981; Önal, 1990; Tompkins et al., 1990; Carter et al., 1991; Yalçın et al., 2002).

In order to determine the average emergence degree, emerged plants were counted daily after the beginning of germination (Bilbro and Wanjura, 1982).

The plant height and number of bolls/plant were determined on 10 plants selected in each plot where different systems were applied. The seed cotton yield (kg $ha^{-1}$) was estimated in 28 $m^2$ plots. First picking percentage was determined as a the ratio of seed cotton harvested in the first picking to total cotton yield. For the determination of the fibre length (mm) and fibre fineness (micronaire) HVI (High Volume Instruments-Motion Control 4000) was used. Fibre strength was determined using a Pressley tester.

The results were evaluated on the basis of the standard plot, 150 m in length, 66.67 m in width and 1 ha in area suggested and used by Uçucu (1981).

## Results and Discussion

The results of variance analysis are of each character's mean values, in Tables 4-6, may the differences among the 4 tillage systems were significant for emergence degree, plant height and first picking percentage. The tillage systems x planting systems interaction was only significant for number of bolls/plant.

Table 4. Values of emergence degree and plant height.

| Applications | 1st Year Emergence Degree (%) | 1st Year Plant Height (cm) | 2nd Year Emergence Degree (%) | 2nd Year Plant Height (cm) |
|---|---|---|---|---|
| Application A1 | 56.47b | 92.07b | 58.05 | 102.08b |
| Application A2 | 59.78a | 103.75a | 62.15 | 112.00a |
| Application A3 | 51.77c | 91.00b | 52.35 | 102.52b |
| Application A4 | 54.48bc | 102.86a | 59.05 | 109.03a |
| Average | | 97.42 | | 106.41 |
| LSD 0.05 | 2.946 | 5.590 | | 3.513 |
| Applications (A) | ** | ** | ns | ** |
| Planting Systems (B) | ns | ns | ns | ns |
| A x B | ns | ns | ns | ns |

*, **, significant at 0.05 and 0.01 probability levels, respectively.

Table 5. Number of bolls/plant.

| Applications | | Number of bolls/plant 1st year | Number of bolls/plant 2nd year |
|---|---|---|---|
| Application A1 | Application B1 | 19.6 | 9.7 |
| | Application B2 | 18.6 | 11.5 |
| Application A2 | Application B3 | 21.1 | 9.7 |
| | Application B4 | 22.7 | 10.4 |
| Application A3 | Application B5 | 16.9b | 11.7 |
| | Application B6 | 21.2a | 10.3 |
| Application A4 | Application B7 | 20.2 | 10.9 |
| | Application B8 | 19.4 | 10.9 |
| Average | | 19.96 | 10.63 |
| LSD 0.05 | | 2.750 | - |
| Applications (A) | | * | ns |
| Planting Systems (B) | | ns | ns |
| A x B | | * | ns |

*, **, significant at 0.05 and 0.01 probability levels, respectively.

Statistical analysis was undertaken according to both the original values and the transformed values. Since no differences were observed among these values, the original values were taken as the basis for the evaluations.

According to the emergence degree values obtained from all plots, it can be assumed that 70,000 plants $ha^{-1}$ was achieved for each plot. The results of variance analysis showed that the differences between planting methods were not significant for emergence degree or plant height in either year, while the differences among tillage systems were significant except for emergence degree in the first year. The average emergence degree values of Application A2 were 5.54% higher than the values obtained from other systems in the first year (Table 4). Application A3 had the lowest emergence

Table 6. Values of seed cotton yield and first picking percentage.

| Applications | 1st Year | | 2nd Year | |
|---|---|---|---|---|
| | Seed Cotton Yield (kg ha$^{-1}$) | First Picking Percentage (%) | Seed Cotton Yield (kg ha$^{-1}$) | First picking Percentage (%) |
| Application A1 | 4129 | 75.2b | 2492 | 71.3b |
| Application A2 | 4517 | 84.5a | 2480 | 82.5a |
| Application A3 | 4231 | 74.4b | 2307 | 72.5b |
| Application A4 | 4284 | 85.1a | 2605 | 83.5a |
| Average | 4290 | | 2471 | |
| Application B+ | 4270 | 81.3 | 2528 | 78.6 |
| Application B++ | 4310 | 78.6 | 2414 | 76.5 |
| Average | 4290 | | 2471 | |
| LSD 0.05 | | 6.40 | | 9.17 |
| Applications (A) | ns | * | ns | * |
| Planting Systems (B) | ns | ns | ns | ns |
| A x B | ns | ns | ns | ns |

*, **, significant at 0.05 and 0.01 probability levels, respectively.

+ The average values of the plots on which a mechanical seed drill was used

++ The average values of the plots on which a pneumatic spacing drill was used

degree value (51.77%). In similar studies matching our results Rathore et al. (1983) and Yalçın and Özarslan (2002) emphasised that ridge planting is more advantageous than conventional planting in terms of both farming the soil crust and emergence degree. Bayat et al. (1993) determined that the emergence degree values were above 40% in all plots using mechanical seed drills and pneumatic spacing drills in various norms.

According to the values obtained from our 2-year study, the average plant height of systems with Applications A2 and A4 was 10% greater than that of those with Applications A1 and A3. Similar results were also obtained by Mobley and Albers (1993) and Yalçın and Uçucu (1999). Who emphasised that cotton grown using ridge tillage was superior in terms of plant height.

The number of bolls/plant varied between 16.9 and 22.7 for the first year and between 9.7 and 11.7 for the second year (Table 5). It was also observed that the use of different planting machinery in Application A3 in the first year significantly affected the number of bolls. The effects of the systems were not all significant. Pettigrew and Jones (2001), indicated that a no-tillage system in cotton farming reducd the number of bolls by as much as 8%, whereas ridge planting (Systems 3, 4, 7 and 8) in this study increased the number of bolls/plant by 9.28%. This difference might be the result of the materials and tillage systems used (Table 5).

Seed cotton yield and first picking percentage were analysed separately in terms of tillage and planting methods (Table 6).

There were no significant differences in the seed cotton yield values for either year. Parsch et al. (2001) emphasised that they did not observe any differences between seed cotton yields. However, Kennedy and Hutchinson (2001) determined that lint yields were 1057 kg ha$^{-1}$ in no tillage, 1007 kg ha$^{-1}$ in conventional tillage and 890 kg ha$^{-1}$ in ridge tillage.

However, the seed cotton yields were very different between the 2 years. Similar trends are shown for plant height and number of bolls/plant in Tables 4 and 5. When the data for plant height, number of bolls/plant and seed cotton yield are evaluated together, it may be said that the second year data for number of bolls/plant and seed cotton yield had lower values than those of the first year data whereas plant height values were higher in the second year. These differences may be attributed to different climate conditions, especially maximum temperatures above 32 °C, between the 2 years (Table 1). In the second year, in the 50% boll initiation period, the average daily maximum temperature was 38 °C in July and 34.7 °C in August. Moreover, in the same period maximum daily temperatures were as high as 44.6 °C. Reddy et al. (1996) reported that such high temperatures would be expected to hasten boll growth and reduce boll size. In addition, these high temperatures may cause considerable boll retention.

In both years, Applications A2 and A4 ranked highest for first picking percentage. Ridge planting had 9.88% higher first picking percentage values than conventional planting. This rate was 11.36% in the second year. Some researchers have emphasised that ridge planting increased first picking percentage (Mobley and Albers, 1993; Yalçın and Uçucu, 1999). The results of this study are consistent with this research.

To determine the fibre quality parameters of the cotton grown on the trial plots, fibre length, fineness and strength were measured (Table 7).

No differences were observed among the fibre quality parameters in either year. These results are consistent with the industrial ranges.

Similar results were detrmined by Mobley and Albers (1993) and Yalçın and Uçucu (1999), who emphasised that there were no differences among the fibre quality parameters of cotton grown using ridge or conventional planting. Similar results were also reported by Philip and Cothren (2000) and Pettigrew and Jones (2001).

## Conclusions

During the first year, emergence degree was 5.54% higher in systems where precision tillage (Systems 3 and 4) was performed than in the other systems.

Where ridge planting was performed, plants were 10% higher than those grown in systems where conventional planting was used.

Among the different reduced tillage systems, no differences in seed cotton yields were observed. However, a 9.88% first picking percentage was observed in the systems in which ridge planting was performed. Considering the rainfall coinciding with the cotton harvest period, this rate is noteworthy.

Reduced tillage systems were more advantageous than conventional tillage systems when machinery use costs were considered. According to Yalçın et al. (2002), the total machinery use cost for reduced tillage systems was an average of 65.63 \$ ha$^{-1}$ less than that for conventional tillage systems.

No differences were observed between the fibre quality parameters and seed cotton yield in terms of different reduced tillage systems. Finally, we suggest that reduced tillage systems can replace the conventional method in cotton farming in view of their lower machinery use costs and improved first picking percentage.

Table 7. Fibre quality parameters.

| Applications | 1st year | | | 2nd year | | |
|---|---|---|---|---|---|---|
| | Micronaire | Fibre length (mm) | Fibre strength (1000 lb/inch$^2$) | Micronaire | Fibre length (mm) | Fibre strength (1000 lb/inch$^2$) |
| Application A1 | 4.9 | 29.7 | 78.75 | 5.0 | 28.5 | 93.0 |
| Application A2 | 4.9 | 29.3 | 85.37 | 5.1 | 28.1 | 92.2 |
| Application A3 | 4.8 | 28.9 | 84.07 | 5.2 | 28.4 | 91.6 |
| Application A4 | 5.0 | 29.1 | 85.90 | 5.4 | 28.9 | 93.7 |
| Application B* | 4.9 | 29.3 | 83.0 | 5.2 | 28.3 | 94.5 |
| Application B** | 4.8 | 29.2 | 85.0 | 5.2 | 28.7 | 90.8 |

*The average values of the plots on which a mechanical seed drill was used

** The average values of the plots on which a pneumatic spacing drill was used

## Acknowledgements

This research was funded by TÜBİTAK (The Scientific and Technical Research Council of Turkey). We wish to thank the Adnan Menderes University Agriculture Faculty for letting us use their fields for the experiments. Additionally, funds to support this research were provided by the Ege University, Agriculture Faculty, Agricultural Machinery Department and the Nazilli Cotton Research Institute.

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