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Effect of Cultivar Blends on Yield and Fiber Quality of Upland Cotton (*Gossypium hirsutum* L.) in Planting in the Çukurova region, Turkey

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Abstract

Field trials were conducted to study the effect of blending different cotton cultivars on yield and fiber quality. Three commercial cotton cultivars grown alone and in blends containing different proportions of two cultivars were evaluated for yield and important fiber quality traits over a two years period. The cultivars were combined by volume, pairing the high fiber quality cultivars with high yielding cultivar in five different ratios, 0:100, 25:75, 50:50, 75:25, and 100:0. Blends had advantages over monocultures in several respects. The seed cotton yield, lint yield and micronaire in the blends were higher than in the pure cultivars. Blends did not differ significantly from components for fiber length, fiber length uniformity and short fiber index, but micronaire was higher in some blends than in the pure stands. The study showed that blending can increase yield significantly for some cultivar pairs. Further investigation of physiological traits in relation to competition and blend performance could help us to choose the best combination of varieties to include in blends.

Key words: Cultivar blends, *Gossypium hirsutum* L., fiber strength, micronaire, yield

Çukurova Bölgesinde Ekimde Çeşit Karışımının Upland Pamuğunun (*Gossypium hirsutum* L.) Verim ve Lif Kalitesine Etkisi

Özet

Tarla denemeleri farklı pamuk çeşit karışımlarının verim ve lif kalitesi üzerine etkisini araştırmak amacıyla yürütülmüştür. İki yıllık çalışmada üç ticari pamuk çeşidinin saf olarak ya da iki çeşidin farklı oranlarını içeren karışımlar halinde yetiştirilmesinin verim ve kalite özellikleri üzerine etkileri değerlendirilmiştir. Çeşitler, lif kalitesi üstün çeşitler yüksek verimli çeşit ile 0:100, 25:75, 50:50, 75: 25 ve 100:0 olmak üzere 5 değişik oranda, hacimce kombine edilmiştir. Karışık ekimler birçok yönden saf ekimlere oranla avantajlı olmuştur. Karışık ekimlerde kütlü pamuk verimi, lif verimi ve lif inceliği (mikroner) saf ekimlerdekine oranla daha yüksek olmuştur. Karışık ekimler lif uzunluğu, lif yeknesaklığı ve kısa lif içeriği yönünden saf ekimlerden farklı olmamakla birlikte, lif inceliği (mikroner) bazı karışık ekimlerde artmıştır. Çalışma bazı çeşit karışımlarının verimi önemli derecede arttırabileceğini göstermiştir. Rekabetle ilişkili olarak fizyolojik özelliklerin ve karışım performansının daha fazla araştırılması karışık ekimlerde yer alacak çeşitlerin en iyi kombinasyonun seçilmesinde yardımcı olacaktır.

Anahtar kelimeler: Çeşit karışımları, *Gossypium hirsutum* L., lif kopma dayanıklılığı, mikroner, verim

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Introduction

Implementation of high volume instrument (HVI) cotton classing system allowed fiber quality parameters to be objectively and rapidly measured (Deussen, 1989). Open-end spinning requires high strength cotton fibers for yarn manufacturing. As this technology became more widely used, cotton with weaker fiber strength has became less desirable and less preferred by textile mills. Environmental and processing factors are known to influence fiber properties. Cotton cultivars differ in growth characteristics such as height, maturity and earliness, yield potential and many fiber properties (Niles and Feaster, 1984). The length and strength of cotton fibers are primarily determined by genetics of the cultivars and, therefore, may be manipulated by producers through cultivar selection (Meredith, 1991). Increasing micronaire values have been a matter of concern for cotton industry in recent years. Variability in length, strength and fineness (micronaire) impedes the capabilities of modern yarn manufacturing technologies to produce the highest quality yarn at a competitive price. Problems associated with increasing trends towards high micronaire values for Upland cotton (*Gossypium hirsutum* L.) have been also a matter of concern for the Turkey cotton industry in recent years. Results obtained from an evaluation of recent fiber quality data revealed increasing micronaire values in Çukurova region (Özbek et al., 2005). Until recently, most varieties that offered improved fiber quality have been later maturing varieties not suited for short-season environments. In addition to the later maturity, the yield potential of these varieties was often less than desirable. In the absence of suitable varieties, some producers have adopted variety blending as means to improve overall fiber quality. Normally, a high-yielding, early-maturing variety is blended with a variety that provides better fiber quality. Therefore, overall fiber quality could be improved while maintaining high yields and earliness. In addition, seed availability and pricing of new varieties has prompted producers to look at blending as a means of making seed allocations go farther. While blending has usually improved overall fiber quality, the result is often intermediate between the two blended varieties. Low fiber quality cultivars and the associated price discounts have led to an interest in the potential of mixing different cultivars to maintain yield and improve fiber quality. Bridge et al. (1984) found that mixing two cultivars with similar yield potential did not result in higher lint yield or staple length, but did increase micronaire and lint strength. Bechere et al. (2008) have found that yields of the blends were intermediate between the low and high yielding cultivars under both irrigated and dry land conditions. Varietal mixtures differ in their efficiency in capturing resources to produce higher yields compared with when varieties are grown in pure stands. Riggs (1970) reported that the yields of mixtures were significantly greater than the yield of the best component in cotton. Blends of cotton cultivars are uncommon practice in Turkey cotton production, where biotic and abiotic stresses reduce yield and quality. In 2010 and 2011, a field experiment was conducted in Adana, Turkey, to compare performance of pure stands of three cotton (*Gossypium hirsutum* L.) cultivars with those of their different blends for yield and optimal fiber quality.

Materials and methods

Field experiments were conducted at the Field Crops' Department Research Area, University of Çukurova, Adana in 2010 and 2011. Cultivars in this study were selected from Delta Pine and Land Co. medium-late maturity cultivar trials across five environments. SG-125 was selected for its high-yielding capacity, DP 419 and DP 499 for their superior quality characteristics. Treatments consisted of three monocultivar treatments, 100% each of SG-125, DPL 419 and DPL 499 and 25/75, 50/50, and 75/25 percentage mix by volume (volumetric) of these cultivars. The cultivars were similar in seed size and maturity. In both years the same arrangement of treatments was used. At two years, plots consisted of three replications of four rows grown in a randomized complete block design. Plots consisting of four rows spaced 0.80 m apart and 12 m long. Region guidelines were followed for seeding rate, insect control, weed control, and soil fertilization. Cotton was planted on 26 April 2010 and 3 May 2011. All seed cotton at 10 meter lengths of the two center rows of each plot was hand harvested at approximately 70% open boll for yield. Subsamples from each plot were ginned on a laboratory type roller gin to determine lint yield and lint turnout. Fiber quality measurements were performed on a HVI 900A (High Volume Instruments). All the variables were subjected to the analysis of variance using the Statistical Analysis with SAS/STAT software. The F-test of the experimental variables was considered significant at α=0.05 level. Means were separated on the basis of Least Significance Difference (LSD) test at the 5% probability level.

Results

Blending of cultivars had significant effects on seed cotton yield, lint yield, gin turnout, fiber strength and micronaire reading. Fiber length, uniformity index and short fiber content were not influenced by cultivar blends. The year by blend interaction was significant for fiber strength and micronaire. Seedcotton yield, lint yield and fiber properties of three pure cultivars and their possible blends are shown in Table 1, Table 2, Table 3 and Table 4, respectively. Seedcotton yields of the cultivars and their blends were found to be significantly different in 2010 and 2011. The seedcotton yield values for most blends were either intermediate to the values of the component cultivars or as high and not statistically different from the highest seed cotton yield values of the component cultivar. Among cotton cultivars in pure stand SG-125 had significantly higher yields than the other two cultivars.

Table 1. Seedcotton yield and lint yield for cultivars and cultivar blends

Cultivar/Blend	Seed cotton yield (kg/ha)			Lint yield (kg/ha)		
	2010	2011	Combined	2010	2011	Combined
DP 419	2793 d*	3250 cd	3022 cd	1203 e	1400 bc	1302 c
DP 419(75)/SG-125(25)	3053 c	2997 d	3025 cd	1320 d	1279 c	1299 c
DP 419(50)/SG-125(50)	3073 c	3000 d	3037 c	1316 d	1268 c	1292 c
DP 419(25)/SG-125(75)	3490 b	3593 bc	3542 b	1537 c	1558 ab	1548 b
SG-125	4080 a	4050 a	4065 a	1802 ab	1744 a	1773 a
SG-125(75)/DP 499(25)	4123 a	3813 ab	3968 a	1867 a	1662 a	1764 a
SG-125(50)/DP 499(50)	3963 a	3757 ab	3860 a	1749 b	1656 a	1703 a
SG-125(25)/DP 499(75)	3960 a	3823 ab	3892 a	1764 ab	1663 a	1713 a
DP 499	2720 d	2893 d	2807 d	1179 e	1245 c	1212 c
LSD($P \leq 0.05$)	237.9	374.9	221.7	110.7	208.5	116.6
Mean	3473	3464	3468	1526	1497	1512

*Means within a column followed by the same letter are not significantly different at the $P \leq 0.05$ according to Least Significant Difference Test.

The blends of SG-125 and DP 499 had the greatest seedcotton yields and were not statistically different from the seedcotton yield of the monoculture SG-125 (Table 1). Blends containing DP 419 were lower yielding than the other blends. The high yielding cultivar SG-125 responded negatively in blends with DP 419, with one exception, where DP 419(25)/SG-125(75) blend was significant, whereas DP 499 when associated with SG-125 showed an increase over its monoculture. The monoculture SG-125 produced an average of 25.6% and 30.9% more seedcotton yields than the DP 419 and DP 499 monocultures, respectively, over two years. Averaged across years, lowest seedcotton yields were in monocultures of DP 419 and DP 499, and in the DP 419(75)/SG-125 (25), DP 419(50)/SG-125(50) blends. Blends of SG-125 and DP 499 produced consistently better yields than DP 419 and as high as SG-125.DP 419 had a yield penalty when compared with the staple of high yielding cultivars. It performed well in terms of low micronaire (Table 3). There were significant differences for the lint yield of cotton in monocultures and blends. Lint yield of the blends ranged from 1316 kg ha^{-1} for the blend of DP 419(50)/SG-125(50) to 1867 kg ha^{-1} for the blend of SG-125(75)/DP 499(25) in 2010, and from 1268 kg ha^{-1} for the blend of DP 419(50)/SG-125(50) to 1663 kg ha^{-1} SG-125(25)/DP 499(75) in 2011 (Table 1). The lint yield values for most blends were either intermediate to the values of the component cultivars or as high as the lint yield values of the component cultivars. Among monocultures, SG-125 had the greatest mean yield, although no significant differences were observed between DP 419 and DP 499 (Table 1). The blends of SG-125 and DP 499 had higher lint yield than DP 499 and as high as that of SG-125. Blends containing both DP 419 and SG-125 had significantly lower lint yields than either of these cultivars, with one exception, where DP 419(25)/SG-125(75) blend was significant. Averaged across years, three of the four higher-yielding blends were: SG-125(75)/DP 499(25), SG-125(50)/DP 499(50) and SG-125(25)/DP 499(75).

Table 2. Gin turnout fiber length for cultivars and cultivar blends

Cultivar/Blend	Gin Turnout (%)			UHM (mm)		
	2010	2011	Combined	2010	2011	Combined
DP 419	43.0* e	43.0	43.0	27.6	27.7	27.7
DP 419(75)/SG-125(25)	43.1 de	42.6	42.8	27.3	27.6	27.5
DP 419(50)/SG-125(50)	42.8 e	42.3	42.6	28.0	28.0	28.0
DP 419(25)/SG-125(75)	44.0 bcd	43.3	43.7	28.0	27.8	27.9
SG-125	44.1 bc	43.1	43.6	27.9	27.4	27.6
SG-125(75)/DP 499(25)	45.2 a	43.5	44.4	27.7	27.8	27.7
SG-125(50)/DP 499(50)	44.6 ab	44.0	44.3	27.7	27.6	27.6
SG-125(25)/DP 499(75)	44.5 ab	43.5	44.0	28.0	27.8	27.9
DP 499	43.3 cde	43.0	43.2	26.4	26.7	26.5
LSD(P≤0.05)	0.95	NS	NS	NS	NS	NS
Mean	43.8	43.1	43.5	27.6	27.6	27.6

*Means within a column followed by the same letter are not significantly different at the P≤0.05 according to Least Significant Difference Test.

In 2010, the gin turnout values for most blends were either intermediate to the values of the component cultivars or as high as the gin turnout values of the component cultivars. Among monocultures, SG-125 had the higher mean gin turnout, although no significant differences were observed between DP 419 and DP 499 (Table 2). Blends containing DP 419 and SG-125 had significantly higher gin turnouts than either of these cultivars. Gin turnout in 2011 was unaffected by any of the blends or cultivars used in this study. Averaged across years, gin turnout values of blends were not significantly different from those of pure cultivars. Among the fiber properties, the largest variations between cultivars and blends were found for fiber strength and micronaire. The micronaire values for blends of SG-125 and DP 499 were either intermediate to the values of the component cultivars or not statistically different from the highest micronaire values of the component cultivar in 2010. Micronaire value in 2011 was not statistically influenced by blends (Table 3). Blend means of SG-125 and DP 499 for micronaire were in the wrong direction with respect to improved fiber quality while were in the right direction for blends of DP 419 and SG-125. Micronaire values in the blends of SG-125 and DP 499 were similar to the value of high yielding SG-125 monoculture. Fiber of SG-125 and DP 499 blends was coarser (higher micronaire), while fiber of DP 419 and SG-125 blends was finer (lower micronaire). Micronaire in the blended cultivars of DP 419 and SG-125 was not statistically different from the lower micronaire of DP 419 in monoculture. Lint in the monoculture of DP 419 had lower micronaire value than the SG-125 and DP 499 monocultures (Table 3). Averaged across years, the blends of DP 419 and SG-125 had significantly lower micronaire compared with the cultivar with the highest micronaire and its blends with DP 499. Fiber strengths of the cultivars and their blends were found to be significantly different in both years. The fiber strengths of the blends were intermediate or as high and similar to the strengths of the component cultivars. In 2010, fiber strength values were higher in monoculture of DP 499 and in the blends of SG-125 (25)/DP 499 (75) and SG-125 (50)/DP 499 (50) than the other monocultures and blends (Table 3).

Table 3. Fiber strength and micronaire for cultivars and cultivar blends

Cultivar/Blend	Fiber strength (g/tex)			Micronaire		
	2010	2011	Combined	2010	2011	Combined
DP 419	30.0 b*	28.4 c	29.2 cd	4.73 d	5.10	4.92 c
DP 419(75)/SG-125(25)	29.3 b	29.8 bc	29.6 cd	4.83 cd	5.23	5.03 bc
DP 419(50)/SG-125(50)	29.4 b	28.3 c	28.9 de	5.07 bc	5.00	5.04 bc
DP 419(25)/SG-125(75)	29.2 b	28.6 c	28.9 de	5.10 bc	4.97	5.03 bc
SG-125	26.8 c	28.2 c	27.5 e	5.50 a	5.43	5.46 a
SG-125(75)/DP 499(25)	30.0 b	28.1 c	29.0 d	5.30 ab	5.20	5.25 ab
SG-125(50)/DP 499(50)	33.3 a	27.8 c	30.5 c	5.30 ab	5.15	5.23 ab
SG-125(25)/DP 499(75)	33.6 a	31.2 b	32.4 b	5.27 ab	5.20	5.24 ab
DP 499	34.4 a	33.8 a	34.0 a	5.10 bc	4.97	5.03 bc
LSD(P≤0.05)	1.42	2.51	1.35	0.28	NS	0.32
Mean	30.7	29.4	30.0	5.13	5.14	5.14

*Means within a column followed by the same letter are not significantly different at the P≤0.05 according to Least Significant Difference Test.

The high-yielding cultivar SG-125 responded positively in blends with DP 499, with one exception, where SG-125 (75)/DP 499(25) blend was statistically similar to blends of DP 419 and SG-125. In 2011, highest strength was observed in the monoculture of DP 499. DP 419 and SG-125 did not significantly differ in fiber strength (Table 3). Averaged across years, fiber strengths of the cultivars and their blends were significantly lower than monoculture of DP 499. Increasing the fraction of DP 499 cultivar in the blends increased the strength of the fiber (Table 3). The proportional fiber strength to DP 499 content ratio of the blend may have been due to differences in yield between the SG-125 plants and DP 499 plants in the blend. The monoculture DP 499 produced an average of 19.1% and 14.1% more fiber strengths than the SG-125 and DP 419 monocultures, respectively, over years.

Table 4. Fiber length uniformity and short fiber content for cultivars and cultivar blends

Cultivar/Blend	Fiber Length Uniformity (%)			Short Fiber Content (%)		
	2010	2011	Combined	2010	2011	Combined
DP 419	85.2*	81.5	83.8	8.66	10.1	9.41
DP 419(75)/SG-125(25)	84.9	82.0	83.4	9.70	9.50	9.60
DP 419(50)/SG-125(50)	85.6	81.8	83.7	7.83	9.43	8.63
DP 419(25)/SG-125(75)	85.0	81.8	83.4	8.56	8.86	8.71
SG-125	85.0	82.7	83.8	8.36	8.40	8.38
SG-125(75)/DP 499(25)	84.7	81.7	83.2	9.30	9.03	9.16
SG-125(50)/DP 499(50)	84.7	81.6	83.1	8.93	9.10	9.01
SG-125(25)/DP 499(75)	84.7	81.9	83.3	9.16	9.80	9.48
DP 499	84.5	81.8	83.1	10.1	8.93	9.55
LSD($P \leq 0.05$)	NS	NS	NS	NS	NS	NS
Mean	84.9	81.9	83.4	8.97	9.25	9.11

*Means within a column followed by the same letter are not significantly different at the P≤0.05 according to Least Significant Difference Test.

In this study differences among treatments were not significant for fiber length, fiber length uniformity and short fiber content. Fiber length and length uniformity values in the blends were similar to the monocultures value (Table 4).

Discussion

Cultivar blends are an alternative to monoculture cultivars and may provide advantages such as acceptable yield production under variable environmental conditions and stresses. In order to be commercially acceptable, components of blends must have uniform maturity and be compatible for end-use processing requirements in fiber quality. In the present study, cotton cultivar blends varied in yield performance and there was quality advantage attributable to blends. Some blends performed competitively with SG-125, which is one of the best varieties under Çukurova conditions. Generally, blends of SG-125 and DP 499 were superior to the blends of SG-125 and DP 419 in yield and quality. The yield response of blend may be due to a competition and yield compensation effects within and between the components of the blend. Blend components may interact in a manner resulting from inter-plant competition. A single cultivar may not exploit all the available root or aerial environment for nutrient and light capture at any one time. Studies have reported yields either higher or not different from the mean of the components or blends yielded more than the highest yielding component (Poehlman and Sleeper, 1995; McConnell et al., 1997; Faircloth et al., 2003; Craig and Gwathmey, 2003). Fiber properties can be strong yield components. It stands to reason that if a plant has more, longer or heavier fibers then it should have a higher yield. Longer and more mature or coarse fibres contribute to higher yields even when boll number and seeds/boll remain equal. The performance of SG-125 was also notable with the highest yields and highest micronaires in both years. The combination of high yield and low micronaire is highly unusual and should be advantegous for cotton. The trends associated with average micronaire on country basis are clearly increasing. Common Upland cotton varieties in Turkey are being grown with enhanced higher micronaire tendencies, their production in an environment conducive to high micronaire should be expected to result in a higher probability of producing high micronaire fiber. In the present study blending of a high micronaire cultivar with a low micronaire cultivar appeared consistently resulted in a lower overall micronaire compared with the highest micronaire cultivar. When SG-125 was used, micronaire was significantly increased in the blends of SG-125 and DP 499 compared with the monoculture of DP 419. Increase in micronaire readings for the blends in our study agree with the findings of Bridge et al. (1984), Bechere et al. (2008). Micronaire in most of our treatments were 5.0 and above. Too high micronaire (> 4.5) may indicate that fiber is coarse and is undesirable for spinners whereas too low micronaire (< 3.8) may mean that fibers are immature, leading to breakages in fibers within the yarn. According to a survey, fibre length and the fiber strength of the cultivated cottons in Çukurova region are mostly suitable for the textile sector and cotton varieties with low micronaire fiber are needed (Özbek et al., 2005). The quality of Çukurova region cotton is gradually changing as new and improved varieties come into production. The blending of the fiber from DP 419 resulted in overall micronaire values that are acceptable. The trend in staple length has been positive but only slightly so. The average staple length and strength of the cotton from this region is 27.9 mm and 29.3 g/tex, respectively. As improvement of yield and fiber quality is necessary to meet the needs of growers and yarn manufacturers, the future utility of this genetic material depends on identifying segregates with yield potential and enhanced fiber properties. In our study, the blends were not significantly different from the means of their components and blending offered no advantage in fiber length and length uniformity. All of our treatments produced fiber length values above the acceptable level (>25.4 mm). The importance of fiber length to textile processing is significant. Longer fibers produce stronger yarns by allowing fibers to twist around each other more times and finer yarns to allow for more valuable end products. The variability in fiber length can be explained 70-80% by genetics, so variety selection is very important. Since length uniformity is derived from length, it is influenced by the same factors as length. Fiber strength in most blends and monocultures was decreased below the monoculture of DP 499.

Conclusion

The data achieved in this study revealed that gains in yields and fiber quality were observed with selected cultivar blends. For the quality traits that were evaluated, blends performed on the whole similarly to components. The exception was fiber strength and micronaire, traits preferred by yarn mills. The blend DP 419 (25)/SG-125 (75) could give good yields and low micronaire levels than it does in a better quality cultivar such as DP 499. Even with low strength DP 419 its blends gave significantly lower yields than DP 499 blends. Therefore, it is worthwhile to test more cultivar blends to exploit their competitive ability. These results suggest that blends are capable of producing yield and quality improvements and have potential benefits over their components in monoculture as long as appropriate combinations can be identified. Poehlman and Sleeper (1995) also reported that a blend of genotypes could yield consistently higher than the average of the pure component genotypes because the buffering effect against genotype by environment interactions could be more stable over locations and years than a pure line cultivar.

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