Factors Affecting Yield of Okra-Leaf Cotton Types in the Mississippi Delta

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ABSTRACT

Research throughout the 20th century has shown that okra-leaf cotton (Gossypium hirsutum L.) exhibits less boll rot, earlier maturity, reduced leaf area index and a higher CO_2-uptake per unit leaf area than normal-leaf cotton. Despite these traits, okra-leaf types remain scarce in the U.S.A. However, okra-leaf cotton represents 30 to 50% of the cotton acreage in Australia, where researchers have placed a priority on breeding high-yielding, okra-leaf types. The objective of this paper is to summarize results from nine years of experiments that tested the effects of different management factors and genetic backgrounds on the yield of okra-leaf cottons in the Mississippi Delta. Factors such as row spacing, planting date, plant density, soil type and genetic background were tested from 1989 to 1997 using okra-normal leaf isolines in field studies near Stoneville, MS. Optimal row spacing for okra-leaf cotton was found to be less than 102-cm rows and optimal plant density (approximately 10 plants m^{-2}) was greater than for normal-leaf types (5 plants m^{-2}). When planted late, the yield of both leaf types decreased but okra-leaf type out-yielded normal-leaf, probably due to its ability to avoid cool fall conditions. Soil type also played a role in the yield comparison. On a Bosket fine sandy loam (fine-loamy, mixed, thermic Mollic Hapludalf), okra-leaf types tended to out-yield their normal-leaf isolines but the opposite was true on a Beulah fine sandy loam (coarse-loamy, mixed, thermic Typic Dystrochrept). Okra-leaf isolines from several cultivars released in the 1980's and 1990's were generated and tested. The genetic background × leaf type interactions were generally small. Instead, environment tended to dictate which leaf type (regardless of genetic background) exhibited the highest yield. When results from all nine years were considered, two factors, narrow rows and a plant density of 10 plants m^{-2} tended to increase okra-leaf yields in the Mississippi Delta. Other factors such as late planting, high mid- and late-season humidity and poor weather during September appeared to favour the yield of okra-leaf types because normal-leaf yields were compromised under such conditions.

Introduction

Okra-leaf ($L_{20}L_{20}$) cotton genotypes exhibit different growth characteristics than normal-leaf (l_2l_2) cottons (Andries *et al.*, 1969; Kerby and Buxton, 1978; Kerby *et al.*, 1980; Kerby and Buxton, 1981). Throughout the 20th century, U.S. breeders and physiologists have compared performance of okra-leaf types to normal-leaf types (Shepherd and Kappelman, 1982; Jones, 1982; Meredith, 1985; Wilson, 1986). At the first World Cotton Conference in 1994, Thomson (1995) reviewed the status of okra-leaf breeding and suggested that okra-leaf cotton was not being used to its full potential. Since only three okra-leaf cultivars were released in the United States (two in 1998, 'FiberMax 819' and 'FiberMax 832', and one 1981, 'Gumbo 500', see Jones *et al.*, 1981), okra-leaf types were generally scarce throughout the U.S.

The scarcity of okra-leaf cultivars in the U.S. is obviously related to its inferior yield and reduced profitability compared to normal-leaf commercial cultivars. The objectives of this paper are (1) to review nine years of research on okra-leaf types, and (2) determine what management factors or environmental conditions might make okra-leaf types competitive with normal-leaf types. To accomplish this, comparisons were focused on okra-leaf types and their normal-leaf isolines. In some tests, recently released, normal-leaf commercial cultivars that almost always produced yield equal to or greater than any of the isolines were included. The factors we examined were row spacing, plant density, soil type, genetic background and planting date.

Material and Methods

Row Spacing Study. Row spacing studies were conducted from 1989 to 1997 on several different soil types near Stoneville, MS (Table 1).

Plant Density Study. Cotton was grown from 1991 to 1993 on the same Bosket fine sandy loam mentioned earlier (Heitholt, 1994). The okra and normal-leaf isolines from DES 24-8ne were used. Plant densities of 5, 10, 15, and 20 plants m^{-2} were used in 1991, 2, 3, 5, 10 and 15 plants m^{-2} in 1992 and 3, 5, 10, and 15 plants m^{-2} in 1993.

Soil Type Comparison. Although soil type, *per se*, is difficult to test directly, tests were conducted on three different soil types for several years (Table 1).

Genetic Background Comparison. Isolines from the genetic backgrounds listed in Table 1 were tested.

Except for DES 24-8ne okra-leaf, isolines were generated by taking the okra leaf trait from MD 65-11ne okra leaf and backcrossing to the recurrent parent for at least four, but usually for five or more generations. DES 24-8ne was tested in 13 environments and MD51ne in eight. The other lines were tested in four environments or less.

Planting Dates. In 1989 and 1990, early and late planting dates were used on one genetic background only, DES 24-8ne (Heitholt *et al.*, 1992). Early planting dates were 20 April 1989 and 25 April 1990, both within conventional times for the mid-Mississippi Delta. The late planting dates were 31 May 1989 and 15 May 1990.

Results and Discussion

Row Spacing. Averaged across years, DES 24-8ne okra-leaf type yield was 5% higher (not significantly, ns) in narrow rows (1,100 kg ha^{-1}) than in wide rows (1,040 kg ha^{-1}). Yield of the normal-leaf isoline averaged 2% higher (ns) in narrow rows (990 kg ha^{-1}) than in wide rows (970 kg ha^{-1}). Averaged across row spacings, yield for DES 24-8ne okra-leaf type was 9% greater (P=0.01) than its normal-leaf isoline.

Plant Density Tests. Averaged across three years, yield of the okra-leaf type was generally greater at 10 plants m^{-2} than at lower densities (Fig. 1A). In one year out of three, 15 plants m^{-2} tended to have a greater yield than 10 plants m^{-2} (data not shown). Yield of the normal-leaf type was greater at 5 plants m^{-2} than at other densities (Fig. 1B).

Soil Type Comparison. Okra-leaf types tended to yield higher than normal-leaf types on the Bosket fine sandy loam but the opposite was found on the Beulah fine sandy loam (Tables 2 and 3).

Genetic Background Comparison. The leaf type and genetic background main effects were often significant (data not shown, see Heitholt and Meredith, 1998). However, genetic background × leaf type interactions were not significant (data not shown). Although differences between the two leaf types seemed to be controlled mostly by environment, we still hypothesize that eventually a few genetic backgrounds will be found where okra-leaf yield is greater than its normal-leaf isoline.

Planting Date Effects. Late planting reduced yield of the okra-leaf type only 39% but reduced the yield of the normal-leaf type 89% (data not shown).

Conclusions

Narrow row spacing and the use of 10 plants m^{-2} (as opposed to lower densities) were the only two factors that increased the yield of okra-leaf cotton in the Mississippi Delta. However, the responses were far from consistent. Late planting favoured okra-leaf types over normal-leaf types but yields were still higher when the normal planting dates were used, regardless of leaf type. The effect of all of the factors we tested were extremely variable and depended upon the environment as is common with most crop yield studies. Growth on soil types that were associated with vigorous vegetative growth tended to provide a yield advantage for okra-leaf types above normal-leaf types. However, whether soil type actually caused the yield increase was not statistically testable because other factors confound soil type. Tests of more okra-leaf types from many genetic backgrounds will probably be needed to identify a role for genetic background in the okra-leaf type yield response. Future experiments comparing the effect of soil fertility and insect control, comparable to work in Australian (Brook *et al.*, 1992a, 1992b) and irrigation on okra-leaf yield are needed in the Mid-South U.S.A. if okra-leaf types are to be exploited.

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Table 1. A summary of the treatments used to compare okra and normal-leaf types from 1989 to 1997 at Stoneville, MS.

Factor	Treatment	Years
Row Spacing	51-cm vs. 102-cm	1989 – 1991
	76-cm vs. 102-cm	1992 – 1997
Plant Density	5, 10, 15, 20 plants m^{-2}	1991
	2, 3, 5, 10, 15 plants m^{-2}	1992
	3, 5, 10, 15 plants m^{-2}	1993
Soil Type	Bosket fine sandy loam	1989 – 1995
	Beulah fine sandy loam	1991, 1996-1997
	Dundee silty clay	1994 – 1995
Genetic Background	DES 24-8ne	1989 – 1997
	MD51ne	1993 – 1997
	Stoneville LA887	1996 – 1997
	Tamcot HQ95	1994 – 1997
	Stoneville 6413	1994 – 1997
	DES 119	1994 – 1997
	Acala Royale	1995 – 1996
Planting Date	Early vs. Late	1989 – 1990

Table 2. DES 24-8ne okra-leaf vs. normal-leaf lint yield comparison on three soil types. Data are averaged across row spacings where row spacing was a treatment.

Soil Type	Years	Okra-leaf	Normal-leaf	Okra-leaf Advantage
			kg ha^{-1}	
Bosket fine sandy loam	1989-1990	1140*	950	20%
	1991-1993	1190*	1130	5%
	1994	1115*	854	30%
	1995	855*	744	15%
	1996	620*	440	41%
Dundee silty clay	1994	963 ns	875	10%
	1995	915 ns	833	10%
Beulah fine sandy loam	1991	1200*	1300	-8%
	1995	760 ns	710	7%
	1996	1000*	1190	-16%

* Indicates that yield of okra-leaf and normal-leaf were significantly different (p<0,05)

Table 3. MD51ne okra-leaf vs. normal-leaf cotton lint yield comparison of eight tests on three soil types. Data are averaged across row spacings where row spacing was a treatment.

Soil Type	Year	Okra-leaf	Normal-leaf	Okra-leaf Advantage
Bosket fine sandy loam			kg ha-1	
	1993	744*	873	- 15%
	1994	1050*	670	57%
	1995a	786*	676	17%
	1995b	722 ns	652	11%
	1996	570*	452	23%
Dundee silty clay				
	1995	802 ns	904	- 11%
Beulah fine sandy loam				
	1996a	1050 ns	1085	- 3%
	1996b	991*	1310	- 25%

* Indicates that yield difference between leaf types was significant at the 5% level.
a or b indicates that two studies were conducted in the same field.

Figure 1. Effect of plant density and row spacing on yield of DES 24-8ne okra-leaf (A) and normal-leaf (B) cotton averaged across three years (1991-1993). Narrow row spacings were 51-cm, 76-cm, and 76-cm for 1991, 1992, and 1993, respectively. Wide row spacings were 102-cm.