FIBER QUALITY STABILITY OF SIGNIFICANT DELTA AND PINE LAND VARIETIES OVER YEARS AND LOCATIONS

Tom Kerby, Marc Bates, Janet Burgess, Ken Lege and Dave Albers
Delta and Pine Land Company
Scott, MS

Abstract

Growers and consultants have been presented new technologies and new varieties at a pace that has previously been unprecidented. Some of the new varieties have the majority of their test data collected during the past three years. Six varieties that have been common in tests between 1994 and 2000 demonstrate that fiber length has been particularly short in these same varieties during the past three years compared to previous years. Fiber strength during the past three years has trended down, while micronaire was very high in 1998 and 1999. Balanced head to head data previously reported demonstrates transgenic varieties had equivalent fiber quality to their recurrent parent. The rate at which technology has been adopted has resulted in more varieties with technology replacing the parent varieties in recent years. For new varieties inftroduced in the last 3 years, length, strength, and micronaire would not be percieved as being equal to their parents which were primarily tested prior to the last three years. This observation raised questions regarding the "stability" of these new varieties. A statistical proceedure was used to compare the individual variety performance to the mean of all varieties at a location (a particular environment). An estimate of "stability" is possible as individual variety response is compared to the mean of all varieties at a test location across many environments. Five families of Deltapine brand varieties (DP 20, DP 50, DP 51, DP 5415, and DP 5690) were compared to their technology versions (Bollgard, Roundup Ready, and stacked) across hundreds of environments (regions and years). Stability measures for 25 individual Delta and Pine Land Company varieties are presented. As expected individual varieties show some variation in fiber quality, and in responsiveness across diverse environments. For the five families of varieties, technology versions were practically identical to their parents. These data strongly indicate no difference in "fiber quality stability" of transgenic varieties when compared directly against their recurrent parents across environments that produced everything from inferior to superior fiber quality.

Introduction

With the advent of transgenic cotton varieties has come a large increase in number of varieties offered for the market. Delta and Pine Land Company has a varietal evaluation scheme which relies on both public university testing as well as an extensive internal large scale on-farm testing effort. Number of trials as well as number of varieties in those trials have both increased over the last 5 years.

This rapid introduction of a high number of new varieties has made it difficult for growers, consultants, and public information providers to have sufficient familiarity with the varieties to be comfortable in their recommendations. During the past 3 years many areas in the SouthEast and Mid-South have suffered prolonged droughts sometimes accompanied by elevated temperatures. This has affected productivity and quality. The result has been a tendancy to question the yield performance, the fiber quality, and the yield and fiber quality stability of these new varieties.

Comparative data for transgenic and conventional parents were reported by Jones, et al. (1996). Previous reports have demonstrated an affect of environment on yield and fiber quality. Bassett and Kerby (1996) reported that within the narrow environmental range of the San Joaquin Valley of California, variation between locations was about equal to variation accounted for by varieties in those tests over a 9 year period. Kerby et al. (1996) summarized results from 110 tests across the country where seven varieties were grown over a 2 year period. Test location combined effects of weather as well as management factors lumped together as "environment". Test environment proved to be far more important than differences in variety for growth and development factors such as number of nodes, final plant height, boll retention patterns, and earliness. Kerby et al. (2000) carried the analysis of environment and variety further using both company and public Official Variety Test data comparing 16 varieties over 3 years and reported results for yield, fiber quality, and growth paramaters. On average, 85, 48, and 68 percent of the total variation (Environment, Variety, or the interaction) was accounted for by environment for fiber length, fiber strength, and micronaire, respectively.

Results from detailed fiber and spinning conducted by the International Textile Center demonstrated DP 5415 and DP 5690 Bollgard and Roundup Ready versions were essentially the same as their parent varieties (Hequet and Ethridge, 2000). In the few instances of statistically significant differences, they were positive with respect to fiber and spinning quality of transgenic varieties. Kerby et al. (2000) presented results where the conventional, Bollgard, Roundup Ready, and stacked (Bollgard® and Roundup Ready®) versions were compared for 7 Deltapine families of varieties. Combined over all head to head comparisons, there were 486 direct comparisons which indicated Bollgard and conventional parents had equivalent fiber length and fiber strength, but slightly lower micronaire. In 213 direct comparisons of conventional and Roundup Ready varieties, staple length was 0.01 shorter for Roundup Ready varieties while fiber strength and micronaire were the same. In 179 direct comparisons of conventional parents to the stacked versions, fiber length and strength were equivalent while micronaire was reduced for the stacked varieties.

Even though these studies have been reported, to our knowledge there have been no summary results published to refute or question these extensive summaries. However, questions persist regarding the stability of these new varieties which contain transgenic technology. This paper reports summary fiber quality stability data directly comparing DP 20, DP 50, DP 51, DP 5415, and DP 5690 to the Bollgard, Roundup Ready, or stacked varieties that were derived from these five conventional parents. Additionally, fiber quality stability measures will be reported for other significant Delta and Pine Land Company varieties.

Material and Methods

Delta and Pine Land Company conducts on-farm performance trials across a wide range of environments. The company has developed a custom Oracle data base where data can be extracted using various querry tools. Data from 1994 until the present are stored in this system which is referred to as the Agronomic Information System (AIS). Data can be separated by variety, region, year, soil type, irrigation, other management variables, and growth parameters obtained from final plant maps. The AIS has the capacity to calculate a variety test mean as well as the mean of all varieties included in a test. Relative stability measures have been calculated using the Eberhart and Russell (1966) method. A test location was excluded unless the number of varieties in a test was at least 6. Number of varieties tested at a location (the basis for the test mean) ranged from 6 to 32 with an mean of 12.

Figures will not be presented for individual variety stability measures. As an example the stability data for DP 5415 is presented in Figure 1. While R^2 does describe scatter in the data across locations (or stability according to a strict definition), true varietal response requires a consideration of R^2 as well as slope (response across environments). In this manuscript we will present R^2, intercept, slope, and the variety regression value at minimal and maximal ranges for fiber length (in hundreths of an inch), fiber strength,

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:410-414 (2001)
National Cotton Council, Memphis TN

and micronaire. The influence of environment on the variable (fiber length, fiber strength, and micronaire) is evident by the range in average values for a test (x-axis).

Results and Discussion

Individual Varieties and Year Effects

Stability measures are given for 25 significant Delta and Pine Land Company varieties. Values are simply the grand average for a variety based upon all the tests where it was entered. There is no balance between varieties and test locations. That makes direct comparison of a mean value for a variable difficult. However, they are compared against the mean of all varieties at a location for stability measures. This makes the comparison of R^2, intercept, and slope a relative measure and therefore a valid comparison. Direct comparison of means has potential bias according to the general environment encountered during the testing year.

Six varieties (ST 474, SG 125, DP 5415, DP 51, NuCOTN 33 B, and NuCOTN 35 B) have been common entries in our tests over the past 7 years. An analysis for year effect on fiber quality is presented in Table 1. Average fiber length was longest in 1996, long in 1994 and 1997, but short in 1995, 1998, 1999, and 2000. New varieties evaluated during the past three years would have fiber length values shorter than it would if the variety had been evaluated during 1996 and 1997. National variety testing over many years is not balanced (not all varieties at all locations all years), and hence quality values can be influenced by year of testing. Once multiple year data is available, this generally would not present a problem. However, for varieties evaluated primarily during the past three years, comparative fiber length is likely being underestimated when compared to varieties tested in 1996 and 1997. Year variation in fiber strength is less severe than for length, but does show a lower value in the recent years. Micronaire has shown year variation with high average micronaire during 1995, 1998, and 1999. Because high and low values are more mixed between years, it does not present as much opportunity for variety bias based upon years of testing.

All conventional picker varieties in tests were also measured against the six varieties reported with similar results, but not presented in Table 1. Their year trends were identical to those for the six varieties common to all years. R^2 between the two (all conventional varieties versus the 6 common across years) was 0.917, 0.977, and 0.921 for fiber length, fiber strength, and micronaire, respecitively.

Table 2 (fiber length), Table 3 (fiber strength), and Table 4 (micronaire) contain the data for 25 significant Delta and Pine Land Company varieties. In addition to R^2, intercept, and slope, the individual variety value regressed against the average of all varieties in a test are given for the lowest and highest range of data. Minimal and maximal test average values presented were 1.00 to 1.22 for fiber length, 22 to 36 g/tex for strength, and 3.0 to 6.0 for micronaire. The minimal and maximal value for a variety compared to the mean of all varieties in a test incorporates intercept and slope into the value. Comparing R^2 and values at the minimum and maximum for each variety compared to the average of all 25 varieties provides some general insight as the the variation in response as well as general quality.

Variety Family and Technology Type Comparisons

DP 20, DP 50, DP 51, DP 5415, and DP 5690 have had Bollgard, Roundup Ready, and stacked (Bollgard and Roundup Ready) versions that were under field testing. Stability components for all five Deltapine brand varieties that have all transgenic versions are summarized in Table 5. Mean values should not be directly compared since different technology versions have tended to be compared during different years with the effects of recent years previously noted for length and strength. Kerby et al. (2000) reported the direct effects of this using only head to head comparisons. Stability measures for R^2, slope, and intercept are relative since they have no year bias (regressed against the mean of all varieties in a trial). R^2 for technology versions of these families are presented in Figure 2. Technology versions appear similar for length and micronaire, but R^2 for the technology versions appear to be higher than for the conventional parent for strength. Slopes across the range of data are presented by technology for fiber length (Figure 3), fiber strength (Figure 4), and micronaire (Figure 5). It is difficult to distinguish the individual lines for the different technologies. These regression lines are based upon very large sample numbers representing the entire US. These data strongly indicate no difference in "fiber quality stability" of transgenic varieties when compared directly against their recurrent parents across environments that produced everything from inferior to superior fiber quality.

Summary

Fiber quality is influenced by environment and this creates year of evaluation effects. This needs to be considered when dealing with varietal or technology generalizations when all test data is not balanced. Head to head (balanced) data does not have this potential bias. Extensive testing across regions and years using head to head data support the conclusion that varieties with technologies perform in an at least an equivalent manner to their recurrent parent. When test data is not balanced, the Eberhart and Russell (1966) method facilitates a relative measure of stability by allowing comparisons of a variety to the mean of all varieties at a test location (a particular environment). Response across environments (stability) can be measure for each variety, or technology type. Stability measures using this method demonstrate technologies averaged over variety families are at least equivalent in stability measures to their recurrent parents. As would be expected, individual varieties do not all have the same fiber quality values, and they show some difference in R^2, intercept, and slope for fiber quality across the wide range of environments where cotton is grown.

Acknowledgement

The authors would like recognize the efforts of Delta and Pine Land Company Technical Service Agronomists who conducted the majority of the field trials reported herein. Our thanks also to the many grower cooperators who provided land and time to accommodate these studies.

References

Bassett, D.M. and T.A. Kerby. 1996. Variety Selection. pp. 123 to 133. *In* Cotton Production Manual. (eds.) S. Johnson Hake, T.A. Kerby, and K.D. Hake. Univ. California Publication 3352.

Eberhart, S.A. and W.A. Russell. 1966. Stability parameters for comparing varieties. Crop Sci. 6:36-40.

Hequet, Eric and M. Dean Ethridge. 2000. Fiber properties and textile performance of transgenic cottons versus parent varieties. pp. 488-494. *In.* P. Dugger and D.A. Richter (eds). Beltwide Cotton Conf. Nat'l Cotton Council, Memphis, TN.

Jones, Keith, Tom Kerby, Harry Collins, Tom Woofford, Marc Bates, Jim Presley, and Janet Burgess. 1996. Performance of NuCOTN with Bollgard. *In.* P. Dugger and D.A. Richter (eds). Beltwide Cotton Conf. Nat'l Cotton Council, Memphis, TN. pp. 46-48.

Kerby, Tom, Janet Burgess, Marc Bates, Dave Albers, and Ken Lege. 2000. Partitioning variety and environment contribution to variation in yield, plant growth, and fiber quality. pp. 528-532. *In.* P. Dugger and D.A. Richter (eds). Beltwide Cotton Conf. Nat'l Cotton Council, Memphis, TN.

Kerby, Tom, Bill Hugie, Kevin Howard, Marc Bates, Janet Burgess, and Jay Mahaffey. 2000. Fiber quality comparisons among varieties for Conventional, Bollgard, and Roundup Ready versions. pp. 484-488. *In.* P. Dugger and D.A. Richter (eds). Beltwide Cotton Conf. Nat'l Cotton Council, Memphis, TN.

Kerby, Tom, Lowell Zelinski, Janet Burgess, Marc Bates, and Jim Presley. 1996. Genetic and environmental contributions to earliness. pp. 592-594. *In.* P. Dugger and D.A. Richter (eds). Beltwide Cotton Conf. Nat'l Cotton Council, Memphis, TN.

Table 1. Average fiber length, fiber strength, and micronaire for the average of ST 474, SG 125, DP 51, DP 5415, NuCOTN 33 B, and NuCOTN 35 B that were common entries in national tests between 1994 to 2000. N represents the sum of data points across the six varieties for all locations where they were tested.

Var.	1994	1995	1996	1997	1998	1999	2000
N	203	227	524	474	319	351	171
Lgth	1.106	1.086	1.122	1.104	1.087	1.093	1.083
Stgh	28.38	29.14	28.87	28.84	26.99	28.05	27.61
Mic	4.37	4.66	4.23	4.42	4.63	4.62	4.32

Table 2. Fiber length stability measures of significant Delta and Pine Land Company varieties.

							Length At	
Variety	Year	N	Mean	R2	Int.	Slope	1.00	1.22
DP 388	98-00	119	1.078	0.805	0.096	0.9006	0.997	1.195
DP 428 B	97-00	171	1.087	0.839	0.000	1.0019	1.002	1.222
DP 451 B/RR	98-00	292	1.086	0.727	0.082	0.9361	1.018	1.224
DP 51	95-99	438	1.106	0.799	0.037	0.9723	1.009	1.223
DP 425 RR	97-00	195	1.070	0.808	0.046	0.9524	0.998	1.208
NuCOTN 33B	95-00	467	1.100	0.833	-0.001	1.0039	1.003	1.224
DP 458 B/RR	97-00	315	1.080	0.805	-0.036	1.0344	0.998	1.226
DP 5415	95-00	337	1.103	0.785	0.001	1.0016	1.003	1.223
DP 5415 RR	95-00	194	1.087	0.812	0.037	0.9712	1.008	1.222
DP 565	99-00	53	1.117	0.806	-0.118	1.1231	1.005	1.252
NuCOTN 35B	95-00	223	1.103	0.815	-0.011	1.0148	1.004	1.227
DP 655 B/RR	97-00	159	1.084	0.826	-0.037	1.0454	1.008	1.238
DP 5690	94-00	204	1.094	0.816	-0.060	1.0462	0.986	1.216
DP 5690 RR	96-00	142	1.081	0.763	0.039	0.9669	1.006	1.219
DP 675	96-00	139	1.106	0.880	-0.101	1.1012	1.000	1.242
DP 90	95-99	158	1.094	0.755	0.037	0.9613	0.998	1.210
PM1218 BG/RR	99-00	152	1.045	0.585	0.213	0.7844	0.997	1.170
PM 1560 BG	97-00	174	1.080	0.738	0.079	0.9250	1.004	1.208
PM 1560 BG/RR	99-00	137	1.081	0.843	-0.032	1.0370	1.005	1.233
SG 105	97-00	53	1.094	0.789	0.021	0.9814	1.002	1.218
SG 125 BR	98-00	236	1.063	0.755	0.135	0.8669	1.002	1.193
SG 125	94-00	356	1.115	0.780	0.061	0.9562	1.017	1.228
SG 501 BR	98-00	181	1.059	0.755	0.121	0.8767	0.998	1.191
SG 501	94-00	224	1.102	0.786	-0.014	1.0154	1.001	1.225
SG 747	97-00	155	1.095	0.763	0.131	0.8837	1.015	1.209
Average		**211**	**1.088**	**0.787**	**0.029**	**0.9744**	**1.003**	**1.218**

Table 3. Fiber strength stability characteristics of significant Delta and Pine Land Company varieties.

							Strength At	
Variety	Years	N	Mean	R^2	Int.	Slope	22	36
DP 388	98-00	123	28.3	0.768	5.04	0.834	23.4	35.1
DP 428 B	97-00	171	26.3	0.791	-0.54	0.968	20.8	34.3
DP 451 B/RR	98-00	293	26.5	0.800	-0.23	0.973	21.2	34.8
DP 51	95-99	437	27.4	0.695	1.36	0.905	21.3	33.9
DP 425 RR	97-00	195	26.3	0.772	0.94	0.941	21.6	34.8
NuCOTN 33B	95-00	465	28.4	0.796	0.19	0.993	22.0	35.9
DP 458 B/RR	97-00	313	28.2	0.792	-0.79	1.038	22.0	36.6
DP 5415	95-00	335	29.4	0.665	1.13	0.972	22.5	36.1
DP 5415 RR	95-00	194	28.8	0.726	2.45	0.936	23.0	36.1
DP 565	99-00	53	28.6	0.767	0.93	0.971	22.3	35.9
NuCOTN 35B	95-00	223	30.0	0.752	-1.75	1.107	22.6	38.1
DP 655 B/RR	97-00	159	29.1	0.856	-0.96	1.087	23.0	38.2
DP 5690	94-00	204	30.5	0.624	-0.62	1.061	22.7	37.6
DP 5690 RR	96-00	142	29.8	0.758	1.09	1.021	23.6	37.8
DP 675	96-00	139	30.8	0.681	3.10	0.980	24.7	38.4
DP 90	95-99	158	30.3	0.613	1.29	0.995	23.2	37.1
PM 1218 BG/RR	99-00	153	26.1	0.670	3.37	0.838	21.8	33.5
PM 1560 BG	97-00	174	28.7	0.759	2.96	0.928	23.4	36.4
PM 1560 BG/RR	99-00	137	28.0	0.812	-1.52	1.056	21.7	36.5
SG 105	97-00	51	28.2	0.717	2.08	0.928	22.5	35.5
SG 125 BR	98-00	235	21.2	0.795	4.27	0.833	22.6	34.3
SG 125	94-00	353	28.0	0.612	2.22	0.891	21.8	34.3
SG 501 BR	98-00	179	28.5	0.771	0.85	1.002	22.9	36.9
SG 501	94-00	221	30.9	0.542	2.44	0.980	24.0	37.7
SG 747	97-00	152	27.4	0.656	6.55	0.744	22.9	33.3
Average		**210**	**28.2**	**0.728**	**1.43**	**0.959**	**22.5**	**36.0**

Table 4. Micronaire stability characteristics of some Delta and Pine Land Company varieties.

							Micro. At	
Variety	Years	N	Mean	R2	Int.	Slope	3	6
DP 388	98-00	123	4.26	0.880	0.23	0.923	3.00	5.77
DP 428 B	97-00	171	4.46	0.857	-0.18	1.038	2.93	6.05
DP 451 B/RR	98-00	295	4.33	0.907	-0.31	1.068	2.89	6.10
DP 51	95-99	437	4.40	0.852	-0.19	1.051	2.96	6.12
DP 425 RR	97-00	195	4.53	0.877	0.00	1.025	3.08	6.15
NuCOTN 33B	95-00	466	4.36	0.887	-0.26	1.043	2.87	6.00
DP 458 B/RR	97-00	311	4.52	0.827	-0.19	1.059	2.99	6.16
DP 5415	95-00	338	4.49	0.797	0.13	0.992	3.11	6.08
DP 5415 RR	95-00	194	4.41	0.860	-0.36	1.085	2.90	6.15
DP 565	99-00	53	4.52	0.899	0.05	1.010	3.08	6.11
NuCOTN 35B	95-00	222	4.31	0.877	-0.45	1.085	2.81	6.06
DP 655 B/RR	97-00	159	4.19	0.815	-0.05	1.069	3.16	6.36
DP 5690	94-00	204	4.36	0.818	-0.29	1.069	2.92	6.12
DP 5690 RR	96-00	142	4.34	0.848	-0.09	1.007	2.93	5.95
DP 675	96-00	140	4.37	0.864	-0.32	1.051	2.83	5.99
DP 90	95-99	161	4.35	0.850	0.01	0.995	3.00	5.98
PM 1218 BG/RR	99-00	153	4.45	0.705	0.29	0.981	3.23	6.18
PM 1560 BG	97-00	174	4.55	0.851	-0.41	1.123	2.96	6.33
PM 1560 BG/RR	99-00	136	4.12	0.744	0.44	0.840	2.96	5.48
SG 105	97-00	53	4.52	0.915	-0.17	1.072	3.05	6.26
SG 125 BR	98-00	238	4.44	0.892	0.16	0.968	3.06	5.97
SG 125	94-00	356	4.48	0.854	0.29	0.944	3.12	5.95
SG 501 BR	98-00	181	4.61	0.890	0.42	0.943	3.25	6.08
SG 501	94-00	222	4.63	0.815	0.90	0.835	3.41	5.91
SG 747	97-00	153	4.69	0.890	0.17	1.012	3.21	6.24
Average		**211**	**4.43**	**0.851**	**-0.01**	**1.012**	**3.03**	**6.06**

Table 5. Comparison across DP 20, DP 50, DP 51, DP 5415, and DP 5690 for fiber quality stability measures for Bollgard (B), Roundup Ready (RR), and Stacked (BR) versions of these families. N represents the sum of variety across locations. Min. and Max. represent the regressed values when trial mean length is 1.00 to 1.22, strength is 22 to 36, and micronaire is 3.0 to 6.0.

Variable	Type	N	Mean	R^2	Int.	Slope	Min.	Max.
Length	B	1170	1.098	0.837	-0.005	1.010	1.005	1.227
Length	BR	1021	1.080	0.800	0.059	0.950	1.009	1.218
Length	C	1469	1.098	0.802	0.013	0.986	0.999	1.216
Length	RR	843	1.077	0.806	0.067	0.939	1.006	1.213
Micro	B	1169	4.35	0.871	-0.23	1.031	2.86	5.95
Micro	BR	1022	4.33	0.866	-0.21	1.053	2.95	6.11
Micro	C	1464	4.36	0.840	-0.20	1.045	2.93	6.07
Micro	RR	838	4.37	0.878	-0.08	1.017	2.97	6.02
Strength	B	1171	27.76	0.756	0.70	0.961	21.83	35.28
Strength	BR	1021	27.34	0.828	0.50	0.975	21.95	35.60
Strength	C	1468	28.44	0.653	0.85	0.950	21.74	35.03
Strength	RR	845	27.62	0.783	2.21	0.922	22.50	35.41

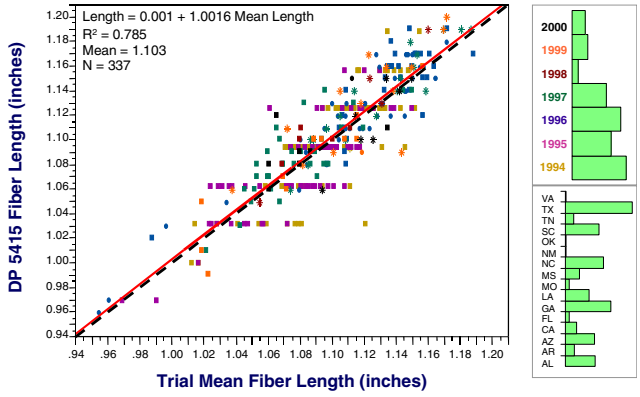

Figure 1. Regression of DP 5415 fiber length against the mean of all varieties at 337 test locations in the US between 1994 and 2000. Year and state distribution are listed at the right as frequency bars. The solid line represents the response for DP 5415 while the dashed line represents the average response of all varieties across the 337 test locations.

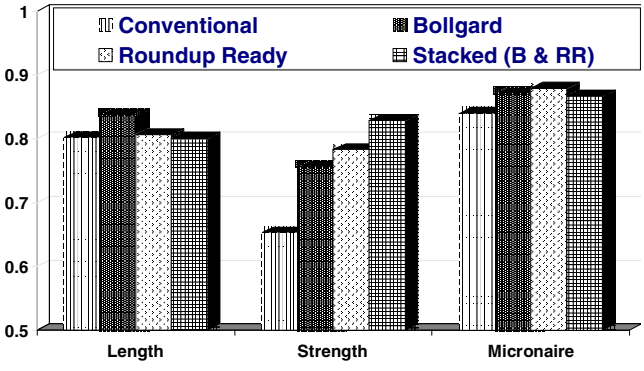

Figure 2. R^2 for technology versions averaged over the DP 20, DP 50, DP 51, DP 5415, and DP 5690 families for fiber length, fiber strength, and micronaire.

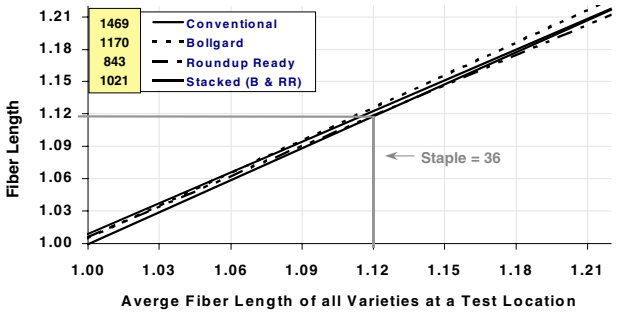

Figure 3. Fiber length values for the various technologies regressed against the mean of all varieties in trials across multiple locations. Values next to the legend indicate the sum of variety and locations for a technology grouping.

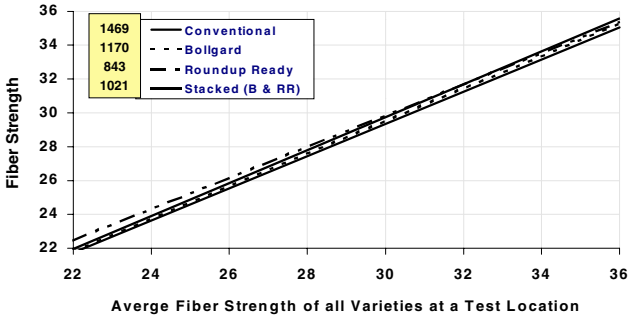

Figure 4. Fiber strength values for the various technologies regressed against the mean of all varieties in trials across multiple locations. Values next to the legend indicate the sum of variety and locations for a technology grouping.

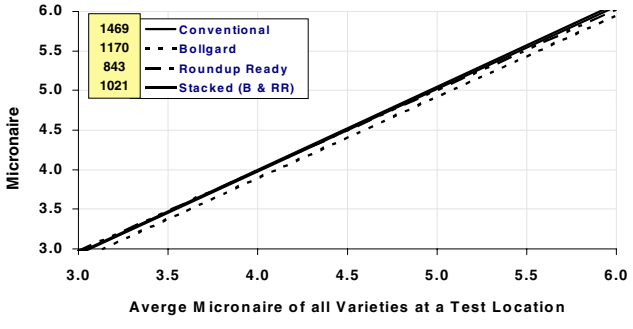

Figure 5. Micronaire values for the various technologies regressed against the mean of all varieties in trials across multiple locations. Values next to the legend indicate the sum of variety and locations for a technology grouping.