VARIETY INFLUENCE ON HYPOCOTYL LENGTH

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Abstract

Hypocotyl lengths have been measured previously as a means of comparing early seedling growth, but not under field conditions. Since the hypocotyl comprises a significant portion of the total shoot height until about 1 month after planting, visual ratings of seedling vigor could potentially be influenced by hypocotyl length, and therefore by the height of the seedlings. On-farm, large-plot field trials were established across the Mid-South and Southeast regions in 2000 and 2001 to determine if hypocotyl length differs among varieties, and to determine if hypocotyl length, seedling vigor ratings, and lint yields are related. Seedling vigor ratings and hypocotyl lengths were recorded at fourth true leaf stage, as well as lint yield at the end of the season. The length of hypocotyl on cotton seedlings significantly differed for early-maturing and full-season Bollgard®/Roundup Ready® varieties in the study, but did not differ for the Roundup Ready® varieties in the study. Seedling vigor ratings differed among varieties in all data sets except full-season Roundup Ready® varieties. The length of the hypocotyl was significantly, though weakly, associated with seedling vigor ratings, suggesting that hypocotyl length may be inadvertently and partially included within breeders' selection for higher seedling vigor. Results from this study suggest that hypocotyl length may be a more reliable method of measuring early seedling vigor versus using visual ratings; however, the time required to measure hypocotyl length versus using a visual rating may deter its use in a commercial breeding program. Lint yield was not associated with either hypocotyl length or seedling vigor, which supports previous work.

Introduction

Seedling establishment of cotton is important for successful growth, yield and fiber development (Roach et al., 1993). Seedling vigor has been extensively researched as an important trait of cotton varieties (Bradow and Bauer, 1994; Vieira et al, 1995; Lege' et al., 1999) as well as a means measuring the cotton plant's tolerance to herbicide injury (Bourland et al., 1985; Vieira et al., 1995) and diseases (numerous references). Seedling vigor has typically been determined by visual rating under field conditions, which takes into account many environmental influences on seedling growth, including temperature (Bradow and Bauer, 1999; Burke and McMichael, 1999; Lege' et al., 1999), soil moisture (Burke and McMichael, 1999, and tillage method (Hoskinson et al., 1986; Gwathmey et al., 1998). These environmental factors could potentially complicate the selection for higher seedling vigor in breeding programs.

Hypocotyl lengths have been measured previously as a means of comparing early seedling growth (e.g., Roach et al., 1993; Bourland et al, 1985); in some cases, the total height of the seedling (hypocotyl and epicotyl) has been recorded to determine early season vigor (e.g., Vieira et al., 1995; Bradow and Bauer, 1994), but not under field conditions. Since the hypocotyl comprises a significant portion of the total shoot height until about 1 month after planting (Oosterhuis and Jernstedt, 1999), visual ratings of seedling vigor could potentially be influenced by the length of the hypocotyl, and therefore by the height of the seedling.

The objectives of this study were 1) to determine if hypocotyl length is influenced by variety and therefore controlled genetically; 2) to determine if hypocotyl length reflects the same measure as visual ratings for seedling vigor; and 3) determine if hypocotyl length and/or seedling vigor is associated with yield performance.

Materials and Methods

Large plot, on-farm cotton variety trials were established across the Mid-South and Southeast regions by Delta and Pine Land Company Technical Services Agronomists in 2000 and 2001. In 2000, 15 replicated trials were established; in 2001, 13 replicated and four non-replicated trials were established. All trials were 'systems' trials in which the trial management corresponded with the transgenic traits possessed by the varieties within each trial. In addition, trials were categorized by maturity, either early or full season. All crop management decisions for each trial were made by the grower-cooperator.

At approximately fourth true leaf stage, seedling vigor visual ratings were recorded for each plot, with a rating of one being 'excellent' and five being 'poor'. At the same time, two random sub-samples of five consecutive plants each were collected from each plot. Efforts were made to keep the root system of the plants intact. The length of the hypocotyl of each plant, defined as the stem section between the cotyledonary node and the topmost lateral root, was determined and recorded to the nearest 0.25 in. Seedcotton yield was determined using boll buggies equipped with load cells. Seedcotton was ginned at Delta and Pine Land Company facilities at either Scott, MS, or Hartsville, SC, on 20-saw gins, which included seedcotton and lint cleaners.

Location/year combinations were considered as replicates in each statistical analysis. Analyses of variance were performed for four sub-sets of data: early-maturing Bollgard®/Roundup Ready® varieties ('early BR varieties': SG 215 BG/RR, DP 451 B/RR, Sure-Grow 501 BR, PM 1218 BG/RR, and ST4892BR), early-maturing Roundup Ready® varieties ('early RR varieties': DP 436 RR, Sure-Grow 521 R, ST4793R, and PM 1199 RR), full-season Bollgard®/Roundup Ready® varieties ('full BR varieties': DP 451 B/RR, Sure-Grow 501 BR, ST4892BR, DP 458 B/RR, and DP 655 B/RR), and full-season Roundup Ready® varieties ('full RR varieties': DP 436 RR, DP 5415 RR, DP 5690 RR, and ST4793R). Regression analyses were performed on all data, regardless of variety type (SAS, 1990).

Results and Discussion

Early BR Varieties

Lint yield significantly differed among the early-maturing BR varieties, with SG 215 BG/RR yielding higher than PM 1218 BG/RR and ST4892BR in 11 trials across the Mid-South and Southeast regions (Table 1). Hypocotyl length also varied significantly among the varieties, with SG 215 BG/RR, Sure-Grow 501 BR, and PM 1218 BG/RR having longer hypocotyls than DP 451 B/RR and ST4892BR. Seedling vigor was rated significantly better for SG 215 BG/RR and PM 1218 BG/RR than the other varieties in this data set.

Early RR Varieties

No significant differences were detected among the early-maturing RR varieties in six trials across the Mid-South and Southeast for lint yield or hypocotyl length (Table 2). Seedling vigor was significantly better for DP 436 RR versus Sure-Grow 521 R or PM 1199 RR.

Full BR Varieties

Across seven trials in the Mid-South and Southeast, lint yields did not differ among the full-season BR varieties (Table 3). However, Sure-Grow 501 BR had the significantly longest hypocotyls of the varieties within this data set. The best seedling vigor ratings were found for DP 451 B/RR and Sure-Grow 501 BR.

Full RR Varieties

Lint yields, hypocotyl lengths, and seedling vigor ratings did not differ significantly among the full-season RR varieties tested at three locations across the Mid-South and Southeast regions (Table 4).

Relationships Among Lint Yield, Hypocotyl Length, and Seedling Vigor Rating

Table 5 shows the regression equations for three relationships. Although a significant (Prob>F <0.0001) association was found between seedling vigor rating and hypocotyl length, the relationship is very weak ($R^2 = 0.05$). The consistently higher R^2 and lower coefficient of variance (CV) values in the analyses of variance for hypocotyl length versus those for seedling vigor rating suggest that hypocotyl length may be a more reliable measure of the general vigor of young seedlings than a visual rating (Tables 1 – 4). There were no significant associations found between lint yield and hypocotyl length or between lint yield and seedling vigor rating.

Variety Influence

Table 6 includes the partitioning of the sum of squares for lint yield, hypocotyl length, and seedling vigor rating for each data set. The percentage of the total variability due to variety for lint yield ranged from 0.5% for the early BR variety data set to 1.0% for the full RR variety set. For hypocotyl length, the total variability attributable to variety ranged from 3.3% for the early RR variety data set to 15.3% for the full BR variety set, indicating that genetics could potentially control the length of hypocotyls in seedlings. The total percentage of variability due to variety for seedling vigor rating ranged from 10.0% for the early RR variety data set to 35.9% for the full RR variety data set. For all three parameters, most of the variability was attributed to replicate (i.e., location/year combination).

Summary

The length of hypocotyl on cotton seedlings significantly differed for early-maturing and full-season BR varieties in the study, but did not differ for the RR varieties in the study. Seedling vigor ratings differed among varieties in all data sets except full-season RR varieties. The length of the hypocotyl was significantly, though weakly, associated with seedling vigor ratings, suggesting that hypocotyl length may be inadvertently and partially included within breeders' selection for higher seedling vigor. Results from this study suggest that measuring hypocotyl length may be a more reliable method of determining early seedling vigor rather than subjective visual evaluations. However, the time required to measure the lengths of hypocotyls versus rating visually would likely hinder its effective use in a commercial breeding program. Lint yield was not associated with either hypocotyl length or seedling vigor, which supports previous work (Lege' et al., 1999).

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Any relative differences among varieties in seedling vigor ratings reported in this study cannot be compared with seedling vigor ratings reported for those same varieties in the 2002 Delta and Pine Land Product Guide, since these data are a subset of the beltwide data set reported in the Product Guide.

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Table 1. Mean lint yield, hypocotyl length, and seedling vigor rating for early-maturing Bollgard®/Roundup Ready® varieties at 11 locations across the Mid-South and Southeast regions in 2000 – 2001.

Variety	Lint Yield (lbs/acre)	Hypocotyl Length (in)	Seedling Vigor Rating†
SG 215 BG/RR	902.33	3.67	1.84
DP 451 B/RR	875.15	3.35	2.35
Sure-Grow 501 BR	868.59	3.57	2.18
PM 1218 BG/RR	856.63	3.60	1.93
ST4892BR	807.78	3.23	2.66
R^2	0.97	0.83	0.62
CV (%)	8.71	7.22	24.98
Prob>F			
Rep	<0.0001	<0.0001	<0.0001
Variety	0.0003	<0.0001	<0.0001
Variety LSD (0.05)	40.48	0.14	0.29

† 1 = excellent; 5 = poor.

Table 2. Mean lint yield, hypocotyl length, and seedling vigor rating for early-maturing Roundup Ready® varieties at six locations across the Mid-South and Southeast regions in 2001.

Variety	Lint Yield (lbs/acre)	Hypocotyl Length (in)	Seedling Vigor Rating†
DP 436 RR	751.50	3.34	1.82
Sure-Grow 521 R	731.50	3.59	2.58
ST4793R	677.00	3.37	2.30
PM 1199 RR	672.50	3.44	2.80
R^2	0.98	0.88	0.79
CV (%)	10.83	6.14	25.27
Prob>F			
Rep	<0.0001	<0.0001	<0.0001
Variety	0.0667	0.0591	0.0067
Variety LSD (0.05)	not significant	not significant	0.55

† 1 = excellent; 5 = poor.

Table 3. Mean lint yield, hypocotyl length, and seedling vigor rating for full-season Bollgard®/Roundup Ready® varieties at seven locations across the Mid-South and Southeast regions in 2000 – 2001.

Variety	Lint Yield (lbs/acre)	Hypocotyl Length (in)	Seedling Vigor Rating†
DP 451 B/RR	1192.26	3.50	2.27
Sure-Grow 501 BR	1176.58	3.79	2.34
ST4892BR	1124.84	3.38	2.70
DP 458 B/RR	1117.53	3.21	2.78
DP 655 B/RR	1113.47	3.32	2.88
R^2	0.92	0.82	0.29
CV (%)	8.97	6.68	23.90
Prob>F			
Rep	<0.0001	<0.0001	0.0063
Variety	0.0542	<0.0001	0.0079
Variety LSD (0.05)	not significant	0.15	0.40

† 1 = excellent; 5 = poor.

Table 4. Mean lint yield, hypocotyl length, and seedling vigor rating for full-season Roundup Ready® varieties at three locations across the Mid-South and Southeast regions in 2001.

Variety	Lint Yield (lbs/acre)	Hypocotyl Length (in)	Seedling Vigor Rating†
DP 436 RR	721.75	3.25	1.88
DP 5415 RR	677.25	2.93	3.00
DP 5690 RR	654.25	3.01	2.38
ST4793R	640.75	3.25	2.75
R^2	0.97	0.87	0.53
CV (%)	10.40	5.72	24.49
Prob>F			
Rep	<0.0001	<0.0001	0.2097
Variety	0.4229	0.0552	0.1140
Variety LSD (0.05)	not significant	not significant	not significant

† 1 = excellent; 5 = poor.

Table 5. Regression equations for relationships between seedling vigor and hypocotyl length, lint yield and hypocotyl length, and yield and seedling vigor across all varieties in Delta and Pine Land Company trials included in this study across the Mid-South and Southeast regions in 2000 – 2001. Number of observations = 448.

Relationship	Regression Equation
Seedling vigor rating† vs. hypocotyl length (in)	Seedling vigor rating = 3.602 – 0.361 (hypocotyl length) R^2 = 0.05, Prob>F <0.0001
Lint yield (lbs/acre) vs. hypocotyl length (in)	Lint yield = 855.37 + 11.981 (hypocotyl length) R^2 = 0.0001, Prob>F = 0.8178
Lint yield (lbs/acre) vs. seedling vigor rating	Lint yield = 867.94 + 12.435 (seedling vigor rating) R^2 = 0.0003, Prob>F = 0.6982

† 1 = excellent; 5 = poor.

Table 6. Partitioning of sum of squares for each data set, and the percent of variability due to variety and replicate (location/year combination) across the Mid-South and Southeast regions in 2000 - 2001.

Parameter†	Sum of Squares	% of Total Sum of Squares
Yield		
Early BR Varieties		
Replicate	25768302.15	97.0
Variety	129922.86	0.5
Total	26575453.75	--
Early RR Varieties		
Replicate	7155247.96	96.9
Variety	46656.88	0.6
Total	7384382.38	--
Full BR Varieties		
Replicate	10520592.02	91.4
Variety	102335.31	0.9
Total	11508477.62	--
Full RR Varieties		
Replicate	1381808.25	95.6
Variety	15064.75	1.0
Total	1445933.75	--
Hypocotyl Length		
Early BR Varieties		
Replicate	32.4392	74.1
Variety	3.7133	8.5
Total	43.7522	--
Early RR Varieties		
Replicate	9.4180	84.3
Variety	0.3678	3.3
Total	11.1657	--
Full BR Varieties		
Replicate	16.2312	66.5
Variety	3.7468	15.3
Total	24.4134	--
Full RR Varieties		
Replicate	1.7614	70.9
Variety	0.3377	13.6
Total	2.4852	--
Seedling Vigor Rating		
Early BR Varieties		
Replicate	46.1867	49.1
Variety	11.8857	12.6
Total	93.9940	--
Early RR Varieties		
Replicate	36.2917	68.8
Variety	5.2875	10.0
Total	52.7500	--
Full BR Varieties		
Replicate	7.5160	23.2
Variety	5.7070	17.6
Total	32.3359	--
Full RR Varieties		
Replicate	1.3750	17.2
Variety	2.8750	35.9
Total	8.0000	--

† Early BR varieties = SG 215 BG/RR, DP 451 B/RR, Sure-Grow 501 BR, PM 1218 BG/RR, ST4892BR; Early RR varieties = DP 436 RR, Sure-Grow 521 R, ST4793R, PM 1199 RR; Full BR varieties = DP 451 B/RR, Sure-Grow 501 BR, ST4892BR, DP 458 B/RR, DP 655 B/RR; Full RR varieties = DP 436 RR, DP 5415 RR, DP 5690 RR, ST4793R.