INFLUENCE OF SAMPLE SIZE ON COTTON SHOOT NITROGEN ACCUMULATION: LINT YIELD RATIOS

P.G. Hunt, T.A. Matheny and P.J. Bauer
USDA-ARS
Florence, SC

Abstract

Accurate samples of cotton vegetation and nitrogen content are important for investigation of both erosion and nitrogen management. The objectives of this investigation were to a) determine if cotton dry matter was upwardly biased and highly variable in small samples and b) determine if the shoot nitrogen per 100 kg of lint (NLR)values were affected by sample size. Three cotton cultivars were planted in four replications on 13 May. Each entire subplot (9.5 m^2) was harvested after sampling by four techniques 1) four randomly selected plants *(4RP)*; 2) randomly selected 0.3 meter of row *(0.3-m)*; 3) randomly selected one meter of row *(1-m)*; and 4) randomly selected two meters of row *(2-m)*. Shoot dry matter for the *whole plot* yielded 7.2 Mg ha^{-1}, and lint yields were good, >1.35 Mg ha^{-1}. Cotton shoot dry matter was significantly overestimated by both the *4RP and 0.3-m* methods, but not by the *1-* and *2-m* methods. The *whole plot* mean for the NLR was 10.1. The NLR for the *4RP* and *0.3-m* methods were significantly greater than the *whole plot* while the *1-* and *2-m* methods were not significantly different. A *1-m* sample would seem to be necessary, and a *2-m* sample is likely desirable to reduce both the bias and the variation. These NLRs are substantially lower than those generally reported for nonirrigated cotton. Nonetheless, these NLRs are in line with data that suggest 1.6 Mg ha^{-1} (3-bale/acre) cotton requires less than 200 kg ha^{-1} of shoot-accumulated N.

Introduction

When crop parameters are estimated, there is need for balance between the size of sample, precision and accuracy required, and the resources available. Common methods of sampling crop parameters per unit area have involved two basic methods 1) the random selection of several plants and multiplying by an estimated plant population or 2) selection of a random portion of row and dividing by the represented fraction of a hectare. For soybean dry matter grown in 20 m^2 plots, neither the 4-random-plant nor the one-foot-of-row *(0.3-m)* method was acceptable for precision or accuracy (Hunt et al., 1987). Both of these techniques gave upwardly biased estimates with high variation. However, simply increasing the sample size to one meter gave good precision and unbiased estimates. Additionally, neither precision nor accuracy was significantly improved by increasing the sample size to two meters.

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Accurate samples of cotton vegetation and nitrogen content are important for estimating erosion control and determination of nitrogen uptake to lint yield relationships. Historically, the shoot nitrogen per 100 kg of lint (NLR) has been used for estimating the nitrogen necessary to produce high yielding cotton (Mullins and Burmester, 1990). These values have generally been in excess of 15, and some of the older values were well in excess of 20. They indicate that greater than 200 kg ha^{-1} of shoot-accumulated N would be needed for production of 2-bale cotton (1.1 Mg ha^{-1}). However, these values were determined on small samples (a few plants or a 0.3 m sample). When one-meter samples were used, values of about 12 were obtained for nonirrigated condition and <10 for microirrigated cotton by Hunt et al. (1998). The objectives of this investigation were to a) determine if cotton dry matter was upwardly biased and highly variable in small samples as previously determined for soybean and b) determine if the NLR values were affected by sample size.

Methods and Materials

Three cotton cultivars (DeltaPine 90, DeltaPine 5415, and Stoneville 474) were planted on 13 May 1997 in 0.97-m-wide rows (Figure 1). Dry matter samples were taken from the center of four rows on 98, 112, and 127 days after planting (Figure 2). On each sampling date, four sampling techniques were used with each subplot (9.5 m^2) before the entire subplot was harvested. The four sampling techniques were 1) four randomly selected plants *(4RP)*; 2) randomly selected 0.3 meter of row *(0.3-m)*; 3) randomly selected one meter of row *(1-m)*; and 4) randomly selected two meters of row *(2-m)* (Figure 2). Four replications were used in the study.

Lint yield was also determined by the same sampling techniques as used for dry matter sampling; however, only lint yields from the whole subplot are reported. Seed cotton was harvested by hand. Plant and lint samples were dried at 70°C and measured for dry weight. Cotton seeds were acid-delinted and oven-dried. Plant and seed samples were ground and analyzed for nitrogen content with a LECO Carbon/Nitrogen Analyzer.

Results and Discussion

As with soybean, the cotton shoot dry matter was overestimated by >12% by both the *4RP* and the *0.3-m* methods (Table 1). Neither the *1-m* nor *2-m* methods were significantly different from the whole plot. The *whole plot* had a mean of 7.2 Mg ha^{-1} shoot dry matter, while the *4RP* and the *0.3-m* methods estimated >8.1 Mg ha^{-1}. The *1-* and *2-m* methods estimated 7.5 Mg ha^{-1} shoot dry matter. Additionally, both the coefficient of variation (CV) values and the root error mean squares (REMS) decreased for the *2-m* method. The estimate of bias for the *4RP* and the *0.3-m* methods was double that of the *1-* and *2-m* methods (Table 2). When compared by the t-test and the sign test, the *4RP* method was highly significantly different from the *whole plot*, and the *0.3-m* method was marginally significantly different. However, the *1-* and *2-m* samples were not significantly different even though they had lower REMS and the associated ability to detect differences. Data from this study show that cotton is variable. At least a *1-m* sample is needed to eliminate sampling bias, and a *2-m* sample may be needed for precision.

Shoot nitrogen in the *whole plot* was similarly overestimated by the *4RP* and the *0.3-m* methods, 144 vs. >170 kg N ha^{-1}, respectively (Table 3). For the comparison of shoot-accumulated nitrogen to yield, we used the *whole plot* yield because researchers and farmers generally have good field plot data for yield. We also used only the later two sampling dates for shoot N because the earliest date was not at the maximum N accumulation level.

The lint yields of all cotton cultivars were good, >1.35 Mg ha^{-1} (Table 4). Thus, we have data for nitrogen accumulated by the shoots of cotton cultivars that produced good yields for the southeastern Coastal Plain.

The *whole plot* mean for the NLR was 10.1 (Table 5). The *whole plot* mean had a CV of 21% and a REMS of 2.09. The *4RP* method gave a significant overestimate of the *whole plot* ratio, 12.0. It also had a CV of 29% and a REMS of 3.53. The estimate of bias for NLR by the *4RP* and the *0.3-m* samples was nearly three times greater than the *1-* and *2-m* methods (Table 6). Also, the *4RP* and *0.3-m* methods were significantly different from the *whole plot*, and the *1-* and *2-m* methods were not significantly different. As in the estimates of shoot dry matter, a *1-m* sample would seem to be necessary, and a *2-m* sample is likely desirable to reduce both the bias and the variation. These NLR values are substantially lower than those reported in the literature for nonirrigated cotton in many early works according to Mullins and Burmester (1990). Our values reflect a good conversion of shoot dry matter into lint. Obviously, yield limiting factors in the late stages of the season would have made the values larger. Nonetheless, these ratios are in line with data suggesting that in the southeastern Coastal Plain, 3-bale cotton requires less than 200 kg ha^{-1} of shoot-accumulated N.

Conclusions

1. Both cotton shoot dry matter and NLR were significantly overestimated by the *4RP* and *0.3-m* methods but not by the *1-* or *2-m* methods.

2. The mean shoot nitrogen per 100 kg of lint value (NLR) of 10.1 is substantially lower than those generally reported for nonirrigated cotton.

3. The NLR values are in line with data that suggest 3-bale cotton requires less than 200 kg ha^{-1} of shoot-accumulated N.

Disclaimer

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References

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Table 1. Cotton shoot weight.

Sampling Technique	Shoot Weight Mg ha^{-1}	CV[†] %	REMS[†]
4RP	8.92	33	2.93
0.3-Meter	8.08	28	2.25
1-Meter	7.51	32	2.43
2-Meter	7.58	25	1.86
Whole Plot[‡]	7.17	18	1.30
LSD 0.05	0.90		

[†] CV = coefficient of variation, REMS = root error mean square.
[‡] Whole plot was 9.5 m^2 of row.

Table 2. Bias of cotton shoot dry matter estimated by four sampling methods.

	4 RP-WP	0.3 m-WP	1 m-WP	2 m-WP
Estimate of Bias (Mg ha^{-1})	1.75	0.91	0.34	0.41
S.E. of Bias	0.56	0.58	0.42	0.29
P-Value, t-Test	0.01	0.08	0.38	0.11
P-Value, Sign Test	0.01	0.13	0.68	0.19

Table 3. Nitrogen accumulated in cotton shoots.

Sampling Technique	Plant Nitrogen kg ha^{-1}	CV[†] %	REMS[†]
4RP	170	33	56
0.3-Meter	172	29	51
1-Meter	155	42	64
2-Meter	153	33	50
Whole Plot[‡]	144	25	36
LSD 0.05	22		

[†] CV = coefficient of variation, REMS = root error mean square.
[‡] Whole plot was 9.5 m^2 of row.

Table 4. Cotton lint yield.

Cultivar	Yield Mg ha^{-1}*
DP 90	1.35
DP 5415	1.57
ST 474	1.46
Mean	1.46
LSD 0.05	0.12

* Bale/acre = 0.54 Mg ha^{-1}.

Table 5. Ratio of shoot nitrogen to 100 kg of cotton lint.

Sampling		CV†	
Technique	NLR†	%	REMS†
4RP	12.0	29	3.53
0.3-Meter	11.8	28	3.25
1-Meter	10.7	36	3.87
2-Meter	10.7	28	2.94
Whole Plot‡	10.1	21	2.09
LSD 0.05	1.6		

† NLR = shoot N per 100 kg of cotton lint, CV = coefficient of variation, REMS = root error mean square.
‡ Whole plot was 9.5 m^2 of row.

Table 6. Bias of cotton shoot nitrogen to lint ratios estimated by four sampling methods.

	4 RP-WP	0.3 m-WP	1 m-WP	2 m-WP
Estimate of Bias	1.98	1.73	0.64	0.62
S.E. of Bias	0.48	0.61	0.50	0.32
P-Value, t-Test	0.01	0.07	0.41	0.22
P-Value, Sign Test	0.01	0.08	0.63	0.29

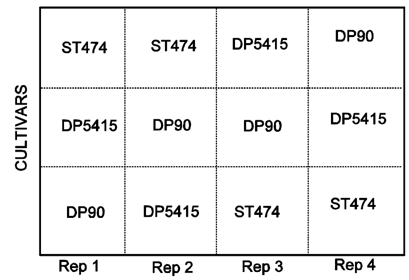

Figure 1. Experimental design of main plots.

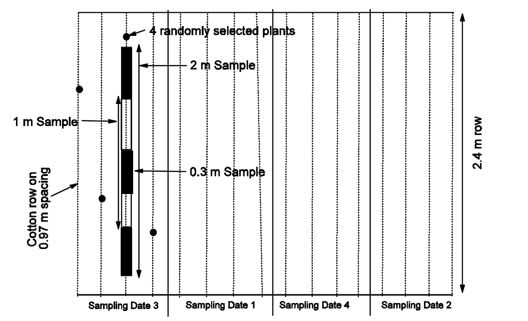

Figure 2. Schematic of subplot sampling techniques for one cultivar and one rep.