Boll Sampling to Predict Lint Yield in Upland and Pima Cotton

Bryan L. Unruh, E. R. Norton, and J. C. Silvertooth

Abstract

Giving a cotton (Gossypium spp.) producer a method to predict lint yield, would be a useful management tool. The objective of this study was to determine if relatively simple measurements could be made near cut-out which could be used to adequately estimate lint yield for Upland (G. hirsutum L.) and Pima (G. barbadense L.) cotton. Data and samples were collected from the nitrogen (N) management study at Maricopa Ag. Center from two N treatments which were imposed on both Upland (var. DPL 5415) and Pima (var. S-7) cotton. The treatments were no added N and N added on an as-needed basis. Twenty hard-green bolls from the first or second fruiting positions were collected from each plot on 19 August 1993. The number of bolls expected to reach maturity prior to crop termination were then determined from five randomly selected plants in each plot. Measurements on each boll collected included fresh weight, diameter, number of locks, number of seeds, and dry seed cotton weight. Plant population was determined from early season stand counts. Seed cotton per boll was most highly correlated to boll weight for DPL 5415 and for Pima S-7 it was most highly correlated with boll diameter. These respective parameters were then used in linear regression to predict seed cotton/boll. Lint yield calculated from the regression models (using boll weight or diameter) and yield calculated from means of the data collected agreed quit well. Predicted yields from regression analysis overestimated the actual Upland yield by about 730 lb lint/acre and under estimated Pima yields to within about 150 lb lint/acre. It appears that this procedure has the potential to estimate lint yields to within about 150 lb lint/acre. However the sampling scheme will be refined especially in regard to estimation of plants/acre and bolls/plant which should improve yield estimate accuracy.

Introduction

Few crops require as many management decisions to be made near physiological maturity as cotton. Since all management decisions are to one degree or another based on the economic return, the final lint yield determines if additional inputs will be feasible. Therefore, if one could estimate crop yield at about the time the crop reaches cut-out, management decisions based on this expected yield could be made. For this reason we set out to determine if relatively simple measurements could be made near cut-out which would adequately estimate lint yield for Upland and Pima cotton.

Materials and Methods

During the cropping season of 1993 several attempts were made to determine what measurements would be useful and how best to handle the resultant samples once removed from the field. The site selected for this study was the N management study at Maricopa Ag. Center, from which all the samples were collected from two of the four N treatments which are imposed on both Upland (var. DPL 5415) and Pima (var. S-7) cotton in three replications. The N treatments were no added N fertilizer (treatment 1), and N added as needed based on feedback from soil and petiole NO_3^--N analysis (treatment 3). Twenty mature hard-green bolls were collected from the first or second fruiting positions within each experimental field plot, along about a 50 ft length of row. Samples were collected on 19 August 1993, 3176 heat units accumulated after planting (HUAP, 86/55°F thresholds). The number of bolls were then determined by counting the bolls expected to reach maturity on five randomly selected plants in each plot. Measurements made on the fresh hard-green bolls included weight and diameter. After samples were transported back to the lab, bolls were placed in a forced-air oven to dry the fiber at 105°F. Prior to placement in the oven, carpel walls were cut to facilitate the drying process. After drying the number of locks, seed cotton weight, and number of seeds per boll were recorded. The plant population was determined from early season stand counts. Lint yield was determined from each plot by mechanically picking the center four rows of each eight-row plot. Turnout was estimated from a single small sample taken from the mechanically picked cotton in one replication of each treatment. The mean lint yields from the mechanically picked plots are used as the actual lint yield values against which all predicted lint yields are compared.

Calculated lint yield was determined using the following equation:

$$\frac{\text{Seed Cotton}}{\text{Boll}} \times \frac{\text{Bolls}}{\text{Plant}} \times \frac{\text{Plants}}{\text{Unit Area}} \times 0.33 \times 0.9 = \frac{\text{Lint}}{\text{Unit Area}} \qquad [1]$$

Where the coefficients 0.33 and 0.9 represent turn-out (33%) and picker efficiency (90%), respectively. Correlation analysis was used to determine which single variable best correlated with seed cotton/boll. Linear regression analysis was then used to predict seed cotton weight/boll using the parameter which had the highest correlation.

Results and Discussion

The plant population used in these calculations was 18.5 and 10 plants m^{-2} for DPL 5415 and S-7, respectively. This translates to 74925 and 40500 plants/acre for Upland and Pima, respectively. All of the data collected during this study is summarized in Table 1. Samples were collected on 19 August, slightly past cut-out for both varieties. On the previous day, plant measurements indicated that all the Upland was at 4 nodes above the top white bloom (NAWB) and Pima was at 3 NAWB for the unfertilized treatment and at 4 NAWB for the N fertilized treatments. Cut-out generally is predicted when NAWB ≤ 5 which generally occurs between 2800 and 3000 HUAP.. Correlation analysis of the data indicated that there was significant correlation between all of these parameters (Table 2). Table 2 illustrates that seed cotton weight for Upland is most highly correlated with fresh boll weight and for Pima, seed cotton is most highly correlated with boll diameter. Lint yield was calculated from both the regression analysis models which predicted seed cotton/boll (Table 3) and the average of the sample data values (Table 1) using Eq. [1]. These values along with the actual lint yield are presented in Table 4.

From Table 4 the lint yield predicted from regression analysis over estimated the actual lint yield for DPL 5415 by about 730 lb lint/acre or about 50 to 60%. For S-7 lint yield was under estimated to within about 150 lb lint/acre or less than a 20% error (Table 4). The lint yield calculated from the sample data mean values for seed-cotton/boll (Table 1) and Eq. [1] also over estimated for Upland and under estimated lint yield for Pima the actual lint yield by similar amounts (Table 4). These results seem to indicated that the sample data and/or sampling scheme affected the over estimates of yield rather than the method used to calculate lint yield. To illustrate this in Table 4, the

right-most column compares the lint yield predicted from regression and yield calculated from the average sample data values found in Table 1. The differences between the predicted and calculated values was between -6 to 7%. This would then support the finding that the regression analysis was a good predictor of the lint yield, as indicated by the sample data means. However, the sampling method to determine parameters other than seed cotton/boll was poor since it was those parameters which adversely affected the accurate prediction of the yield.

Therefore, the sampling scheme must be further refined to determine which measured parameter(s) were responsible for the over/under estimated yield. Areas that could have introduced significant errors in estimation of lint yield was the determination of the number of bolls/plant and plant population at crop termination. Plant population was taken from early season stand counts which were not adequately confirmed to determine if plant populations were over estimated by the time the crop reached maturity. The number of bolls/plant was determined from the total number of bolls at the first two positions on all fruiting branches. This included hard-green bolls at the bottom the plant to very small bolls at the top of the plant. When lint yield is calculated, all of the bolls were considered to be the same size as the average hard-green boll size, which necessarily were obtained from the bottom of the plant. This would tend to over estimate yield from the bolls at the top of the plant which are not likely to reach the size of bolls at the bottom of the plant. In addition, the number of bolls/plant tended to be highly variable, making precise predictions more difficult, since this parameter would also introduce variability into the calculation.

This research will continue in the 1994 season. The current results which were marginal for Upland and fairly good for Pima in terms of accurate lint yield prediction, will hopefully provide clues to ways in which prediction accuracy may be improved. It is proposed that sampling be done on a given area (length of row, such as 1 m or yard) in which the number of plants, bolls, etc. will be recorded. This should improve the determination of bolls/unit area (i.e., bolls/plant $\times$ plants/unit area). It is felt that the regression analysis did provide a model with which seed cotton/boll, as a function of either boll weight or diameter, can be accurately determined. However, before this technique can be used to make yield predictions, the other issues of quantifying bolls/unit area must be resolved.

Table 1. Mean values of the parameters measured in Upland and Pima cotton at Maricopa Ag. Center in the N management study, 1993.

Treatment†	Boll Weight	Boll Diameter	Locks per Boll	Seeds per Boll	Bolls per Plant	Seed Cotton per Boll
	g	mm				g
			Variety DPL 5415			
1	18.2	31.4	4.3	33.0	11.3	3.7
3	18.0	31.1	4.3	31.6	12.8	3.2
			Variety Pima S-7			
1	12.5	27.5	3.0	16.3	17.4	1.9
3	13.8	28.3	3.1	16.5	23.1	1.8

† Treatment 1 had no added N, treatment 3 had N added based on feedback approach from soil and petiole NO_3^--N analysis.

Table 2. Pearson correlation coefficients for Upland and Pima cotton at Maricopa Ag. Center, 1993. Where values close to ±1 indicate a linear association between the two variables.

	Weight	Diameter	# Locks	# Seeds	Seed Cotton
			Variety DPL 5415		
Weight	1.00	0.91***	0.47***	0.69***	0.56***
Diameter		1.00	0.63***	0.70***	0.46***
# Locks			1.00	0.56***	0.29*
# Seeds				1.00	0.32*
Seed Cotton					1.00
			Variety Pima S-7		
Weight	1.00	0.92***	0.43***	0.77***	0.60***
Diameter		1.00	0.49***	0.65***	0.61***
# Locks			1.00	0.32*	0.42**
# Seeds				1.00	0.39**
Seed Cotton					1.00

*, **, *** Significant at the 0.05, 0.01, and 0.0001 probability levels, respectively. These levels indicate the probability that the associated correlation between the two variables is purely a chance occurrence, in other words, the likelihood that the correlation coefficient should be zero.

Table 3. Regression models to predict seed cotton/boll for Upland and Pima cotton at Maricopa Ag. Center in the N management study, 1993.

Variety	Intercept	Independent Variable	Coefficient Estimate	Model R^2
DPL 5415	-1.87588	Boll Weight	0.29599***	0.31
S-7	-3.43688	Boll Diameter	0.18914***	0.37

*** Significant at the 0.0001 probability level.

Table 4. Lint yield from mechanical picking, regression analysis, and sample data and differences between actual and predicted yield in the N management study at Maricopa Ag. Center, 1993.

N Treatment†	Actual‡	Predicted from Regression		Predicted from Sample Data		Difference Between Predictions††
		Calculated§	Difference¶	Calculated#	Difference	
	lb/acre					
			Variety DPL 5415			
1	1203	1939	736 (61)‡‡	2069	866 (72)	-130 (-6)§§
3	1436	2167	732 (51)	2020	584 (41)	147 (7)
			Variety Pima S-7			
1	966	814	-152 (-16)	869	-97 (-10)	-55 (-6)
3	1258	1175	-83 (-7)	1102	-156 (-12)	73 (7)

† Treatment 1 had no added N. treatment 3 had N added based on feedback approach from soil and petiole NO_3^--N analysis.

‡ Lint yield average obtained from mechanical picking of the center four rows of each eight-row plot in three replications.

§ Lint yield calculated from regression analysis of seed cotton/boll as a function boll weight for DPL 5415 and boll diameter for S-7.

¶ Difference between predicted and actual yield.

Lint yield calculated from the average seed cotton weight/boll obtained from the boll samples.

†† Difference between the yield predicted by regression analysis and the yield predicted from the sample data.

‡‡ Values in parenthesis are the percent the predicted values exceed actual lint yield.

§§ Values in parenthesis are the percent the predicted values from the regression analysis exceed the values predicted by the sample data.