Agronomic Evaluations of Bt Cotton

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Abstract

In 1996 transgenic Bt cotton was first grown on a commercial level in Arizona and the U.S. cottonbelt. Insecticidal properties of Bt varieties had been evaluated rather thoroughly in both the private and public sectors prior to commercial release. However, the agronomic characteristics had not been evaluated to any sufficient extent beyond the level of the developing companies. Lab and field tests were conducted in Arizona in 1996 dealing with the Delta and Pine Land Co. (DPL) companion varieties 5415 / NuCOTN 33b (similar to 5415 but with the Bt gene) and 5690 / NuCOTN 35b (with Bt gene). Most field comparisons were between 5415 and 33b. Lab and field studies revealed very similar agronomic characteristics between the companion varieties. No differences were detected with respect to heat tolerance, as determined by comparative fruit loss and abortion rates at the onset of the monsoon season. Only slightly higher vigor or growth rates were noted for 33b over 5415, which was considered to be negligible. Yield results revealed higher lint yields for 33b over 5415 in most cases. The difference in yields were attributed to pink bollworm infestations and damage, even when chemical control measures were being taken. It was concluded that 33b, as a transgenic version of 5415, is indeed very close to it's non-Bt counterpart.

Introduction

With 1996 being the first year that transgenic Bt cotton was commercially available in Arizona, we had a good opportunity to monitor it's agronomic performance (i.e. growth, development, yield, etc.) at a number of locations across the cotton producing regions of Arizona. Of course the most critical difference associated with a Bt variety is that it contains some genetic information that was extracted from a naturally occurring soil bacteria called *Bacillus Thuringiensis*, or Bt, which has insecticidal properties. Essentially, this genetic information was spliced into the cells of cotton plants and crossed back into favorable varieties through conventional breeding techniques. Accordingly, it is important to note that the Bt varieties that we are dealing with in the field are very similar to their non-Bt counterparts, but they are unique varieties in themselves. With or without internally controlled insecticidal properties, the variety of cotton plants grown in a field has a tremendous impact on the yield potential of the crop. Therefore, monitoring the agronomic characteristics of a Bt variety, as with any variety, is an important part of the variety evaluation.

The objective of this study was to conduct a thorough agronomic evaluation of a new Bt variety (DPL NuCOTN 33b) and it's non-Bt counterpart (DPL 5415).

Materials and Methods

A total of nine varieties, consisting of two Bt varieties, were collected for a set of laboratory and field tests to compare seedling vigor characteristics (Table 1). The lab and field tests comparing Bt varieties and their non-Bt companion varieties conducted in Arizona in 1996 dealt with the Delta and Pine Land Co. (DPL) companion varieties 5415 / NuCOTN 33b (similar to 5415 but with the Bt gene) and 5690 / NuCOTN 35b (with Bt gene). Most field comparisons were between 5415 and 33b. All nine varieties were subjected to a series of laboratory germination procedures (alternating temperature germination tests and cool tests). Following the laboratory tests, the same set of varieties were dry planted and watered-up in a Casa Grande sandy loam soil at the University of Arizona Maricopa Agricultural Center (MAC) on 9 and 20 February 1996. Plots consisted of four, 40 inch rows, extending 40 feet in length, arranged in a randomized complete block design with eight replications. To each row of each plot, 200 seeds of the appropriate variety were planted in the 40 foot length of row. To determine stand and emergence rates, viable plants were counted for every row of each plot on two dates following each planting (Table 2).

Comparisons of DPL 5415 and 33b were conducted as a part of the University of Arizona Statewide Upland Cotton Variety Testing Program at nine locations across Arizona in 1996 (Table 3). These field studies were conducted on commercial farming operations across the state. In each case, plots were a minimum of eight (40 or 38 in.) rows wide, extended the full length of the irrigation run, and were arranged in a randomized complete block design with four replications. On approximately 14 day intervals, a complete set of plant measurements (plant height, mainstem node numbers, bloom counts per 167 $ft.^2$ area, nodes above the top white bloom (NAWB), percent fruit retention, and percent canopy closure) were taken from each plot. Plant maps were also made from composite samples of each variety. Nitrogen fertility levels were also monitored during the season by sampling petioles and analyzing their NO_3^--N concentrations on approximately 14 day intervals. Management of each study area was carried out in a uniform manner with regard to irrigation and pest control. Yields were determined by harvesting the seedcotton from the entire center four rows (eight rows at Paloma), collecting seedcotton subsamples which were subsequently ginned, and resultant turnout values were used to determine lint yields/acre.

All response variables measured were subjected to analysis of variance and a Fisher's LSD means separation test at the α=0.05 level of significance according to guidelines put forth in Gomez and Gomez (1984) and the SAS institute (1988).

Results and Discussion

From the results shown in Tables 1 and 2, and Figures 2 through 10, evidence is presented that supports the claims that these two new Bt varieties are indeed very similar agronomically to their non-Bt counterparts. Some very subtle differences were detected, such as a slightly more vigorous growth potential with 33b, even with a strong boll load, as was measured in Yuma in 1996 (Figure 4). It is also important to note that FR patterns for the two varieties were very similar at all locations in this study in 1996. This is particularly important with respect to questions concerning possible differences in heat tolerance between 5415 and 33b. A distinct drop in FR was measured for both varieties at Yuma (and several other locations as well) at about 2,000 HUAP, which coincided very closely with peak bloom, and was about the first of July in 1996 when humidities (dew points), and night temperatures increased substantially, apparently contributing to the FR losses. Differences in yield (Figure 11), therefore, are attributed to differences in insect damage, primarily pink bollworm, and not due to agronomic differences.

Another important observation from this study was provided by the field vigor tests, planted in February at MAC. Following the 9 February planting date, minimum soil temperatures were marginal (Figure 1) but sufficient to support germination and emergence with a range from 32 to 64 % emerged seeds on 28 February. However, weather conditions cooled off considerably following the 20 February planting, with minimum daily soil temperatures dropping below 50 °F over the next 14 days. As a result, most seeds germinated but not a single seed emerged in the entire study area from this planting, irrespective of seed quality and vigor. This information serves to reinforce UA recommendations concerning planting recommendations where we commonly identify ideal minimum soil temperatures at planting of 65 °F and a minimum threshold temperature of 55 °F.

Acknowledgment

The authors gratefully acknowledge the support provided by the Delta and Pine Land Co., Stonville Pedigreed Seed Co., and SureGrow Seed Co.; the valuable assistance provided by the very capable personnel at the Maricopa Agricultural Center of the University of Arizona; and the student research assistants with the cotton agronomy research program at the University of Arizona.

Table 1. Results of alternating and cool germination tests.

	Percent Germination	
Variety	Alternating	Cool
Sure Grow 501	92	70
DPL 5461	89	75
DPL 50	97	83
Stoneville 474	91	87
DPL 5461	87	77
DPL 5415	85	65
DPL 35b	92	83
DPL 5690	93	80
DPL 33b	94	26

Table 2. Results from the field emergence test, planted 9 February 1996.

Sample Date			
20 February		28 February	
Variety	% Emergence	Variety	% Emergence
DPL 35b	25.97 a*	Stoneville 474	64.34 a*
Stoneville 474	25.72 a	DPL 50	62.75 a
DPL 50	18.38 b	DPL 35b	60.96 a
Sure Grow 125	18.34 b	DPL 5690	52.50 b
DPL 5461	17.81 b	Sure Grow 125	52.06 b
DPL 5690	16.56 b	DPL 5461	48.38 bc
DPL 5415	15.03 b	DPL 5415	46.72 bc
DPL 33b	7.09 c	DPL 33b	44.72 c
Sure Grow 501	6.03 c	Sure Grow 501	32.28 d
†$LSD_{(0.05)}$	6.989		6.247
‡OSL	0.0001		0.0001
§C.V.(%)	57.12		16.43

*Means followed by the same letter are not significantly different (α=0.05) according to an Fisher's LSD mean separation.

† Least Significant Difference

‡ Observed Significance Level

§ Coefficient of Variation

Table 3. General production outline for each comparison location.

Location	Planted	Final Irrigation	Defoliated	Harvested
Marana	18 April	26 August	7 October	22 October
Yuma	25 March	20 August	25 September	15 October
Coolidge	30 April	27 August	14 October	7 November
Maricopa	5 April	21 August	4 September	4 November
Parker	30 March	3 August	5 September	30 September
Mohave Valley	2 April	9 August	25 September	15 November
Buckeye	28 March			8 November
Paloma	27 March			18 November
Queen Creek	16 April			16 October

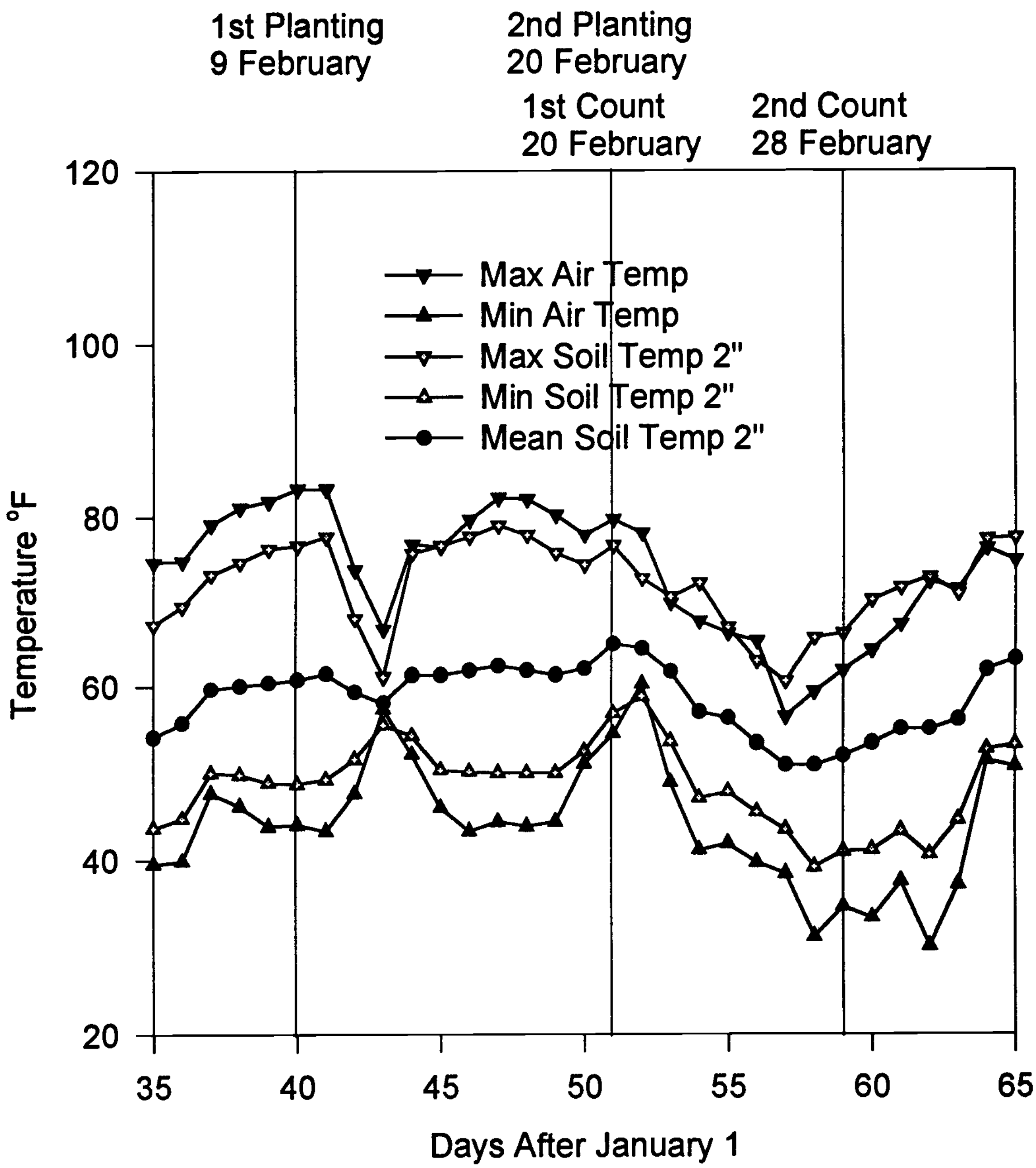

Figure 1. Air and soil temperatures around time of planting and sampling.

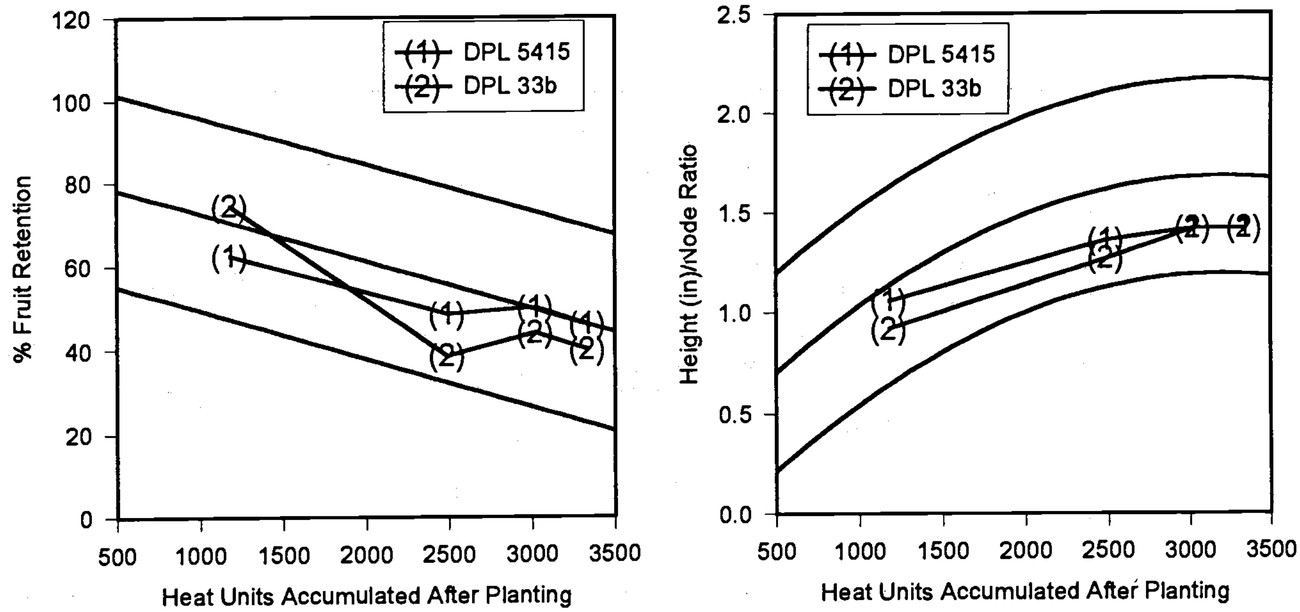

Figure 2. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Mohave Valley, AZ, 1996.

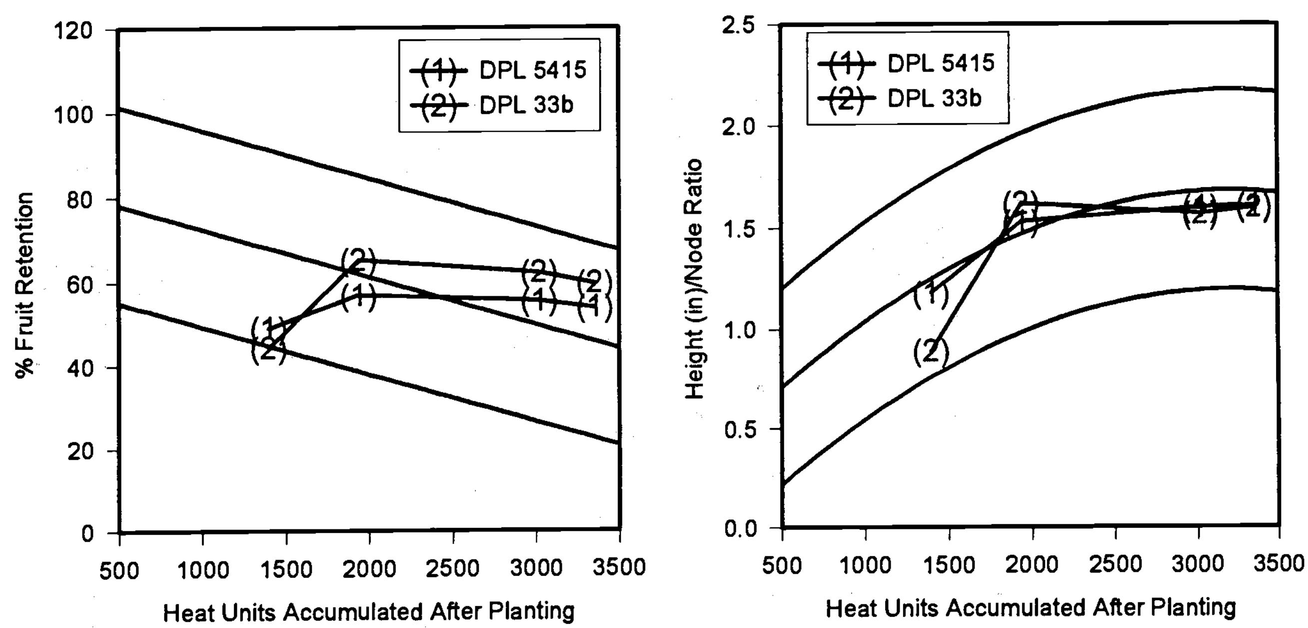

Figure 3. Caomparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Parker Valley, AZ, 1996.

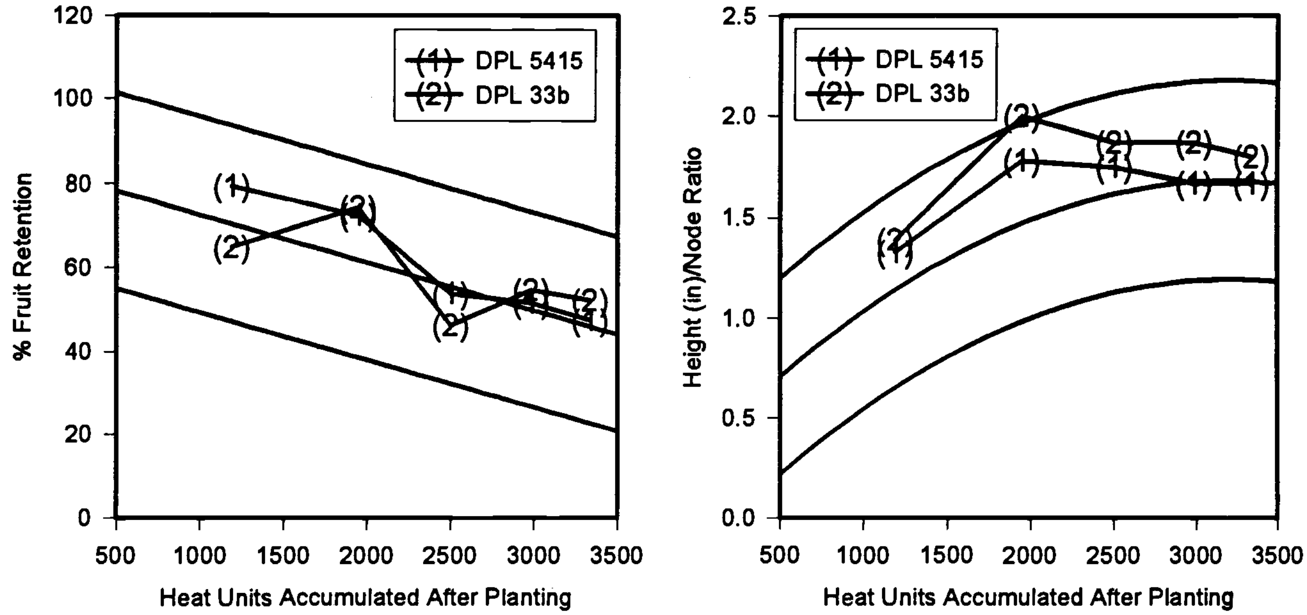

Figure 4. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Yuma, AZ, 1996.

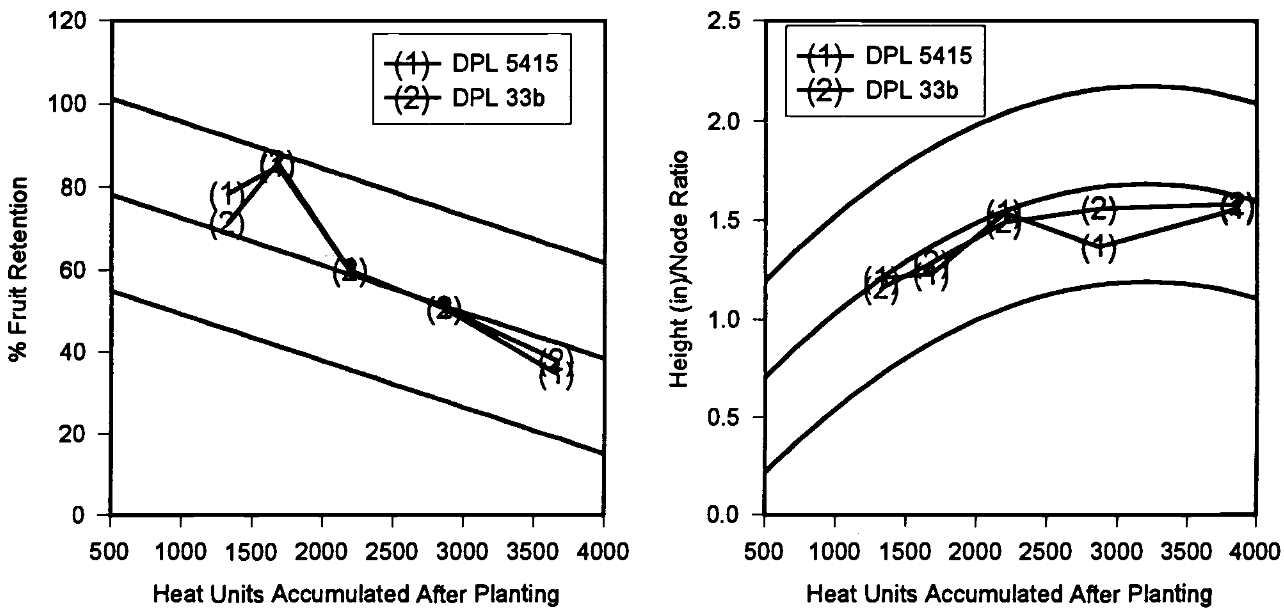

Figure 5. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Paloma Ranch, AZ, 1996.

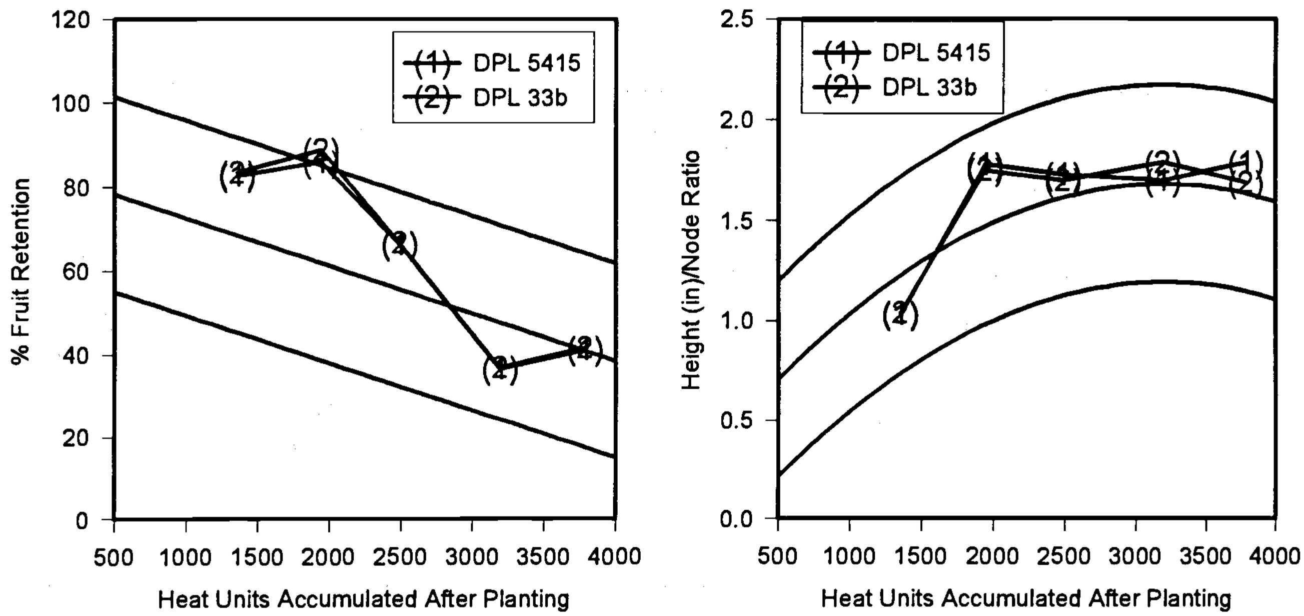

Figure 6. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Buckeye, AZ, 1996.

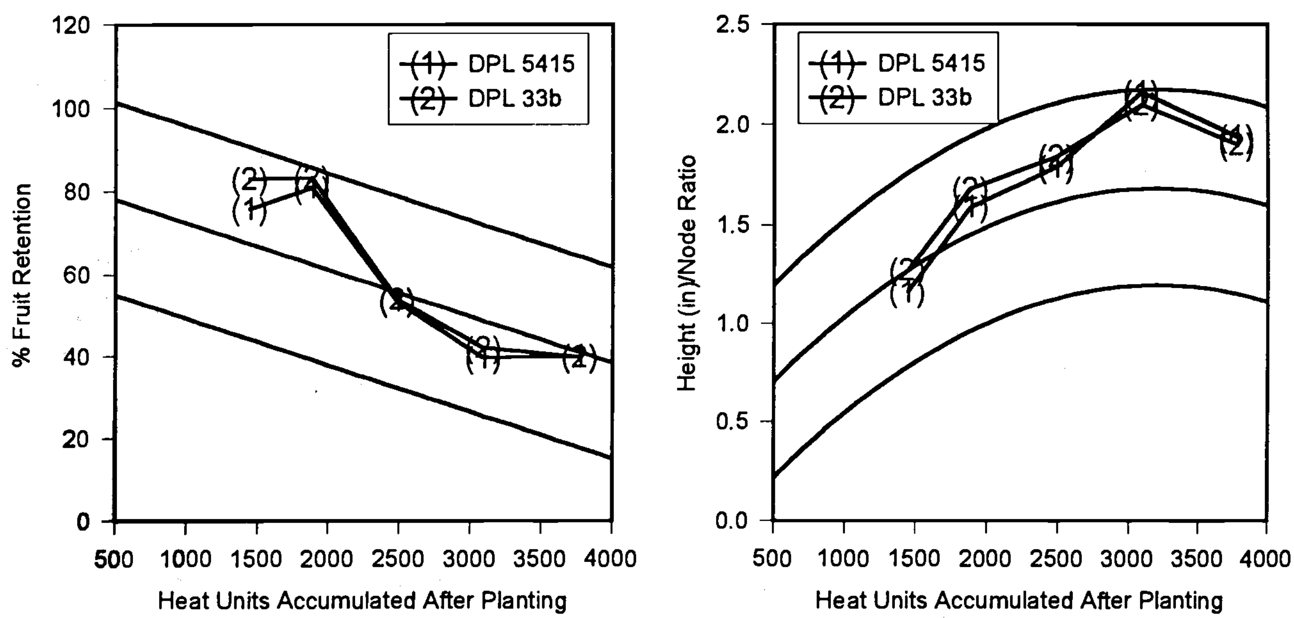

Figure 7. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Queen Creek, AZ, 1996.

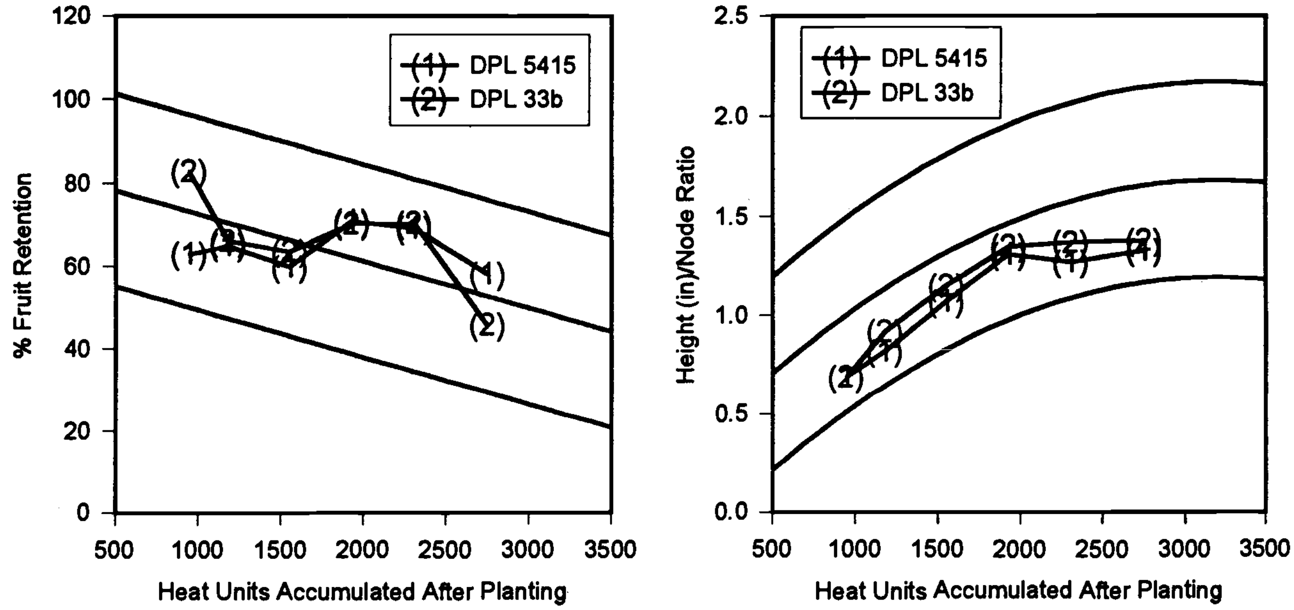

Figure 8. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Maricopa, AZ, 1996.

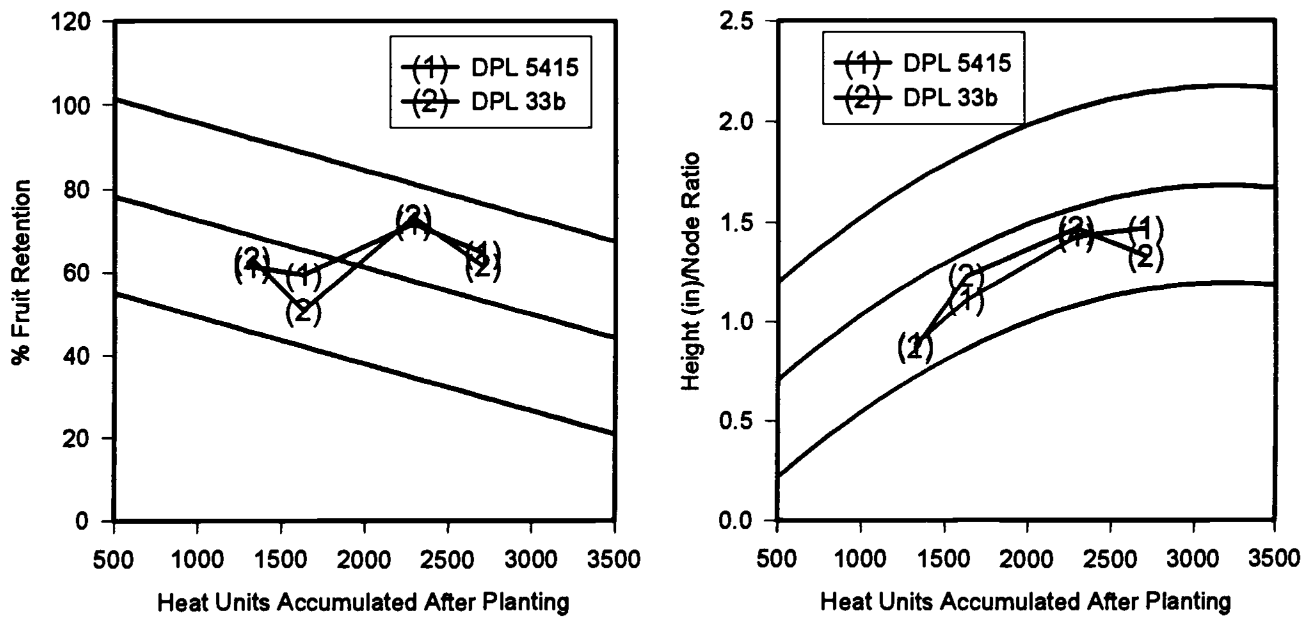

Figure 9. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Coolidge, AZ, 1996.

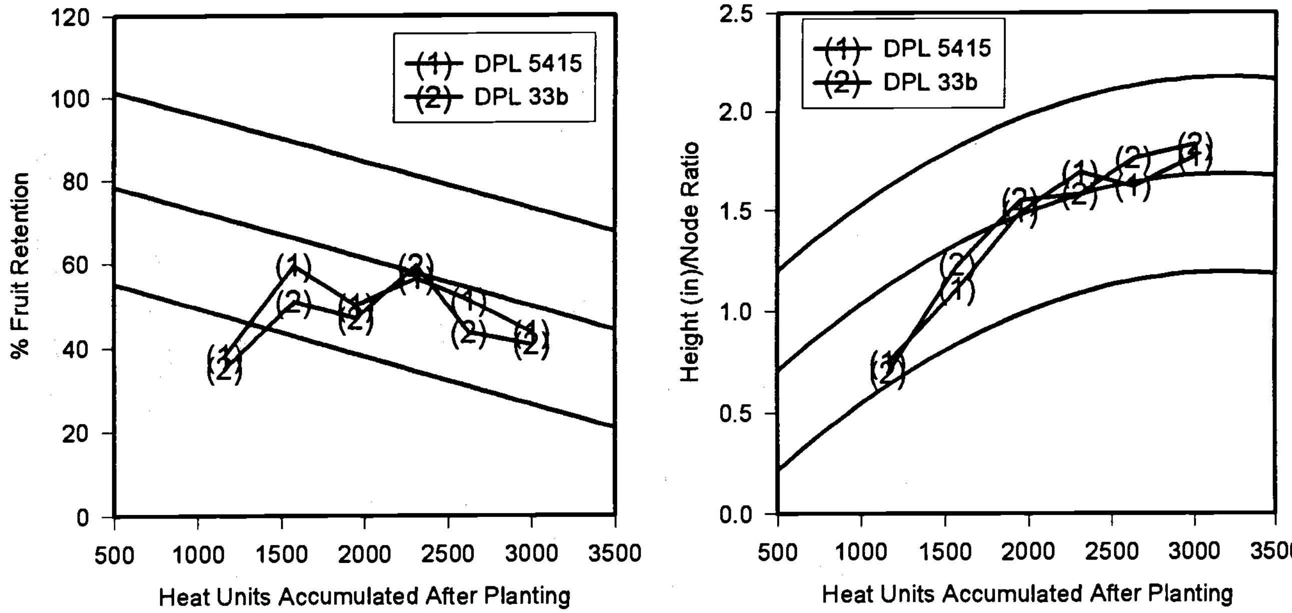

Figure 10. Comparison of plant vigor (HNR) and fruit retention between DPL 5415 and 33b, Marana, AZ, 1996.

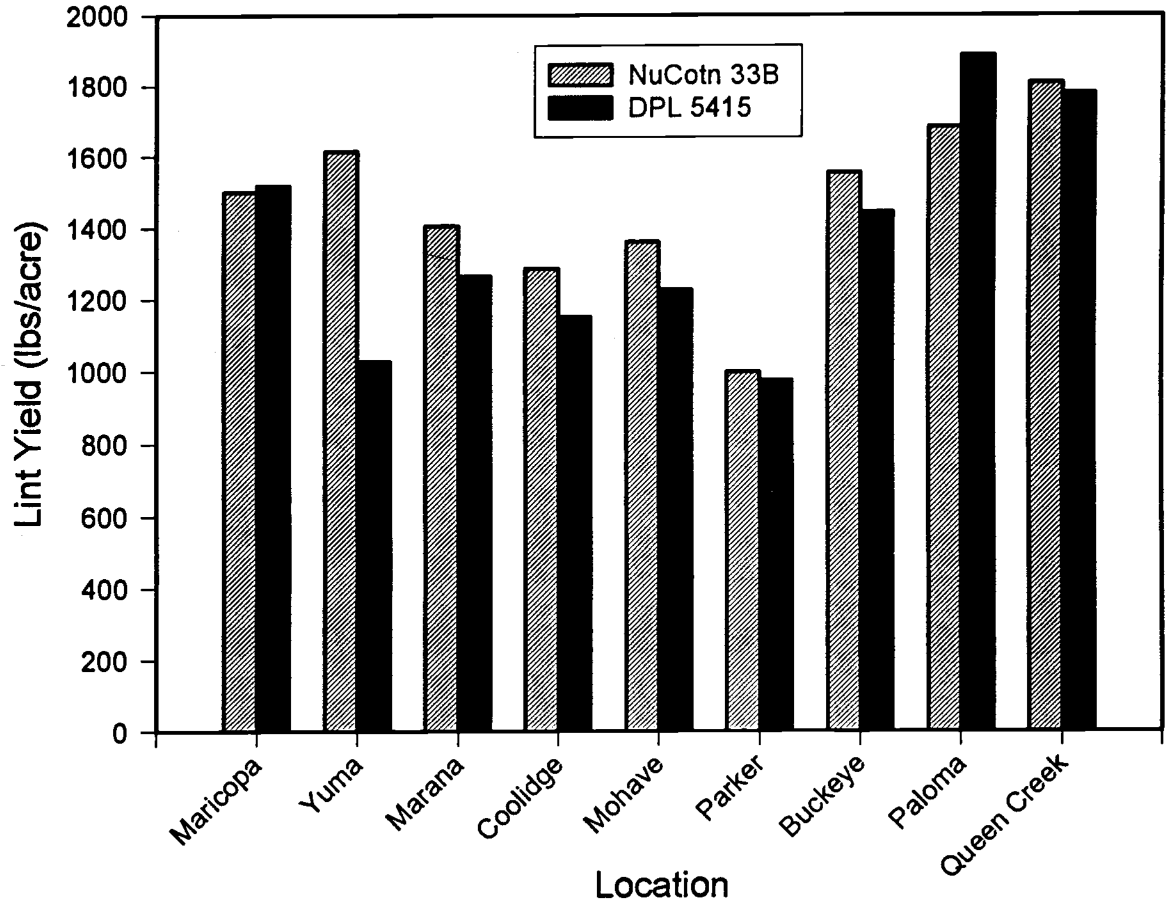

Figure 11. Comparison of lint yield between DPL 5415 and NuCotn 33B, 1996.