Agronomic Evaluations of Transgenic Cotton Varieties, 1998

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Abstract

Several field experiments were conducted in many of the cotton growing areas of Arizona in 1998 for the purpose of evaluating agronomic characteristics of many new transgenic Upland cotton varieties. In many cases, the new transgenic lines were compared directly with their recurrent (non-transgenic) parents. Evaluations were carried out by collecting plant mapping data from each variety on a regular 14 day interval throughout the season and relating the resultant information to established baselines for Upland cotton in Arizona. Lint yield measurements were also taken on each variety at all locations. Results indicate that all transgenic lines tested are very similar to their recurrent parents in terms of growth, development, and yield. Some subtle differences were noted but they were very slight and should not impact management of the varieties significantly in comparison to their recurrent parents.

Introduction

The cotton (*Gossypium spp.*) plant is the centerpiece to a cotton production system. Accordingly, the variety being grown is extremely important. Transgenic varieties can possess tremendous potential by providing unique tools to the farmer, being delivered directly in the plant system. However, it is important that the variety carrying the transgenic property is a strong variety for the situation in which it is being used. It is also important to note that although statements may be made relative to a new transgenic variety being "the same as" it's non-transgenic parent variety; the new transgenic variety is actually a separate and unique variety. Under these circumstances it becomes even more critical to have access to objective, well documented information regarding the agronomic nature (growth, development and yielding potentials in response to soil and environmental factors) of the variety in question. This point was illustrated quite dramatically in 1997 and 1998 with concerns and reports of problems associated with several Roundup Ready (RR) cotton varieties in various cotton producing states in the U.S.

As an example, 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 back crossed 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 the cotton plant 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. This is true not only for Bt cotton, but also for any new transgenic variety that is developed (i.e. Roundup Ready, Buctril resistant, or stacked-gene varieties).

To be competitive and to maintain economic sustainability in either a short- or long-term sense, it is important that cotton growers in Arizona have access to the best and latest in technology. To use this technology effectively, it is equally important to have a complete understanding of what the technology offers and what it can and cannot do. To utilize transgenic varieties effectively and to provide appropriate management, it is very important to understand the agronomic characteristics of them.

The purpose of this study was to compare crop growth, development, and yield of several new Upland (*G. hirsutum* L.) transgenic varieties with their recurrent parents and other varieties in relation to established crop growth and development baselines for Arizona cotton. This project is a continuation of similar work that was conducted in 1996 and 1997 (Silvertooth et al., 1997 and Silvertooth and Norton, 1998).

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Methods

A group of field experiments were conducted at several locations across Arizona in 1998 containing numerous transgenic cotton lines that are currently available or being evaluated for introduction into the commercial market in 1999. Lines include varieties with Bt genes, Roundup Ready (RR), and stacked (Bt and RR) genes. For each primary site (six) in this project, a complete battery of crop growth and development parameters were conducted on all pertinent varieties throughout the season on approximately 14 day intervals (Figures 1-6). The following measurements were made in each plot on all dates of sampling: plant height, number of mainstem nodes, node of the first fruiting branch, aborted sites at positions one and two, the number of nodes above the top white flower (NAWF), % canopy closure, the length of the top five nodes, and petiole nitrate-N concentrations. From these measurements we calculate the height to node ratio (HNR) and percent fruit retention (% FR). The HNR, FR, petiole NO_3^- -N and NAWF values are then plotted for each treatment (variety) relative to established baselines for these parameters. Harvest and lint yield estimates were conducted at all locations. In each case, seedcotton yields, turnout, lint yields, and HVI measurements were conducted. All of the data was analyzed statistically in a manner consistent with the experimental design by use of analysis of variance methods (Steel and Torrie, 1980), and procedures outlined by the SAS Institute (SAS, 1988).

Results

Results from plant measurements (FR and HNR) are shown in figures 1 – 6. Yield results are shown in Tables 1-6.

Basic features evident from this data include the following points:

- Most transgenic lines are very similar to their recurrent parents.
- The problems associated with RR varieties reported from several locations in the mid-south in 1997 and 1998 were not apparent in any of these studies.
    - Misshapen bolls and lower rates of fruit retention were not were not observed to be a greater problem for RR varieties.
- Slight differences were detected between some varieties in terms of vigor and in-season fruit retention.
- Most of the new varieties are sensitive to stress, which is commonly expressed by low vigor and reduced fruit retention.
- Differences in yield were not attributed to agronomic properties.
- In many cases, the more determinate varieties had good FR levels, were less vegetative in growth (lower HNRs) and had higher yields. This was common in 1998 due to the nature of the growing season. In general, the longer season (indeterminate) varieties had lower FR, more vigorous growth (higher HNRs), and lower yields. This was true irrespective of transgenic properties.
- Agronomic evaluation of transgenic lines without a direct comparison to the recurrent parent is possible in Arizona due to the availability of regional baselines for vigor (HNR, FR, NAWF, etc.).
- Transgenic lines of this type are commonly not placed in advanced strain studies. Therefore, studies of this type are needed for the evaluation and comparison of transgenic lines.

References

SAS Institute. 1988. SAS/STAT:Procedures. Release 6.03 ed. SAS Inst., Cary, NC.

Silvertooth, J.C., E.R. Norton, S.H. Husman, T. Knowles, and D. Howell. 1997. Agronomic evaluations of transgenic Bt cotton varieties in Arizona. Cotton, A College of Agriculture Report. University of Arizona. Series P-108:31-40.

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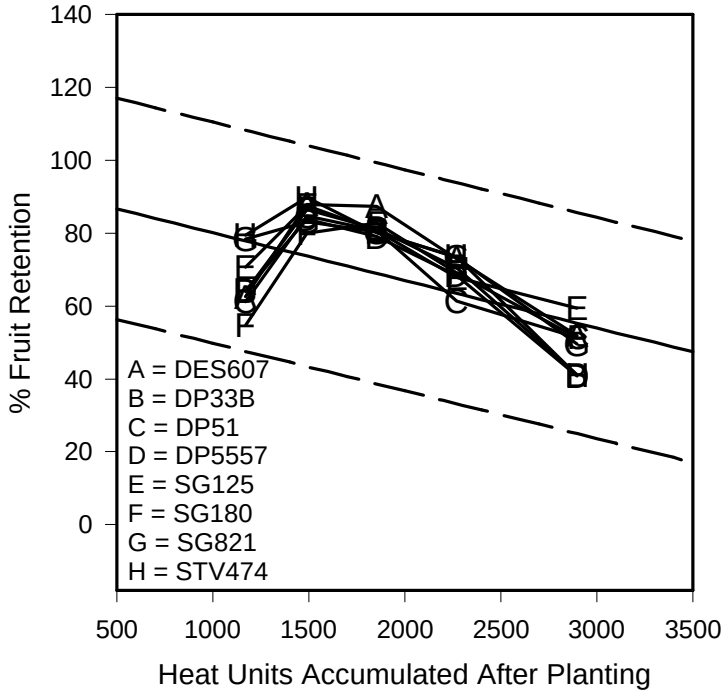
Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw-Hill, New York.



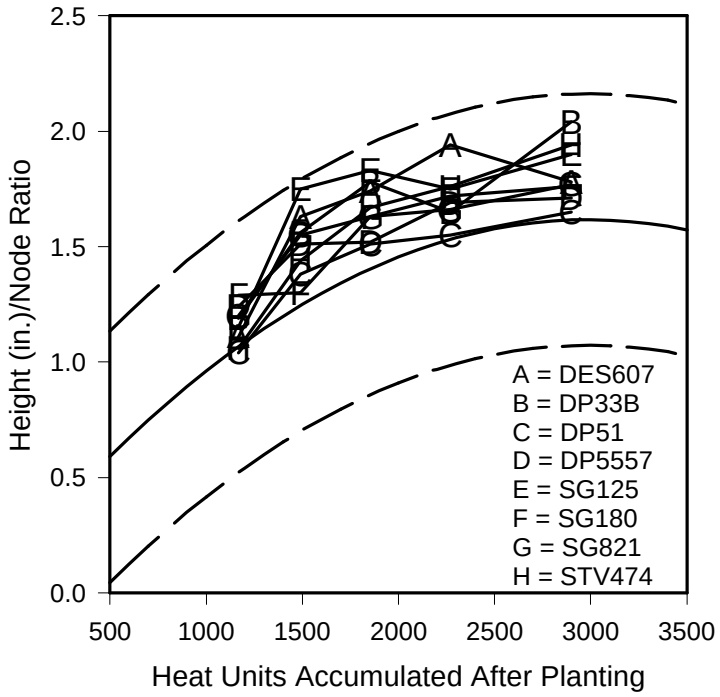


Figure 1. Fruit retention and height to node ratio patterns for transgenic comparison, Roll, AZ, 1998.

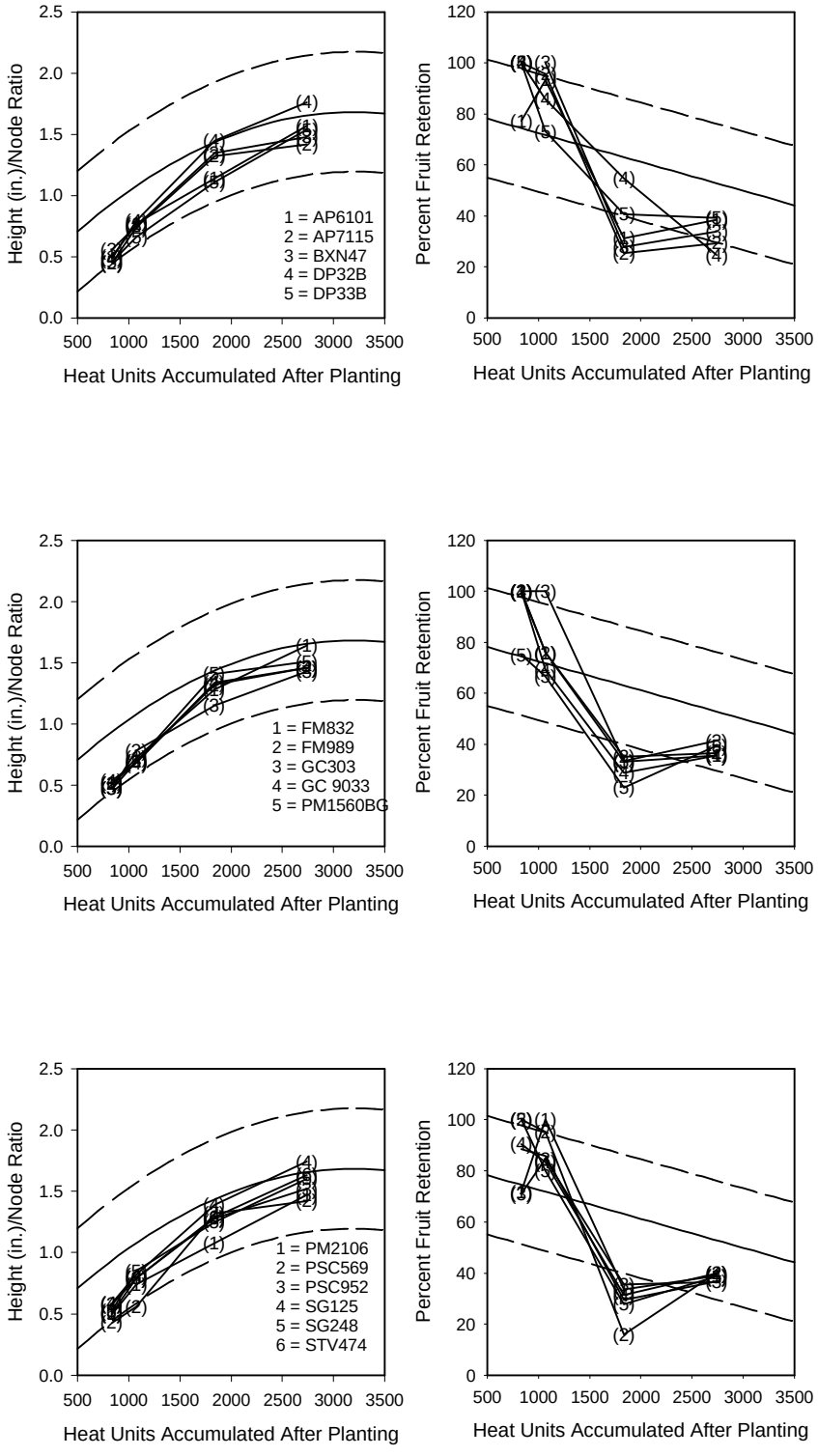


Figure 2. Fruit retention and height to node ratio levels for Paloma Ranch variety trial, 1998.

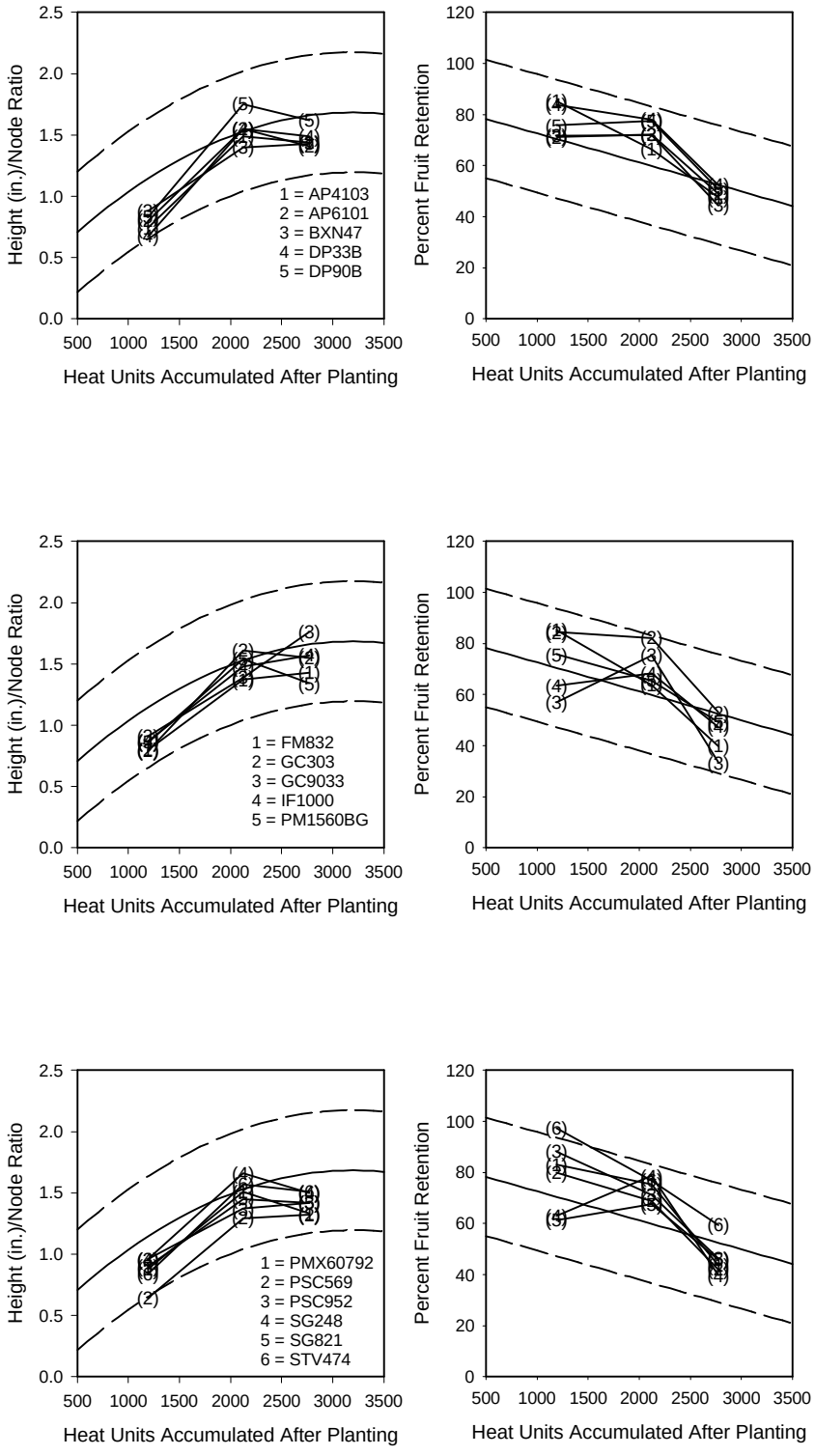
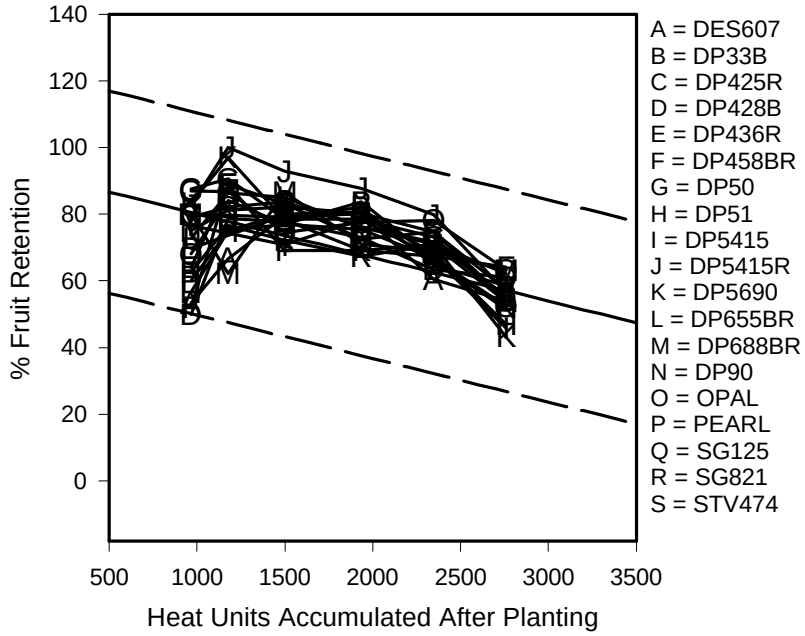


Figure 3. Fruit retention and height to node ratio levels for Buckeye variety test, 1998.



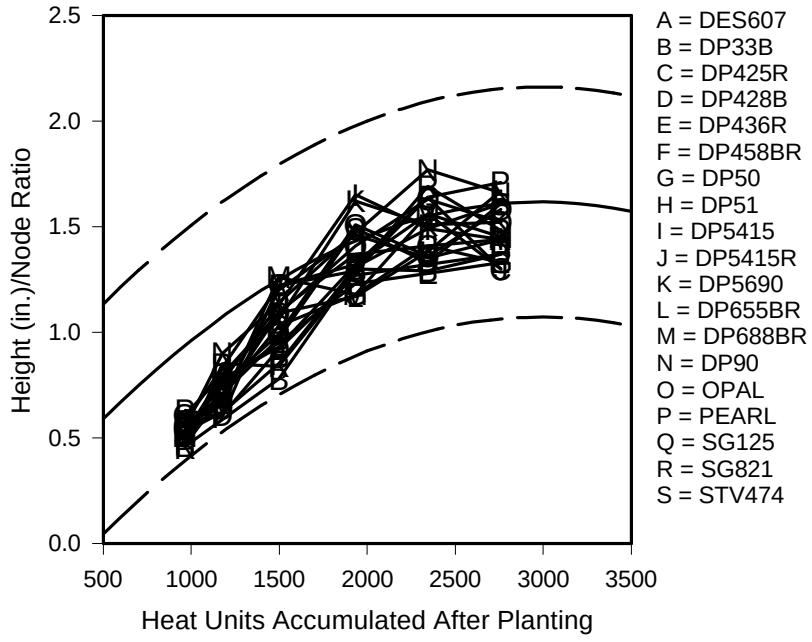
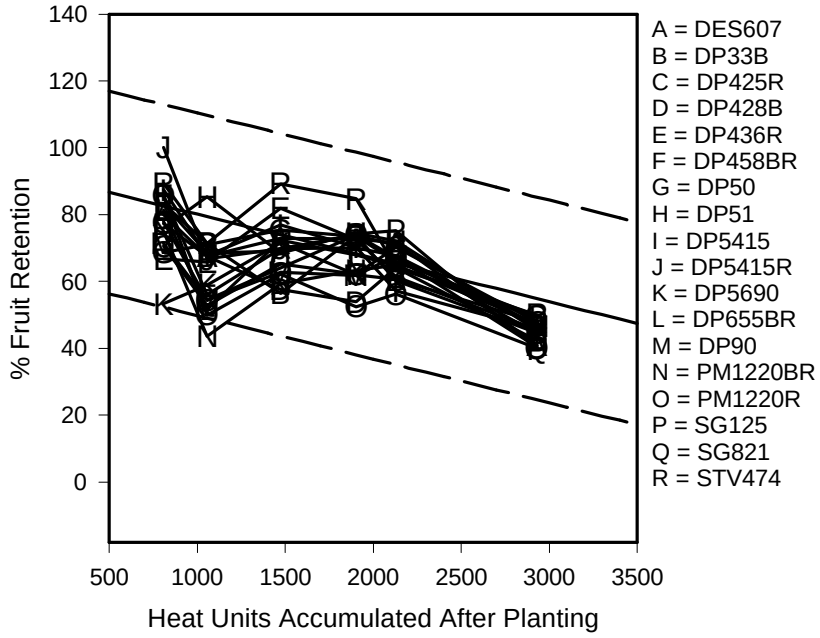


Figure 4. Fruit retention and height to node ratio patterns for transgenic comparison, Buckeye, AZ, 1998.



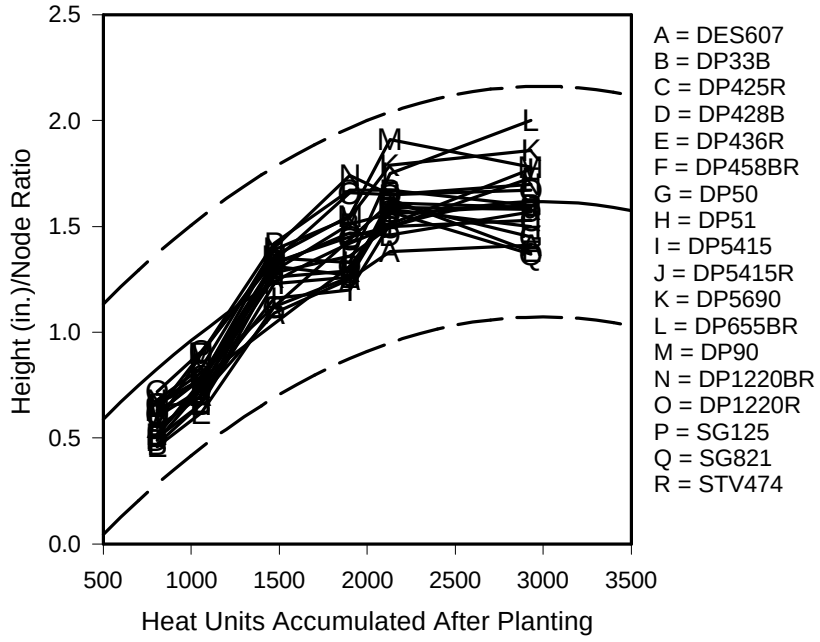
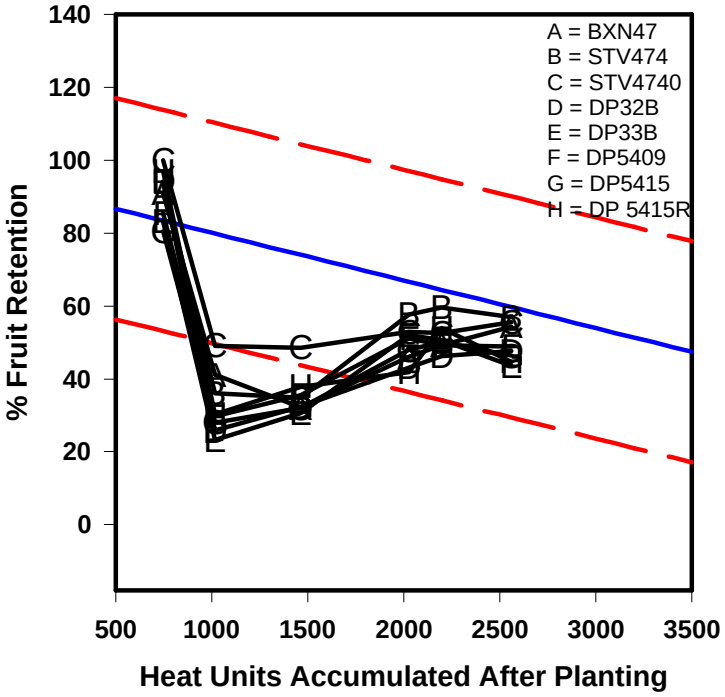


Figure 5. Fruit retention and height to node ratio patterns for transgenic comparison, Casa Grande, AZ, 1998.



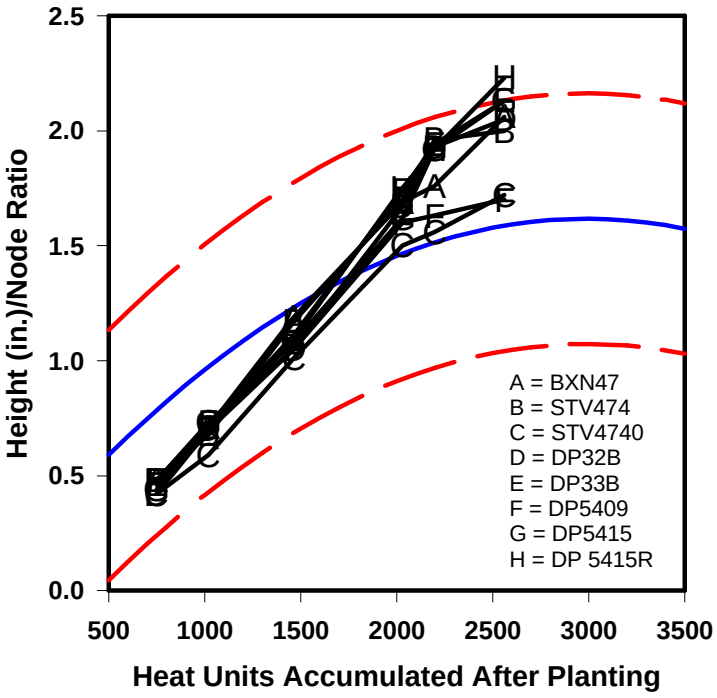


Figure 6. Fruit retention and height to node ratio patterns for transgenic comparison, Marana, AZ, 1998.

Table 1. Lint Yield results for transgenic comparison, Roll, AZ, 1998.

Variety	Lint Yield (lbs lint/acre)
Sure Grow SG747	1082
Deltapine DP51	1013
Sure Grow SG821	948
Sure Grow SG125	941
Stoneville STV474	915
Deltapine DES607	838
Sure Grow SG180	774
Deltapine DPX9775	710
Deltapine DP33B	710
Deltapine DP5557	557
LSD (α=0.05)†	178
OSL‡	0.0001
C.V. (%)§	6.94

¶Planted 6 March
Harvested 17 September
*Means followed by the same letter are not significantly different according to a Duncan's Multiple Range Test.
†LSD = Least Significant Difference
‡ OSL = Observed Significance Level
§ C.V. = Coefficient of Variation (%)

Table 2. Lint yields from 1998 Maricopa County Variety Test, Paloma Ranch.¶

Variety	Lint Yield (lbs lint/acre)
Stoneville BXN 47	833 a*
Phytogen PSC569	828 a
Stoneville 474	744 ab
Paymaster 72106	689 bc
AgriPro AP6101	681 bcd
Deltapine 33B	666 bcde
Sure Grow 125	657 bcde
Sure Grow 248	612 cde
Phytogen PSC952	597 cdef
Germains 9033	571 cdef
Deltapine 90B	567 cdef
Germains 303	561 def
Paymaster 1560BG	545 ef
AgriPro AP4103	485 fg
AgrEvo FM989	384 g
AgrEvo FM832	370 g
LSD (α=0.05)†	122
OSL‡	0.0001
C.V. (%)§	12.0

¶Planted 17 April
Harvested 17 December
*Means followed by the same letter are not significantly different according to a Duncan's Multiple Range Test.
†LSD = Least Significant Difference
‡ OSL = Observed Significance Level
§ C.V. = Coefficient of Variation (%)

Table 3. Lint yields from 1998 Maricopa County Variety Test, Buckeye, H-4 Farms.¶

Variety	Lint Yield (lbs lint/acre)
Phytogen PSC569	1568 a*
Sure Grow 248	1539 ab
Sure Grow 821	1507 abc
Deltapine 33B	1493 bc
Stoneville 474	1483 bc
AgriPro AP6101	1458 cd
Stoneville BXN 47	1442 cd
AgriPro AP4103	1413 de
Deltapine 90B	1404 de
Germains 303	1355 ef
Phytogen PSC952	1354 ef
Germains 9033	1351 ef
AgrEvo IF1000	1323 f
Paymaster 1560BG	1250 g
Paymaster 60792	1238 g
AgrEvo FM832	1168 h
LSD (α=0.05)†	65
OSL‡	0.0001
C.V. (%)§	2.80

¶Planted 7 April
Harvested 5 December

*Means followed by the same letter are not significantly different according to a Duncan's Multiple Range Test.

†LSD = Least Significant Difference

‡ OSL = Observed Significance Level

§ C.V. = Coefficient of Variation (%)

Table 4. Lint yield results for transgenic comparison, Buckeye, AZ, 1998.

Variety	Lint Yield (lbs lint/acre)	
Deltapine DP458BRR	1820	a*
Deltapine DP5415	1687	ab
Deltapine DP33B	1671	ab
Deltapine DP5415R	1668	ab
Deltapine DPX9775	1645	abc
Deltapine DP428B	1627	bcd
Deltapine DP688BR	1623	bcd
Stoneville ST474	1620	bcd
Sure Grow SG821	1610	bcd
Deltapine DP425R	1602	bcd
Deltapine DPX9729B	1583	bcde
Deltapine DES607	1571	bcde
Deltapine DP655BR	1565	bcdef
Deltapine DP51	1564	bcdef
Deltapine DPX9758	1549	bcdef
Deltapine DPX8C88	1531	bcdef
Deltapine DP5690	1519	bcdef
Deltapine DP90	1513	bcdef
Deltapine DPX8C80	1485	cdef
Sure Grow SG125	1465	defgh
Deltapine DPX8C27	1419	efgh
Deltapine DP436R	1390	fgh
Deltapine DP50	1321	gh
Deltapine DPX9765	1292	h
LSD (α=0.05)†	178	
OSL‡	0.0001	
C.V. (%)§	6.94	

¶Planted 16 April
Harvested 4 November

*Means followed by the same letter are not significantly different according to a Duncan's Multiple Range Test.

†LSD = Least Significant Difference

‡ OSL = Observed Significance Level

§ C.V. = Coefficient of Variation (%)

Table 5. Lint yield results for transgenic comparison, Casa Grande, AZ, 1998.

Variety	Lint Yield (lbs lint/acre)	
Deltapine DPX9729B	1610	a*
Deltapine DPX9725	1599	a
Deltapine DPX9758	1586	ab
Sure Grow SG821	1583	ab
Stoneville ST474	1567	abc
Deltapine DPX8C27	1540	abcd
Deltapine DES607	1536	abcd
Deltapine DP425R	1504	abcde
Deltapine DP428B	1478	abcdef
Deltapine DP5415	1463	abcdef
Sure Grow SG125	1454	abcdefg
Deltapine DP50	1445	abcdefgh
Deltapine DP51	1429	bcdefghi
Deltapine DP436R	1410	cdefghi
Deltapine DPX9775	1403	cdefghi
Deltapine DP458BR	1390	defghi
Deltapine DP33B	1366	efghij
Paymaster PM1220BR	1337	fghij
Deltapine DP5415R	1290	ghij
Deltapine DPX9765	1286	hijk
Paymaster PM1220R	1273	ijk
Deltapine DP5690	1202	jk
Deltapine DP655BR	1164	k
Deltapine DP90	1133	k
LSD (α=0.05)†	166	
OSL‡	0.0001	
C.V. (%)§	7.10	

¶Planted 18 April
Harvested 14 October
*Means followed by the same letter are not significantly different according to a Duncan's Multiple Range Test.
†LSD = Least Significant Difference
‡ OSL = Observed Significance Level
§ C.V. = Coefficient of Variation (%)

Table 6. Lint yield results for transgenic comparison, Marana, AZ, 1998.

Variety	Lint Yield (lbs lint/acre)	
Stoneville STV4740	1068	a*
Stoneville STV474	1006	ab
Deltapine DP20B	950	bc
Deltapine DP20	913	bcd
Deltapine DP5409	895	bcd
Stoneville BXN47	870	cd
Deltapine DP32B	827	d
Deltapine DP90B	815	d
Deltapine DP33B	802	d
Deltapine DP5415R	636	e
Deltapine DP5415	623	e
Deltapine DP90R	555	ef
Deltapine DP90	481	f
LSD (α=0.05)†	113	
OSL‡	0.0001	
C.V. (%)§	8.38	

¶Planted 28 April
Harvested 29 October
*Means followed by the same letter are not significantly different according to a Duncan's Multiple Range Test.
†LSD = Least Significant Difference
‡ OSL = Observed Significance Level
§ C.V. = Coefficient of Variation (%)