

# COMPARISON OF OBSOLETE AND MODERN COTTON CULTIVARS FOR IRRIGATED PRODUCTION IN ARIZONA

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## **Abstract**

*A study was conducted at the University of Arizona Maricopa Agricultural Center (MAC) to compare growth and development characteristics and determine differences in fruiting pattern and retention among two obsolete (Deltapine 16 and Acala 442) and three modern (Deltapine Acala 90, Deltapine 5415, and NuCotn 33b) Upland (*G. hirsutum* L.) cotton cultivars grown in an irrigated production system in Arizona. Results indicated that the majority of yield was produced at fruiting branches 10 through 18 at position one. Lint yield results indicated no significant differences among all cultivars tested, except for Acala 442, which was significantly lower than all others. Obsolete cultivars produced significantly higher amounts of lint on vegetative branches than modern varieties. Deltapine 16, followed by NuCotn 33b, had the highest harvest index and was the most efficient cultivar grown with respect to dry matter partitioning.*

## **Introduction**

Cotton (*Gossypium spp.*) has been modified over many decades of breeding and selection in an effort to ultimately improve yield. Through this effort, cultivars have been developed expressing differences in developmental characteristics such as fruit load. However, it is the retention of that fruit that is essential for optimum yield and profit. Understanding which varieties not only produce the highest number of bolls, but are most likely to retain those bolls through maturity, would be of great benefit.

Cotton plants grow with a monopodial vegetative mainstem and lateral monopodial and sympodial fruiting branches. They must grow vegetatively to produce fruiting sites. A crop production system usually allows the cotton plant to grow, set a boll load, and mature these bolls. In the modification of cotton from a perennial to an annual growth habit, plant breeders have selected a growth habit of the cotton plant that reduces the number of lateral monopodial branches that are formed before sympodial fruiting branches are formed, resulting in an earlier onset of flowering (Kohel and Benedict, 1987).

In general, modern cultivars make an earlier and more complete transition from vegetative to reproductive dry matter partitioning. They also partition more dry matter into reproductive structures. However, modern cultivars do not usually produce more total dry matter than obsolete cultivars, indicating that assimilatory activity is not greater in these cultivars. Modern cultivars have a greater proportion of their reproductive development at an earlier stage. This results in a greater amount of reproductive growth occurring when maximal leaf area and mass are present. These cultivars also generally produce a greater amount of smaller bolls with a higher lint percentage (Wells and Meredith, 1984).

According to Jones et al. (1996), mature cotton plants often exhibit altered fruiting patterns due to the abscission of fruiting forms caused by stress or insect damage during reproductive development. Guinn (1982) states that insect feeding can cause serious losses of yield by interfering with plant growth. This is due to leaf malformations or abscission, increased shedding of squares and bolls, damaged seed and lint, or by a combination of these. The stimulus for square and boll shedding may be either direct or indirect. A direct stimulus is one in which there is feeding on the square or boll. For example, *Lygus* (*Lygus hesperus* K.) feed on squares and cause them to abort or shed. However, it is difficult to determine whether small squares have been damaged by *Lygus* bugs without resorting to microscopic examination. An indirect

stimulus includes a physiological withdrawal of nutrients from leaves, petioles, or stems; or a loss of leaf area due to malformation or abscission.

Guinn (1982) indicated that the location or position of squares and bolls on the plant also has a profound effect upon their retention. Squares present on the first fruiting branch, which is typically shorter than the next one, have a lower probability of being retained to the mature boll stage. Retention also varies with position on the fruiting branch. Retention is usually high at the first node and decreases at successive lateral nodes out on the fruiting branch. In irrigated Upland cotton grown in Arizona, under typical conditions for the area, Mauney (1979) reported that 73 percent of matured bolls were present at the first node, 24 percent at the second node, and only 2 percent at the third node.

The objectives of this study were to compare growth and development characteristics and determine differences in fruit retention patterns among several obsolete and modern Upland cotton cultivars grown in an irrigated production system in Arizona.

### Methods

The present study was conducted in 1999 at the University of Arizona Maricopa Agricultural Center (MAC) which is located in south-central Arizona at 357 m elevation. The site was planted on 14 April with obsolete (Acala 442 and Deltapine (DP) 16) and modern (DP Acala 90, DP 5415 and DP NuCotn 33b) Upland (*G. hirsutum* L.) cultivars on a Casa Grande sandy loam soil (fine-loamy, mixed, hyperthermic Typic Natrargid). The experimental design was a randomized complete block with four replications. Plots consisted of four, 1 m rows, 13 m in length. All inputs such as water, fertilizer, and pest control were managed in an optimal fashion. Four applications of nitrogen (N) were made consisting of approximately 38 kg N/ha on 15 May, 38 kg N/ha on 24 May, 46 kg N/ha on 4 June, and 62 kg N/ha on 16 June for a total of 184 kg N/ha applied. Nine in-season irrigations were made of approximately 152 mm each for a total of 1368 mm. The final irrigation was applied on 31 August. Plots were managed for complete first fruiting cycle development.

Crop growth and development measurements were taken throughout the season on approximately 14 day intervals. The following measurements were made in each plot on all sampling dates: 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), and petiole nitrate-N concentrations. The aboveground portions of entire plants were collected from 1 m<sup>2</sup> areas in a non-harvest row at early bloom, peak bloom, and post cut-out, to determine total dry matter accumulation and partitioning of dry matter between vegetative and reproductive components. These measurements were used to determine harvest index (HI) values, which is the ratio of desirable biomass to total biomass produced.

A three meter row segment (3 m<sup>2</sup> area) of a non-harvest row was identified and staked within each experimental unit. All fresh open blooms were tagged within these areas three days per week (M, W, and F), throughout the fruiting cycle. Tags were coded so bolls from specific tagging dates could be differentiated from one another, and records were kept in terms of the number of blooms tagged per plot for each date. Flower tagging began on 30 June and continued until irrigation termination. The final date of tagging was 17 September. Tags were collected from all plots on 3 November.

After the field was defoliated, five plants from each plot were collected from non-harvest rows. Seedcotton was removed and separated by each fruiting site on each sympodial branch. The bolls harvested on each fruiting branch at positions one through four were recorded independently with the cotyledonary node counted as zero. An electronic balance was used to determine the weight of the seedcotton from each fruiting branch by position. All seedcotton on the monopodial branches was harvested collectively and identified as one common position (fruiting branch = 0). To estimate total lint yield production, all plots were harvested by use of a two-row mechanical picker in the center rows of each plot. Data was analyzed statistically in accordance to procedures outlined by Steel and Torrie (1980) and the SAS Institute (SAS, 1991).

## Results

Fruit retention (FR) and plant vigor (height to node ratios, HNR) patterns are shown in Figure 1. Vegetative growth tendencies were approximately the same for all varieties except DP 16 and DP Acala 90. None of the varieties approached the upper threshold that indicates highly vegetative growth tendencies, so based on that measure none of the varieties were exceptionally vegetative. However, DP 16 possessed a lower HNR than the other varieties and DP Acala 90 a slightly higher level. This indicated shorter, less vegetative plants for DP 16, and the opposite for DP Acala 90. There were no differences among cultivars in progression towards cut-out (NAWF). Petiole nitrate-N data (Figure 2) exhibited normal trends among all cultivars. Plants did not experience stress due to N deficiency nor were there any differences among cultivars.

Fruit retention levels noted were uncommonly low for all cultivars throughout the entire season. This was due to lygus infestations that occurred relatively early in the season and persisted for several weeks, despite control efforts. A steep drop in FR levels occurred at approximately 2000 HUAP. This same decrease was detected in the tag collection data presented in Figure 3. This common relationship between data sets reinforces the use of general plant mapping as an indicator of FR.

The obsolete and modern cultivars did not differ significantly in the amount of total dry matter produced. The differences lay in how that dry matter was partitioned. Harvest index (HI) values differed significantly ( $P < 0.05$ ) for DP 16, DP 5415, and Acala 442, with DP 16 having the highest value of the three (Table 1). There were no significant differences detected for the reproductive dry matter results for the five cultivars (Table 2). However, the vegetative dry matter results differed significantly (Table 3 and Figure 5). DP 16 produced a significantly lower amount of vegetative dry matter than all other varieties except DP NuCotn 33b. This relates to the high HI value found with DP 16 (Figure 4).

Lint yield results indicated a significantly lower yield for Acala 442 than all other varieties (Table 4 and Figure 6). Collectively, the data in Tables 1 through 4 indicate that DP 16 was the most efficient cultivar grown in this study in terms of dry matter production and partitioning. It produced the least amount of vegetative matter when compared to the other cultivars and did not differ significantly in the reproductive dry matter or yield produced.

In terms of lateral fruiting patterns among the first through fourth positions on the fruiting branches, DP Acala 90 was the only cultivar that clearly exhibited a fruiting pattern with decreasing yield with further lateral positions. Significant differences were found among varieties within positions 1, 3, and 4. (Figure 7). In an effort to determine where on the plant the majority of yield was produced within cultivars, the plants were divided into vertical zones by groups of fruiting branches (FB) (zone 1 = FB 1-9, zone 2 = 10-18, zone 3 = 19-28) for analysis. There was a general trend that showed the majority of the yield was produced in zone 2, followed by zones 3 and 1. However, DP NuCotn 33b was the only cultivar in which the yield produced in zones 2 and 3 was significantly higher than that in zone 1 (Figure 8). Within zone 2, position 1 produced the greatest yield for every cultivar except Acala 442 (Figures 9-13). Yield at the third position was significantly higher ( $P < 0.05$ ) than positions 1 and 4 in zone 3 for Acala 442. No data was available in zone 1 for position 1 (Figure 9). Yield at the first position was significantly higher ( $P < 0.05$ ) than positions 2 and 4 in zone 2 for DP NuCotn 33b. No data was available in zone 1 for position 3. (Figure 12). The first position was significantly higher ( $P < 0.05$ ) than positions 2-4 for zones 2 and 3 for DP Acala 90 (Figure 13). The decreased yield in zone 1 was due to fruit damage and losses caused early in the season by lygus. Vegetative branches produced a substantial amount of the total lint yield for most cultivars. The percentage lint yield produced by vegetative branches for Acala 442 was significantly higher than that produced by the modern cultivars, DP 5415, DP NuCotn 33b, and DP Acala 90 (Figure 14).

## Summary

Fruit retention was uncommonly low for all cultivars in this study. This low FR was due to the extensive lygus infestations that occurred. Vegetative growth tendencies were generally the same for all cultivars with the exception of DP 16 and DP Acala 90. There were no significant differences in the reproductive dry matter produced among varieties. The flower tagging method employed provided a description of detailed

FR. Flower tagging can be used to evaluate relationships between FR and short-term changes in management (i.e. water stress) or environmental conditions (i.e. heat stress). There was a very close relationship between the flower tagging data and the FR estimates provided by routine plant measurements and mapping. Results exhibited a general trend indicating the majority of yield was produced in zone 2 (FB 10-18) at position 1. Obsolete cultivars produced significantly higher amounts of lint on vegetative branches than modern cultivars. The results from this study indicate that under the production conditions experienced, DP 16, followed by DP NuCotn 33b, was the most efficient variety grown with respect to dry matter partitioning. Further studies should be conducted to determine how growth and FR patterns develop under production conditions where damage due to lygus infestation is not as severe as it was in this case.

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Table 1. Harvest index results for each cultivar, 10 September 1999 (3573 HUAP).

<u>Variety</u>	<u>Harvest Index</u>
DP 16	39.473 a*
DP NuCotn 33b	33.596 a b
DP 5415	29.129 b
DP Acala 90	27.251 b c
Acala 442	20.573 c
LSD**	6.8377
OSL †	0.0008
C.V. (%) ‡	14.79

\* Means followed by the same letter are not significantly different according to a Fisher's means separation test.

\*\*Least Significant Difference

† Observed Significance Level

‡ Coefficient of Variation

Table 2. Reproductive dry matter results for each cultivar, 10 September 1999 (3573 HUAP).

<u>Variety</u>	<u>Dry Matter (kg/ha)</u>
DP NuCotn 33b	4388.6 a*
DP 16	4179.8 a
DP 5415	3872.3 a
DP Acala 90	3636.2 a
Acala 442	2750.7 a
LSD**	NS
OSL †	0.1303
C.V. (%) ‡	22.77

\* Means followed by the same letter are not significantly different according to a Fisher's means separation test.

\*\*Least Significant Difference

† Observed Significance Level

‡ Coefficient of Variation

Table 3. Vegetative dry matter results for each cultivar, 10 September 1999 (3573 HUAP).

<u>Variety</u>	<u>Dry Matter (kg/ha)</u>
Acala 442	10831 a*
DP Acala 90	10287 a
DP 5415	9749 a
DP NuCotn 33b	8714 a b
DP 16	6903 b
LSD**	2313.7
OSL †	0.0225
C.V. (%) ‡	16.15

\* Means followed by the same letter are not significantly different ( $P < 0.05$ ) according to a Fisher's means separation test.

\*\*Least Significant Difference

† Observed Significance Level

‡ Coefficient of Variation

Table 4. Lint yield results for each cultivar, 10 September 1999 (3573 HUAP).

<b>Variety</b>	<b>Yield (kg lint/ha)</b>
DP NuCotn 33b	1407.57 a*
DP Acala 90	1395.63 a
DP 16	1323.74 a
DP 5415	1302.78 a
Acala 442	981.45 b
LSD**	140.7
OSL †	<.0001
C.V. (%)‡	7.97

\* Means followed by the same letter are not significantly different according to a Fisher's means separation test.

\*\*Least Significant Difference

† Observed Significance Level

‡ Coefficient of Variation

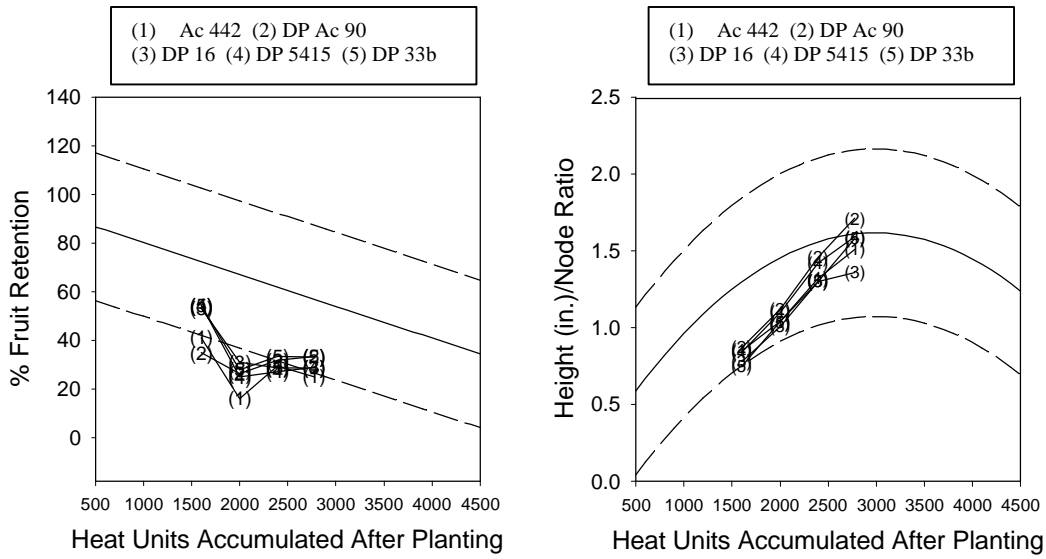


Figure 1. Fruit retention and height to node ratio results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

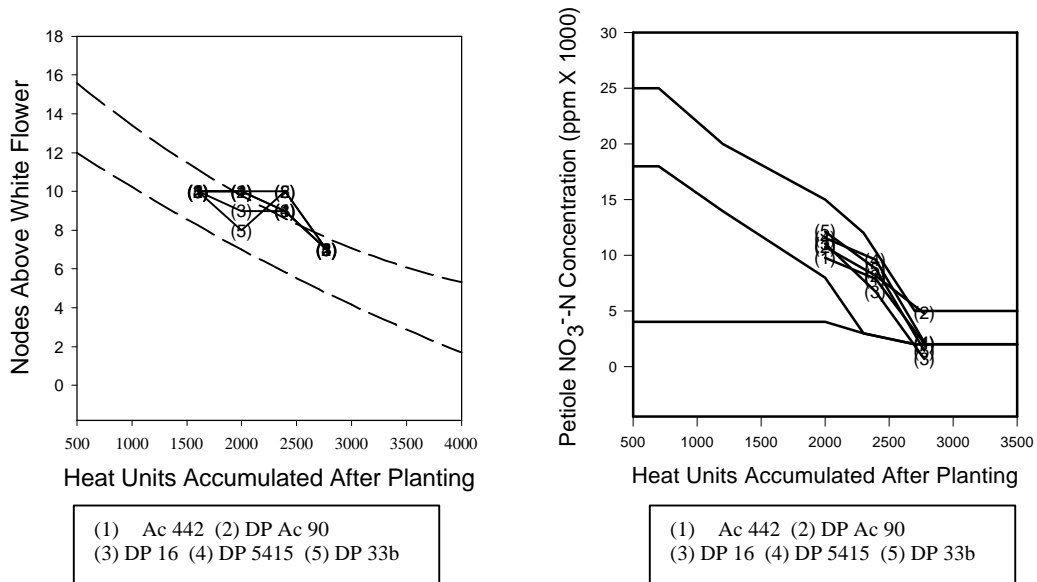


Figure 2. Nodes above white flower and petiole nitrate nitrogen results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

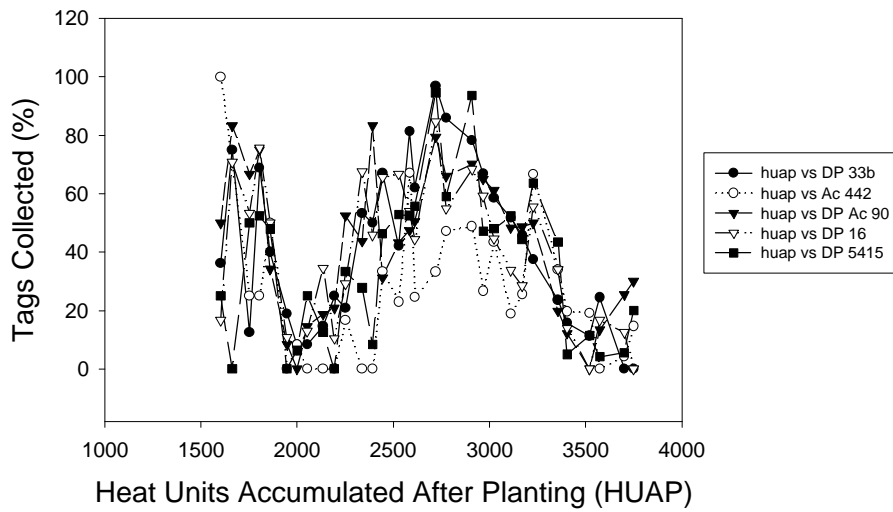


Figure 3. Tag collection results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

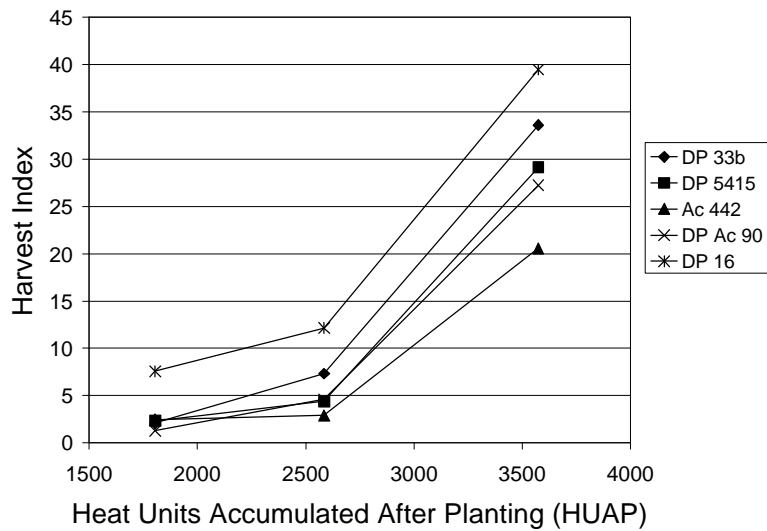


Figure 4. Harvest index results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

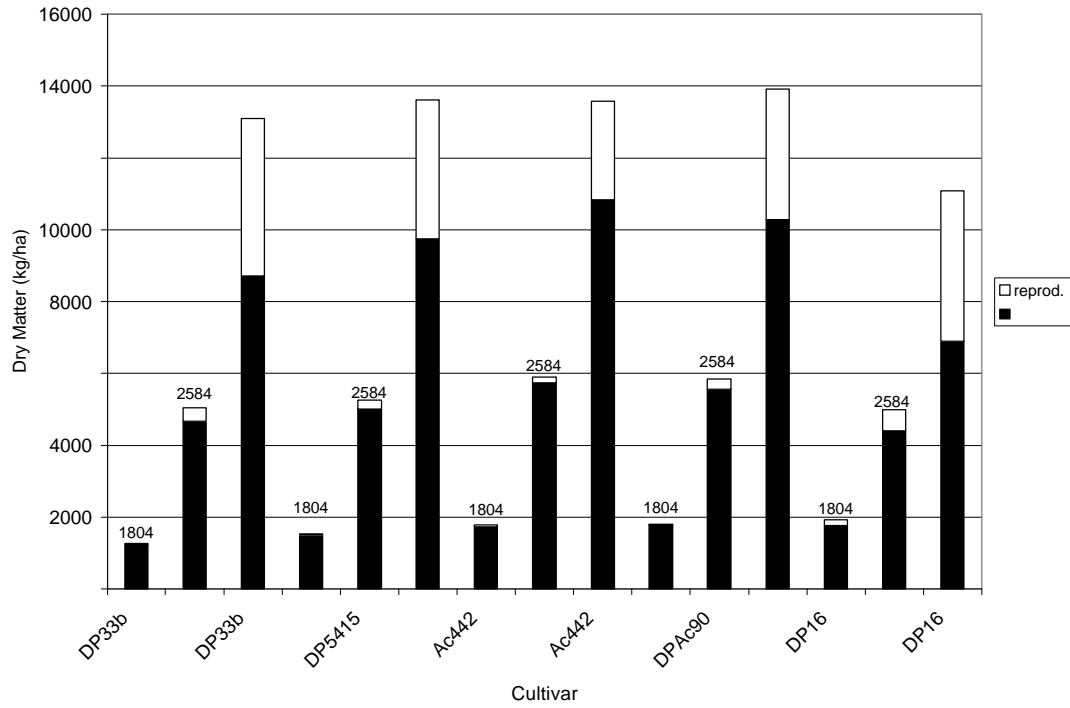


Figure 5. Dry matter partitioning results for 1804, 2584, and 3573 HUAP, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

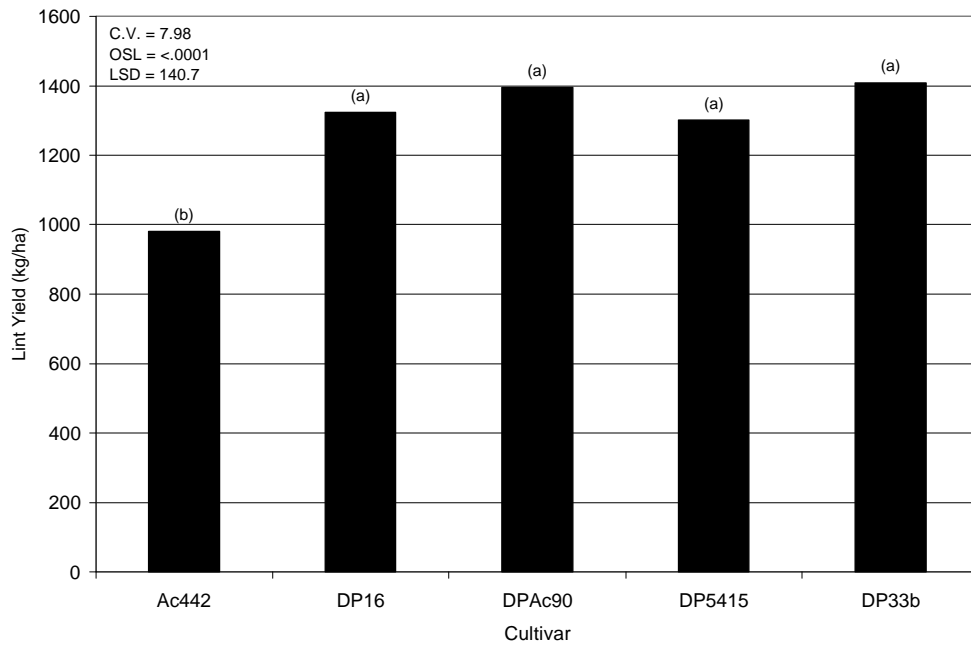


Figure 6. Lint yield results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

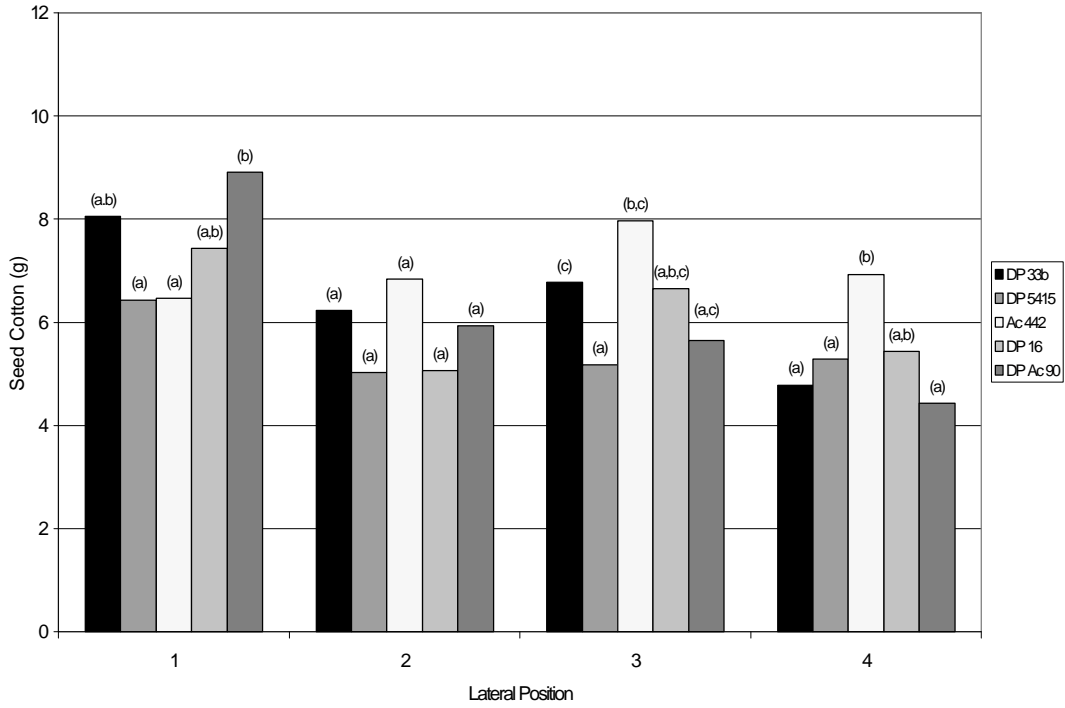


Figure 7. Box mapping results, averages of all fruiting branches for each of the first four lateral fruiting branch sites, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among varieties within a position.

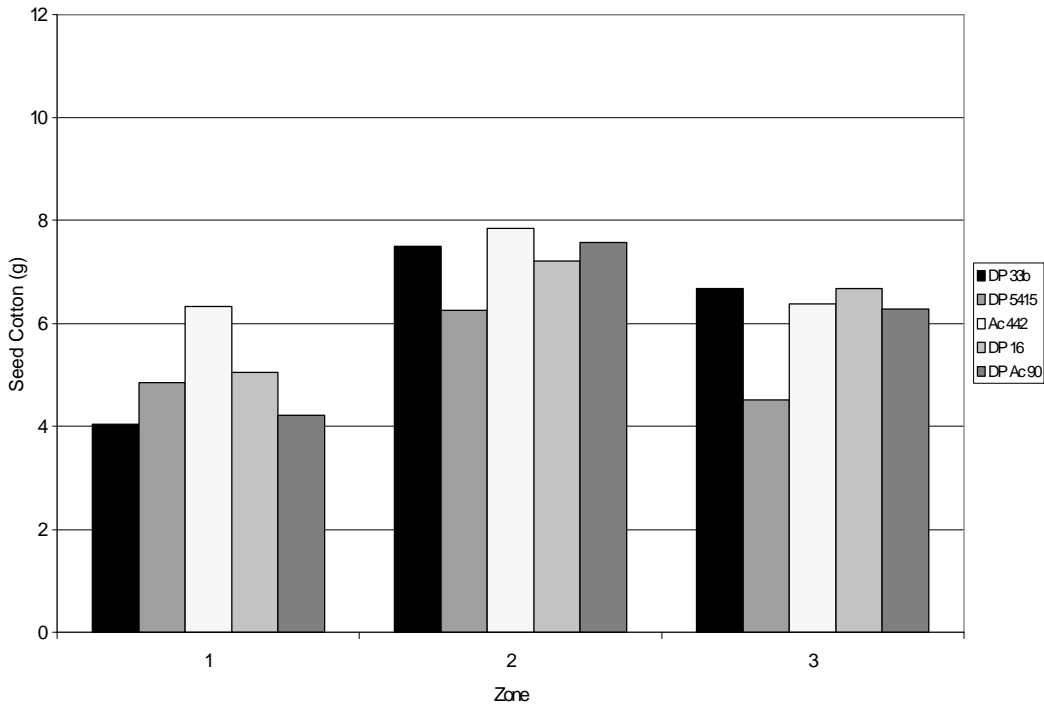


Figure 8. Box mapping results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

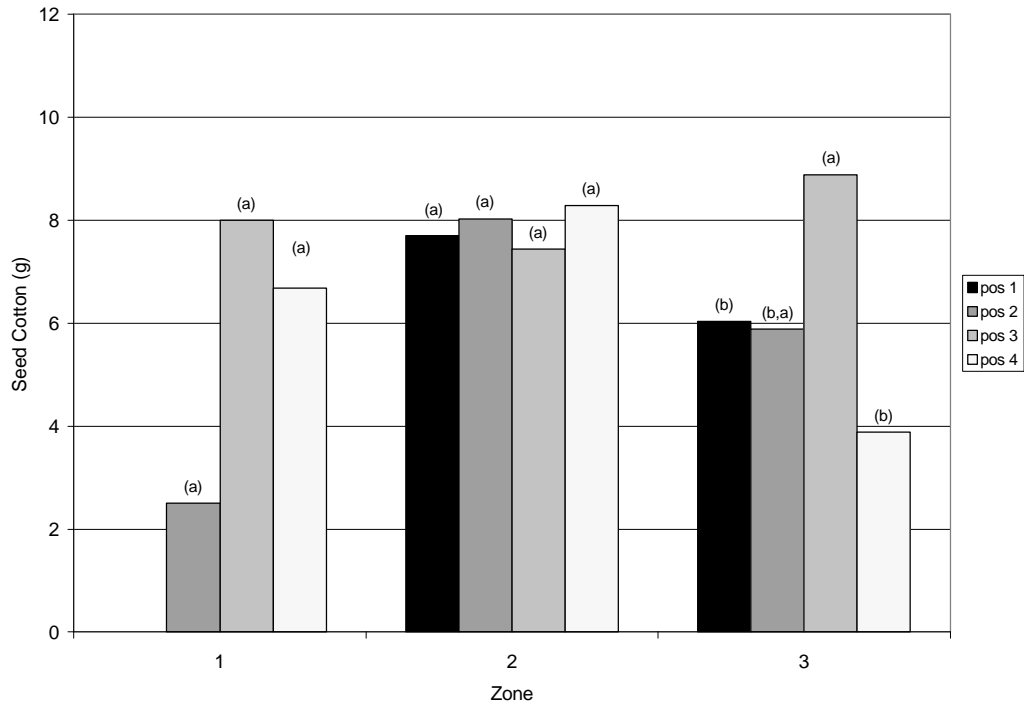


Figure 9. Box mapping results for Acala 442, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

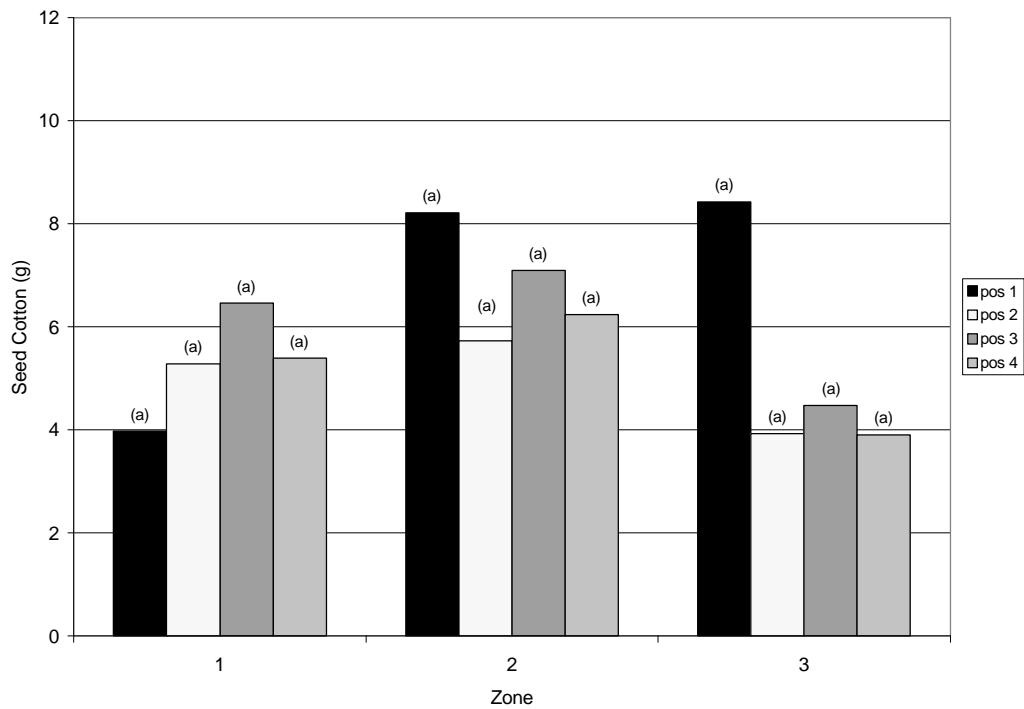


Figure 10. Box mapping results for DP 16, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

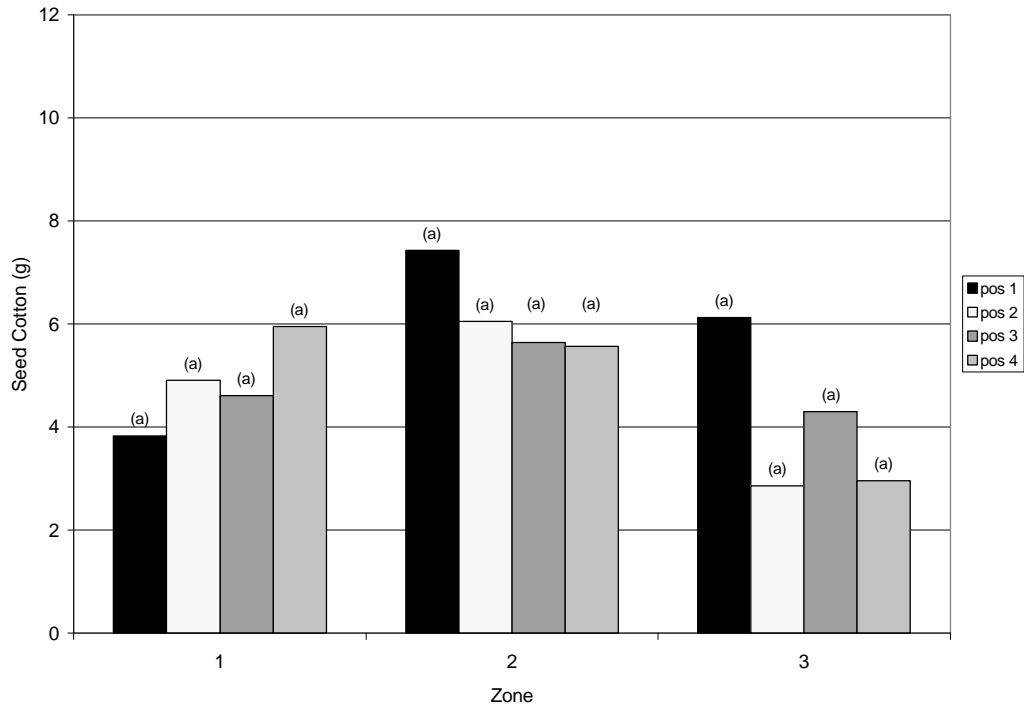


Figure 11. Box mapping results for DP 5415, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

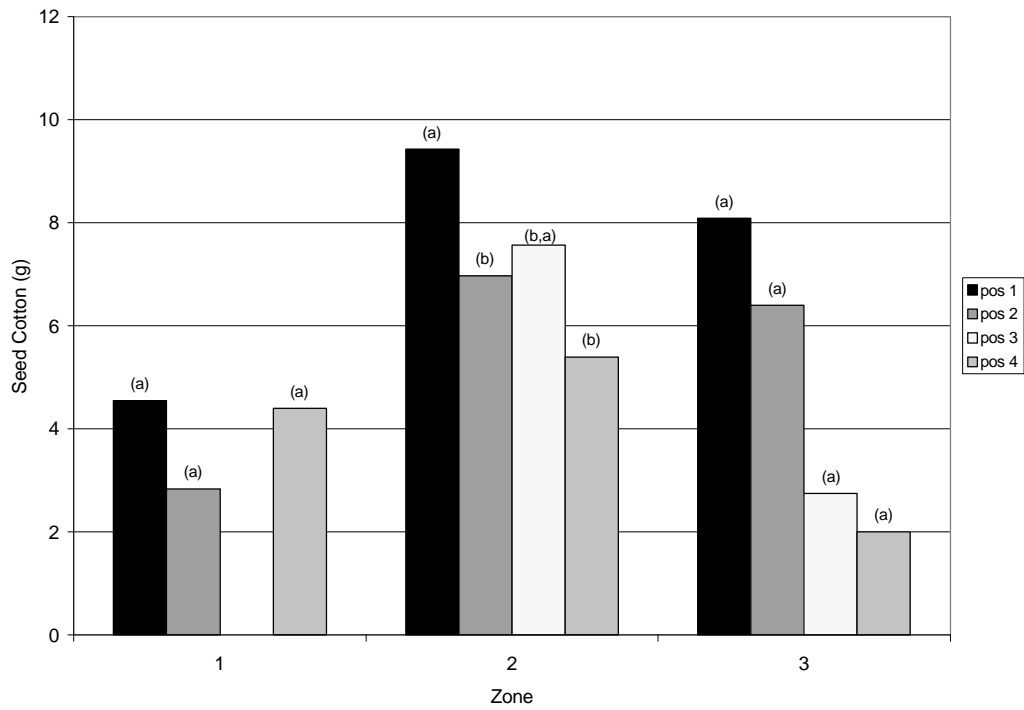


Figure 12. Box mapping results for DP NuCotn 33b, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

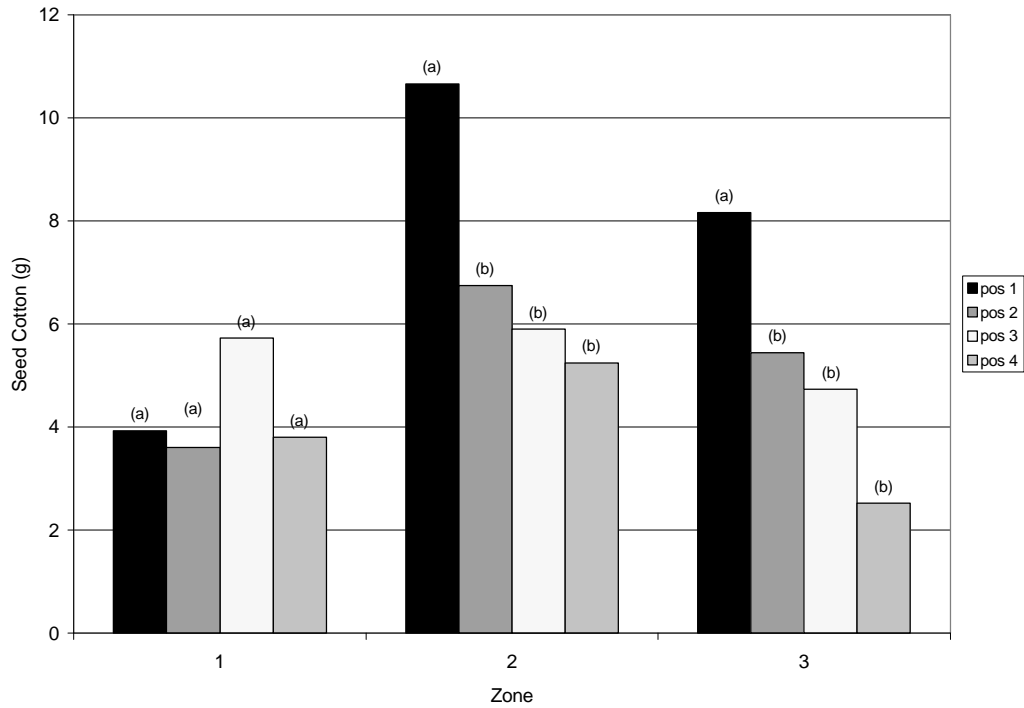


Figure 13. Box mapping results for DP Acala 90, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

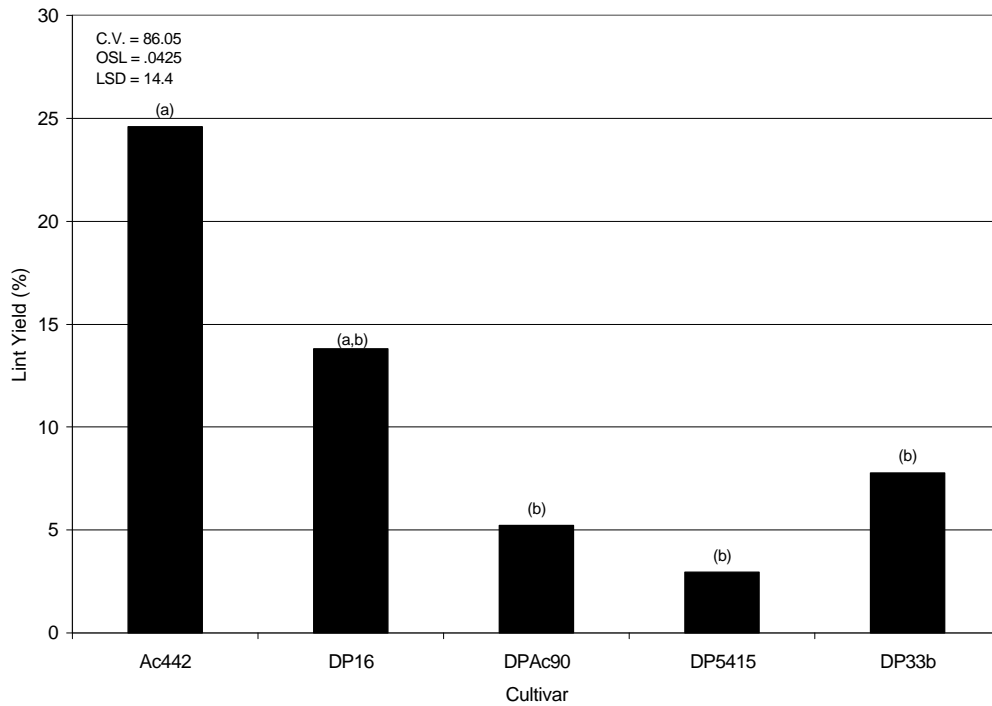


Figure 14. Lint yield from vegetative branches, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.