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

by

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## APPROVAL BY THESIS DIRECTOR

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# DEDICATION

To my parents for all of their support, to Kara for helping me remember to laugh, and to James and C.J. for always believing.

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## ABSTRACT

Many decades of breeding and selection have taken place in an effort to ultimately improve the yield of cotton (*Gossypium spp.*). It has been stated, and is a common belief among many farmers, that modern cotton cultivars are not as good as those now considered obsolete. To explore this concern, a study was conducted in central Arizona in 1999 and 2000 comparing several obsolete and modern Upland (*G. hirsutum* L.) cultivars. It examined growth and development characteristics, fruit retention, and fruiting patterns. Results from this study indicated that an obsolete cultivar was the most efficient with respect to dry matter accumulation and partitioning.

# INTRODUCTION

## 1.1 The Cultivar Problem

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.

The yield of a cotton plant is generally determined by the number of bolls, boll size, and the percentage of lint produced. In theory, increasing one component while holding others constant will result in an increase in total yield. However, in practice, increasing one component of yield tends to cause others to decline due to competition for available growth assimilates (Poehlman and Sleper, 1995).

According to Poelman and Sleper (1995), the characteristic that contributes most to yield is boll number. Therefore, for high-yielding plants must set a large number of bolls. Unfortunately, this is not enough. It is the retention of those bolls that is essential for optimum yield and profit.

Cotton plants grow with a vegetative mainstem and lateral monopodial and sympodial fruiting branches. They must first grow vegetatively in order to produce fruiting sites (Kohel and Benedict 1987). This means that in addition to those assimilates lost to metabolic processes required for continued plant growth, assimilates must be partitioned between these two areas of growth (vegetative and reproductive).

It has been stated, and is a belief among many farmers, that the modern cotton cultivars are not as good as those that are now considered obsolete. Therefore, instead of

only considering how many bolls a plant can produce, it may also be important to look into how these plants are partitioning their assimilates. Further, understanding which cultivars not only produce the highest number of bolls, but are likely to retain those bolls through maturity, would be of great benefit.

Wells and Meredith (1984a, 1984b, 1984c) conducted three studies in an effort to specifically examine the differences in growth and performance among several obsolete and modern cultivars. However, these studies were conducted in the mid-South and there is a marked absence of literature describing similar studies conducted in the desert Southwest within the last 10 years. Therefore, 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 (*G. hirsutum* L.) cultivars grown in an irrigated production system in Arizona.

## 1.2 Review of Literature

### 1.2.1 *Growth and Development Characteristics*

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 a study conducted by Wells and Meredith (1984a), modern Upland cultivars generally produced a maximal vegetative dry weight which was smaller and occurs earlier than their previously released counterparts. This response is partially due to an earlier reduction and eventual termination of dry weight partitioning into vegetative plant portions, especially stems. Their observations suggest that most cultivars in this study produced more leaf area than required to intercept the available light. According to Bridge and Meredith, Jr. (1983), modern cultivars showing increased yield potential had higher lint percentages, smaller bolls, smaller seed, and higher micronaire values than the obsolete cultivars tested.

The Wells and Meredith (1984b) study suggests that cultivar differences in cotton yield were primarily due to differences in the size of reproductive sinks, rather than photosynthetic capacity. Basically, selection for yield has resulted in genotypes with reproductive growth that occurs earlier in relation to the age of the vegetative organs, and therefore, exhibits a greater synchrony with assimilatory activity. The data from this study support the supposition that recently released cultivars partition a greater proportion of growth into reproductive, rather than vegetative plant parts. The modern cultivars (released since 1950) accumulated a greater mass in their reproductive portions and less mass in their vegetative portions. It is likely that the obsolete cultivars lost a greater number of squares as a result of shedding due to the vigorous vegetative growth of the older cultivars. The results from this study further suggest that two mechanisms of major importance have undergone alteration as a consequence of selection processes aimed towards greater lint yields. These mechanisms are : 1) an increased amount of dry

matter routed into reproductive growth and 2) the production of a greater proportion of reproductive constituents earlier in plant development with a greater amount of the fruit developing during the presence of greater leaf area index.

Wells and Meredith (1984c) showed that the percentage of lint has been increased as a result of lint selection cycles and the development of more modern cultivars. The modern cultivars exhibited the greatest lint yields. Modern cultivars initiated more bolls than obsolete cultivars, which may have enhanced interboll competition for photosynthate, resulting in smaller bolls.

Several conclusions can be drawn concerning the differences among old and new cultivars. 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 produce more total dry matter than obsolete cultivars. This indicates that total assimilation has not increased in modern 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, 1984c).

Meredith and Wells (1989) found that there were no detectable differences in total dry matter produced. However, the dry matter was partitioned differently between the obsolete and more modern cultivars. Obsolete cultivars were taller and invested more dry

matter into stems, 41% as compared to 34% for the more modern cultivars. On the other hand, the modern cultivars had 48% of their dry matter in bolls as compared to 39% for the obsolete cultivars.

1.2.2 *Factors Affecting Fruit Retention*

There are several factors that can be responsible for square and boll shedding, however, the following will only focus on a few of those factors. Johnson and Addicott (1967) noted that some studies have indicated that factors such as soil moisture, temperature, boll load, mineral nutrition, light, genotype, applied growth regulators, and insect damage, are among those that may affect the rate and amount of shedding that takes place. When cotton plants are stressed, boll shedding and a cessation of vegetative growth occurs. Growing bolls have priority for plant assimilates, therefore, when the accumulated boll growth rate equals the crop growth rate, vegetative growth ceases and young bolls are shed (Jackson and Gerik, 1990). Further, Jones et al. (1996a) stated that mature cotton plants often exhibit altered fruiting patterns due to the abscission of fruiting forms caused by stress or insect damage during reproductive development.

*(Weather)*

According to Guinn (1982), temporary increases in rates of square and boll shedding can be caused by a period of cloudy weather. This effect can be caused by a resulting decrease in photosynthesis. Some varieties are more sensitive to the light decrease than others. However, it is plants with the heaviest boll loads that are the most sensitive. This is probably due to their heavy demand for photosynthates. Johnson and Addicott (1967) stated that the fact that the highest shedding rates occur under low

light conditions or late in the season when plants are carrying a heavy boll load indicates that the availability of assimilates may be a factor limiting boll retention. Therefore, the key factors in retention seem to be the mobilization of assimilates, and their availability as governed by the growth status of the plant.

*(Position on Plant)*

Jenkins et al. (1990) found that all fruiting sites on the plant did not make equal contributions to yield. Kerby and Buxton (1981) indicated that cotton crops produce many more fruiting sites than mature bolls. During the first few weeks of flowering, the number of flowers that develop into mature bolls is large. However, this usually diminishes as the cumulative number of fruiting positions produced continues to increase.

Guinn (1982) states that the location of squares and bolls 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 high at the first node and decreases at successive lateral nodes out 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. However, retention rates may vary somewhat with spacing, cultivar, and environment.

Kerby and Buxton (1981) presented evidence that adjacent fruiting forms compete, and that the degree of competition affects abortion. They showed that the abortion of the first postion as a square enhanced the probability of boll retention at the

second position. When the first position did not abort until it was a young boll, boll retention of the second position was depressed. They also reported that if insect infestations or other stress conditions result in high square abortion, the losses may be partially offset by an increased set of adjacent positions after the return to more favorable conditions.

*(Insects)*

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, by increasing the shedding of squares and bolls, by damaging the seed and lint, or by a combination of these factors. 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. An indirect stimulus includes a withdrawl of nutrients from leaves, petioles, or stems; or a loss of leaf area due to malformation or abscission. 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. Thrips, boll weevils, cotton bollworm, pink bollworm moth, and leaf feeding insects are also known to cause problems. Jones et al. (1996a) indicated that late-season insect damage can lead to a loss of harvestable bolls. Further, fruit abscission can cause plants to redirect assimilates to alternate sinks and shift dry matter allocation from reproductive to vegetative organs.

*(Cultivar)*

Cultivars often differ in their rates of boll shedding. Patterson et al. (1978) found

that Acala 44, a relatively indeterminate cultivar, retained a low percentage of bolls early in the season and continued to retain about the same or higher percentage later in the season. On the other hand, Deltapine Smooth Leaf initially retained a high percentage of early bolls, which decreased to low values by mid-August, but then increased again in late August and September.

Guinn (1982) indicated that cotton plants with the okra leaf characteristic produced more blooms and shed a higher percentage of their bolls than plants with normal leaves when grown under Arizona conditions. Further, plants with superokra leaves produced even more blooms and shed a higher percentage of their bolls than plants with okra leaves.

Rates of boll shedding of determinate cultivars are typically low at the beginning of the season and increase to almost 100 percent at cutout. During this time, cotton plants almost stop growing and producing flowers. This decline in growth and fruiting and the increase in boll shedding are apparently caused by an increasing boll load. The older bolls serve as powerful sinks for available organic and inorganic nutrients and deprive roots, growing points, and young bolls of the nutrients needed for continued growth. Later, when the older bolls begin to mature, growth and fruiting activities are resumed if the season is sufficiently long (Guinn 1982).

### 1.2.3 *The Cotton Plant's Reaction to Fruit Shed*

Dale (1959) states that the number of fruiting points produced by different plants growing under similar conditions may vary considerably because of the fruiting structure's indeterminate development. Further, the development of new buds on the

plant may compensate for loss of fruiting bodies due to shedding.

According to Holman and Oosterhuis (1999), there are four types of responses in which an individual plant may compensate for square loss. The first is passive and instantaneous, meaning squares are damaged that would have shed anyway. The second is passive and time dependent. In this case, squares that would abscise for reasons other than insect damage are retained, thereby replacing those lost to insect damage. The third response is active and instantaneous. In this instance, resources such as carbon, water, and minerals, which would have been partitioned to the damaged squares are sent to the undamaged ones, leading to larger fruit. The last is active and time dependent. The loss of squares leads to prolonged vegetative growth causing the creation of additional fruiting forms. However, these responses are not mutually exclusive and field observations can usually not be explained by any single response hypothesis.

Experiments have shown that a cotton crop can respond to the removal of fruiting bodies in a number of ways. Increased vegetative growth, increased production of squares, increased flowering, and increased boll weight are among these responses. All of these responses tend to compensate for the fruiting body loss. The result is that these losses often do not decrease yield, however yield build-up is always delayed (Kletter and Wallach, 1982). Several studies have demonstrated that the cotton plant can fully compensate for yield under quite severe damage levels early in the season, provided there are good growing conditions later in the season. However, when fruiting bodies with a high probability of contributing to yield are removed late in the season, the plant cannot compensate for damage (Ungar et al., 1987).

Patterson et al. (1978) showed that the number of cotton flowers produced and the percentage that develop into mature bolls normally decreases rapidly from high values in June to low values during late July and early August, especially in the desert Southwest. They stated that this decrease usually coincides with periods of high humidity and high night temperatures common with the desert monsoon season. This has been suggested as being at least partially responsible for cut-out. Eaton (1931) conducted a study in Arizona which showed that early season defloration resulted in increased yield because of increased boll set and boll size late in the season. Saleem and Buxton (1976) found that vegetative and reproductive growth compete for available plant carbohydrates and that development of a heavy boll load reduces the carbohydrate level. This reduction may be important in stimulating high abortion rates of fruiting forms and reducing new vegetative growth necessary to support development of additional fruiting forms.

Patterson et al. (1978) also found that plant boll load exerts a large influence on fruiting behavior in cotton. Deltapine Smooth Leaf, which has a more determinate growth habit, was more responsive to alterations of boll load by defloration than Acala 44.

Early maturity is sometimes associated with a low first fruiting node position, rapid early node production, and greater retention of fruiting forms. Numerous fruit removal studies have demonstrated that enhanced cotton vegetative growth and development result from reproductive sink removal. These studies showed increased plant height, increased total vegetative dry weight, increased nodal development and

branching, larger leaves, a greater leaf area index, and a lengthening of anthesis. Fruit removal also increased square production, flower production, delayed the termination of anthesis, and increased fruit retention (Jones et al. 1996b).

Dale (1959) found that increased growth of sympodial branches, and production of more and larger secondary sympodia from buds that would normally remain dormant, were responses of plants to bud removal. Kletter and Wallach (1982) found that normal shedding of square and bolls considerably reduced the effect of fruit removal, because many of the fruit would have been shed naturally. This mechanism reduced the effect of late season damage to small squares. The crop compensated for damage by increasing the rate of flowering late in the season, increasing the percentage of bolls set, and increasing boll weight. However, the possibility of compensation is reduced by the lateness, both in terms of the growth pattern of the crop and in terms of calendar date, at which the damage takes place (Ungar et al., 1987).

### 1.3 Thesis Format

This thesis includes a summary of the study that is appended as a manuscript. The manuscript is a comparison of modern and obsolete cultivars for irrigated production in Arizona and has been published in Cotton, A College of Agriculture Report University of Arizona. I played an active role in the field work and data analysis of the experiments conducted. I was also responsible for writing the paper that is included in Appendix A.

## PRESENT STUDY

The methods, results, and conclusions of this study are presented in the manuscript appended to this thesis. The following is a summary of the most important findings in that manuscript.

## 2.1 Summary of Results

### *2.1.1 Growth and development characteristics*

Vegetative growth tendencies were approximately the same for all cultivars in 1999 and 2000. The cultivars did not become excessively vegetative and there were no differences among cultivars in maturity or progression towards cut-out. There were also no significant differences in reproductive dry matter produced among cultivars in either year. Reproductive index values differed significantly ($P<0.05$) with the obsolete cultivar, DP 16, possessing the highest value in both years.

### *2.1.2 Fruiting patterns and retention*

Plant mapping and flower tagging techniques were used to evaluate fruit retention (FR) throughout the growing season. There was a very close relationship between the flower tagging data and the FR estimates provided by routine plant measurements and mapping. FR levels were relatively low for all cultivars in 1999, but improved in 2000. Box mapping results exhibited a general trend indicating the majority of yield was produced at fruiting branches 10 through 18 at position 1 in 1999 and 2000. In 1999, obsolete cultivars produced significantly higher amounts of seedcotton on vegetative branches than modern cultivars. However, there were no such differences in 2000.

## 2.2 Summary of Conclusions

DP 16 did not differ significantly from modern cultivars with respect to lint yield in 1999, and did not differ from modern cultivar DP 5415 in 2000. Reproductive index values indicated that the obsolete cultivar DP 16 was the most efficient with respect to dry matter partitioning.

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

This manuscript will be submitted for publication in the Agronomy Journal or the Journal of Cotton Science.

## Abstract

A study was conducted at the University of Arizona Maricopa Agricultural Center (MAC) in 1999 and 2000 to compare growth and development characteristics and determine differences in fruiting patterns 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. Results from both years indicated that the majority of yield was produced at fruiting branches 10 through 18 and at position one. In 1999, lint yield results indicated no significant differences among all cultivars tested, except for Acala 442, which was significantly lower than all others. Further, obsolete cultivars produced significantly higher amounts of seedcotton on vegetative branches than modern cultivars. In 2000, lint yield results indicated that there were significant differences among all cultivars tested. Acala 442 continued to be significantly lower than all other cultivars. There were no significant differences in the amount of seedcotton produced on vegetative branches among modern and obsolete cultivars. In both years, Deltapine 16, followed by NuCotn 33b, had the highest reproductive index and was the most efficient cultivar grown with respect to dry matter accumulation and partitioning.


## Introduction

Cotton (*Gossypium spp.*) has been modified over many decades of breeding and selection in an effort to ultimately improve yield and quality. 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 cultivars 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 a sufficient plant structure to support fruiting branches and fruiting sites. A crop production system usually allows the cotton plant to grow, establish a boll load, and mature these bolls. In the modification of cotton from a perennial to an annual growth habit, plant breeders have selected cotton plants that have a reduced 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 produce 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 number 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 factors. 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 often causing 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 of fruit abortion includes a physiological withdrawl 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 (*G. hirsutum* L.) 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.

## Materials and Methods

The present study was conducted in 1999 and 2000 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 1999 and 13 April 2000 with obsolete (Acala 442 and Deltapine (DP) 16) and modern (DP Acala 90, DP 5415 and DP NuCotn 33b) Upland 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 prior to peak bloom for a total of 184 kg N/ha applied in 1999. Similar split applications were made in 2000 for a total of 166 kg N/ha applied. Nine in-season irrigations were made of approximately 152 mm each for a total of 1368 mm in 1999. In 2000 similar irrigations were made of approximately 109 mm each for a total of 1100 mm. The first post-plant irrigations were applied on 28 May 1999 and 27 May 2000. Final irrigations were applied on 31 August 1999 and 30 August 2000. Plots were managed through cut-out for complete first fruiting cycle development.

Crop growth and development measurements were taken throughout the season on approximately 14 day intervals consisting of the following measurements: plant

height, number of mainstem nodes, node of the first fruiting branch, aborted sites at positions one and two, and the number of nodes above the top white flower (NAWF). The aboveground portions of entire plants were collected from 1 $m^2$ 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 reproductive index (RI) values, which is the ratio of reproductive biomass to total biomass produced.

A three meter row segment (3 $m^2$ 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 1999 and continued until irrigation termination. The final date of tagging was 17 September 1999. Tags were collected from all plots on 3 November 1999. In 2000, tagging began on 20 June and continued until irrigation termination. The final tagging date was 11 August, and tags were collected on 18 September.

After the field was defoliated, five plants from each plot were collected from non-harvest rows. A wooden box forming a matrix of 20 rows and 4 columns was used to represent the fruiting branches (rows) and fruiting positions (columns) on a cotton plant. Seedcotton was removed from each sympodial branch and placed in the corresponding location (fruiting branch and position) in the box. The bolls harvested on each fruiting branch (with the cotyledonary nodes counted as zero) at positions one through four were

recorded independently. Seedcotton within each box was bagged and labeled according to fruiting branch and position. An electronic balance was used to determine the weight of the seedcotton. 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 and Discussion

Fruit retention (FR) and plant vigor (height to node ratios, HNR) patterns for1999 and 2000 are shown in Figures 1 and 2 respectively. Vegetative growth tendencies were approximately the same for all cultivars except DP 16 and DP Acala 90. None of the cultivars approached the upper threshold that indicates highly vegetative growth tendencies, (Silvertooth and Norton, 1998) DP 16 possessed a lower HNR than the other cultivars 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) (Figure 3).

Fruit retention was uncommonly low for all cultivars throughout the entire 1999 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 5. This common relationship between these data sets reinforces the use of general plant mapping as an indicator of FR.

In 2000, all cultivars remained close to the HNR baseline, indicating growth tendencies that were not excessively vegetative (Figure 2). DP 5415 and DP Acala 90 exhibited slightly higher HNR values, indicating taller more vegetative plants. There were also no differences among cultivars in progression towards cut-out (Figure 4).

Fruit retention levels improved in 2000, however, levels were low due to fleahopper (*Pseudatomoscelis seriatus* R.) damage early in the season. Control efforts were exercised and the crop was able to partially recover. This decrease in FR was also detected in the tag collection data presented in Figure 6.

In 1999, 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, best described with the results for the last sampling date (3573 HUAP). Reproductive index (RI) values differed significantly ($P<0.05$) for DP 16, DP 5415, and Acala 442, with DP 16 having the highest value of the three (Table1). There were no significant differences detected for the reproductive dry matter results for the five cultivars (Table 3 and Figure 9). However, the vegetative dry matter results differed significantly (Table 5 and Figure 7). In 1999, DP 16 produced a significantly lower amount of vegetative dry matter than all other cultivars except DP NuCotn 33b. This relates to the high RI value found with DP 16 (Figure 11).

In 2000, there were no significant differences in the reproductive dry matter results for the last sampling date (3371 HUAP) (Table 4 and Figure 10). There were also no significant differences in the vegetative dry matter results (Table 6 and Figure 8). However, the RI values differed significantly. The RI value for DP 16 was significantly ($P<0.05$) higher than those for DP 5415 and Acala 442, but DP 5415 and Acala 442 did

not differ from one another. DP Acala 90 was significantly higher than Acala 442 (Table 2 and Figure 12).

Lint yield results indicated a significantly lower yield for Acala 442 than all other cultivars (Table 7). Collectively, the data in Tables 1, 3, 5, and 7 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 2000, DP NuCotn 33b and DP 5415 produced significantly ($P<0.05$) higher lint yields than all other cultivars. DP Acala 90 and DP 16 had yields that were significantly higher than Acala 442 (Table 8). The data in Table 2 indicates that DP 16 continued to be the most efficient cultivar grown in terms of dry matter accumulation and partitioning.

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 in 1999. Significant differences were found among cultivars within positions 1, 3, and 4. (Figure 13).

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 in zone 1 (Figure 15). Within zone 2, position 1 produced the greatest yield for every cultivar except Acala 442 (Figures 17, 19,

21, 23, and 25). Yield at the third position was significantly higher ($P<0.05$) than positions 1 and 4 in zone 3 for Acala 442. No retained bolls were found in zone 1 for position 1 (Figure 17). Yield at the first position was significantly higher ($P<0.05$) than positions 2 and 4 in zone 2 for DP NuCotn 33b. No bolls were retained in zone 1 for position 3. (Figure 23). The first position was significantly higher ($P<0.05$) than positions 2-4 for zones 2 and 3 for DP Acala 90 (Figure 25). The decreased yield in zone 1 was attributed to fruit damage and losses caused early in the season by lygus. Vegetative branches produced a substantial amount of the total yield for most cultivars. The percentage of 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 27).

In 2000, all of the cultivars generally exhibited a fruiting pattern of decreasing yield with further lateral position. Significant differences were only found among cultivars within position 1 (Figure 14). The general trend showed the majority of the yield was produced in zone 2, followed by zones 1 and 3 (Figure 16). Acala 442 and DP 16 were the only cultivars with no significant differences among zones indicating a uniform vertical fruiting pattern. Yield in zone 2 was significantly ($P<0.05$) higher than in zone 3 for DP NuCotn 33b, DP 5415, and DP Acala 90. In zone 2, position 1 was significantly ($P<0.05$) higher than position 2-4 for DP 16 and Acala 442. Bolls were not retained for position 4 in zone 3 for DP 16, DP 5415, and DP NuCotn 33b (Figures 18, 20, 22, 24, and 26). The percentage of yield produced by vegetative branches was substantial, but did not differ significantly among cultivars.

## Summary

Fruit retention was relatively low for all cultivars in this study for 1999. This low FR was attributed to the extensive lygus infestions that occurred in 1999. 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 cultivars. 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, insect damage, etc.) 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 seedcotton 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 cultivar grown with respect to dry matter partitioning.

In 2000, fruit retention was improved for all cultivars, although some loss occurred due to fleahoppper damage. Growth tendencies were not excessively vegetative and were similar for all cultivars. Flower tagging again demonstrated a very close relationship with FR estimates provided by routine plant measurements and mapping. The general trend indicating the majority of yield being produced in zone 2 at position 1 was consistent with 1999 results. There were no significant differences in the amount of seedcotton produced on vegetative branches in obsolete versus modern cultivars. The

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Table 1. Reproductive index results for each cultivar, 1999.

| Cultivar | Reproductive Index | | |
|---|---|---|---|
| | (1804 HUAP) | (2584 HUAP) | (3573 HUAP) |
| DP 16 | 7.6 a* | 12.2 a* | 39.5 a* |
| DP NuCotn 33b | 2.1 b | 7.3 b | 33.6 a b |
| DP 5415 | 2.3 b | 4.4 c | 29.1 b |
| DP Acala 90 | 1.3 b | 4.6 b c | 27.3 b c |
| Acala 442 | 2.5 b | 2.9 c | 20.6 c |
| LSD** | 3.6224 | 2.801 | 6.8377 |
| OSL † | 0.0178 | <0.0001 | 0.0008 |
| C.V. (%)‡ | 74.82 | 28.94 | 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 index results for each cultivar, 2000.

| Cultivar | Reproductive Index | | |
|---|---|---|---|
| | (1742 HUAP) | (2334 HUAP) | (3371 HUAP) |
| DP 16 | 5.5 a* | 19.8 a* | 51.0 a* |
| DP NuCotn 33b | 4.3 a b | 14.8 a c | 48.6 a |
| DP 5415 | 2.7 b c | 10.2 b | 43.4 b c |
| DP Acala 90 | 2.2 c | 11.1 b c | 46.9 a c |
| Acala 442 | 5.8 a | 16.8 a | 40.0 b |
| LSD** | 2.0699 | 4.531 | 5.173 |
| OSL † | 0.0037 | 0.0197 | 0.0078 |
| C.V. (%)‡ | 27.61 | 20.21 | 6.01 |

* 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. Reproductive dry matter results for each cultivar, 1999.

| Cultivar | Dry Matter (kg/ha) | | |
|---|---|---|---|
| | (1804 HUAP) | (2584 HUAP) | (3573 HUAP) |
| DP 16 | 156.5 a* | 593.6 a* | 4179.8 a* |
| DP NuCotn 33b | 25.5 a | 367.7 b | 4388.6 a |
| DP 5415 | 35.5 a | 240.4 b c | 3872.3 a |
| DP Acala 90 | 25.3 a | 280.7 b c | 3636.2 a |
| Acala 442 | 49.0 a | 177.7 c | 2750.7 a |
| LSD** | NS | 188 | NS |
| OSL † | 0.0525 | 0.0037 | 0.1303 |
| C.V. (%)‡ | 106.73 | 36.75 | 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 4. Reproductive dry matter results for each cultivar, 2000.

| Cultivar | Dry Matter (kg/ha) | | |
|---|---|---|---|
| | (1742 HUAP) | (2334 HUAP) | (3371 HUAP) |
| DP 16 | 144.3 a c* | 1086 a* | 4995 a* |
| DP NuCotn 33b | 103.5 a b c | 810.8 a | 6057 a |
| DP 5415 | 69.3 b | 615.8 a | 5301.3 a |
| DP Acala 90 | 62.3 b | 664.5 a | 4986.8 a |
| Acala 442 | 161.0 a | 1020.5 a | 4217.5 a |
| LSD** | 74.92 | NS | NS |
| OSL † | 0.0128 | 0.1202 | 0.0609 |
| C.V. (%)‡ | 34.41 | 28.48 | 14.43 |

* 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 5. Vegetative dry matter results for each cultivar, 1999.

| Cultivar | Dry Matter (kg/ha) | | |
|---|---|---|---|
| | (1804 HUAP) | (2584 HUAP) | (3573 HUAP) |
| DP 16 | 1763.3 a* | 4401.8 a* | 6903.0 a* |
| DP NuCotn 33b | 1231.3 a | 4665.1 a | 8714.0 a b |
| DP 5415 | 1494.8 a | 5018.8 a | 9749.0 b |
| DP Acala 90 | 1774.0 a | 5559.4 a | 10287.0 b |
| Acala 442 | 1727.3 a | 5732.1 a | 10831.0 b |
| LSD** | NS | NS | 2313.7 |
| OSL † | 0.2737 | 0.2369 | 0.0225 |
| C.V. (%)‡ | 24.27 | 17.68 | 16.15 |

* 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 6. Vegetative dry matter results for each cultivar, 2000

| Cultivar | Dry Matter (kg/ha) | | |
|---|---|---|---|
| | (1742 HUAP) | (2334 HUAP) | (3371 HUAP) |
| DP 16 | 2427.0 a* | 4401.5 a* | 4766.0 a* |
| DP NuCotn 33b | 2290.5 a | 4628.8 a | 6498.8 a |
| DP 5415 | 2497.3 a | 5544.8 a | 6919.5 a |
| DP Acala 90 | 2676.5 a | 5394.3 a | 5670.5 a |
| Acala 442 | 2649.8 a | 5165.8 a | 6467.8 a |
| LSD** | NS | NS | NS |
| OSL † | 0.7110 | 0.5314 | 0.4586 |
| C.V. (%)‡ | 17.40 | 15.34 | 17.49 |

* 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 7. Lint yield results for each cultivar, 1999.

| Cultivar | Yield (kg lint/ha) |
|---|---|
| DP NuCotn 33b | 1408 a* |
| DP Acala 90 | 1396 a |
| DP 16 | 1324 a |
| DP 5415 | 1303 a |
| Acala 442 | 981 b |
| LSD** | 140.7 |
| OSL † | <0.0001 |
| 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

Table 8. Lint yield results for each cultivar, 2000.

| Cultivar | Yield (kg lint/ha) |
|---|---|
| DP NuCotn 33b | 1700 a* |
| DP Acala 90 | 1455 b |
| DP 16 | 1429 b |
| DP 5415 | 1640 a |
| Acala 442 | 1064 c |
| LSD** | 108.6 |
| OSL † | <0.0001 |
| C.V. (%)‡ | 4.84 |

* 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

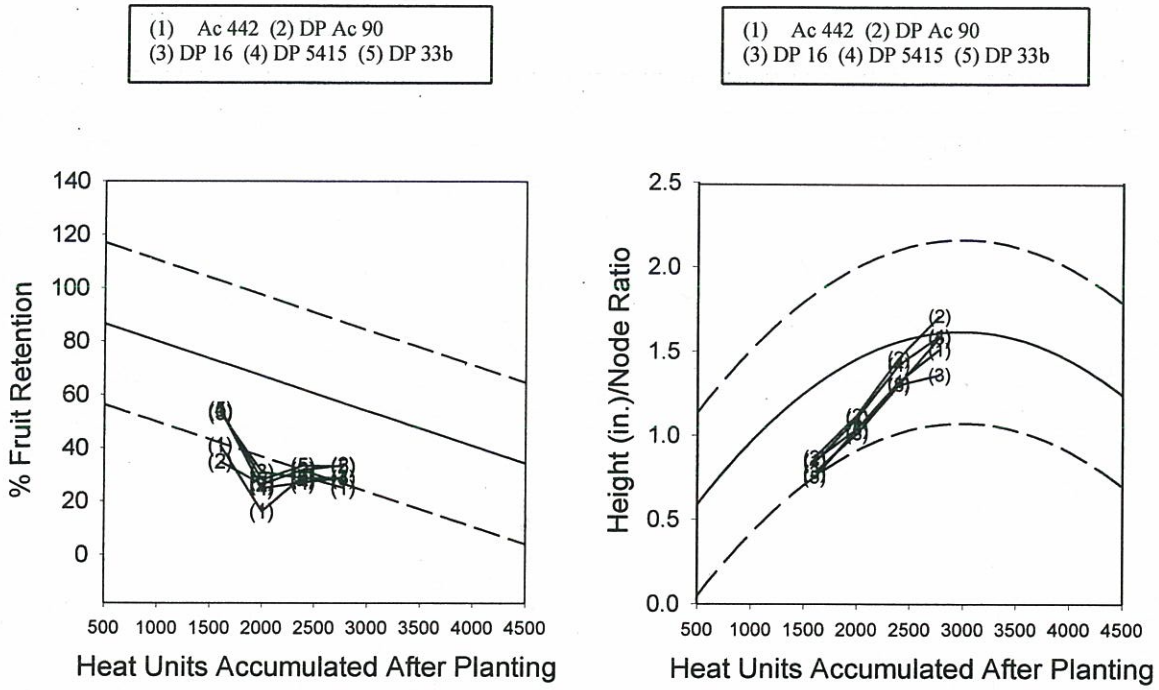


Figure 1. Fruit retention and height to node ratio results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

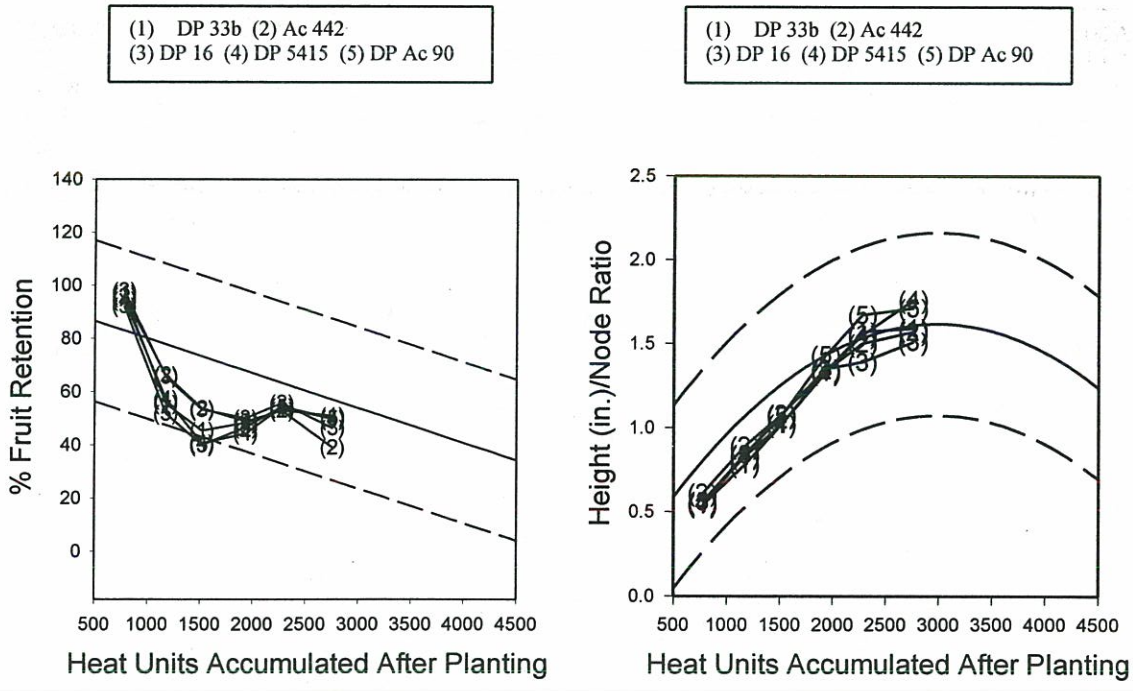


Figure 2. Fruit retention and height to node ratio results, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000.

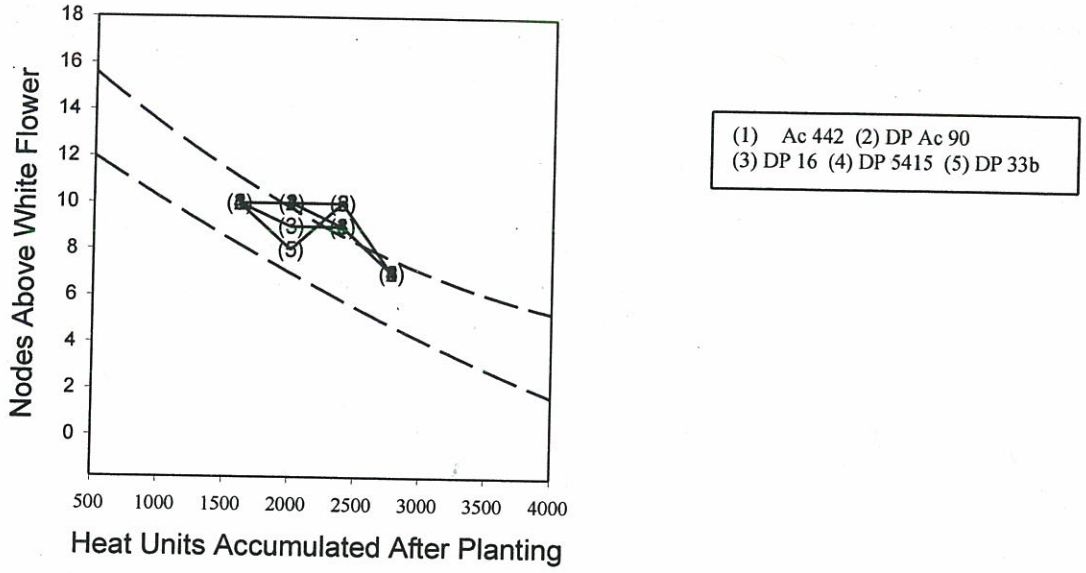


Figure 3. Nodes above white flower results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

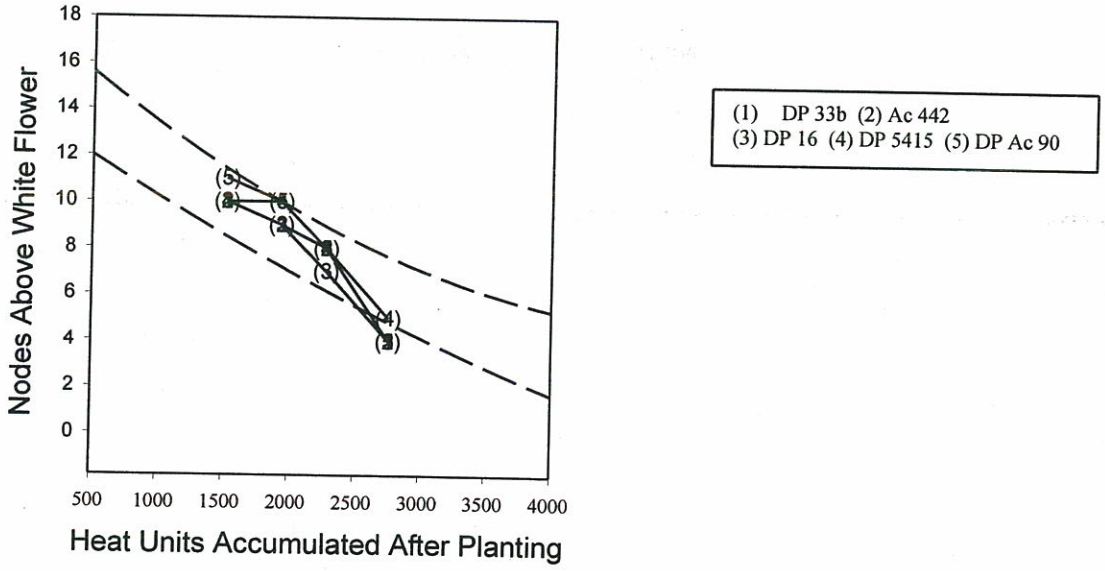


Figure 4. Nodes above white flower results, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000.

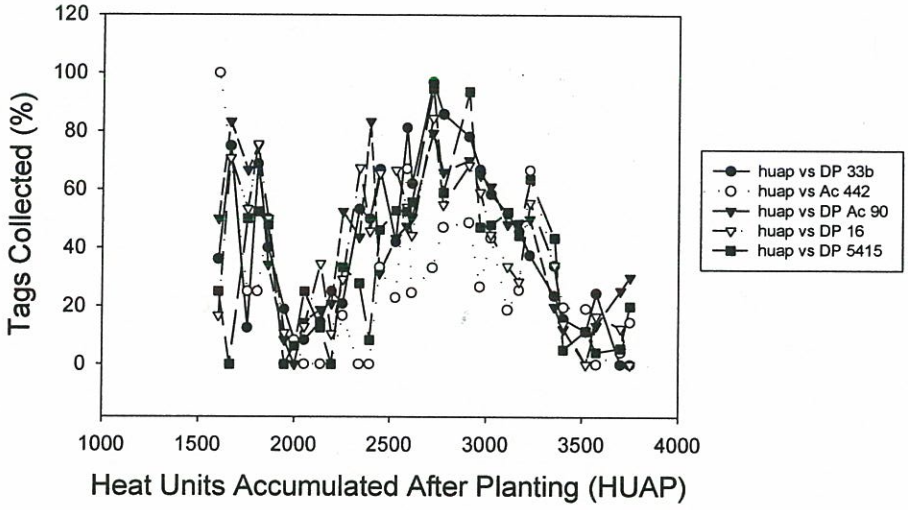


Figure 5. Tag collection results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

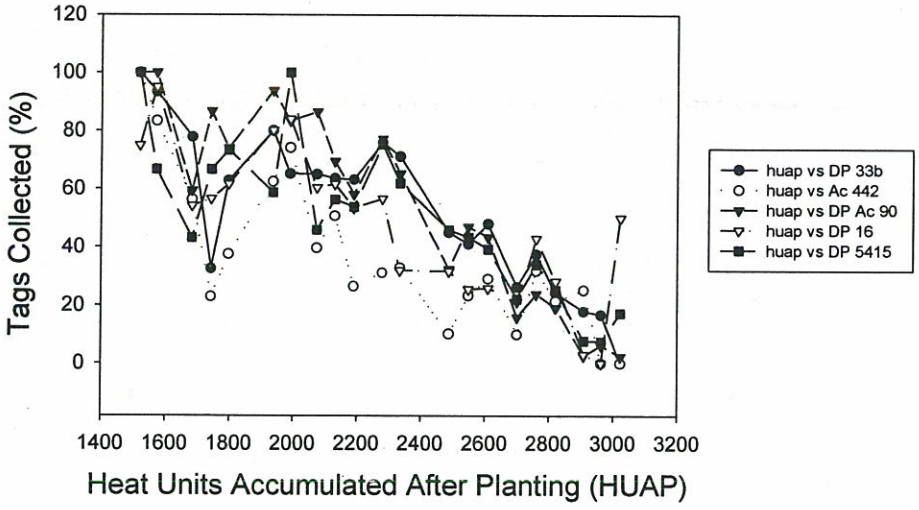


Figure 6. Tag collection results, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000.

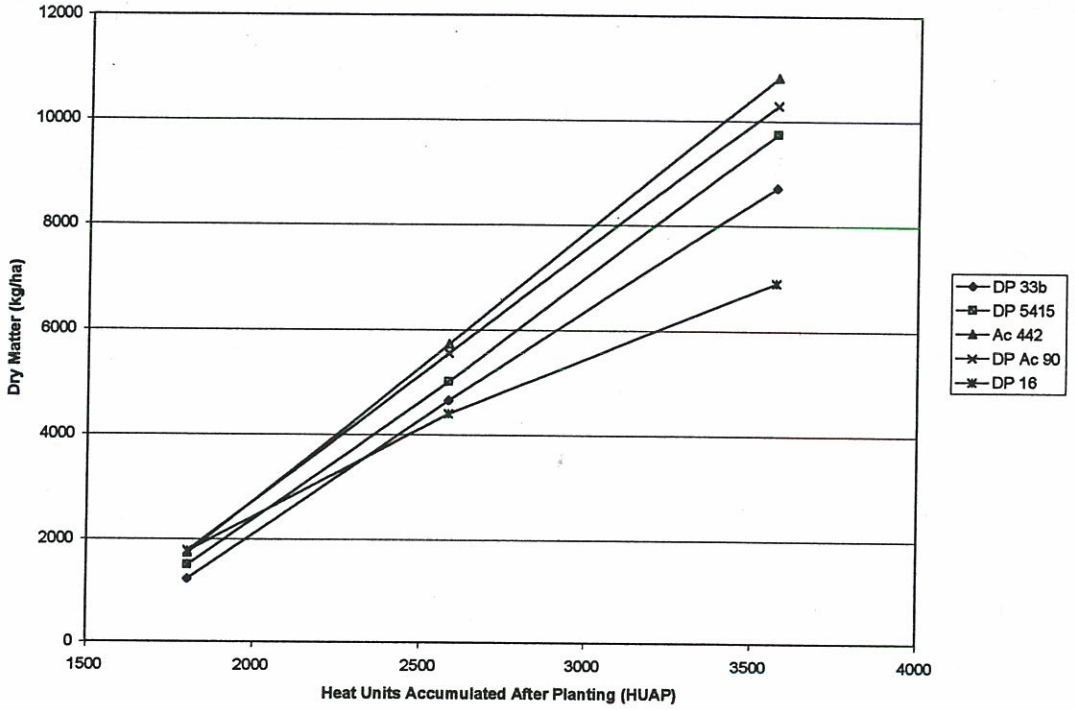


Figure 7. Vegetative dry matter results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

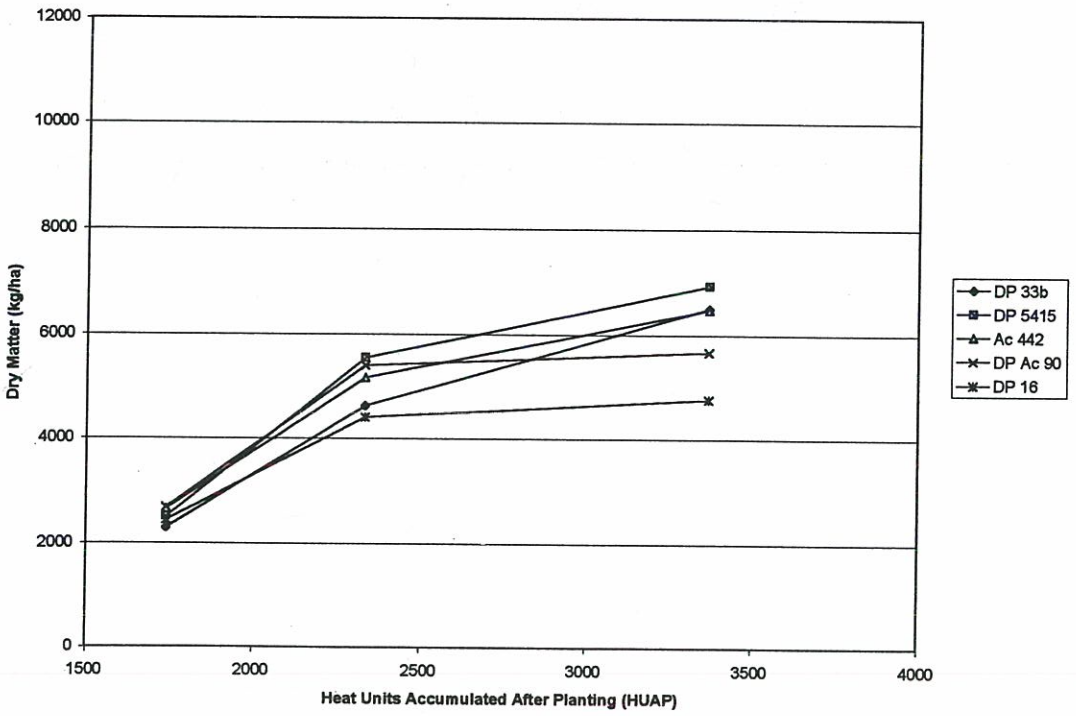


Figure 8. Vegetative dry matter results, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000.

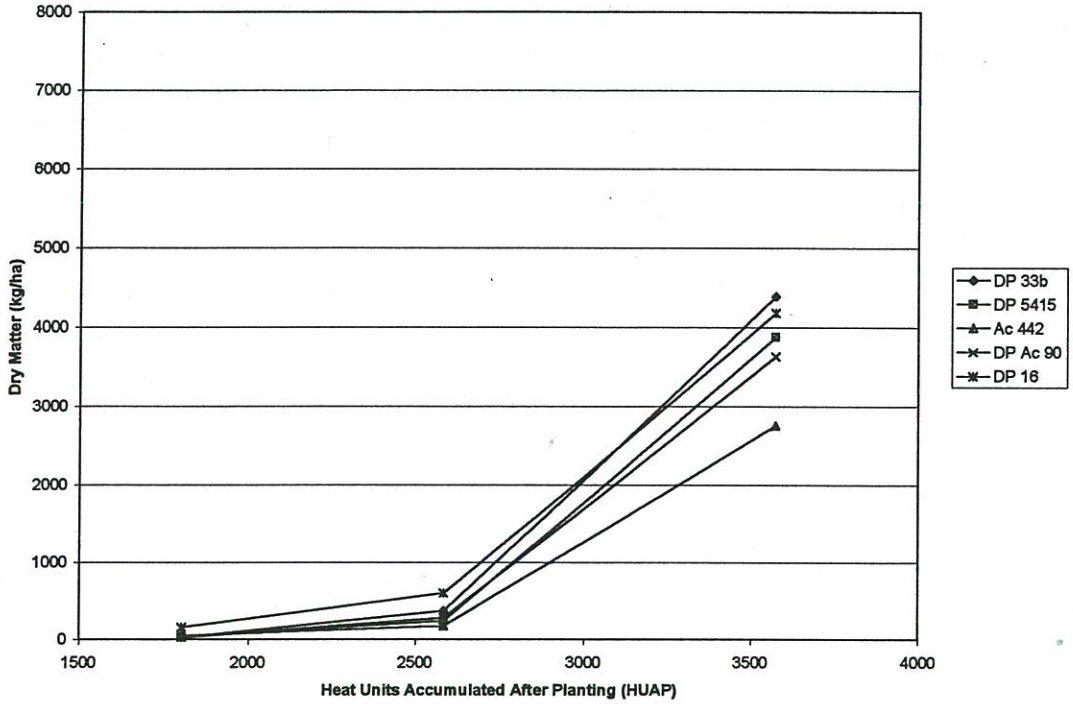


Figure 9. Reproductive dry matter results, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

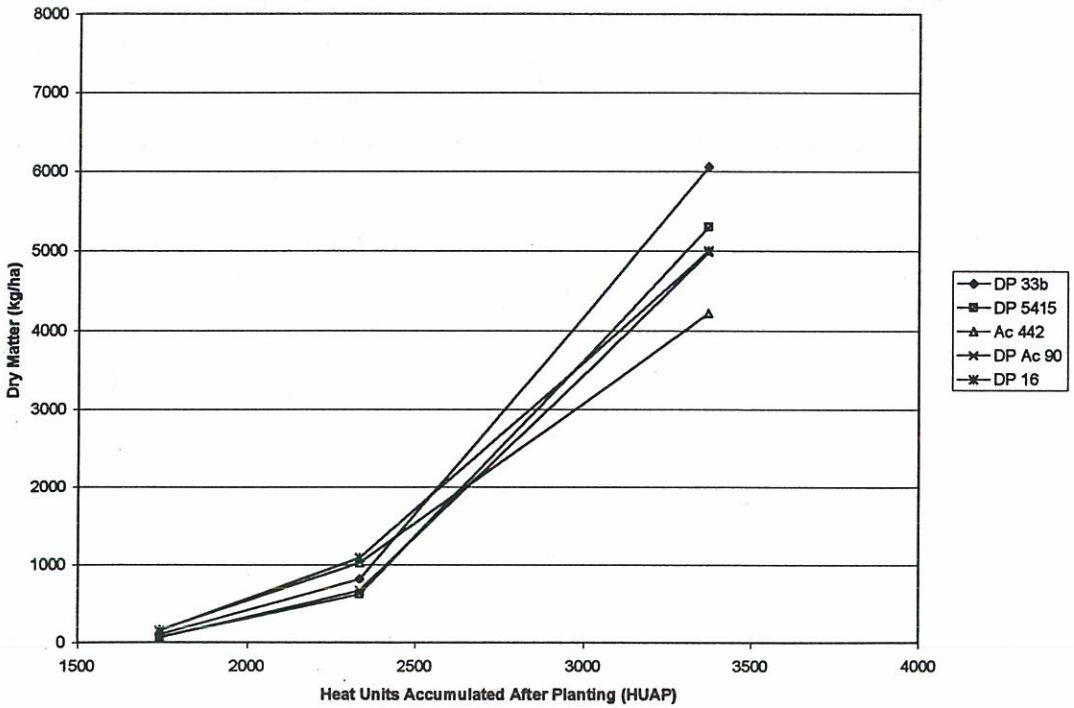


Figure 10. Reproductive dry matter results, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000.

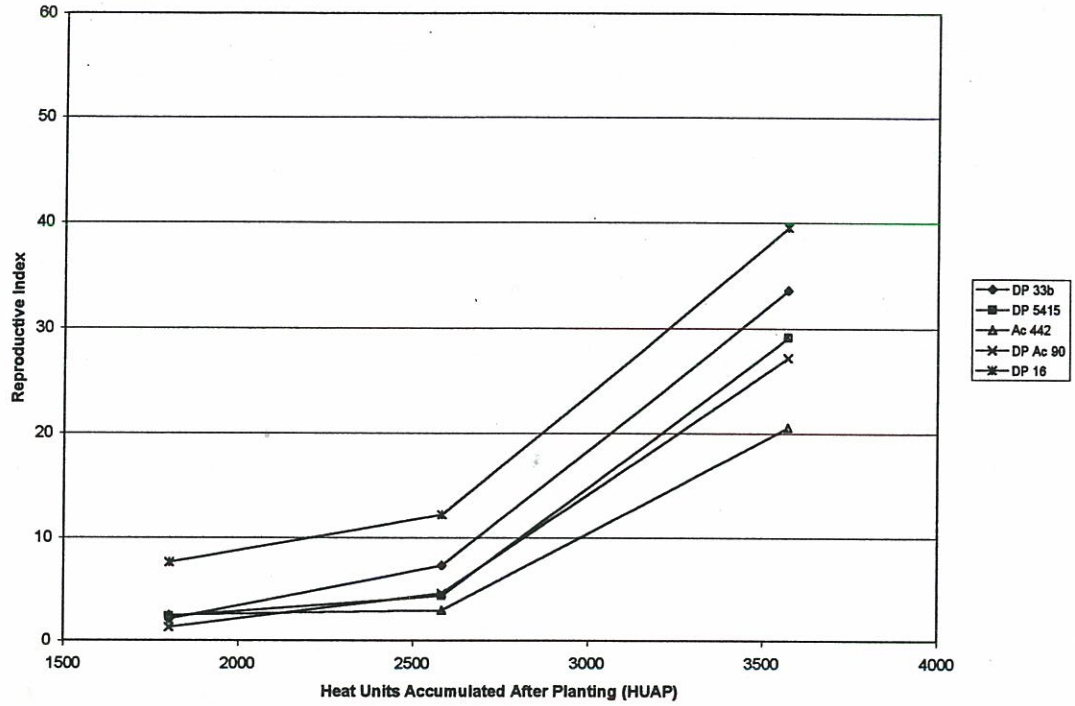


Figure 11. Reproductive index results, obsolete cultivar comparision study, Maricopa Agricultural Center, 1999.

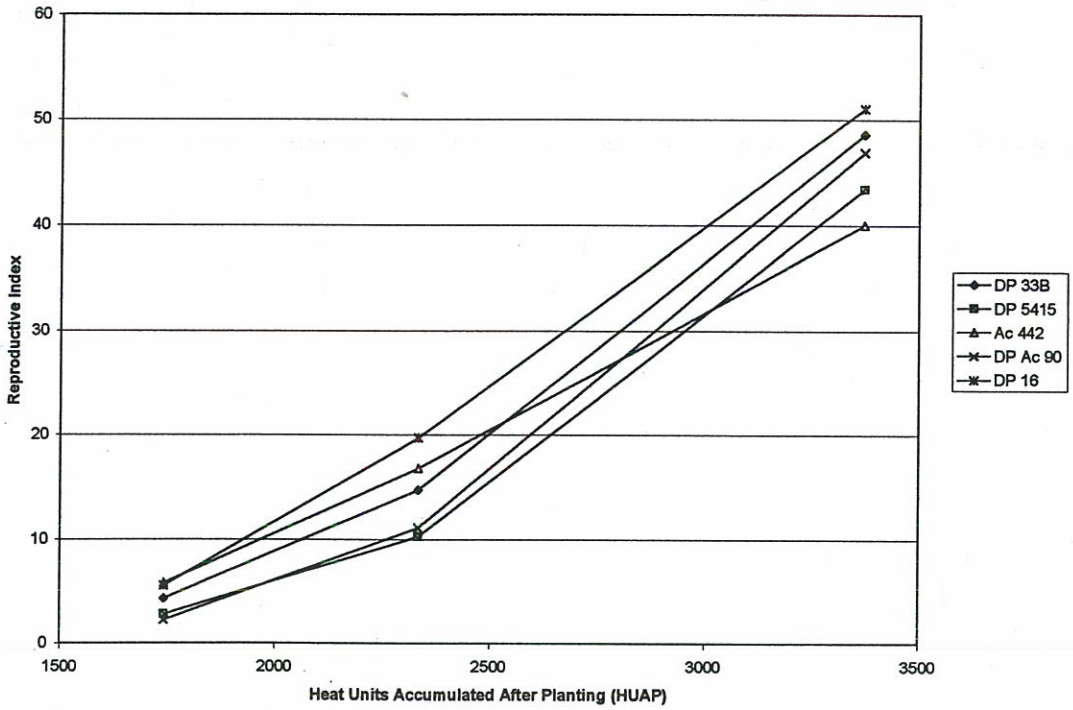


Figure 12. Reproductive index results, obsolete cultivar comparision study, Maricopa Agricultural Center, 2000.

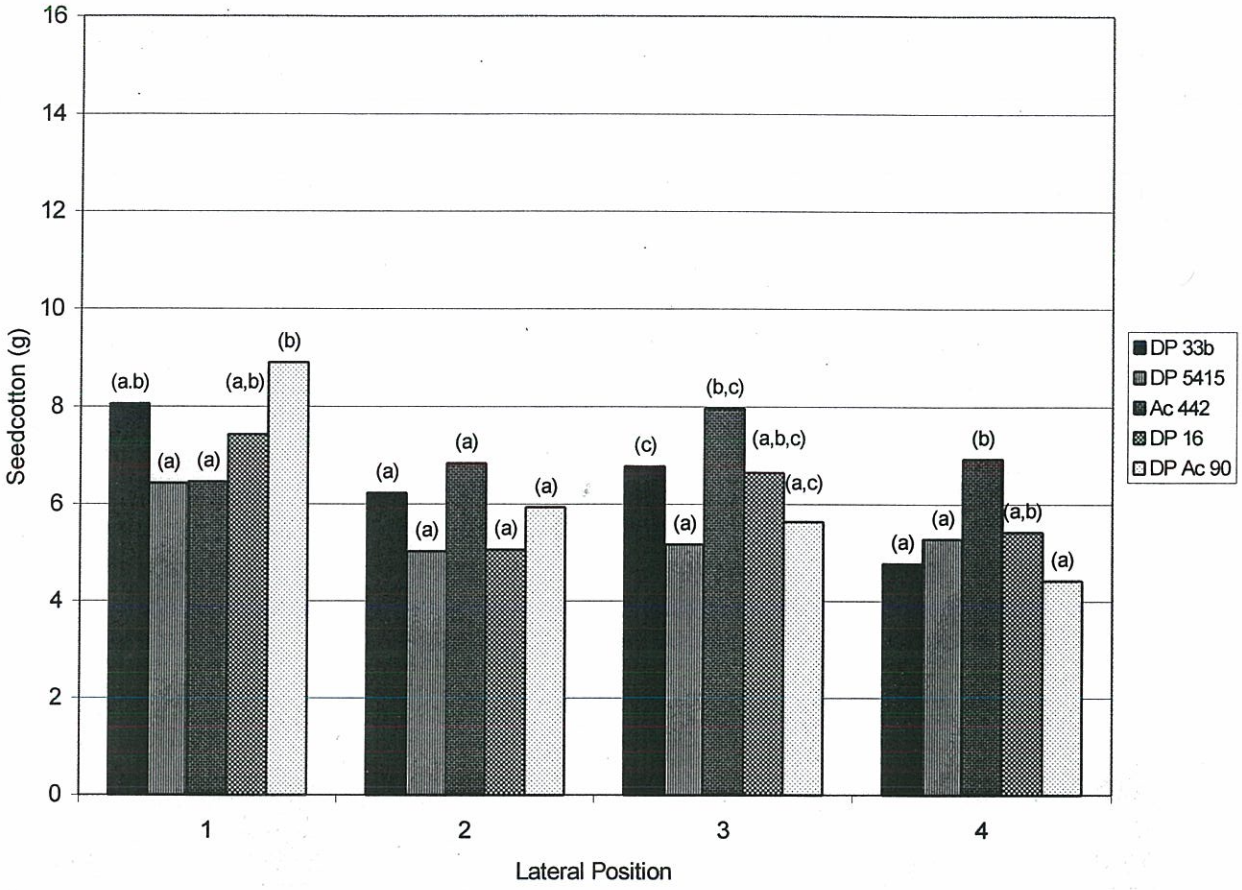


Figure 13. Box mapping results, averages of all fruiting branches for each of the first four lateral fruiting branch sites, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among cultivars within a position.

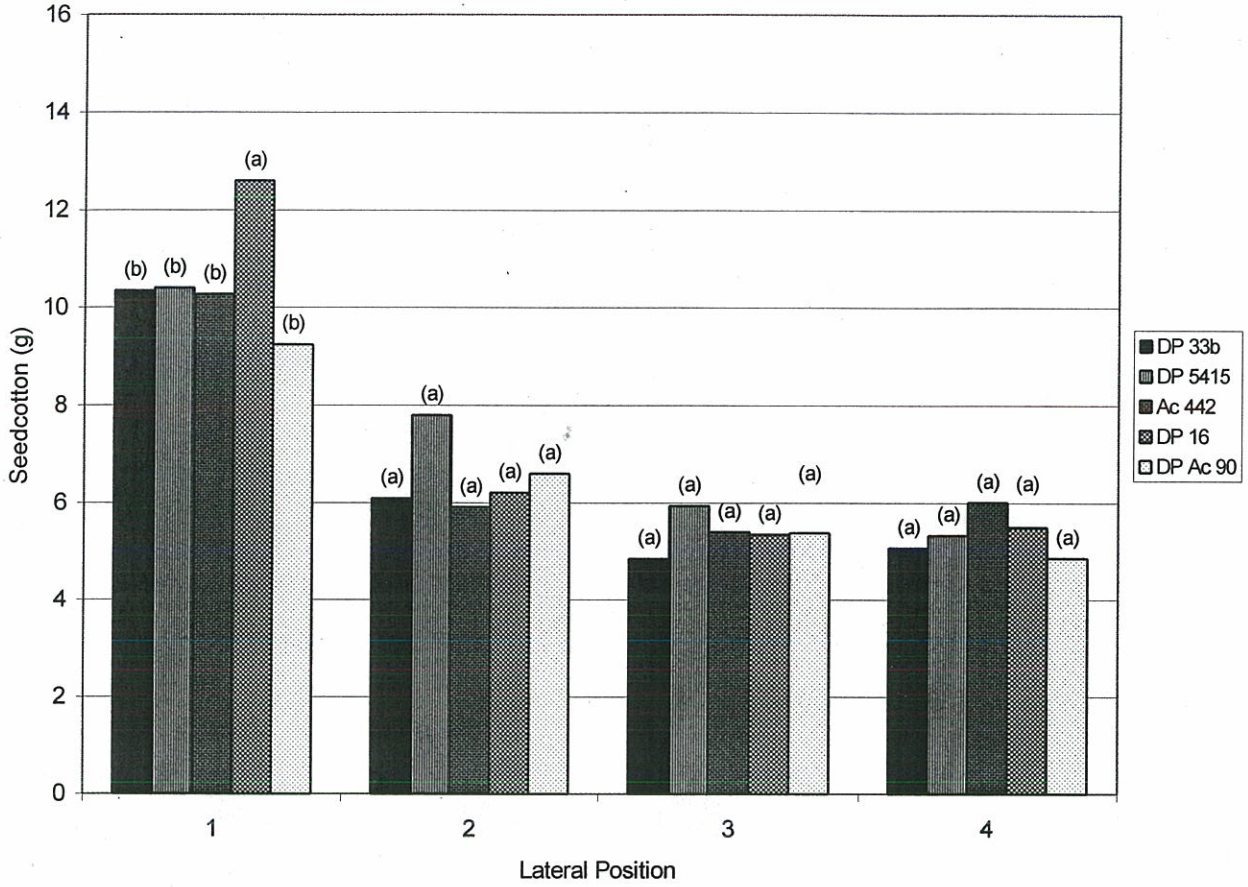


Figure 14. Box mapping results, averages of all fruiting branches for each of the first four lateral fruiting branch sites, obsolete cultivar comparision study, Maricopa Agricultural Center, 2000. Bars labeled with the same letter are not significantly different among cultivars within a position.

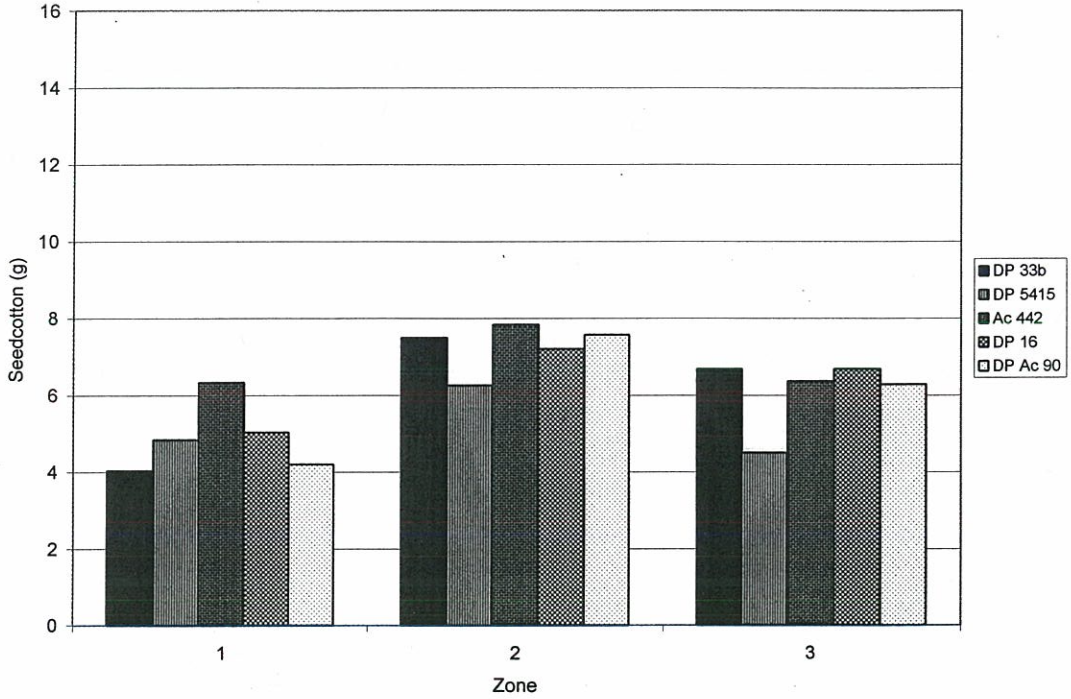


Figure 15. Box mapping results by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

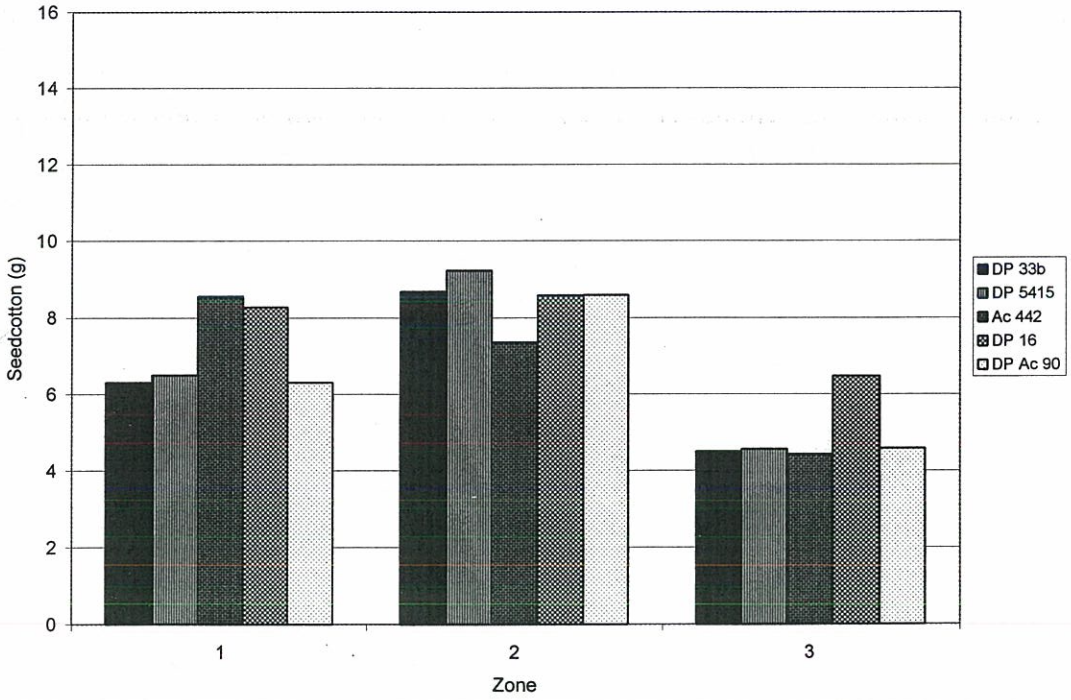


Figure 16. Box mapping results by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000.

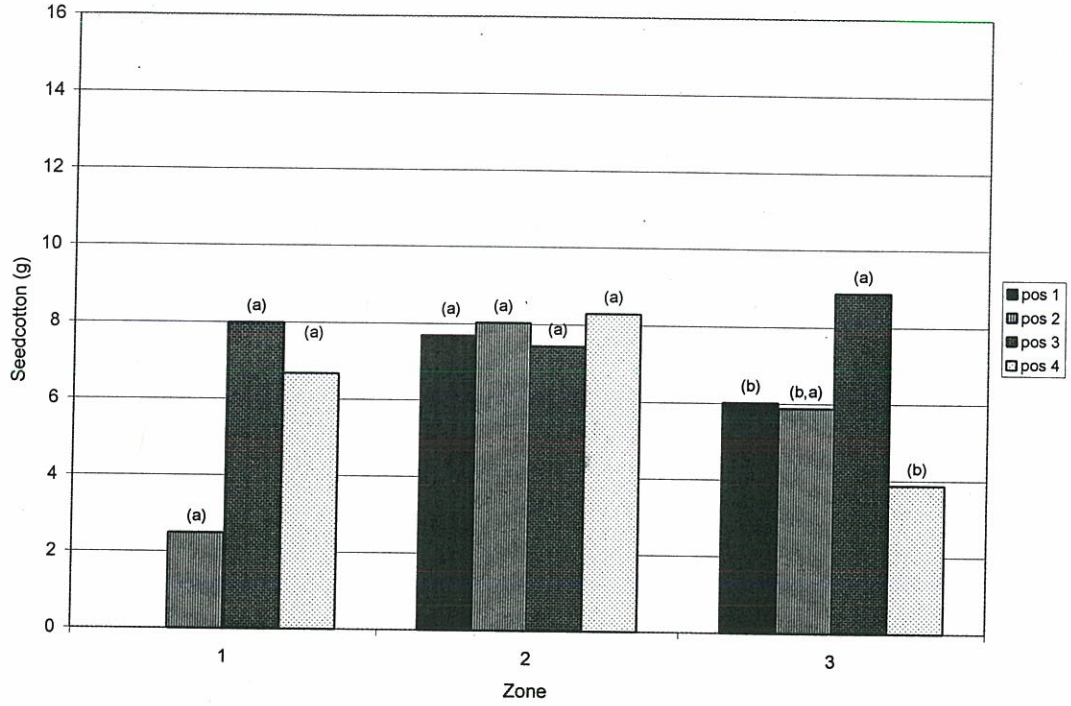


Figure 17. Box mapping results for Acala 442, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

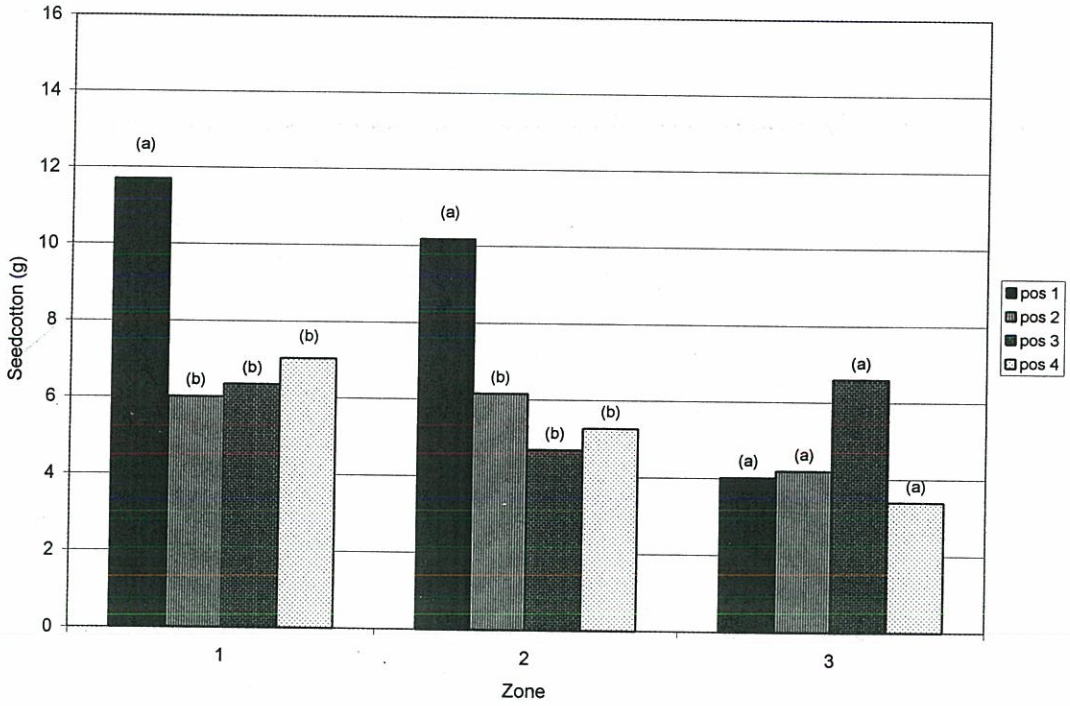


Figure 18. Box mapping results for Acala 442, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000. Bars labeled with the same letter are not significantly different among positions within a zone.

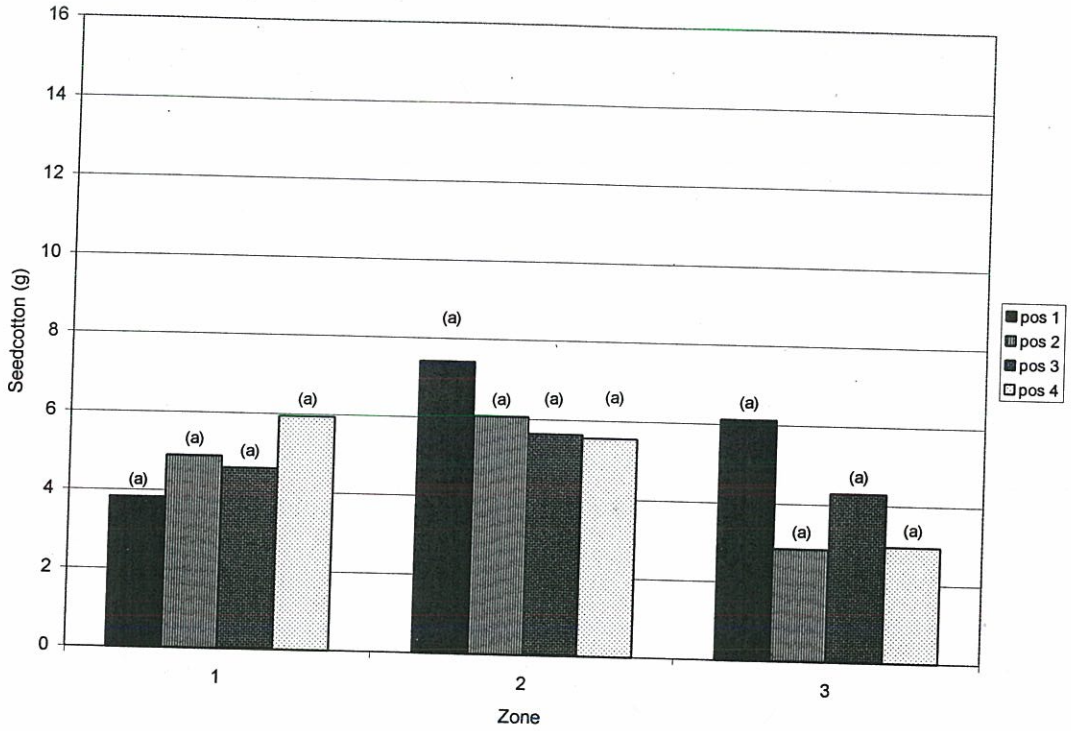


Figure 21. Box mapping results for DP 5415, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

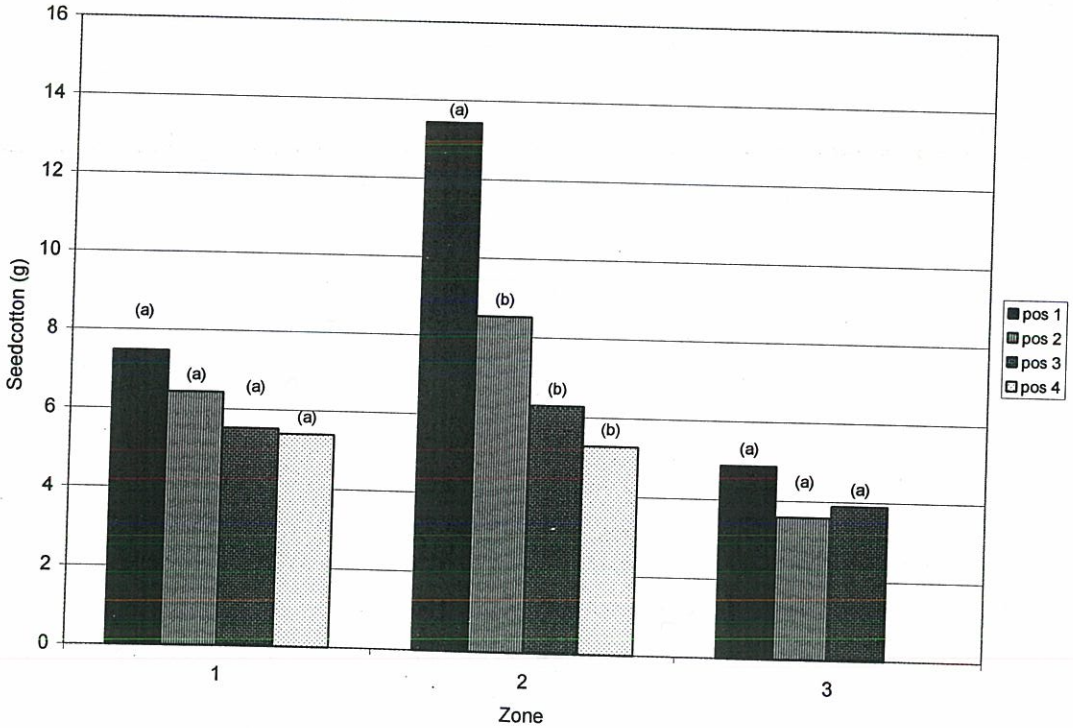


Figure 22. Box mapping results for DP 5415, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000. Bars labeled with the same letter are not significantly different among positions within a zone.

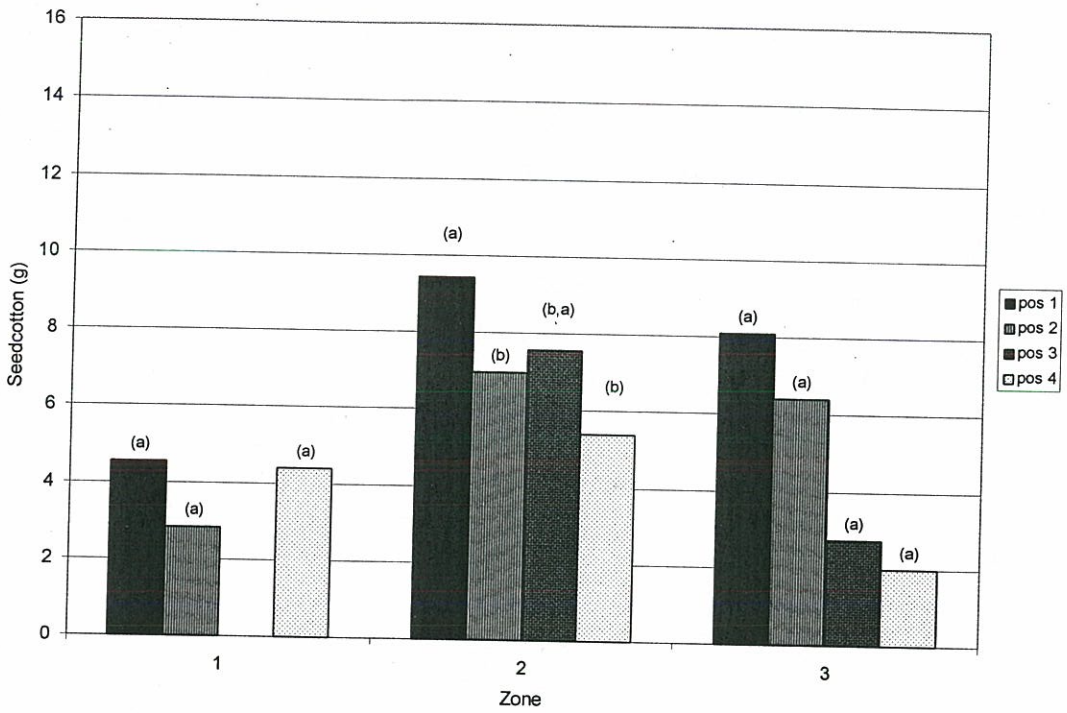


Figure 23. Box mapping results for DP NuCotn 33b, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

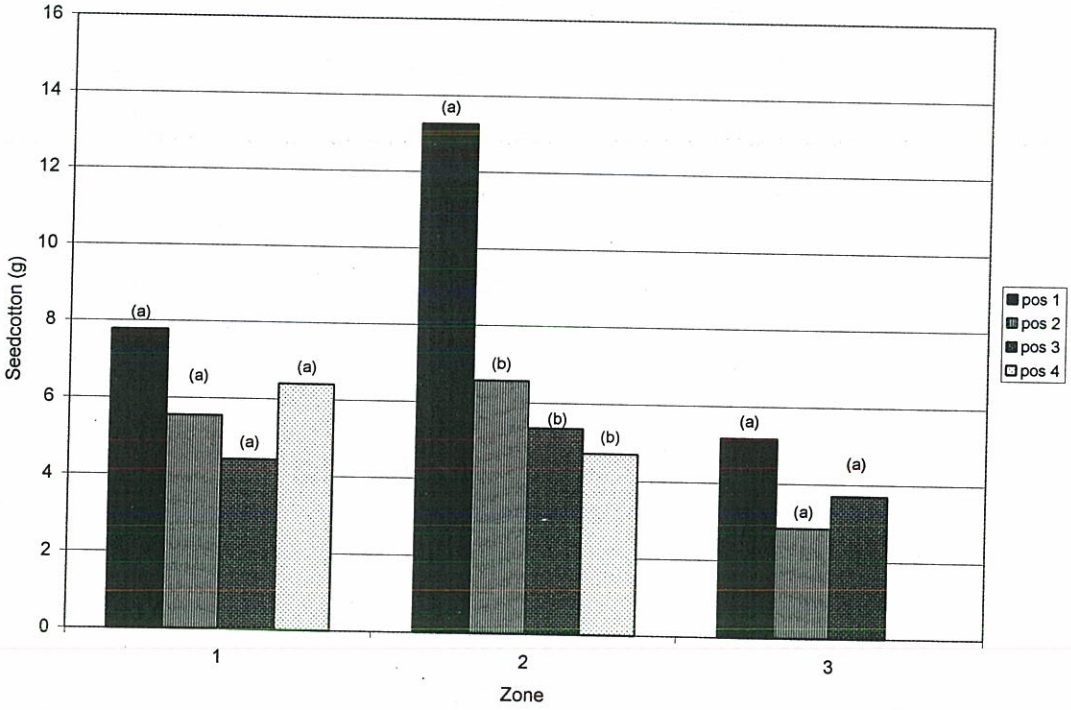


Figure 24. Box mapping results for DP NuCotn 33b, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000. Bars labeled with the same letter are not significantly different among positions within a zone.

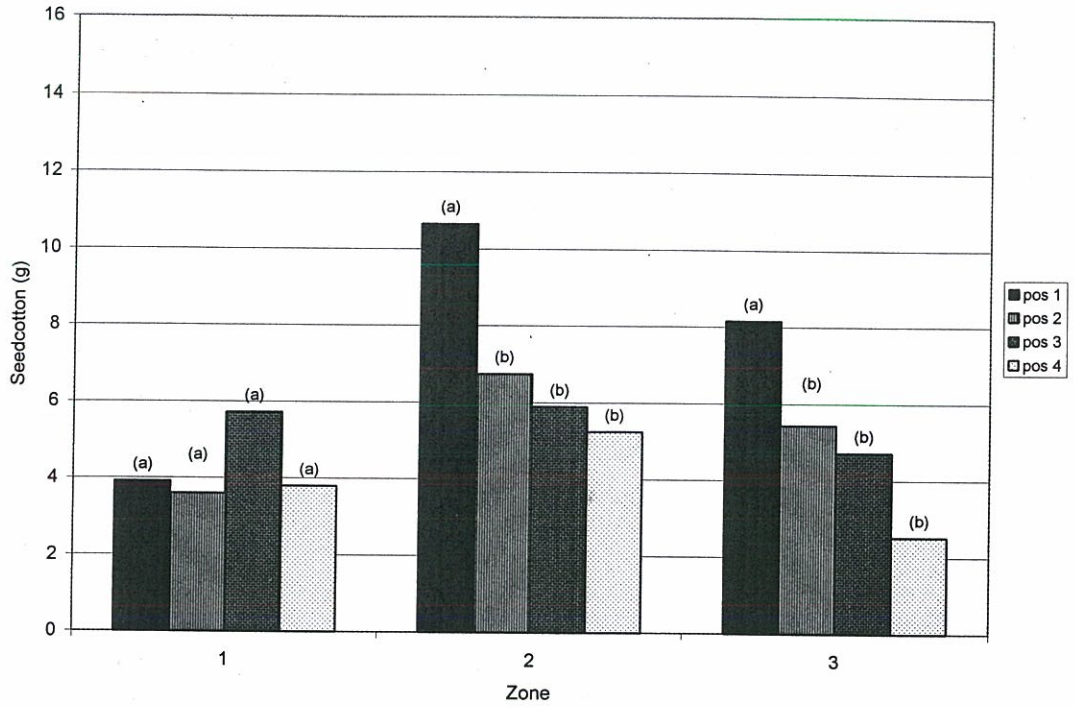


Figure 25. Box mapping results for DP Acala 90, by zone, obsolete cultivar comparision study, Maricopa Agricultural Center, 1999. Bars labeled with the same letter are not significantly different among positions within a zone.

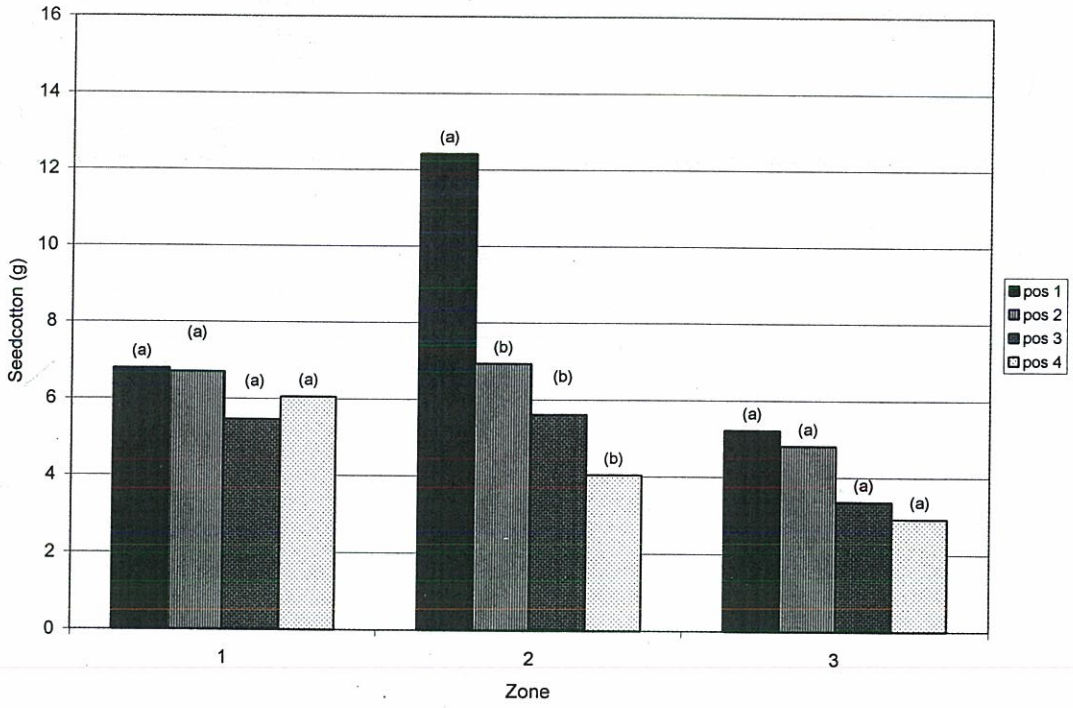


Figure 26. Box mapping results for DP Acala 90, by zone, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000. Bars labeled with the same letter are not significantly different among positions within a zone.

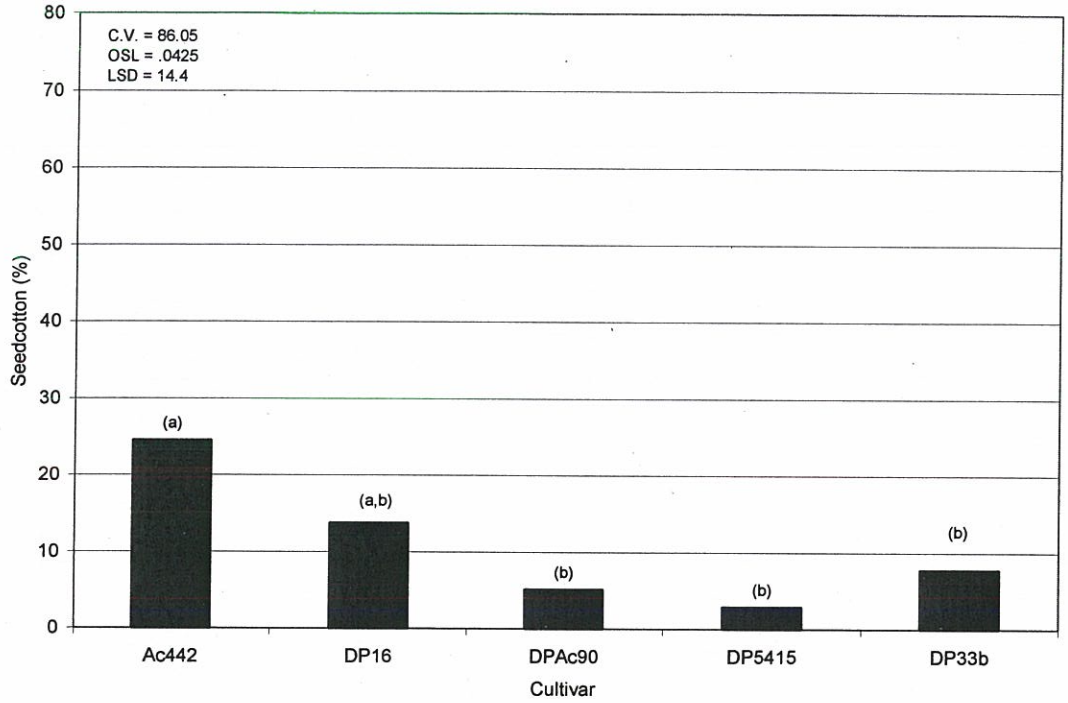


Figure 27. Box mapping results, yield from vegetative branches, obsolete cultivar comparison study, Maricopa Agricultural Center, 1999.

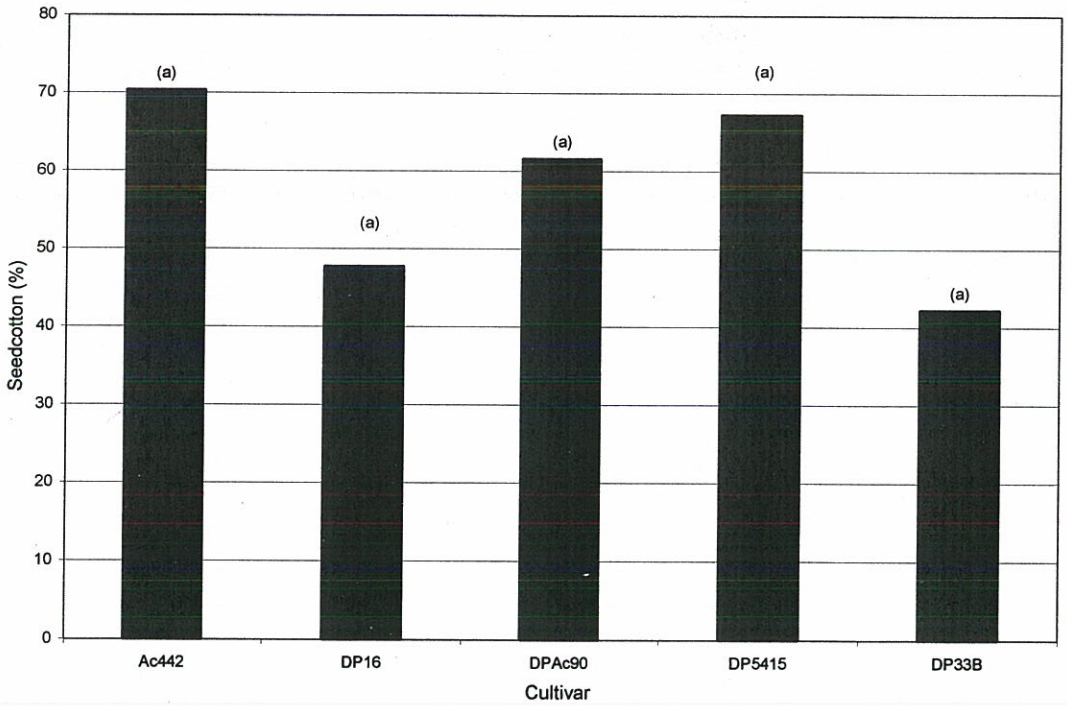


Figure 28. Box mapping results, yield from vegetative branches, obsolete cultivar comparison study, Maricopa Agricultural Center, 2000.

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