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# DEVELOPMENTAL RESPONSES OF COTTON GENOTYPES AS AFFECTED BY WATER APPLICATION REGIMES

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## Abstract

Water stress has two primary effects on cotton development depending on when it occurs and its intensity. Stress prior to flowering usually restricts the number of mainstem nodes and the number of fruiting sites; whereas, stress during early boll development results in fruit abortion. Field experiments were conducted over a two-year period (2001 & 2002) using varying volumes and frequencies of application of water to determine their effects on the developmental processes of cotton (*Gossypium hirsutum*, L.) cultivars differing in degrees of indeterminacy. This was a two-variable experiment with one regime designed to evaluate different volume applications of 0, 3, 4, and 5 gallons per minute per acre (GPMA), delivered on a constant 6-day frequency. The second regime was designed to create stress and recovery cycles by delivering water at a fixed volume (5GPMA) over 3, 6, 9 and 12-day irrigation intervals. Comparisons of the effects of these regimes on plant height, main stem node production, production of fruiting sites, percent fruit retention and final boll number per plant revealed genotypic differences in response to both water volume and frequency regimes in all developmental categories evaluated. Picker-types were more sensitive to water stress but were more responsive to increasing water supply than were stripper-types. Growth habit effects were also apparent in that the determinate types responded to increasing volume per application by producing more fruiting sites and harvestable bolls per plant than the more-indeterminate types. The more-indeterminant types responded to longer irrigation intervals with larger volume per application by producing more fruit than at short intervals.

The results suggest not only genetic differences in response to water supply, but also opportunity to develop management strategies to match genetic response.

## Introduction

In most areas of the United States, water is the most limiting factor in growth and development of cotton plants. In the major cotton producing regions of Texas, the opportunity for short-term water stress is great as a result of high growing season temperatures and extended periods between rainfall events. Due to the indeterminate growth habit of the cotton plant, the effects of this short-term stress are readily quantifiable at distinct stages of development. McMichael (1986) reported that changes in water content of the soil affect the growth and productivity of plant tops via changes that occur in absorption of water by plant roots. Davies and Zhang (1991) emphasized the importance of the role of plant roots in sensing the amount of water in the soil by observing that the variation in shoot physiology can often be linked more closely to changes in soil water status than to changes in leaf water status. They suggested that plants must "sense" the drying of the soil around the root and communicate the information to the shoot by some means other than a reduction in the flux of water to the shoots (Davies and Zhang, 1991). Other studies cited by Davies and Zhang suggest that this detection mechanism involves the transfer of chemical, presumably hormonal, information from roots to shoots

This study was conducted to identify how water stress affects shoot development especially as it affects production and retention of fruit and whether there is any significant genetic variability in sensitivity or response to water supply.

## Materials and Methods

The study was conducted for two years (2001 and 2002) at the Texas Tech University Crop Production Facility in Brownfield, Texas. The soil at this site is a Fine Sandy Loam about 4 feet deep with a volumetric water holding capacity of ~ 20%. Six varieties of cotton, 3 picker-types (DPL 90, SureGrow 521, DPL 2156) and 3 stripper-types (PM 2326, PM 2200, and PM2145) were selected for degree of indeterminacy. Seed were planted in 32-inch rows (6 rows, 200 feet long per plot) under two variable water delivery systems. One delivery system was a surface drip system with drip tape in every other furrow. This system was operated as a constant volume ( 5 GPMA = 0.26 ac-in/day), variable frequency system. Application frequencies consisted of 3, 6, 9 and 12-day intervals. The 3-day treatment received 0.78"/acre of water per cycle, the 6-day treatment 1.56"/acre, the 9-day treatment 2.31"/acre, and the 12-day treatment 3.12"/acre for each application period. The second system was designed to be a variable rate, constant frequency application system. A center pivot, operated in the LEPA mode with drop hoses in every other furrow delivered variable volumes of 3, 4, and 5 GPMA at a constant 6-day frequency. The volume applied each time was 0.90, 1.20 and 1.60 acre inches. A total of eight water treatments were evaluated.

Seven involved the rate and frequency treatments just described and one was a rainfed treatment that received no supplemental irrigation. Plant mapping was conducted at first flower, peak flower, cut-out and final harvest, using 10 plants/sample per replication of each treatment. Plants were mapped for height, mainstem node number, number of fruiting branches, total fruiting sites, retained sites and mature bolls per plant.

## Results

Water supply had a significant impact on development of the cotton plant. Mainstem node production increased as water supply volume increased when averaged across both years and cultivars (Figure 1A). The magnitude of the response was greater in 2002 than in 2001 indicating that environmental factors other than water supply also affected mainstem node production. The plant response to constant volume-variable irrigation frequency was not as expected. Increasing the interval between water applications resulted in increased numbers of mainstem nodes (Figure 1B). We were expecting a curvilinear response with a peak at 6 to 9 day intervals. The number of fruiting sites responded to water supply (both volume and frequency) to an even greater extent than mainstem node numbers. The response to volume treatments was greater in 2002 than in 2001 (Figure 2A). Fruit retention, expressed as a percentage of total fruiting sites, exhibited a mixed response. In 2001 a positive relationship existed between volume and percent retention; whereas, in 2002 a negative relationship existed (Figure 3A). Considerably more fruiting sites per plant were produced in 2002, than in 2001. No consistent response was observed with respect to frequency treatments (Figure 3B). The product of production and retention is summarized in the harvested bolls per plant. Increasing boll number per plant was observed as water supply increased and as frequency decreased (Figure 4). The harvested bolls per plant reflected the production of fruiting sites rather than percent retention responses.

Analyses of genetic differences in the developmental responses to water supply was done by separating picker and stripper types and also by separating into degree of indeterminacy. Picker types appeared to be slightly more sensitive to water deficits than stripper types for production of fruiting sites (Figure 5). However, picker types were more responsive to increasing water supply than were stripper types. Pickers increased production of fruiting sites with increasing intervals between irrigation events compared with stripper types (Figure 5B). A similar response was noted for production of harvestable bolls per plant between pickers and strippers (Figure 6). The magnitude of the difference was only minor for the response to water supply volume. However, the frequency response was strongly in favor of the picker types over the stripper types. The response to frequency may reflect the origin of today's picker versus stripper types. The strippers are developed under irrigated conditions where irrigation frequency is quite short compared to the development of the pickers under rainfed conditions were water replenishment is usually less frequent.

Genetic differences were further evaluated as a function of degree of indeterminacy. Within both strippers and picker types we have very indeterminate, moderately-indeterminate and more-determinate types. The results obtained over the past two years were consistent with respect to growth habit responses to water supply. Only minor genetic differences were observed in production of fruiting sites in response to water supply volume. Both growth habits increased the number of fruiting sites per plant as water supply increased (Figure 7A). The more-determinate type cultivars appeared to reach a maximum at 4 GPMA; whereas, the moderately-indeterminate types continued to increase fruiting sites per plant as water supply increased. As water supply was varied due to application frequency, the more indeterminate types increased the number of fruiting sites per plant to a greater extent than the more-determinate types. The number of harvested bolls per plant paralleled the production of fruiting sites reaching a maximum at 4 GPMA (Figure 8A) with a slight advantage for the determinate types. Longer intervals between applications and larger volume per application resulted in greater numbers of bolls per plant with the same total volume of applied water. The moderately-indeterminate type growth habits were more responsive than the determinate types.

## Summary

This experiment was conducted to determine if differences existed among cotton cultivars in response to water supply. The results did reveal genetic differences between picker-types and stripper-types in response to both volume and frequency of the water supply. The picker-types were more sensitive to low water supplies but more responsive to increasing water supplies in the production of fruiting sites and harvestable bolls per plant. Growth habit differences were also observed, especially in response to irrigation frequency. The more-indeterminate types produced more bolls per plant as irrigation frequency decreased. We believe that the volume of the effective root system has a major effect on the number of root tips, which then has a major effect on shoot development.

## References

Davies, W.J. and Zhang, J. 1991. Root Signals and the Regulation of Growth and Development of Plants in Drying Soil. Annu. Rev. Plant Physiol. & Plant Mol. Biol. 42:55-76.

McMichael, B.L. 1986. Growth of Roots. Cotton Physiology: Number One: The Cotton Foundation Reference Book Series. J.R. Mauney and J. McD. Stewart (eds.). p. 29-38.

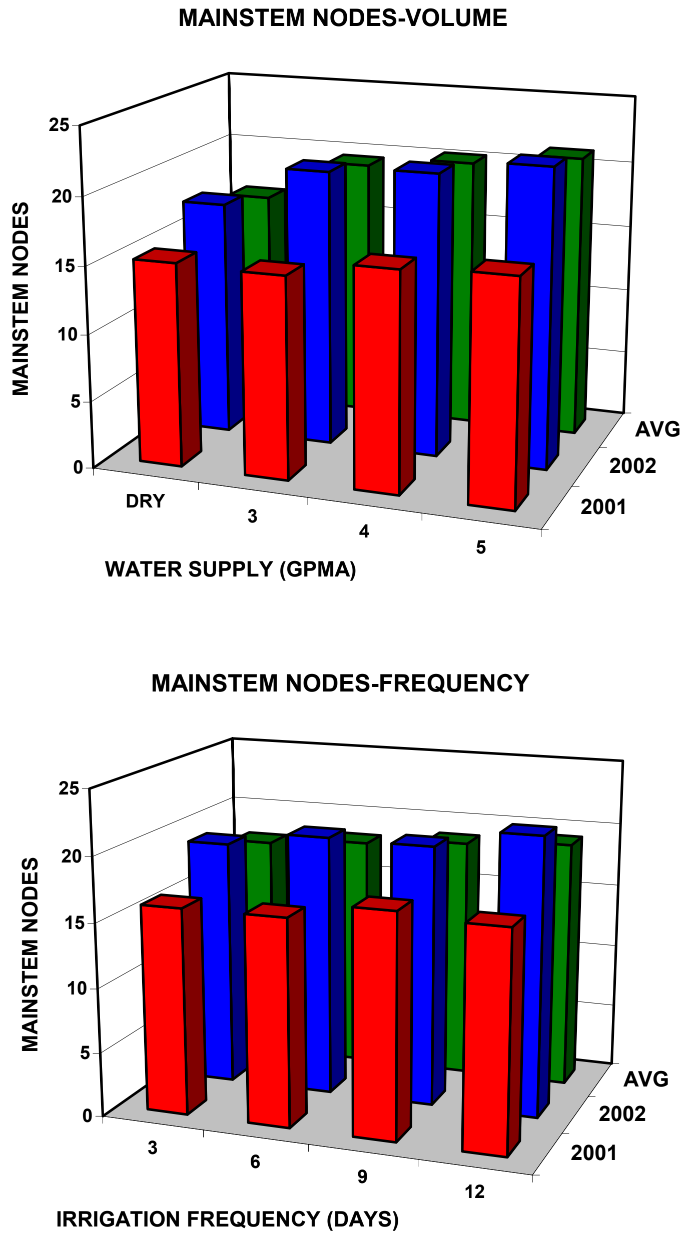
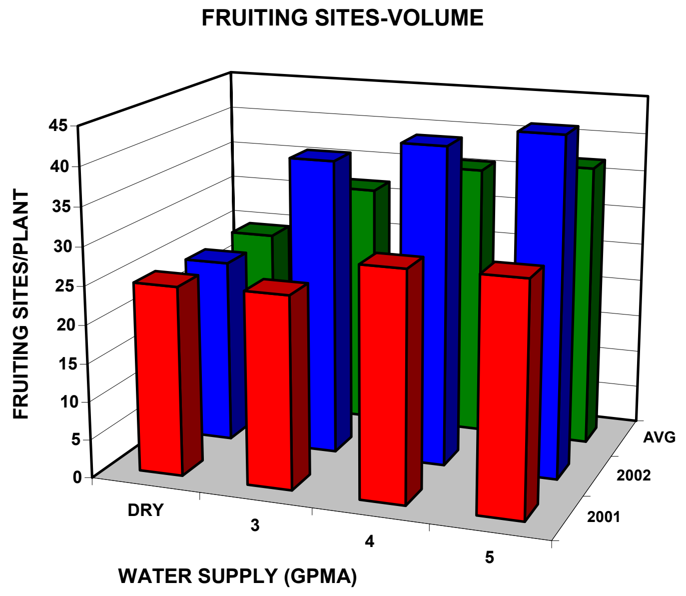



Figure 1. Mainstem nodes per plant as affected by water supply (A = Volume and B = Frequency).



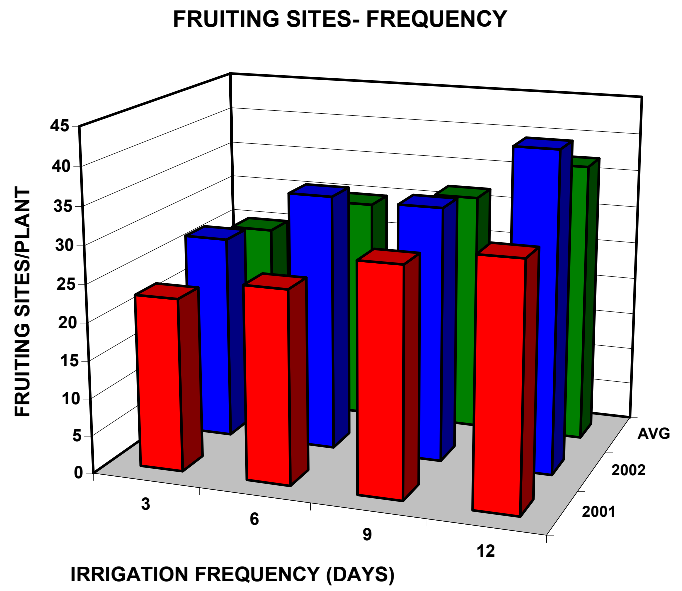




Figure 2. Total fruiting sites per plant as affected by water supply (A= Volume, B= Frequency).

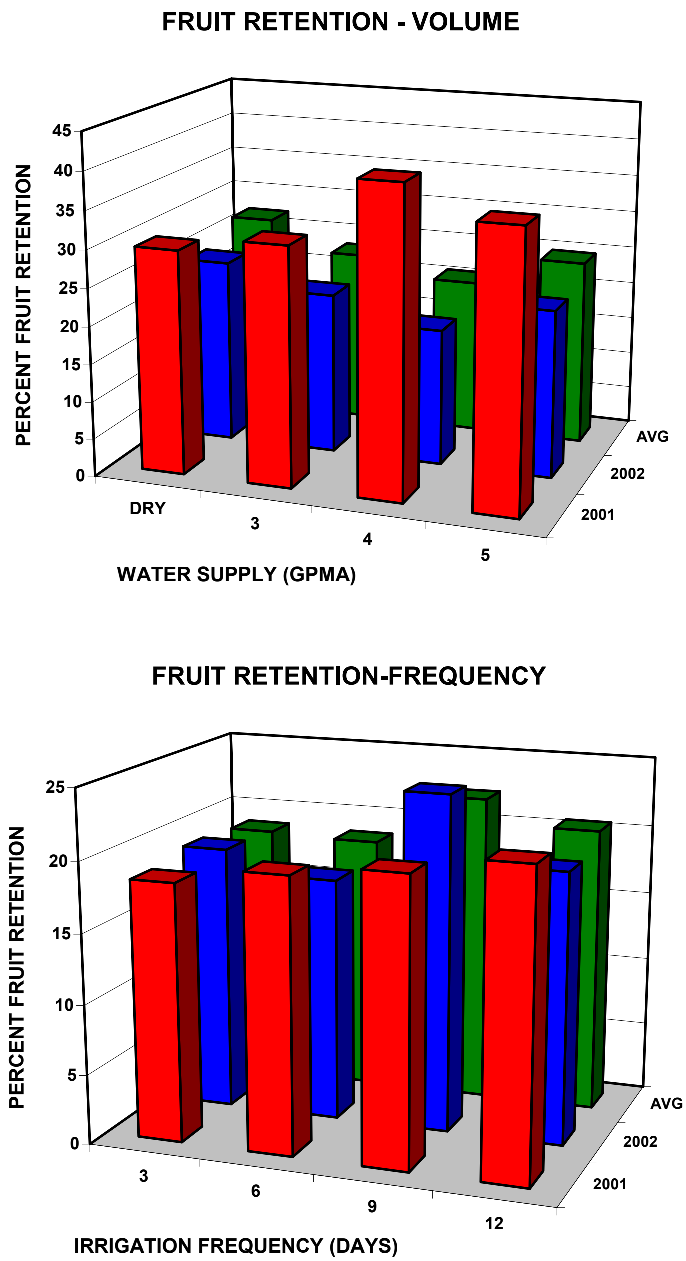
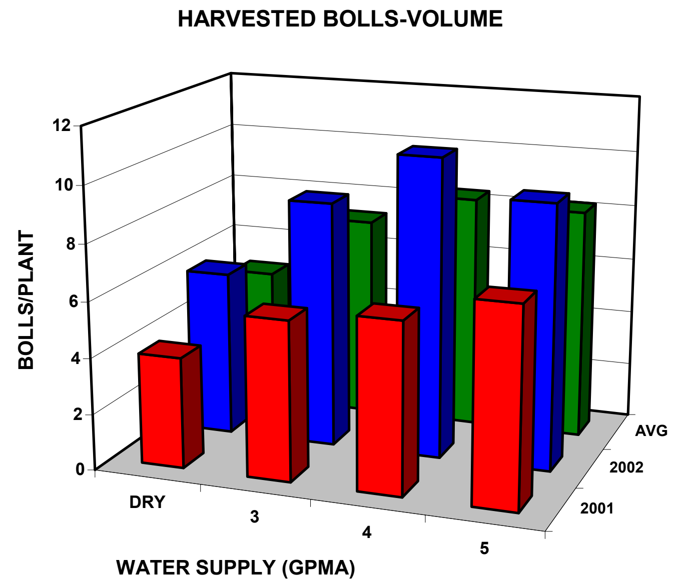



Figure 3. Fruit retention (% of total fruiting sites) as affected by water supply (A = Volume, B = Frequency).



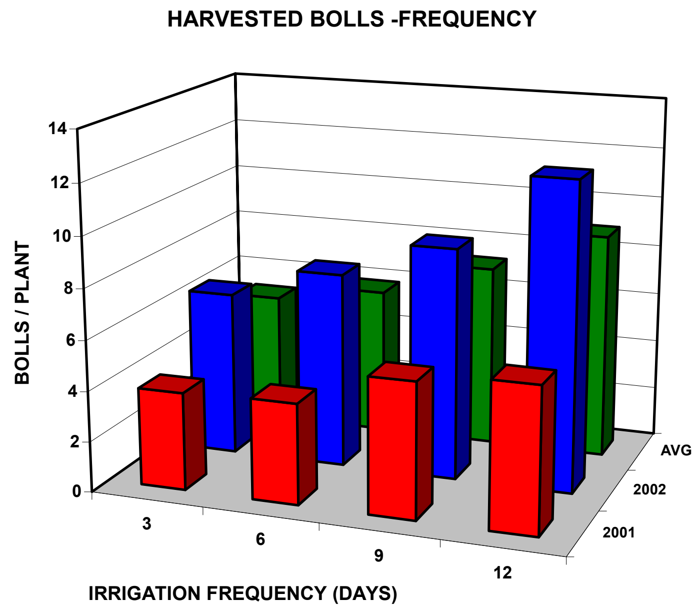
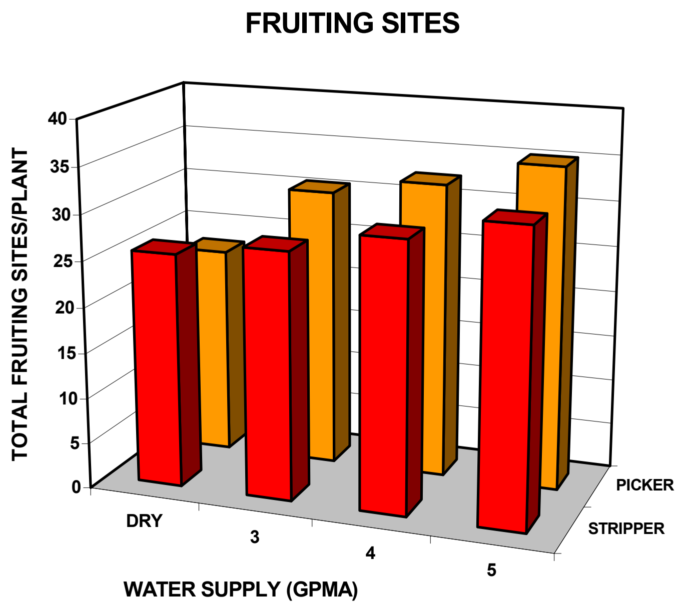




Figure 4. Harvested bolls per plant as affected by water supply (A = Volume, B = Frequency).



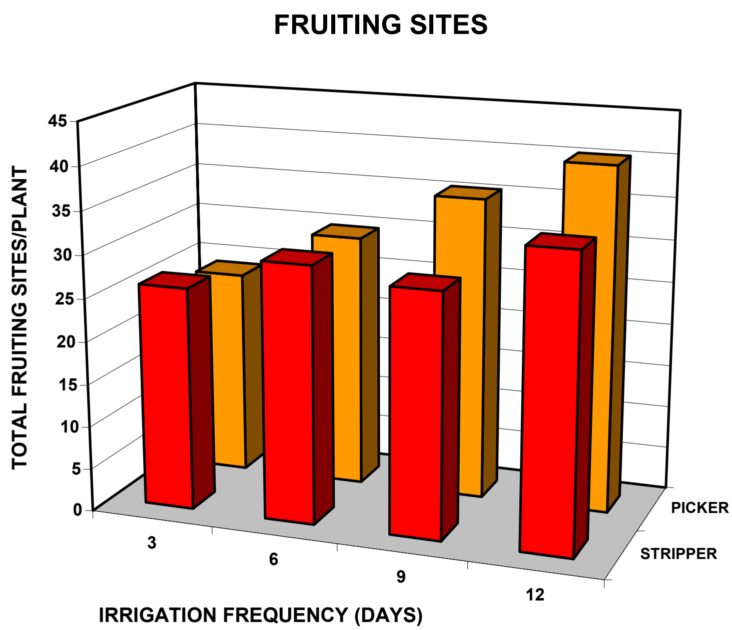
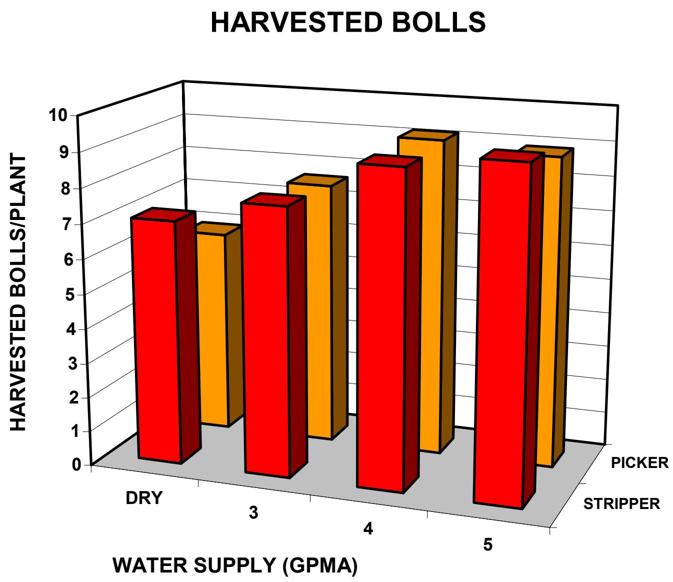




Figure 5. Total fruiting sites per plant as affected by water supply for picker versus stripper type cultivars. Data averaged over two years and three cultivars in each type (A = Water Volume ; B = Irrigation Frequency).



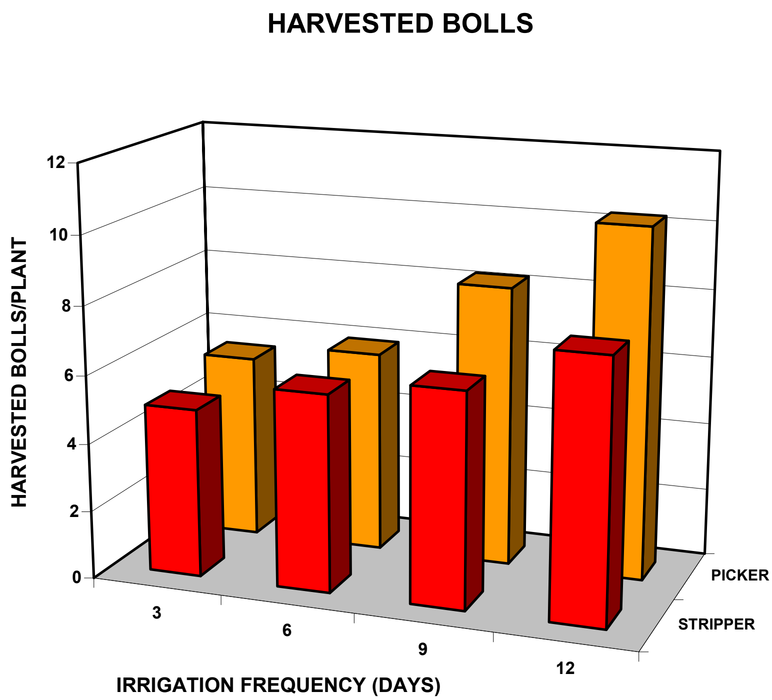
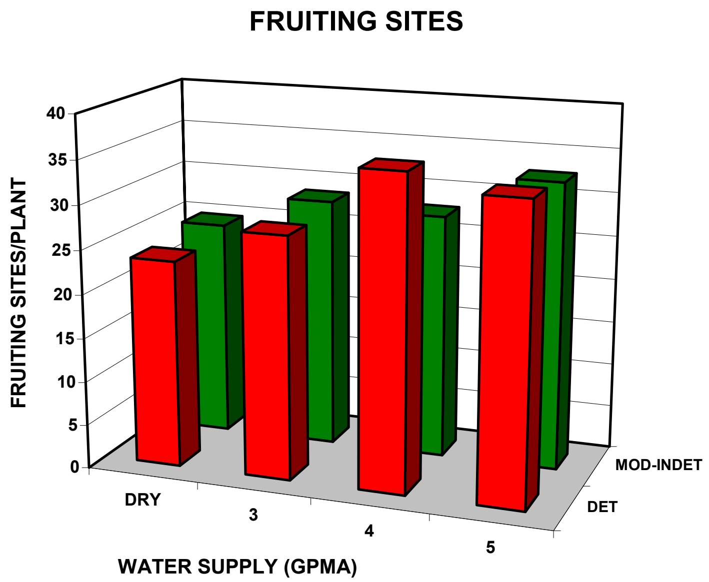




Figure 6. Harvested bolls per plant as affected by water supply for picker versus stripper type cultivars. Data averaged over two years and three cultivars in each type (A = Water Volume ; B = Irrigation Frequency).



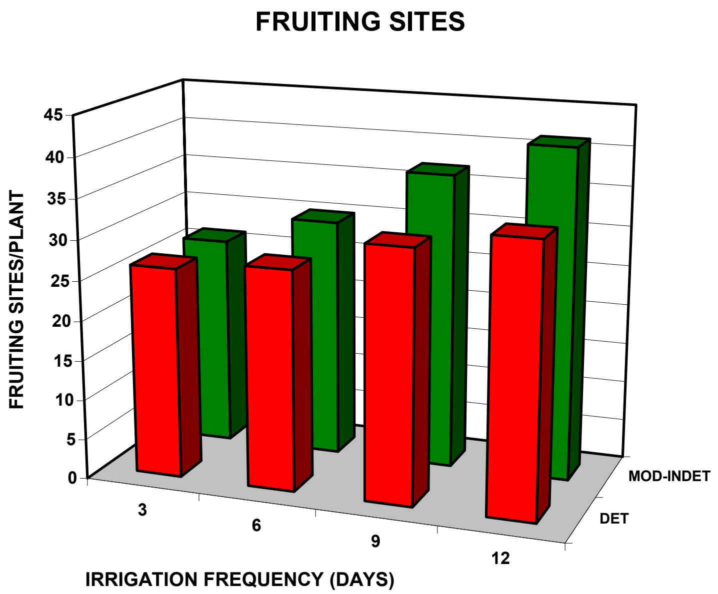




Figure 7. Fruiting Sites per plant as affected by water supply (A = Volume; B= Frequency) and growth habit. Data averaged over two years and two cultivars within each year.

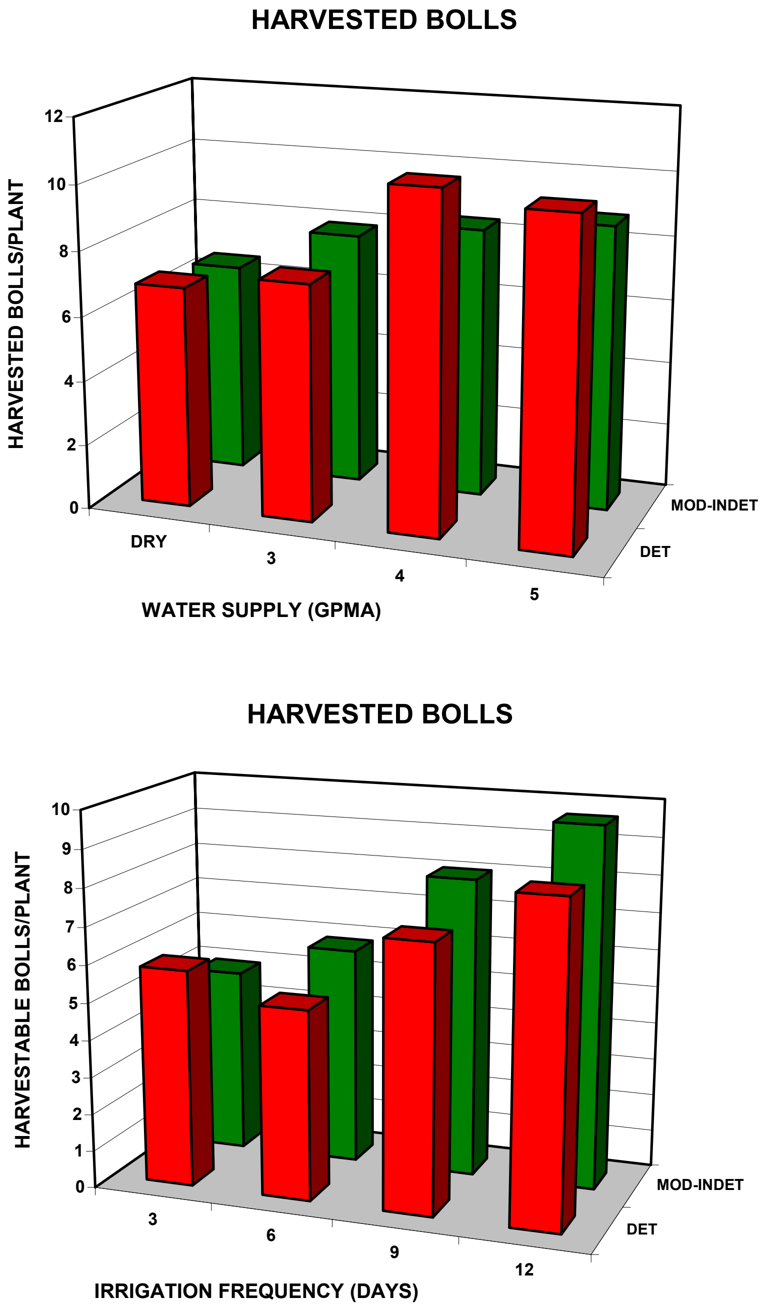



Figure 8. Harvested bolls per plant as affected by water supply (A = Volume; B= Frequency) and growth habit. Data averaged over two years and two cultivars within each year.