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ARE COTMAN'S COMPENSATION CAPACITY VALUES SET TOO LOW?

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Abstract

COTMAN is an expert system developed by the University of Arkansas, which utilizes plant-mapping information to assist in making both early and late season management decisions. It can be particularly useful in identifying stress during the pre-bloom period affording the manager an opportunity to identify the cause of the stress and make management corrections. Since its inception in 1994, it has been involved in validation studies in over eight states. The SQUAREMAN component uses a default square shed limiter of 19% although user entered values ranging from 5-50% are available. This shed rate limiter is based on the plant's ability to compensate and the effect of this compensation through later fruit production on maturity and harvest. Studies in the Texas High Plains area have continued since 1996 to validate this model under our short season conditions. Of particular interest has been the shed rate limit of the model. We typically manage early season cotton fleahoppers and western tarnished plant bugs fairly aggressively allowing only 10% square loss the 1st week of squaring, 15% accumulative square loss the 2nd week and 25% accumulative loss for the 3 weeks prior to first flower. This aggressive approach can result in additional management costs and early disruption of beneficial arthropods resulting in flare-ups of aphids and bollworms. The results of a three year study examining the effect of varying levels of early manual removal of squares indicated no negative impact on yields or fiber quality at any level of square removal. There was however a delay in maturity penalty which could push harvest as much as 37 days later. The most important finding of this study was that for levels of square loss of 40% or less, there were not adverse effects on cotton production. The results from loss of squares from actual insect feeding may differ. The second most important finding was that because compensation was mainly through the increased retention of 2nd and 3rd position bolls, COTMAN would not adequately track compensation under the severest square loss conditions.

Introduction

Economic thresholds for early season fruit protection from both cotton fleahoppers and *Lygus* spp. have been the cornerstone of most cotton production systems, especially in those areas where earliness has particular value due to weather limited growing seasons or weather hampered harvest seasons. Because of this, most areas of the mid-South and Texas have incorporated rather aggressive square protection strategies of 10% to 25% square loss action levels prior to first flower (Gutierrez et al., 1981; Johnson and Jones, 1996; Muegge et al 2003; Turnipseed et al., 1995). Yet the controversy over the cotton plant's ability to compensate for early square losses continues (Frisbie et al., 1989, Spencer, 1987). Several studies have demonstrated that cotton plants can compensate for most if not all square loss prior to first flower (Dunnam et al., 1943; Hammer, 1941; Holman, 1996; Kletter & Wallach, 1982; Montez & Goodell, 1994; Passlow & Trudgian, 1960; Terry, 1992). Some other earlier studies even demonstrated increased yields (Blackwell & Buie, 1924; Eaton, 1931; Ludwig, 1931; Smith, 1922) from early square removal. This increased square loss allowance could result in maturity delays resulting in harvest difficulties from the increased risk of adverse weather and/or in increased late season insect management costs and yield losses (Bagwell & Tugwell, 1992; Cochran et al., 1994; Eaton, 1931; Munro, 1971; Sadras, 1995).

COTMAN is an expert system developed by the University of Arkansas to help make decisions pertaining to early season stress management, timing of harvest aid applications and insecticide termination timing for late season pests (Cochran et al., 1998). The model does not actually grow cotton but rather utilizes plant mapping and monitoring data coupled with temperature data to provide a visual representation of crop development and progress. The SQUAREMAN component of COTMAN utilizes a default square shed level of 19% as the compensation capacity of the plant. This is based solely on first position squares prior to flower. Users can input values between 5% and 50%. In a continuing effort to validate COTMAN in the weather-shortened growing area of the Texas High Plains, a three year study was initiated to examine the effect of manually removing varying numbers of pre-bloom first position squares prior to first flower on yield, fiber quality and earliness. Additionally, mechanisms for this compensation were elucidated. Square losses in the Texas High Plains area can be very high but are rarely closely associated with corresponding high levels of plant bugs or lower yields. The initiation of a boll weevil eradication program in recent years and improved late season bollworm management tools has substantially decreased the risk of yield losses and increased control costs for these late season pests.

Material and Methods

Tests were conducted during the period of 2001-2003 at the AGCARES farm north of Lamesa, Texas. All tests were planted with PM2326RR under LEPA irrigation. A randomized complete block design was utilized with four replications. The various tests, planting dates and treatments are listed in Table 1.

First position squares were removed using jeweler's forceps once they achieved matchhead size. The maximum square removal treatment in the 2003 test was even more severe where all squares prior to first flower were removed. This did not allow the plant to begin compensation until after first flower. Plants were mapped weekly using standard COTMAN methodology until first flower at which time Nodes Above White Flower (NAWF) was monitored. Because compensation occurred primarily through 2nd and 3rd positions (Doederlein et al., 2002) a modified SQUAREMAN was utilized where all three positions were monitored in years 2 and 3. Harvest aids were applied once cotton reached NAWF=5 (defined cutout). Ginstar (5 oz./a) + Prep (21 oz./a) was the treatment in 2001 and 2002 with harvest following 7 days later. Only Prep was utilized in 2003 and harvest followed 14 days later. This change resulted in less handling loss during the box mapping phase.

Box mapping by position was conducted all three years with individual bolls weighed but grouped among plants for ginning and fiber analysis. A bulk harvest was also obtained each year and ginned at the Lubbock Experiment Station. HVI analysis was conducted at the International Textile Center in Lubbock. Data was analyzed using SAS. Mean separation was determined using ANOVA and either LSD or DMRT (SAS 1985).

Results and Discussion

Yields were not decreased by pre-flower first position square removal rates between 30% and 100% in all three years of tests involving irrigated cotton (Fig. 1). In fact, super compensation occurred in two of three years of timely planted tests. If cotton was planted late (2001) then there was no super compensation yet yields were still unaffected by any of the square loss treatments. When all squares were removed, even 2nd and 3rd positions, prior to flower yield was the highest. Only when square removal exceeded 50% was dryland yield adversely affected (Fig. 2). These tests clearly demonstrated that when water resources were adequate and heat units available for later fruit maturation, compensation was the rule rather than the exception. None of the HVI fiber quality measurements indicated a penalty for a later maturing crop due to early fruit removal. Loan values were unaffected. In this respect then, our findings are comparable to the many earlier studies that demonstrated that removal of fruiting structures prior to flowering does not necessarily decrease yield or crop value.

There can be several mechanisms as to how cotton plants compensate for earlier square removal. Cotton can increase plant height with the addition of nodes and more first position squares. Our data would indicate that very little compensation takes place by adding vertical nodes when only early first position squares are removed (Fig. 3). An average increase of only one to two first position fruit were added in any of the first position only removal treatments. Only when compensation was delayed until after first flower by the removal of 1st, 2nd and 3rd positions on the first 9 fruiting braches did we observe a significant increase in vertical nodes and later 1st position squares. Plants can also increase the weight of individual bolls. This was found to be the case although there were no significant treatment effects. But the trend was generally for increased boll weight for increasing early square loss. We did find that most compensation took place by increasing the importance or retention of 2nd and 3rd position fruit. Plants produce an over abundance of squares, which cannot all be matured, leading to the abscission of excess fruit, usually in the early boll stage (Gore et al., 2000). We found that most compensation took place in our studies through the increased retention of 2nd and 3rd position bolls (Fig. 4). The super compensation observed in the severest treatment in 2003 was thought to be due to the moisture situation. Because of some issues with the LEPA system, early irrigation was delayed causing stress on those plants that had the greatest early fruit load. When fruit loading was delayed until soil moisture conditions improved, plants were able to take advantage of the better conditions.

Only the most severe square loss treatment resulted in the actual growth curve after first flower shifting to the right of the target development curve suggested by COTMAN (Fig. 5). This shift did not result in sufficient delay to prevent physiological cutout prior to seasonal cutout with the exception of the late planting in 2001 and the severest square loss treatment of 2003. However, square loss treatments exceeding 40% did result in significant delays (up to 37 days) in maturity and ultimately harvest (Fig. 6).

The findings of this study indicates that where water and heat units are not a major limiting factor, plants can compensate for most if not all pre-bloom square loss caused by manual removal. While crop maturity is pushed later into the season when the risk of damage and added control costs from boll feeding insects is greatest, boll weevil eradication and better bollworm management tools have reduced this risk significantly. Also, warmer late season growing conditions the last seven years have favored later maturing crops. Higher square loss levels do push crop maturity and harvest later into the year, increasing harvest risk from adverse weather, but this risk does not increase substantially until after the 40% square loss level. This would indicate that the 19% default square loss compensation capacity level of COTMAN is set too low for current growing conditions, varieties and management practices. However, further testing will be required using actual insects to produce square loss levels used in these tests. Insects with piercing-sucking mouthparts often inject chemicals into plants they are feeding upon. This may be more detrimental to plants than the mere physical removal of a fruiting structure.

A most important finding of this study was that COTMAN as it is traditionally used couldn't monitor compensation since it utilized only 1st position plant mapping data. Under excessive square loss conditions, plant mapping must focus on 2nd and 3rd positions in addition to 1st position squares if it is to truly track crop progress and response to corrective measures.

Acknowledgments

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Table 1. Treatment and monitoring parameters for COTMAN compensation studies conducted at Lamesa, TX. 2001-2003.

Planting date	Irrigated?	% retention 1st positions (1st nine fruiting branches)	SQUAREMAN (positions monitored)
May 30, 2001	Yes	100, 80, 70, 60, 0	1st
June 18, 2001	Yes	100, 80, 70, 60, 0	1st
May 8, 2002	Yes	100, 70, 60, 0	1st – 3rd
May 8, 2002	No	100, 50, 0	1st – 2nd
May 8, 2003	Yes	100, 70, 60, 0, 0+++[1]	1st – 3rd

[1]All fruiting positions removed from each of the first 9 fruiting branches.

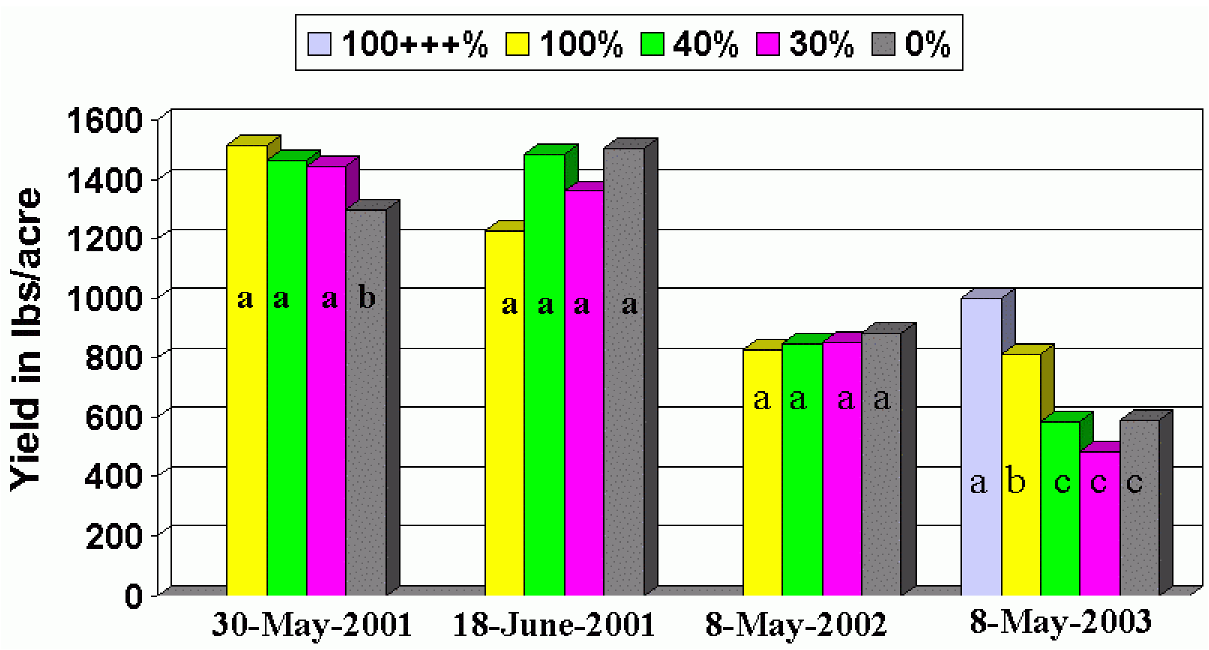

Figure 1. Irrigated yields from different pre-flower square loss levels. Lamesa, TX. 2001-2003.

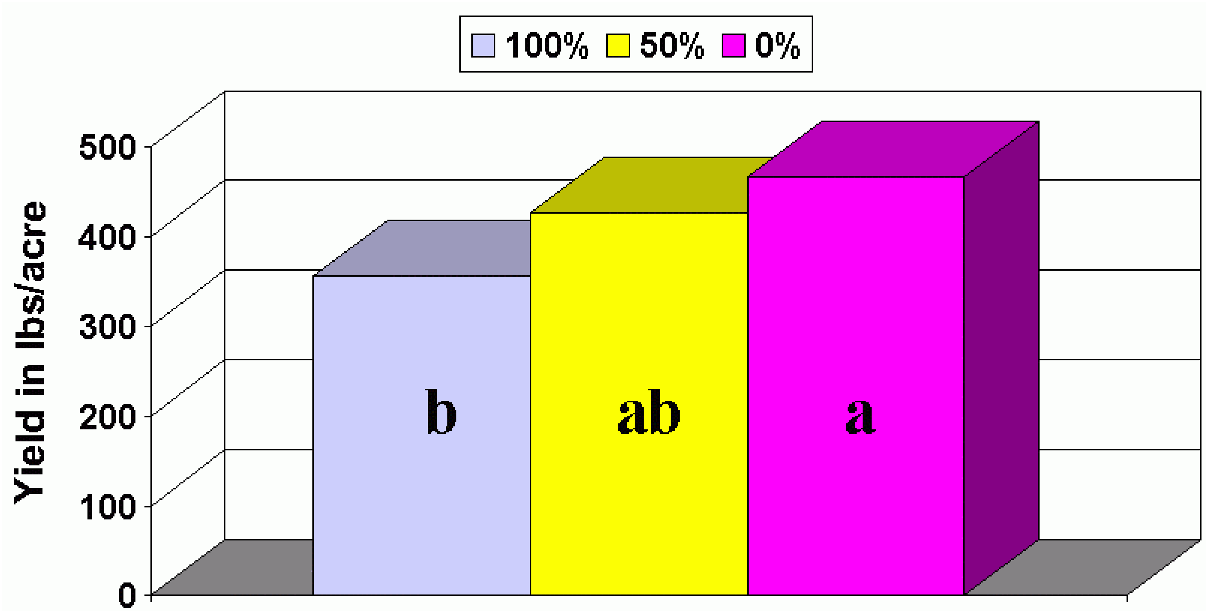

Figure 2. Dryland yields from different pre-flower square loss levels. Lamesa, TX. 2002.

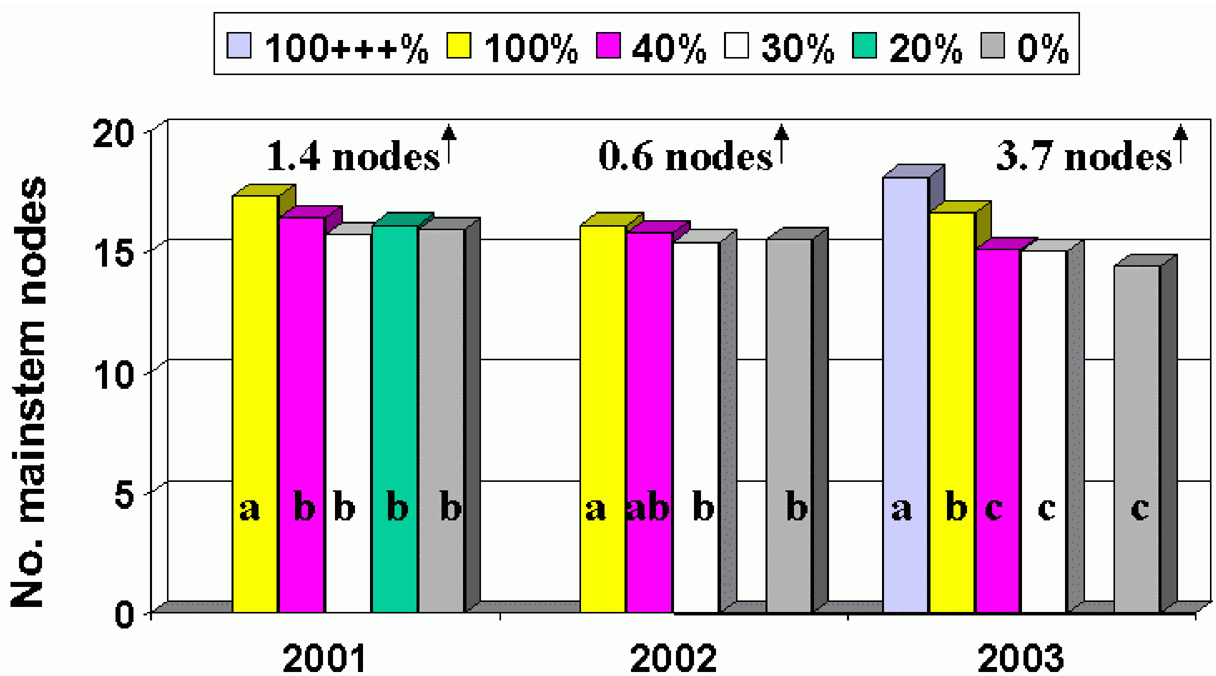

Figure 3. Number of mainstem nodes as affected by different levels of square loss. Lamesa, TX.

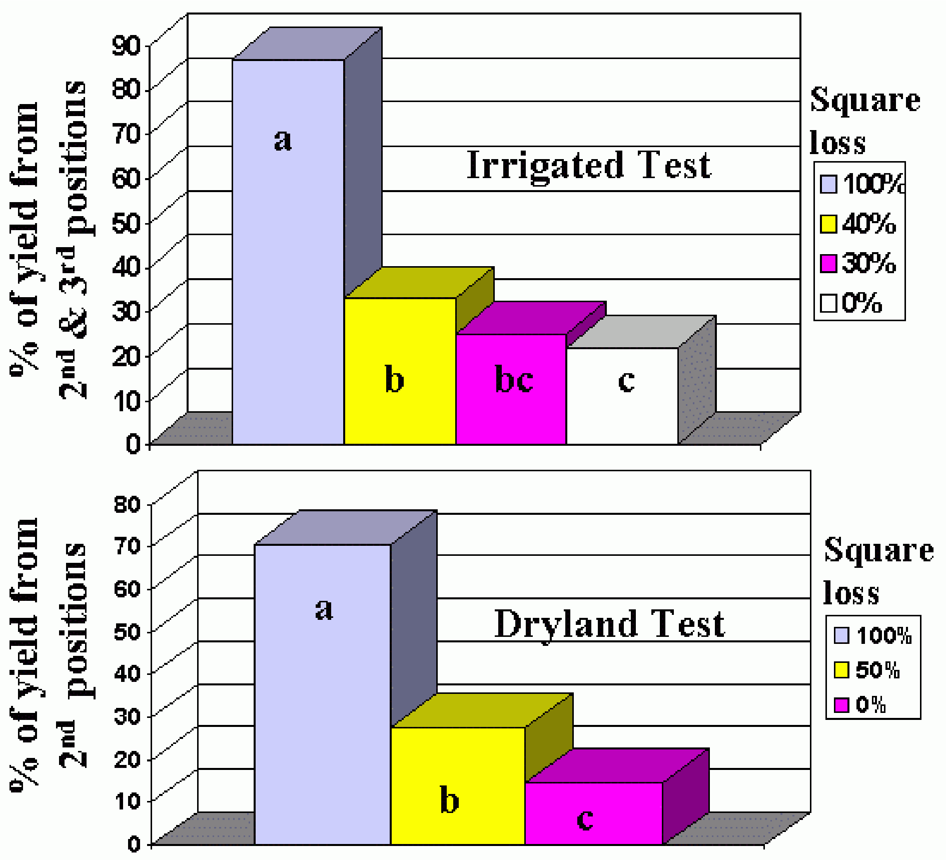

Figure 4. Percent yield compensation through 2nd and 3rd position fruit contributions. Lamesa, TX 2002.

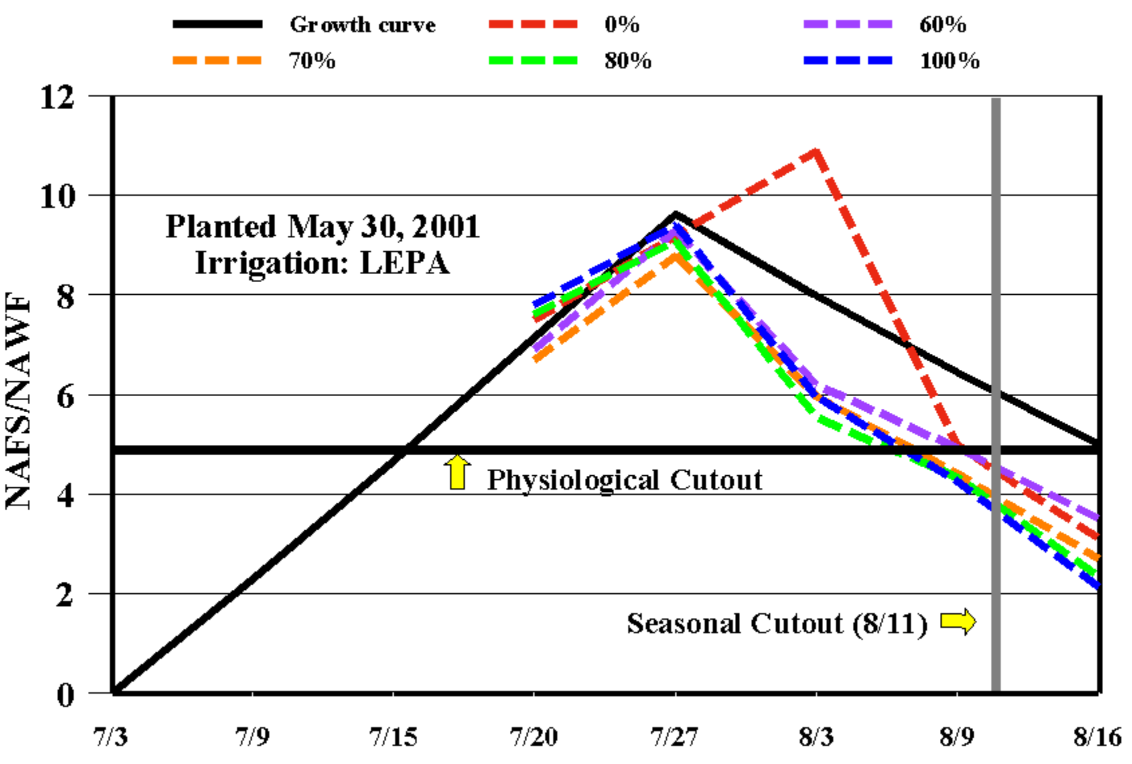

Figure 5. SQUAREMAN crop growth curves in response to varying levels of square retention. Lamesa, TX 2001.

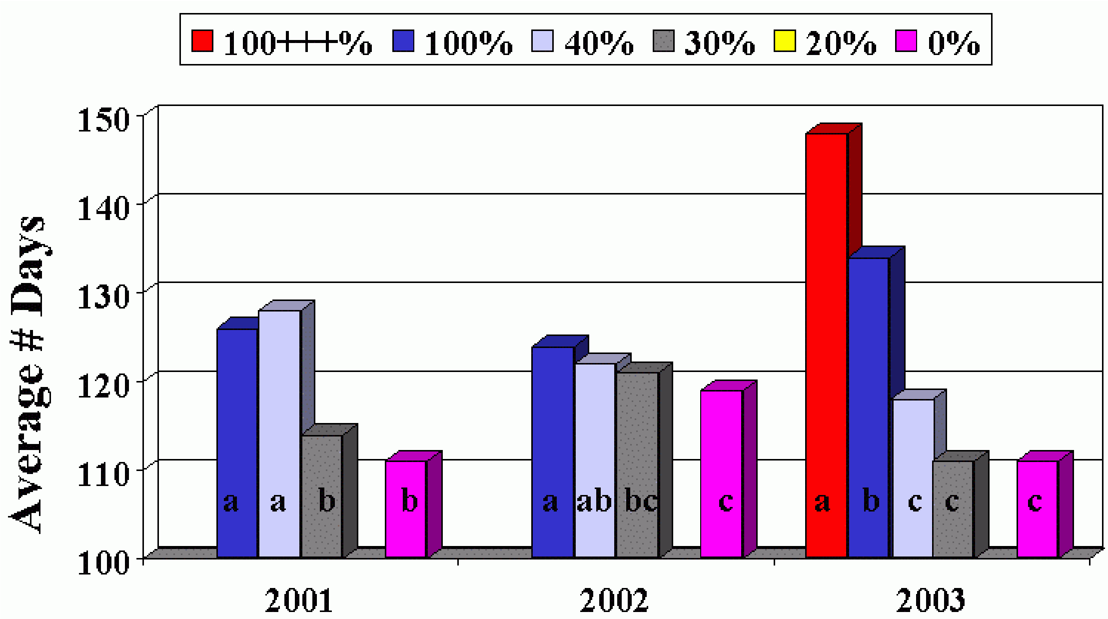

Figure 6. Number of days from planting to maturity in response to varying levels of square loss in three irrigated tests. Lamesa, TX.