EFFECT OF TWO GROWTH REGULATORS ON YIELD, BOLL, AND FIBER PROPERTIES OF UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.)

by

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ABSTRACT

Field studies were conducted in 1974 at Marana and Phoenix, Arizona, to investigate the effect of two growth regulators, BAS 0660W and BAS 83394X on cotton (*Gossypium hirsutum* L.) yield, plant height, boll and fiber characteristics.

Cotton was grown on two rows, 31 cm apart, on 102 cm beds at both locations. Standard cultural practices were used during the growing season. Seed cotton was hand picked weekly in sub-plots and the remainder of the plots were harvested with a mechanical stripper.

Yield was not significantly affected by any of the growth regulator treatments used; however, yield differences between harvest periods were highly significant. Mature plant height was significantly reduced when both growth regulators were applied at onset of flowering.

Lint percent was significantly decreased by all treatments of BAS 0660W and 83394X. The 2.5% span length was significantly increased when BAS 83394X was applied either at low or high concentrations at onset of flowering.

INTRODUCTION

Upland cotton, Gossypium hirsutum L., is inherently a perennial crop but is usually cultured as an annual with an indeterminate growth pattern. This pattern may be undesirable in some cases. With a long growing season, it may result in lodging and boll rotting and makes defoliation and mechanical harvesting more difficult. To obtain a more determinate fruiting habit and reduce excessive vegetative growth, particularly in narrow-row, high population cotton culture, researchers have used breeding techniques, cultural practices, and growth regulators on established cultivars.

Early work with growth regulators for cotton was aimed at reducing mature plant height. Recent investigations in high density culture have identified some problems and research is now being undertaken to obtain minimum vegetative growth, flowering compatible with high productivity, and early termination of growth and fruiting. There is a limited amount of information available in the literature concerning the effect of growth regulators on vegetative growth of cotton grown in narrow-row, high density cotton.

The objective of this study was to investigate the effect of two growth regulators, BAS 0660W (N,N-dimethylmorpholinium chloride) and BAS 83394X (BASF Wyandotte Exp.

Chem.) on yield, morphological characteristics, and boll and fiber properties of cotton.

LITERATURE REVIEW

Plant growth is regulated by a set of plant hormonal growth factors interacting in a complex fashion. The history of these regulatory mechanisms began over 50 years ago (37) with the discovery of the growth regulatory agent auxin by Went. Extensive research subsequently led to the isolation of a number of native regulators in addition to the auxins. We now have considerable information regarding the chemical and physiological properties of the gibberellins (17, 20), the cytokinins (27) and more recently ethylene (1), abscisic acid (2), and a number of growth retardants (7).

In addition to these endogenous growth regulators, synthetic organic chemical compounds are available which act by affecting natural regulatory mechanisms of plant growth (23). These compounds have been implicated as agents participating in various aspects of growth and development; e.g. in process of cell division (28), cell differentiation (29), shoot growth (22), root growth (30), geotropism (38), flowering (8), abscission (9), seed and bud dormancy (36), translocation (13), and other phenomena.

Extensive literature has accumulated on the action of synthetic growth regulators and retardants toward plant development and fruiting phases of many horticultural crops.

Only limited work has been reported regarding other crops (11). Literature relating to use of growth regulators in narrow-row, high-plant population cotton under irrigation is very limited. This literature review considers two aspects: a) classification of synthetic organic plant growth regulators, and b) effects of plant growth regulators on yield, boll characteristics, and fiber quality of cotton.

Classification of Synthetic Organic Plant Growth Regulators

In 1964, Cathey (7) classified synthetic growth regulators into six families based on the chemical structure. These were Nicotiniums, Hydrazines, Phosphoniums, Substituted Cholines, Succinamic acids and Quaternary ammonium carbamates. The description of each family is as follows:

1. Nicotiniums: In this group, the most active chemical compound is 1-(2,4-dichlorobenzyl)-1-methyl-2(3-pyridyl pyholidinium chloride). It contains chloro-substitutions on the 2 and 4 position of the benzene ring, while other substitutions either at the 3, 4 or the 4 position reduced the activity of the compound.

2. Hydrazines: Only the unsymmetrical compounds are active in this family. The most active compound is B-hydroxethylhydrazine (BOH). It was first used in the induction of pineapple (*Ananas comosus* L.) flowering.

3. Phosphoniums: The most active compound in this group is 2,4-dichloro-benzyl-tributyl phosphonium chloride (phosphon-D).

4. Substituted Cholines: 2-Chlorethyl trimethyl-ammonium chloride (CCC or Cycocel) is one of the most extensively studied growth regulators in this group. Compounds in this family are active only when the trimethyl quaternary ammonium cation is present.

5. Succinamic acids: This group of growth regulators consists of N-dimethyl-amino succinamic acids (B995). It is unique in its chemical structure as a growth regulator because it has no substituent benzene ring or associated quaternary ammonium or phosphonium cation, and is of small molecular size, nucleophilic and nonionizable.

6. Quaternary ammonium carbamates: This group of growth regulators is comprised of morpholinium, picolinium, piperidium, pyridinium, quinaldinium, and quinolinium compounds among which Amo 1618 (4-hydroxyl-5-isopropyl-2-methylphenyl trimethyl ammonium chloride 1-piperdine carboxylate) is the most active. This compound, however, is not widely used because of its long persistence in the soil.

Effect of Plant Growth Regulators on Yield, Boll Characteristics and Fiber Quality

According to Cathey (7), any experiment with growth regulators to determine yield is only suggestive because experiments in successive years may not give similar results due to variation in environmental conditions, cultural practices, techniques used, and cultivar.

BAS 0660W (N,N-Dimethyl-morpholinium chloride) is an organic compound used as a plant growth regulator. It was first synthesized in Germany by BASF in 1972. It is absorbed by the plant either from soil or foliar application. Foliar applications are generally more effective. It has the same mode of action as Cycocel (CCC) causing reduction in internode length and thus reduces plant height (34).

Kittock, Arle, and Bariola (19) used BAS 0660W at 1121 grams active ingredient/hectare (g ai/ha) on cotton for 3 years in chemical termination experiments. They concluded that BAS 0660W was a persistent growth regulator and had a similar mode of action to Cycocel but was not efficient in terminating the late growth of the crop.

Almeida (3) compared BAS 0660W with other growth regulators for the effect on cotton seedling development in the succeeding generation. He found that seed from treated plants did not show detrimental effects in the seedling stage of the next generation.

The effects of BAS 0660W sprayed on irrigated cotton at 250 g ai/ha just before the onset of flowering were reported by Follin (12). Lint yield was increased by 16.6% without affecting fiber qualities. Mature plant height was reduced and flowering increased by 20% during the 2nd and 3rd week although total flowering was not altered significantly. This increase in early flowering resulted in early maturity.

Thomas and Hacskaylo (32) and Thomas (33) investigated the effects of BAS 0660W applied on the cotton cultivar 'Stoneville 213' at 35 and 70 g ai/ha rates respectively. Flowering was not suppressed, but boll retention was substantially reduced from flowers opening during the 3rd and 4th weeks which was contrary to the results of Follin (12). Thomas concluded that late vegetative growth and fruit development can be suppressed chemically without seriously affecting productivity.

Chlormequat (CCC) was first introduced by American Cyanamid Co. in 1960 (35). It is one of the most widely used synthetic growth regulators in agriculture. It has a similar mode of action to BAS 0660W (19, 34).

The effects of application time and concentration of CCC on size and fruiting responses of cotton plants grown in the greenhouse were studied by Thomas (31). His results showed that main stem and fruiting branch elongation were reduced when the treatment was applied at 100 ppm concentration prior to or at the onset of flowering. There was also a reduction in the rate of flowering, boll set, and seed cotton yield.

With applications of chlormequat at 10 to 320 ppm to cotton plants (G. hirsutum L. and G. arboreum L.), 70 to 80 days old, Singh (24) noted that plant growth was retarded and yield was significantly increased by increasing the number of bolls/plant and boll weight. The highest yield increases (18 to 45%) in G. hirsutum L. cultivars occurred with a spray of 40 ppm while yield increased in G. arboreum L. cultivars (16 to 34%) with an application of 160 ppm. Singh and Singh (26) applied chlormequat at 0.025 to 0.300 kg ai/ha at pre-flowering stage to cotton (G. arboreum L.) cv. 'Shyamali.' At 0.200 kg ai/ha, plant height and upper-internode length decreased while boll weight and seed cotton yield increased. Foliar applications of 0.005 to 0.1% chlormequat solution to cotton plants in studies by Kariev (18) showed that leaf area index, boll set, number, and weight of seed/boll all increased.

Under field conditions, Zur, Marani, and Karadavid (39) studied the effects of two plant growth regulators, CCC and CMH (N-dimethyl-N-B-chloroethyl-hydrazonium chloride) on cotton. They applied 50, 100, and 150 g ai/ha to 60, 85, and 105-day-old plants. The greatest effect on plant height was obtained when cotton was sprayed at an early stage of development. Reduced plant height was associated with reduced yield and delayed maturity. Yield reduction was more marked with CCC application than CMH. Late sprays, applied after peak flowering resulted in no effect on plant height or yield. Finally, they observed no adverse effects on fiber quality. Marani et al. (21) sprayed cotton with 50 g ai/ha CCC and 480 g ai/ha CMH applied during the 1st week of flowering. Both of these chemicals reduced plant height without adversely affecting lint yield or quality. When the chemicals were applied in the middle of the flowering period, they were less effective in reducing plant height. They concluded that excessive vegetative growth of cotton plants could be reduced by using CCC and CMH at the beginning of flowering.

Elsner and Ashley (11) sprayed Cycocel at a rate of 280 g ai/ha to cotton plants at incipient inflorescence and during full bloom. There was a 20% reduction in plant height in narrow-row cotton without significantly affecting yield. This height reduction was a result of fewer and shorter internodes.

They applied gibberellic acid in aqueous solution at 100 ppm to cotton at square formation and again 3 weeks later. Plant height, number of nodes, dry weight, and fiber length were significantly increased by GA_3 treatment in studies by Ghatt and Ramanujam (5). No effect on seed cotton yield was observed. Bhatt et al. (6) studied foliar applications of growth regulators on lint characters of several cotton genotypes. Alpha-napthalene acetic acid at

10 ppm increased fiber-fineness but higher concentrations resulted in coarse fiber. The auxin indole-acetic acid increased fiber length slightly and decreased fiber-fineness. B-995 increased length and Phosfon-D increased fineness. CCC at 20 ppm gave slightly coarser fibers without affecting other characters, whereas 100 or 200 ppm increased length and fineness but decreased maturity and strength.

Eaton (10) sprayed cotton plants with 20 ppm sodium salts of 4-chlorophenoxyacetate, beta-napthoxyacetate, and alpha-napthalenecetate at weekly intervals, starting about 2 weeks prior to anthesis and continued until late August. There was a reduction in the number of bolls per plant of plants treated with 4-chlorophenoxyacetate and a small increase on those plants treated with beta-naphloxyacetate.

Studies of the effect of gibberellic acid applied to cotton plants or individual flowers and bolls of flowering, fruiting, yield, and fiber characteristics have been reported by Johnson (14) and Johnson, Lane, and Cowley (15). They applied gibrel, an emulsfiable concentrate containing potassium gibberellate, at weekly intervals from flowering until bolls were mature. They noted a general increase in the number of bolls set per plant when both irrigated and non-irrigated cotton were treated. This increase was not reflected in yield, however. Micronaire tended to be higher in treated plants, but fiber length and strength were not affected. Similar results were reported by Johnson et al. (16).

In studies conducted by Singh and Dargan (25), applications of indole acetic acid, napthalene acetic acid, and indole butyric acid did not affect boll number, yield/plant, ginning percent, seed and lint indexes, and yield.

MATERIALS AND METHODS

Four experiments were conducted in 1974 with Stoneville 213 cotton at two locations: The University of Arizona's Marana Experimental Farm and the Cotton Research Center, Phoenix.

Experiments I and II were located at the Marana Experimental Farm on a Pima clay loam soil and were planted April 10. The previous crop was wheat (*Triticum aestivum* L.) grown for grain. Experiments III and IV were grown at the Cotton Research Center on an Adelanto clay loam soil following alfalfa (*Medicago sativa* L.). Cotton was planted on March 28.

At both locations, standard land preparation for narrow-row cotton production was followed. At Marana, after plowing, 54 and 67 kg/ha of N and P_2O_5, respectively, were applied. For weed control, 1.8 liters/ha of Trifluralin (a,a,a-trifluro-2,6-dinitro-N,N-diprophyl-p-toluine) and 1.4 kg/ha Diuron 3-(3-4-dichlorophenyl)1,1-dimethylurea were applied. At Phoenix only nitrogen fertilizer at 78 kg/ha was applied and the herbicide treatment was similar to Marana. At both locations the land was disked to incorporate these herbicides. Beds 102 cm apart were made with a lister. A bedshaper was used to form the beds for planting two rows 31 cm apart on each bed. Following listing and shaping, the pre-plant irrigation was applied on March 15 and April 4 at Phoenix and Marana, respectively.

Acid delinted seed was planted to obtain a population of 148,260 plants/ha at Phoenix and 224,390 plants/ha at Marana with the exception of Treatment 2 in Experiment I and II where the plant population was thinned to 148,260 plants/ha.

The experimental design was a randomized complete block in a split-plot arrangement with growth regulators as mainplots and harvesting dates of the same plots as subplots. Each experiment contained four replications. The plot size was two-beds wide and 10.7 and 12 meters long at Marana and Phoenix, respectively. Hand thinning at Marana was done when the seedlings were at the 4 to 6 leaf stage. The normal farm schedule for insect control was followed at both locations.

After the preplant irrigation, water was applied when plants showed symptoms of water stress. About 10 cm of water were applied at each irrigation on the following dates: May 21, June 8 and 26, July 11, August 1 and 16 at Marana and May 20, June 16, July 1 and 18, August 1 and 27 at Phoenix. Total rainfall during the growing season was 20 cm at both Marana and Phoenix.

The chemicals used in this study were BAS 0660W and 83394X. They were obtained from the BASF Wyandotte Chemical

Corporation. These chemicals were chosen because in previous observational trials in Arizona these chemicals showed potential for increasing yield and/or creating a more desirable plant type under irrigated narrow-row cotton production. The rates and frequency of application used in this study were suggested by the manufacturer. The treatments used in experiments at Marana and Phoenix are shown in Tables 1 and 2. A low plant population treatment was included in Experiments I and II at Marana to compare a lower planting rate with the effects of chemical treatments on high population cotton.

A 13.5-liter hand sprayer equipped with three nozzles mounted on a boom placed 32.5 cm apart was used for applying the chemicals. Each nozzle had a 1.59 mm hole with a flat opening (Tee-Jet 8003). This arrangement sprays one 102 cm bed. Spraying was done between 9 a.m. and 12 noon, with the wind essentially calm to eliminate drift. Sufficient spray solution was prepared to treat all replications plus an additional quantity for proper operation of the sprayer. To allow for a uniform spray application, a constant walking speed was maintained with a beginning tank pressure of 2.8 kg/cm^2 (40 psi). After spraying a plot, the tank pressure was raised to 2.8 kg/cm^2 before applying to the next plot. With each chemical, spraying proceeded from the low to high concentration. After spraying all replications, the sprayer

Table 1. BAS 0660W and BAS 83394X treatments used with rate and date of application to cotton in Experiments I and II at Marana.

Treatment	Rate of Application g ai/ha	Date of Application
1	Check - 224,390 pl/ha	-
2	148,260 pl/ha	-
3	336 - 224,390 pl/ha	½ on Jun. 13 & ½ on Aug. 7
4	336 "	½ on Jul. 2 & ½ on Aug. 7
5	168 "	Aug. 7
6	168 "	Jul. 2
7	336 "	Aug. 7
8	336 "	Jul. 2

Table 2. BAS 0660W and BAS 83394X treatments used with rate and date of application in Experiments III and IV at Phoenix.

Treatment	Rate of Application g ai/ha	Date of Application	
		Exp. III	Exp. IV
1 Check	-	-	-
2 BAS 0660W	168	Jun. 13	Jul. 11
3 BAS 0660W	336	Jun. 13	Jul. 11
4 BAS 83394X	168	Jun. 13	Jul. 11

and nozzles were rinsed before beginning the next treatment.

Seed cotton was hand harvested from 3.1 m^2 from each plot at weekly intervals after bolls began to open. The first harvest was on August 27 and 30 at Phoenix and Marana, respectively. Ten undamaged open bolls were used for determination of fiber quality and boll characteristics. The remaining bolls were used for yield determination. Cotton was harvested with an Allis-Chalmers stripper harvester on November 31 and December 4 at Marana and Phoenix, respectively. The plots for harvest had adjacent rows of similar treatments to eliminate border effects. Before harvesting for total yield, 25 undamaged open bolls were hand picked from each plot for determination of boll and fiber characteristics.

Boll samples for fiber and boll characteristics were kept in paper bags under controlled environmental conditions (65% relative humidity and 22 C) until the samples were tested at the University of Arizona Cotton Fiber Laboratory. Laboratory analysis included: boll weight, lint percent, lint index, seed index, fiber length (Fibrograph), fiber strength (Pressley strength index), and fiber fineness (Micronaire).

Plant height was recorded at Marana on July 31 and at maturity. At Phoenix heights were measured only at maturity.

All yield data were analyzed using the standard analysis of variance with combined harvest dates and also using individual harvest dates. Because of limited boll numbers, boll and fiber property data were analyzed for the first four and five combined harvest dates for BAS 0660W and BAS 83394X, respectively, and then separately for each of the harvest dates. Treatment means were compared using the Least Significant Difference (LSD) and Student-Newman-Keuls' Multiple Range Test.

RESULTS AND DISCUSSION

Yield

Neither BAS 0660W or 83394X treatment significantly increased total seed cotton yield at either Marana or Phoenix. Cumulative yield for the BAS 0660W treatments at Marana for each of eight harvest dates is shown in Fig. 1. Treatments within each harvest date were not significantly different except on October 24, when 336 g ai/ha applied at onset of flowering increased seed cotton yield over the 336 g ai/ha treatment applied at late flowering stage.

Total seed cotton as a percentage of the check for both hand and machine harvested plots is shown in Table 3. High and low concentrations of BAS 0660W applied at onset of flowering in the hand-picked plots were 7 and 5% higher, respectively, than the check although differences were not statistically significant. Applying the high concentration late in the flowering stage reduced yield significantly compared to the low concentration applied at onset of flowering. Similar trends were also reported by Follin (12), Marani et al. (21), and Thomas (33).

Cumulative seed cotton yield among BAS 83394X treatments at Marana for each of the nine hand harvests is shown in Fig. 2. No significant differences were observed at

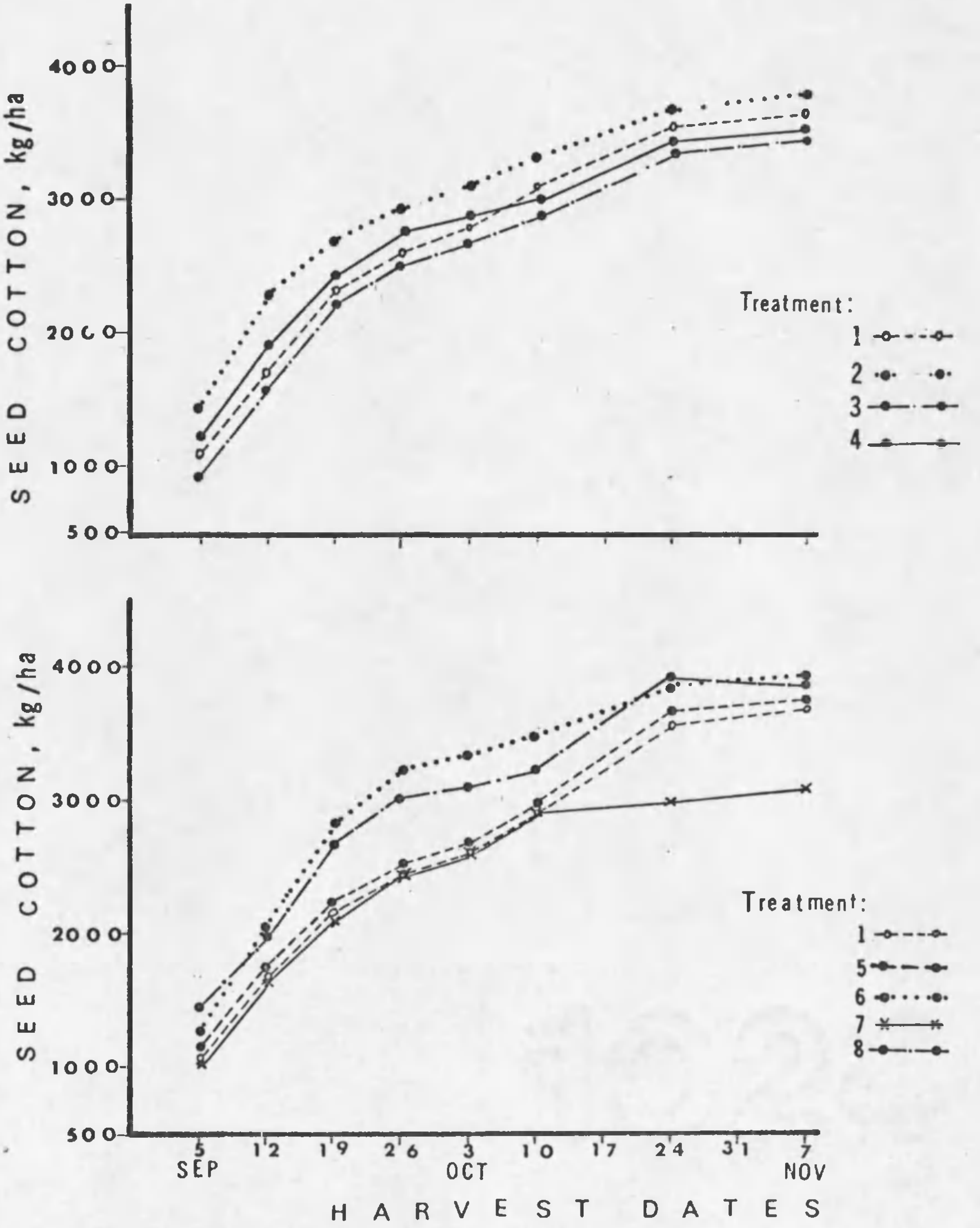

Fig. 1. Cumulative seed cotton from six BAS 0660W treatments, 148,260 pl/ha population, and check obtained from eight harvests at Marana.-- The L.S.D. value at 5% level was 486 kg/ha.

Table 3. Effect of application date and rate of BAS 0660W on total seed cotton yield of hand and machine harvested plots at Marana.*

Treatments	Yield (percentage of check)	
	Hand Picked	Machine Picked
1 Check	100 ab	100 a
2 148,260 pl/ha	104 ab	97 a
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	94 ab	89 a
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	96 ab	95 a
5 168 g ai/ha, Aug. 7	103 ab	94 a
6 168 g ai/ha, Jul. 2	107 a	96 a
7 336 g ai/ha, Aug. 7	85 b	92 a
8 336 g ai/ha, Jul. 2	105 a	93 a

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

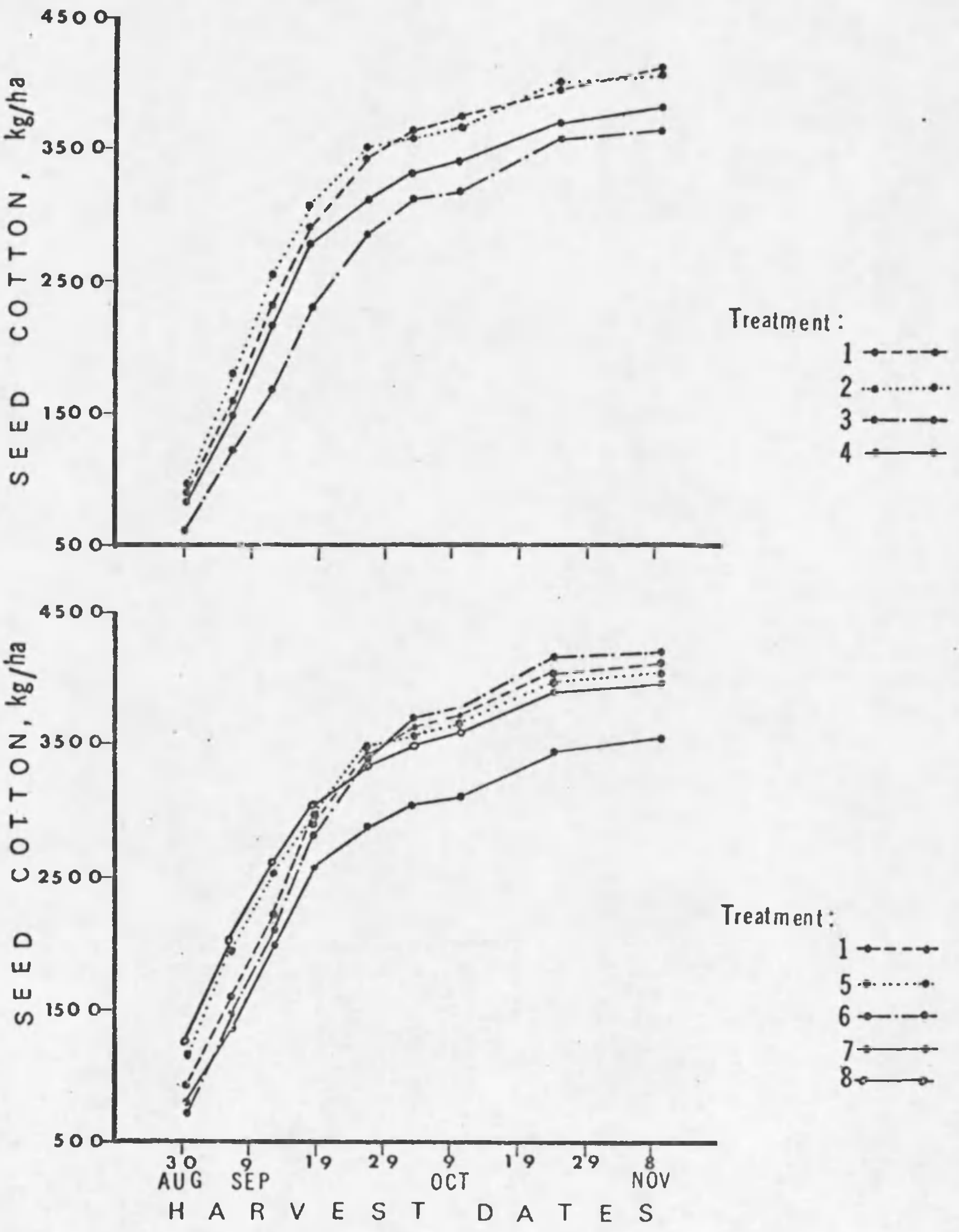

Fig. 2. Cumulative seed cotton from six BAS 83394X treatments, 148,260 pl/ha, and the check from nine harvest periods at Marana.-- The L.S.D. value for harvest periods was 100.7 kg/ha.

either concentration or date of application. However, highly significant differences among harvest dates was indicated by the analysis of variance.

Total seed cotton as a percentage of the check for both hand and machine harvested plots are shown in Table 4. None of the treatments had significantly higher yield than the check in the hand harvested plots. In the stripper harvested plots, split application of 336 g ai/ha either before or at onset of flowering significantly reduced cotton yield by 15 and 14% respectively compared to the untreated check.

Neither BAS 0660W or 83394X applied before blooming (June 13) on cotton grown at Phoenix showed significant differences in yield; however, when applied at onset of flowering (July 11) significant differences were observed in cumulative seed cotton yields (Fig. 3) on September 10 and October 15. At both of these harvest dates either low or high concentration of BAS 0660W increased cotton yields significantly.

Plant Height

Plant height at maturity was significantly reduced by both BAS 0660W and 83394X treatments when applied at onset of flowering at both Marana and Phoenix. Plant height recorded at Marana on July 31 and November 1 for BAS 0660W treatments

Table 4. Effect of application date and rate of BAS 83394X on seed cotton yield of hand and machine harvested plots at Marana.*

Treatments	Yield (percentage of check) Hand Picked	Machine Picked
1 Check	100 a	100 a
2 148,260 pl/ha	100 a	96 ab
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	88 a	85 b
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	92 a	86 b
5 168 g ai/ha, Aug. 7	97 a	88 ab
6 168 g ai/ha, Jul. 2	102 a	92 ab
7 336 g ai/ha, Aug. 7	86 a	91 ab
8 336 g ai/ha, Jul. 2	100 a	93 ab

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

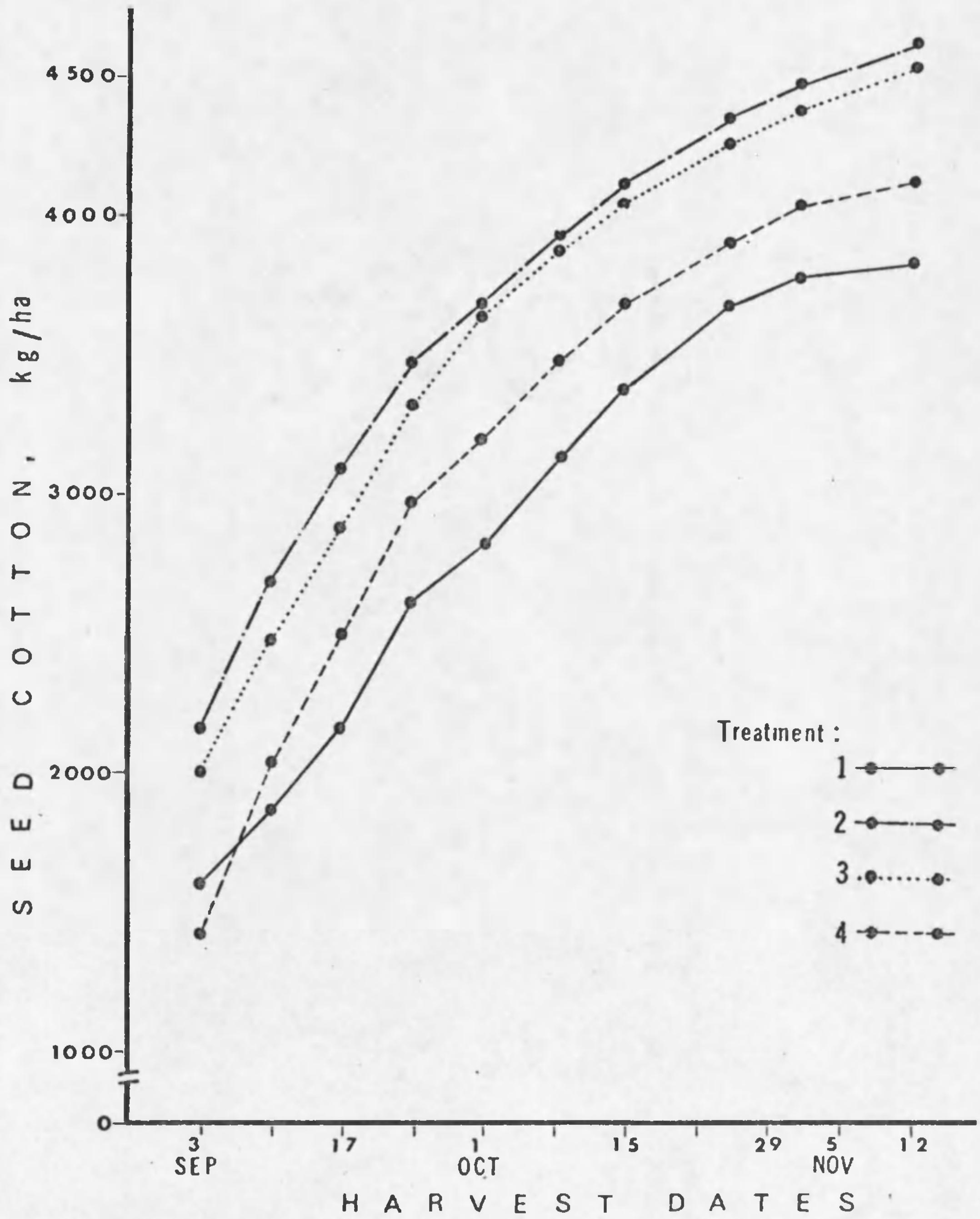

Fig. 3. Cumulative seed cotton from three chemical treatments sprayed on July 11 at Phoenix.-- The L.S.D. value at 5% level for treatments was 142 kg/ha.

and check are presented in Table 5. Heights recorded on July 31 were not significantly different, while height measurements recorded on November 1 indicated highly significant differences. Application at onset of flowering either in split or single application (Treatments 4 or 8) reduced mature plant height compared to the check or the 148,260 pl/ha treatment. These results agree with the manufacturer's observations as summarized by Thomas (34) that application of BAS 0660W reduces internode length and plant height. These data are in agreement with those of Thomas and Hacskaylo (32) and Thomas (33).

The results of BAS 83394X treatments on plant height recorded on July 31 and November 1 are shown in Table 6. Plant height on July 31 did not differ significantly. Application of BAS 83394X significantly reduced plant height at maturity compared to 148,260 pl/ha. The high concentration of 336 g ai/ha either in single or split application reduced height significantly compared to the check. Similar results were also obtained at Phoenix for both BAS 0660W and 83394X treatments (Table 7). Again, early application before flowering did not significantly alter plant height. However, applying the growth regulators at the onset of flowering significantly reduced plant height. High or low concentrations of the growth regulator did not change plant height at maturity.

Table 5. Effect of application date and rate of BAS 0660W on plant height at Marana.*

Treatments	Height (cm) July 31	Height (cm) November 1
1 Check	65 a	79 a
2 148,260 pl/ha	65 a	77 a
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	59 a	69 abc
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	57 a	63 c
5 168 g ai/ha, Aug. 7	62 a	75 ab
6 168 g ai/ha, Jul. 2	56 a	72 abc
7 336 g ai/ha, Aug. 7	65 a	73 abc
8 336 g ai/ha, Jul. 2	56 a	65 bc

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

Table 6. Effect of application date and rate of BAS 83394X on plant height at Marana.*

Treatments	Height (cm)	
	July 31	November 1
1 Check	64 a	84 bc
2 148,260 pl/ha	62 a	86 c
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	58 a	67 a
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	52 a	65 a
5 168 g ai/ha, Aug. 7	60 a	73 ab
6 168 g ai/ha, Jul. 2	58 a	73 ab
7 336 g ai/ha, Aug. 7	62 a	72 ab
8 336 g ai/ha, Jul. 2	50 a	69 a

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

Table 7. Effect of application date and rate of BAS 0660W and BAS 83394X on mature plant height at Phoenix.*

Treatments	Height (cm) Applied on June 13	Height (cm) Applied on July 11
1 Check	113 a	111 a
2 BAS 0660W, 168 g ai/ha	105 a	93 b
3 BAS 0660W, 336 g ai/ha	93 a	95 b
4 BAS 83394X, 168 g ai/ha	98 a	92 b

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

Boll, Seed, and Fiber Characteristics

BAS 0660W and 83394X treatments did not significantly affect boll weight, seed/boll, and 50% span length characteristics. The Analysis of Variance (ANOVA) revealed highly significant differences among harvest dates for boll weight, seed/boll, seed index, lint index, lint percent, 25 and 50% span length, fiber fineness, and fiber strength.

The mean lint percent was significantly decreased by all treatments of BAS 0660W (Fig. 4). These results agree with the results obtained by Zur et al. (39), who used CMH applied at 480 g ai/ha during the first week of flowering. Lint percent of the 25-boll sample collected 1 week before final harvest are presented in Table 8. Highly significant differences among treatments were observed. The 148,260 pl/ha population treatment had a significantly higher lint percent than other treatments including the check.

All BAS 83394X treatments decreased lint percent (Fig. 5). Twenty-five boll samples, collected 1 week before harvesting with a mechanical stripper (Table 9), indicated that the untreated check had significantly higher lint percent compared to the plots treated with a high concentration of BAS 83394X (Treatments 3, 4, and 7) applied either in a single or a split application.

High concentration of BAS 0660W applied at onset of flowering significantly increased lint index (Table 10). At

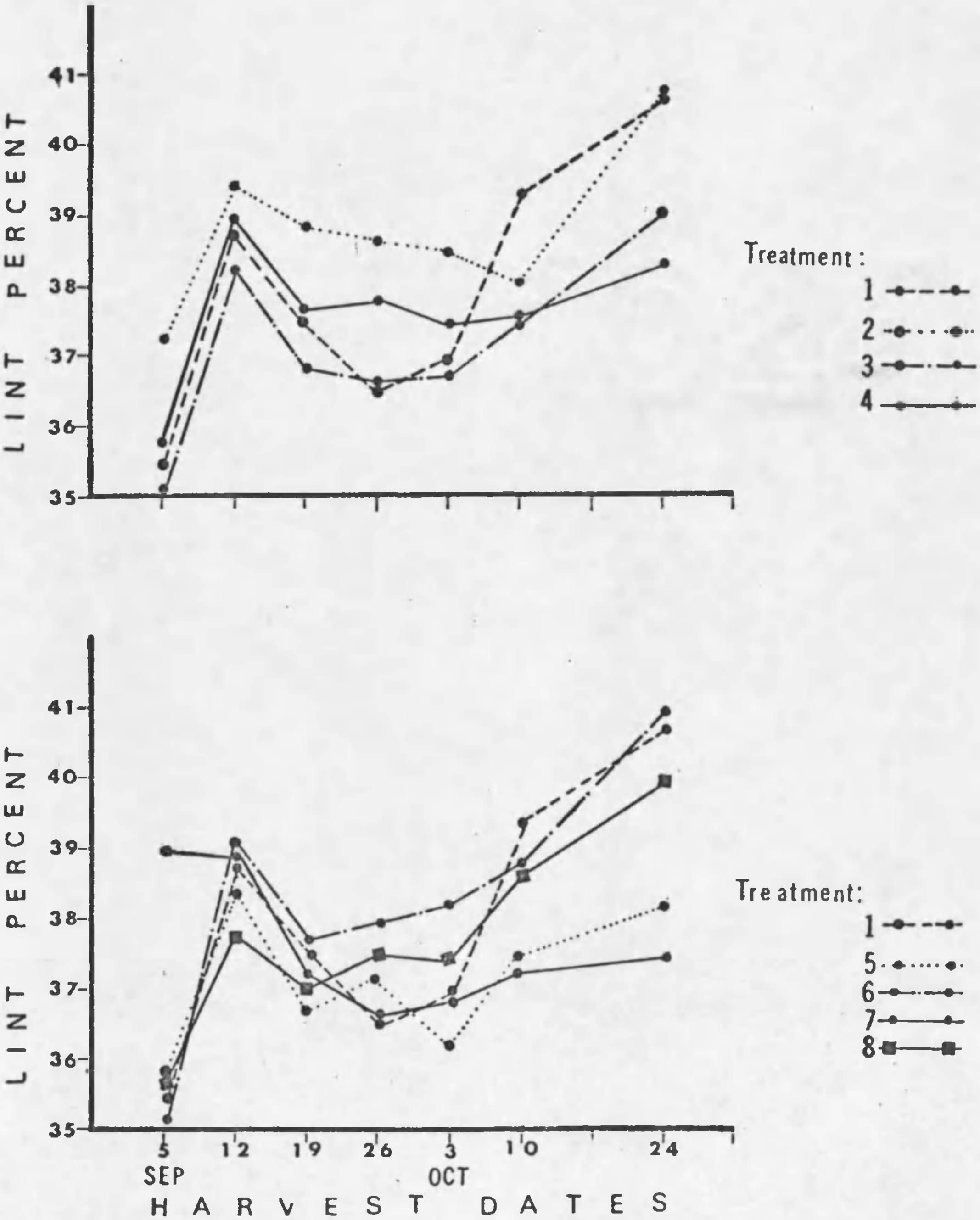

Fig. 4. Lint percent from six BAS 0660W treatments, 148,260 pl/ha, and check obtained from seven harvests at Marana.-- The L.S.D. value at 5% level was 1.28.

Table 8. Effect of BAS 0660W on mean lint percent for the 25 boll sample at Marana.*

Treatments	Lint Percent
1 Check	38.98 b
2 148,260 pl/ha	39.68 a
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	37.83 c
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	38.18 bc
5 168 g ai/ha, Aug. 7	38.13 bc
6 168 g ai/ha, Jul. 2	38.70 bc
7 336 g ai/ha, Aug. 7	37.78 c
8 336 g ai/ha, Jul. 2	38.50 bc

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

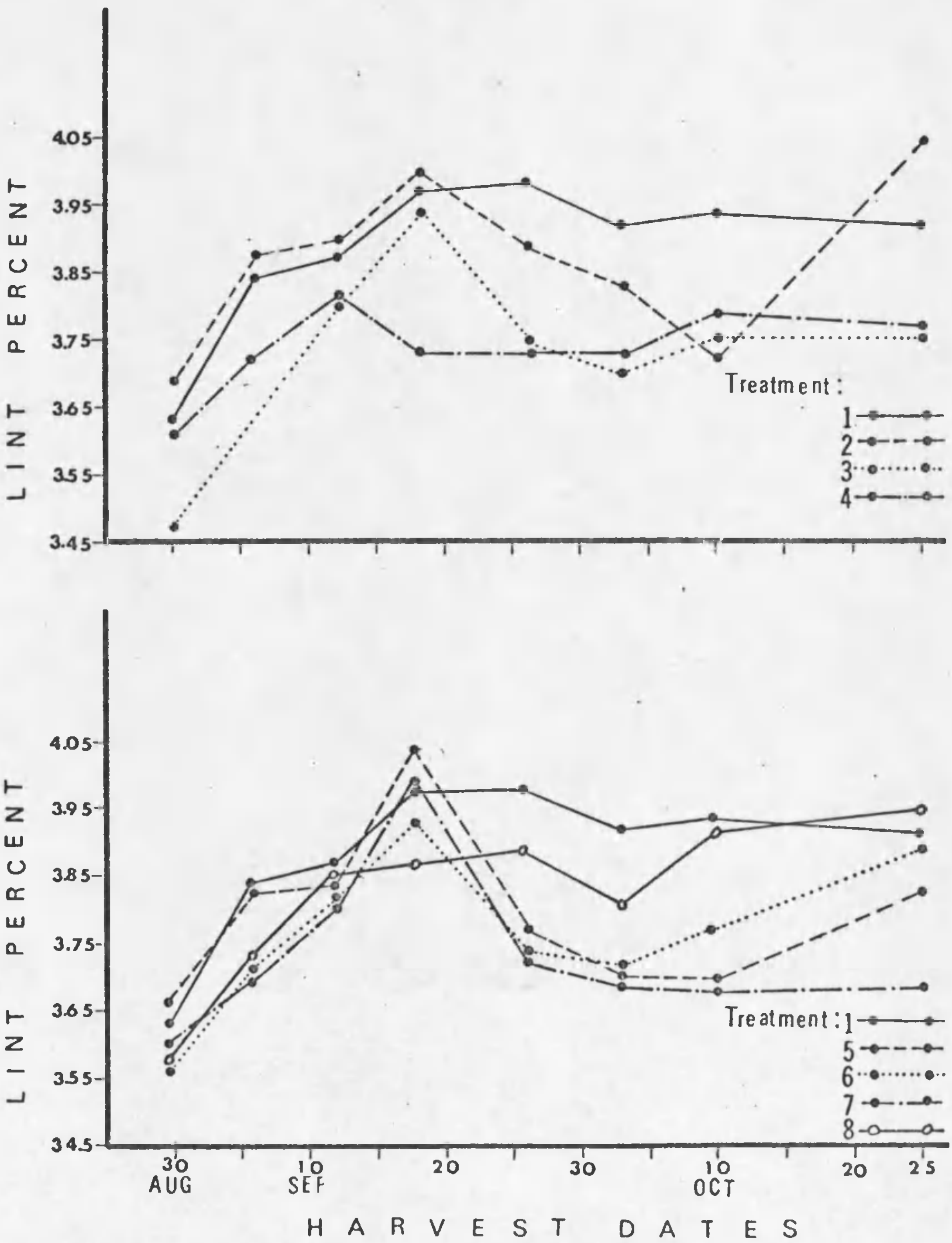

Fig. 5. Lint percent from six BAS 83394X treatments, 148,260 pl/ha, and check obtained from eight harvest periods at Marana.-- The L.S.D. value at 5% level was 0.95 for the treatments.

Table 9. Effect of BAS 83394X on mean lint percent for the 25 boll sample at Marana.*

Treatments	Lint Percent
1 Check	39.48 a
2 148,260 pl/ha	39.10 ab
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	38.08 bc
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	38.10 bc
5 168 g ai/ha, Aug. 7	38.83 abc
6 168 g ai/ha, Jul. 2	38.63 abc
7 336 g ai/ha, Aug. 7	37.63 c
8 336 g ai/ha, Jul. 7	38.45 abc

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

Table 10. Effect of BAS 0660W on mean lint index values from the combined harvest dates and September 26 harvest at Marana.*

Treatments	Lint Index Values: Harvest Dates From Sept. 5-Oct. 3	Lint Index Values: Harvest on Sept. 26
1 Check	6.85 bc	6.65 ab
2 148,260 pl/ha	7.18 ab	7.15 a
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	6.94 abc	6.55 ab
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	7.01 abc	6.93 ab
5 168 g ai/ha, Aug. 7	6.80 bc	6.78 ab
6 168 g ai/ha, Jul. 2	7.09 abc	6.93 ab
7 336 g ai/ha, Aug. 7	6.76 c	6.25 b
8 336 g ai/ha, Jul. 7	7.25 a	7.25 a

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

the September 26 harvest date, only the 148,260 pl/ha population and high concentration applied at onset of flowering significantly showed an increased lint index compared to the high concentration applied late in the flowering stage.

Seed index values for BAS 0660W treatments are presented in Fig. 6. There were no significant differences among treatments at any of the harvest dates except on September 17 where high concentration, applied either in single or split application, significantly increased seed index values over the untreated check or 148,260 pl/ha treatment.

Application of BAS 83394X either before or at onset of flowering significantly increased seed index (Fig. 7). Either high or low concentration applied either before or at onset of flowering increased seed index values compared to the untreated check or 148,260 pl/ha treatment (Table 11).

Mean fiber length (25% span length) treatments and check are shown in Fig. 8. Application of BAS 83394X did not result in any significant differences either in the combined analysis or for separate harvest dates except on September 6 and 18. On September 6, the high concentration applied in split application before flowering and at the late stage of flowering (Treatment 3) increased fiber length compared to the 148,260 pl/ha population treatment (Table 12). Similar results were also obtained on

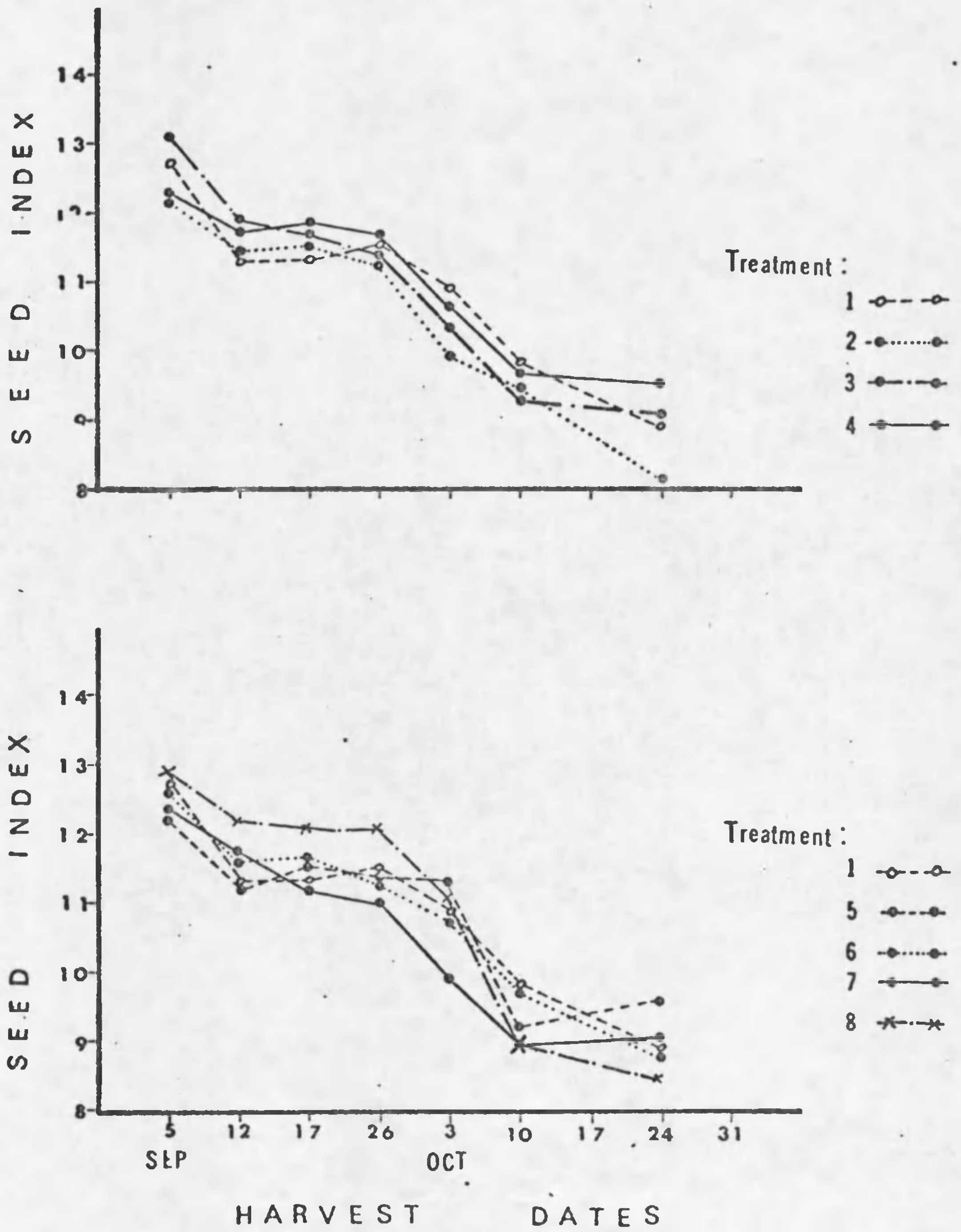

Fig. 6. Seed index from six BAS 0660W treatments, 148,260 pl/ha, and the check obtained from seven harvests grown at Marana.-- The L.S.D. value at 5% level was 0.51.

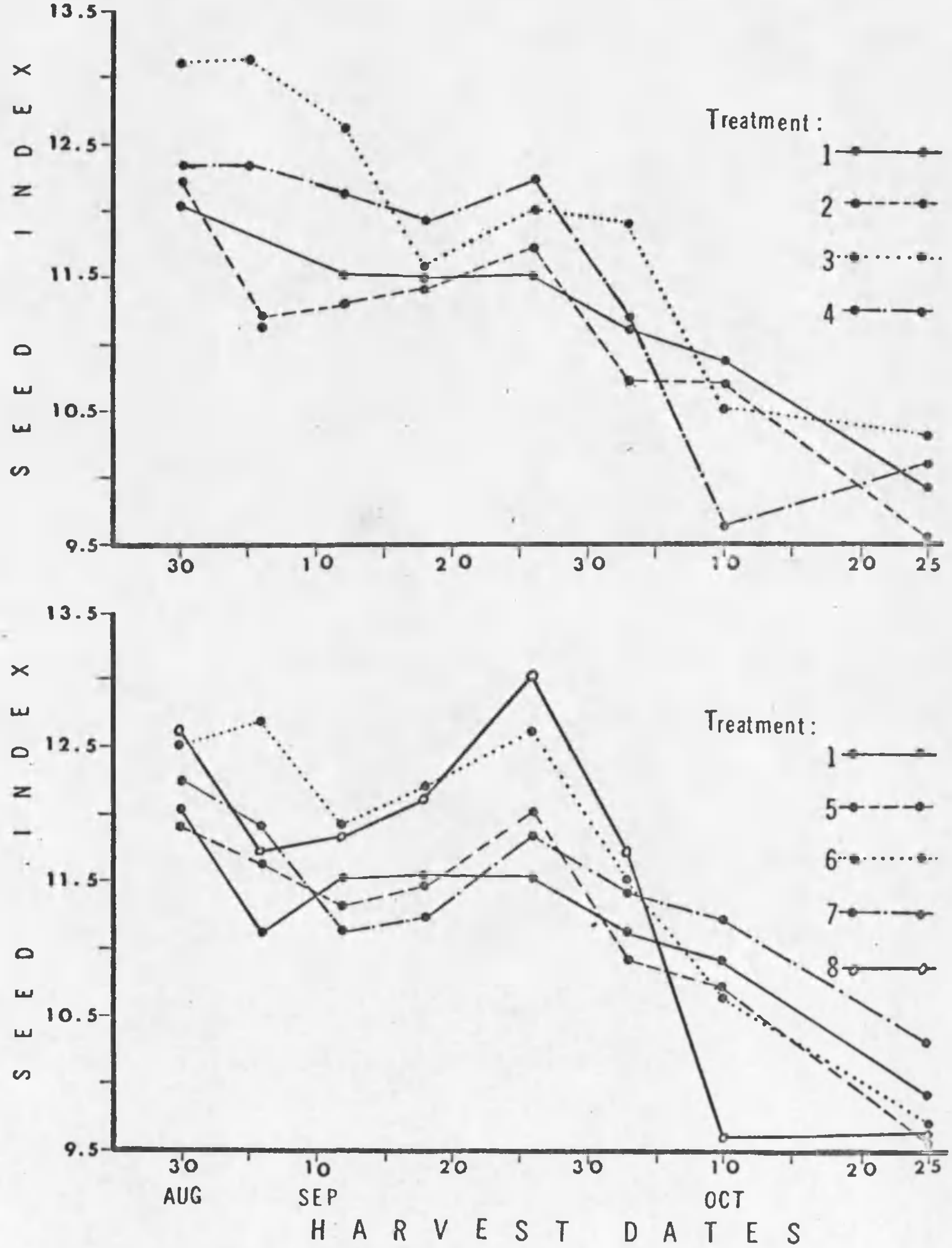

Fig. 7. Seed index from six BAS 83394X treatments, 148,260 pl/ha and check obtained from eight harvest periods at Marana.-- The L.S.D. value at 5% level was 0.45 for the treatments.

Table 11. Effect of BAS 83394X on mean seed index from the first five harvest dates at Marana.*

Treatments	Seed Index Values
1 Check	11.4 b
2 148,260 pl/ha	11.5 b
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	12.4 a
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	12.1 a
5 168 g ai/ha, Aug. 7	11.6 b
6 168 g ai/ha, Jul. 2	12.4 a
7 336 g ai/ha, Aug. 7	11.6 b
8 336 g ai/ha, Jul. 7	12.2 a

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

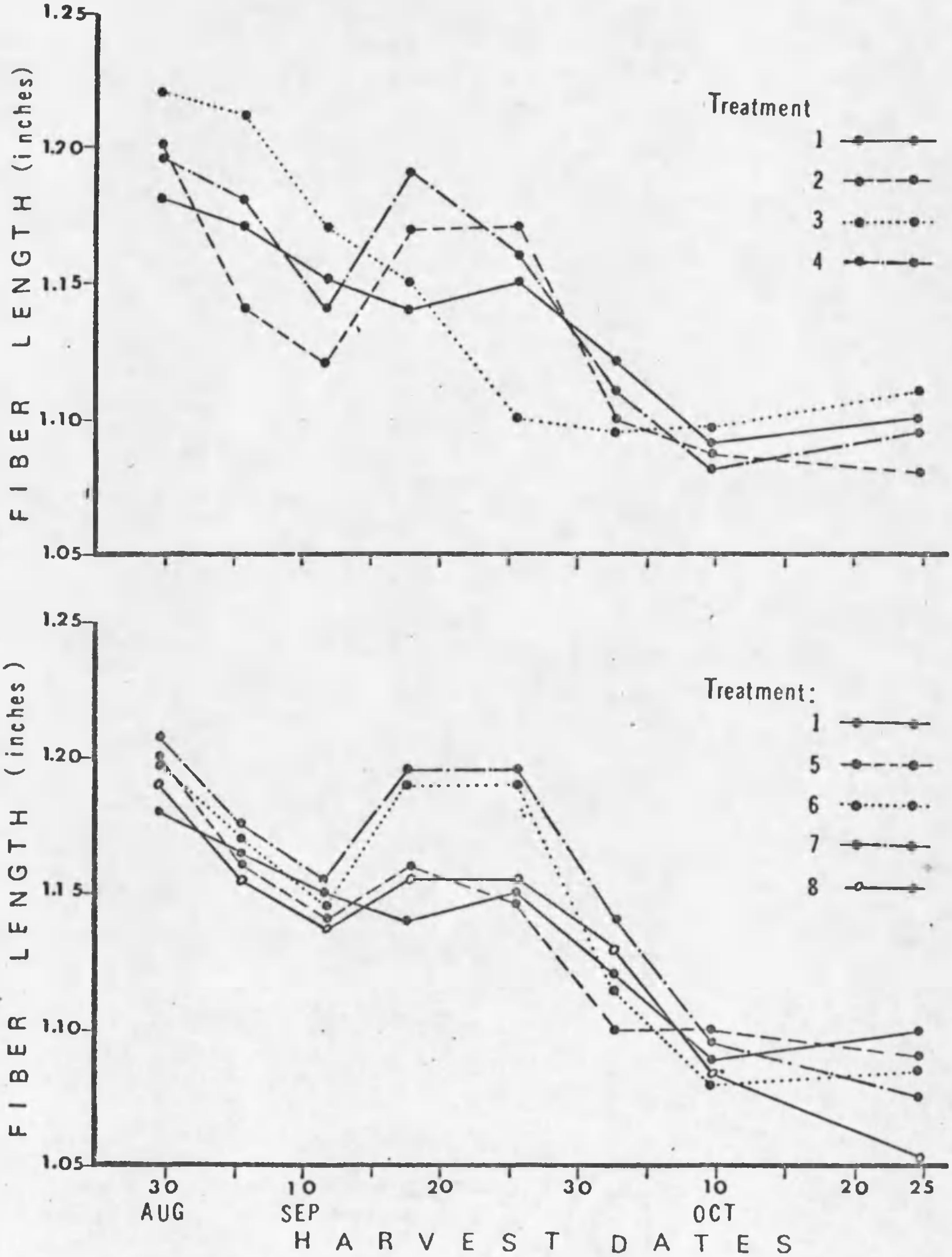

Fig. 8. Fiber length from six BAS 83394X treatments, 148,260 pl/ha, and check obtained from eight harvests at Marana.-- The L.S.D. value at the 5% level was 0.017 for the treatments.

Table 12. Effect of BAS 83394X on mean fiber length (25% span length) from harvests on September 6 and 18 at Marana.*

Treatments	Fiber Length (2.5% span length)	
	Harvest on Sept. 6	Harvest on Sept. 18
1 Check	1.17 ab	1.17 ab
2 148,260 pl/ha	1.14 b	1.14 a
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	1.21 a	1.20 a
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	1.18 ab	1.18 ab
5 168 g ai/ha, Aug. 7	1.17 ab	1.17 ab
6 168 g ai/ha, Jul. 2	1.17 ab	1.17 ab
7 336 g ai/ha, Aug. 7	1.17 ab	1.17 ab
8 336 g ai/ha, Jul. 7	1.17 ab	1.17 ab

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

September 18. These results agree with those obtained by Asici (4). He noted that application of CCC at 75 ppm increased fiber length.

No significant differences in fiber strength were observed for all treatments of BAS 0660W either as a combined or separate harvest dates except for the September 26 harvest date (Table 13). On September 26, fiber strength was significantly increased by applying 336 g ai/ha on August 7 compared to the untreated 148,260 pl/ha treatment. Similar results were obtained by Asici (4). He used CCC at 75 ppm applied in three applications at an interval of 15 days. His results indicated that cotton picked on October 15 gave the highest fiber strength.

The mean fiber fineness index values from seven harvest dates are shown in Fig. 9. Highly significant differences among treatments were indicated when analyzed as a combination of the first four harvest dates (Table 14). Treatment 2, the 148,260 pl/ha population, gave significantly higher Micronaire values than all other treatments except for the 168 and 336 g ai/ha treatments on July 2. When 336 g ai/ha were applied on August 7, fiber fineness was reduced significantly compared to the high concentration applied in one application at onset of flowering.

Within harvest dates, significant differences were only found on September 26 (Table 14). These results were

Table 13. Effect of BAS 0660W on mean fiber strength for the September 26 harvest at Marana.*

Treatments	Fiber Strength Index
1 Check	3.09 ab
2 148,260 pl/ha	2.97 b
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	3.09 ab
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	3.08 ab
5 168 g ai/ha, Aug. 7	3.03 ab
6 168 g ai/ha, Jul. 2	3.18 ab
7 336 g ai/ha, Aug. 7	3.21 a
8 336 g ai/ha, Jul. 2	3.15 ab

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

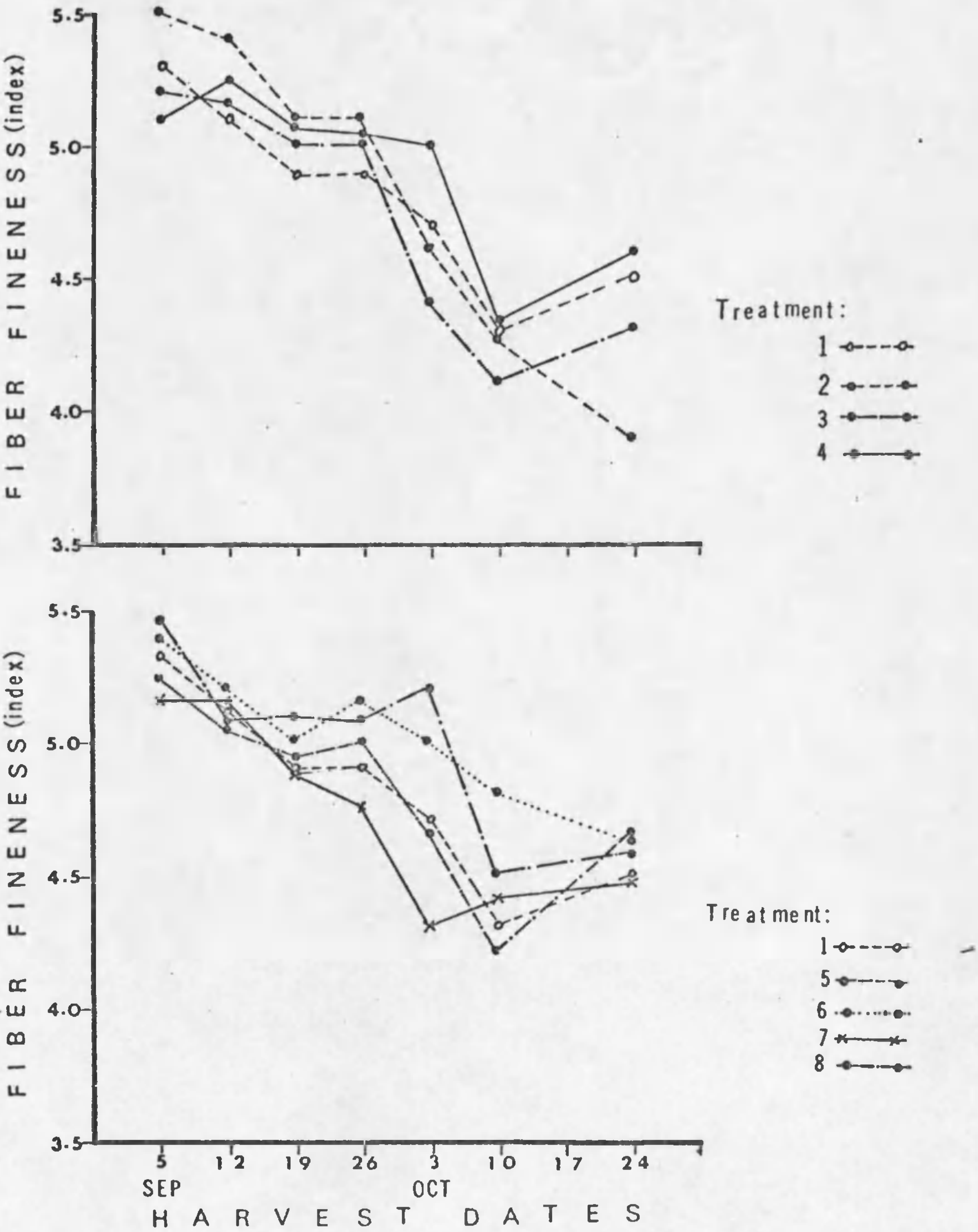

Fig. 9. Fiber fineness from six BAS 0660W treatments, 148,260 pl/ha, and the check obtained from seven harvests at Marana.-- The L.S.D. value at 5% level was 0.014.

Table 14. Effect of BAS 0660W on mean fiber fineness index for first four harvests combined and the September 26 harvest at Marana.*

Treatments	Fiber Fineness Index Combined Harvest 1-4	Harvest on Sept. 26
1 Check	5.04 bc	4.90 bc
2 148,260 pl/ha	5.31 a	5.23 a
3 336 g ai/ha, ½ Jun. 13, ½ Aug. 7	5.06 bc	4.95 bc
4 336 g ai/ha, ½ Jul. 2, ½ Aug. 7	5.11 bc	5.00 bc
5 168 g ai/ha, Aug. 7	5.06 bc	5.03 abc
6 168 g ai/ha, Jul. 2	5.19 abc	5.16 ab
7 336 g ai/ha, Aug. 7	4.99 c	4.75 c
8 336 g ai/ha, Jul. 2	5.24 ab	5.29 a

*Values lacking common letters in a column differ significantly from each other at the 5% level according to the Student-Newman-Keuls' Multiple Range Test.

similar to the analysis of the first four combined harvest dates. Both the 148,260 pl/ha treatment and the high concentration applied at the onset of flowering significantly increased Micronaire values compared to the untreated check.

SUMMARY AND CONCLUSION

Field studies at Marana and Phoenix were conducted to investigate the effect of two growth regulators, BAS 0660W and 83394X, on yield, plant height, and boll and fiber properties of Stoneville 213 cotton.

Both of these regulators, at Marana, were applied at two concentrations, either in one or split application, and at three flowering stages. These flowering stages were either before, at onset of, or at late stage of flowering. At Phoenix, both of these growth regulators were applied at two concentrations in one application at two stages of flowering, either before or at onset of flowering.

BAS 0660W and 83394X did not increase total seed cotton yield significantly at either Marana or Phoenix. Yield differences between harvest dates were highly significant.

At Marana, BAS 0660W applied at high concentration at onset of flowering either in one or split applications significantly reduced plant height at maturity. All treatments with BAS 83394X significantly reduced mature plant height. At Phoenix, both chemicals applied at onset of flowering significantly reduced mature plant height.

Concentration and time of application of BAS 0660W did not significantly affect boll weight, seed/boll, seed index, or the 25 or 50% span length characteristics.

The untreated 148,260 pl/ha population increased lint percent except at the last two harvest dates. Significantly increased lint percent values were obtained from 25-boll samples taken before harvesting by the stripper. All treatments decreased the lint percent values compared to the untreated 148,260 pl/ha population.

High concentration of BAS 0660W applied at onset of flowering significantly increased lint index for all harvest dates. Similar results were obtained at the September 26 harvest date.

Mean seed index did not show significant differences among treatments within any of the harvest dates except for September 17. On September 17, high concentrations applied in either single or split application increased seed index values significantly over the untreated check or low population treatment.

Fiber strength was significantly increased by applying high concentrations of BAS 0660W during late stages of flowering at the September 26 harvest date, compared to the untreated 148,260 pl/ha population treatment. Fiber fineness was also significantly increased at high concentration (336 g ai/ha) applied at late stages of flowering.

Concentration and time of application of BAS 83394X did not significantly affect boll weight, lint index, seed/boll, 50% span length, fiber fineness, or strength characteristics.

The mean lint percent values showed significant differences for the 25-boll sample. BAS 83394X generally reduced lint percent. Seed index from different harvest dates showed significant differences, when analyzed as a combination of the first five harvest dates. Application at either before or at onset of flowering increased seed index values. Application of BAS 83394X at onset of flowering increased fiber length significantly when applied either at low or high concentrations.

Both BAS 0660W and 83394X applied at the onset of flowering reduced mature plant height and suppressed vegetative growth. This reduction in growth is particularly beneficial under irrigated and narrow-row planting conditions to reduce lodging problems and increase harvesting efficiency.

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