Published March, 1977

# Termination of Late Season Cotton Fruiting with Plant Growth Regulators[1]

D. L. Kittock and H. Fred Arle[2]


## ABSTRACT

**Chemical termination of cotton (*Gossypium* spp.) fruiting is a new proposed insect control technique. Development of effective fruiting termination treatments is the objective of this research. Treatments were applied to field plots (11 to 20 m long) between 15 August and 10 September. We found two types of plant-growth-regulator response: 1) fast acting and non-persistent; and 2) slow acting and persistent. Mixutres of the two types produced the most effective chemical termination treatments. Two effective growth regulators of each type were identified. The slow acting, persistent growth regulators were chlormequat or CCC, [(2-chloroethyl)trimethylammonium chloride], and chlorflurenol, (methyl 2-chloro-9-hydroxyfluorene-9-carboxylate). The fast acting growth regulators were 2,4-D. [(2,4-dichlorophenoxy) acetic acid], and TD 1123, (3,4-dichloroisothiazole 5-carboxylic acid). 2,4-D was applied at 37 g/ha when used alone, and usually at 28 g/ha in mixture with other plant growth regulators. The most effective rates for chlormequat and chloroflurenol were 560 g/ha in mixture and about twice that rate when applied alone. TD 1123 was applied in mixture at 1121 g/ha. Mixtures of 2,4-D with either of the two persistent growth regulators produced more effective chemical termination than 2,4-D applied alone. These three treatments have been tested extensively and found effective. They are suitable for use by entomologists for large scale testing of chemical termination for insect control. In limited testing, TD 1123 appeared to be superior to 2,4-D when used in mixture with the persistent plant growth regulators.**


***Additional index words:* Gossypium hirsutum L., Gossypium barbadense L., 2,4-D (2,4-dichlorophenoxy) acetic acid, 3,4-dichloroisothiazole 5-carboxylic acid, CCC, Chlormequat, (2-chloroethyl)trimethylammonium chloride, Chlorflurenol, Methyl 2-chloro-9-hydroxyfluorene-9-carboxylate, Chemical termination, Seed quality, Fiber quality, Seedling emergence.**

EARLY termination of cotton (Gossypium spp.) fruiting for pink bollworm (*Pectinophora gossypiella* Saund.) control through application of defoliants or desiccants was proposed by Adkisson (1). Chemical termination of cotton, which differs from Adkisson's proposal by retaining foliage in a state that permits continued photosynthesis, was first proposed and evaluated in 1971 (7). At that time results of growth regulator treatments were promising, but were not considered adequate for commercial use. Since 1971, testing has continued with other plant growth regulators, and mixtures of plant growth regulators at various rates and times of application. Each year, the most promising treatments have been included in uniform tests on Upland (*G. hirsutum* L.) and American Pima (*G. barbadense* L.) cotton at several locations in Arizona and California. The objective of this report is to evaluate four plant growth regulators, applied in these uniform tests, for plant responses and effectiveness for chemical termination of cotton.

## MATERIALS AND METHODS

We are reporting the results of 18 chemical termination tests on Upland and American Pima cotton that were conducted in Arizona and California over a 3-year period (1972, 1973, and 1974). In 15 of the tests, there were four treatments and a check. In the other three tests (1972), data for treatments in excess of four (less effective treatments) have been deleted for this report. Pertinent data on plot size, treatment dates, harvest dates, etc. are given in Table 1.

The treatment date test listed in Table 1 was a split plot, with dates as main plots and treatments as sub-plots. All other tests were randomized blocks. The 1972 test at Marana was not harvested for yield because the entire top crop was damaged heavily by pink bollworm.

All plots were four rows wide, with 102 cm between rows. Seed cotton yield and immature boll counts were obtained from the center two rows of each plot. Immature bolls, those which had not opened sufficiently for picking, were counted shortly before or immediately after first harvest. The tests were harvested by spindle picker, except for the Mesa test in 1972, which was hand picked.

Defruiting efficiency index (DE index) was used to evaluate efficiency of treatments. It consisted of the sum of lint yield reduction expressed as percent of check ($100 - \frac{Y_t}{Y_c} \times 100$) and the percentage of immature bolls at first harvest ($\frac{IB_t}{IB_c} \times 100$).

Upland cotton cultivars were 'Deltapine 16' (DPL 16) and 'Deltapine 61' (DPL 61). The American Pima cotton cultivar was 'Pima S-4' (S-4).

Tests were on University of Arizona Experiment Stations, except at Brawley, which was on a USDA Experiment Station. Elevations for the stations are as follows: Safford, 880 m; Marana, 600 m; Phoenix and Mesa, 350 m; Yuma 40 m; and Brawley —30 m.

The four plant growth regulators used in these tests were: 1) dimethyl amine salt of (2,4 dichlorophenoxy) acetic acid (2,4-D)[3]; 2) methyl 2-chloro-9-hydroxyfluorene-9-carboxylate (chlorflurenol)[3]; 3) (2-chloroethyl)trimethylammonium chloride (CCC or chlormequat)[3]; and 4) 3,4-dichloroisothiazole 5-carboxylic acid (TD 1123)[3]. They were applied with a two-row hand sprayer at volumes indicated in Table 1. The material was applied at pressure of approximately 2.75 kg/cm$^2$ using wide-angle-fan type nozzles.

Seed cotton samples were stored for 1 week to 4 months, then weighed, cleaned, reweighed, ginned, and seed and lint weighed. From these data, gin turnout, lint percentage, trash percentage, and lint yield were determined. Small subsamples of lint and seed were taken for additional testing.

Lint samples were processed and tested at the ARS, USDA fiber laboratory at the University of Arizona Cotton Research

[1] Contribution of ARS, USDA and Univ. of Arizona, Univ. of Arizona Cotton Res. Center, Phoenix, Ariz. Arizona Agric. Exp. Stn. Journal Article No. 2608. Received 10 Aug. 1976.

[2] Agronomists, ARS, USDA and Univ. of Arizona, respectively, Univ. of Arizona Cotton Res. Center, 4207 Esat Broadway, Phoenix, AZ 85040.

[3] Chlorflurenol used was Maintain CF 125® from US Borax & Chem. Corp., chlormequat was Cycocel® from American Cyanamid Co., and TD 1123 is an experimental growth regulator obtained from Pennwalt Corp. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable. These agricultural chemicals are not registered nor recommended for use on cotton by the USDA. All uses of these chemicals must be registered by the appropriate state and federal agencies before they can be recommended.

**Table 1. Experimental methods, treatments, etc. for 18 chemical termination tests on cotton.**

| Year and location | Cultivar | Reps | Plot length | Treatment | Harvest | Immature bolls | Defoliation | Spray volume | Treatments: 2,4-D | Chlormequat | Chlorflurenol | 2,4-D + chlormequat | 2,4-D + chlorflurenol | TD 1123 + chlorflurenol |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1972 | | | m | | date | | | liters/ha | | | | g/ha | | |
| Phoenix | DPL 16 | 4 | 11 | 28 Aug. | 27 Nov. | 16 Nov. | 6 Oct. | 418 | 37 | 841 | 1,681 | 37-841 | | |
| Phoenix | S-4 | 4 | 11 | 28 Aug. | 27 Nov. | 16 Nov. | 6 Oct. | 418 | 37 | 841 | 1,681 | 37-841 | | |
| Marana | S-4 | 5 | 20 | 24 Aug. | None | 8 Nov. | -- | 209 | 37 | 841 | 1,681 | 37-841 | | |
| Safford | S-4 | 5 | 14 | 25 Aug. | 7 Nov. | 6 Nov. | 9, 26 Oct. | 209 | 19 | 841 | 1,681 | 37-841 | | |
| Mesa | DPL 16 | 4 | 11 | 22 Aug. | 29 Oct. | 30 Oct. | None | 418 | 37 | 841 | 1,121 | 37-841 | | |
| 1973 | | | | | | | | | | | | | | |
| Brawley | DPL 16 | 4 | 12 | 22 Aug. | 27 Nov. | 28 Nov. | 18, 31 Oct. | 418 | 37 | | 1,121 | 28-560 | 28-560 | |
| Yuma | DPL 16 | 4 | 12 | 22 Aug. | 5 Nov. | 5 Nov. | None | 418 | 37 | | 1,121 | 28-560 | 28-560 | |
| Phoenix | DPL 16 | 4 | 11 | 27 Aug. | 6 Nov. | 7 Nov. | 4, 20 Oct. | 418 | 37 | | 1,121 | 28-560 | 28-560 | |
| Phoenix | S-4 | 4 | 11 | 27 Aug. | 21 Nov. | 28 Nov. | 4, 20 Oct. | 418 | 37 | | 1,121 | 28-560 | 28-560 | |
| Marana | S-4 | 3 | 18 | 31 Aug. | 23 Nov. | 27 Nov. | 23 Oct. | 418 | 37 | | 1,121 | 28-560 | 28-560 | |
| Safford | S-4 | 4 | 14 | 29 Aug. | 20 Nov. | 20 Nov. | 18 Oct., 13 Nov. | 418 | 37 | | 1,121 | 28-560 | 28-560 | |
| 1974 | | | | | | | | | | | | | | |
| Brawley | DPL 61 | 4 | 12 | 5 Sept. | 11 Dec. | 10 Dec. | 30 Oct., 19 Nov. | 209 | 37 | | | 28-560 | 19-420 | 1,121-560 |
| Yuma | DPL 16 | 4 | 12 | 5 Sept. | 7 Nov. | 7 Nov. | None | 209 | 37 | | | 28-560 | 19-420 | 1,121-560 |
| Phoenix | DPL 16 | 4 | 12 | 26 Aug. | 13 Nov. | 14 Nov. | 10 Oct. | 209 | 37 | | | 28-560 | 19-420 | 1,121-560 |
| Phoenix | S-4 | 4 | 12 | 26 Aug. | 13 Nov. | 18 Nov. | 10 Oct. | 209 | 37 | | | 28-560 | 19-420 | 1,121-560 |
| Marana | DPL 16 | 4 | 12 | 29 Aug. | 18 Nov. | 18 Nov. | None | 209 | 37 | | | 28-560 | 19-420 | 1,121-560 |
| Safford | S-4 | 4 | 12 | 29 Aug. | 12 Nov. | 12 Nov. | 12 Oct. | 209 | 37 | | | 28-560 | 19-420 | 1,121-560 |
| Phoenix | DPL 16 | 4 | 12 | 6 treatment† dates | 13 Nov. | 15 Nov. | 10 Oct. | 209 | 37 | | 1,121 | 28-560 | 28-560 | |

† This test was a split plot with the following treatment dates as man plots: 15 Aug., 21 Aug., 26 Aug., 30 Aug., 3 Sept., and 10 Sept.

**Table 2. Chemical termination effects on lint yield, number of immature bolls at first harvest, and certain quality parameters of seed cotton, seed, and fiber in five tests on cotton in 1972.**

| Characteristics measured | Value for check | Unit of measure | Chemical termination treatment†: 2,4-D | Chlormequat | Chlorflurenol | 2,4-D + Chlormequat |
|---|---|---|---|---|---|---|
| | | | Lint—immature bolls | | | |
| Lint yield | 1,127 kg/ha | % reduction | 9.5 | 4.8 | 10.2 | 9.0 |
| Immature bolls | 179,000/ha | % of check | 26.2* | 38.4* | 36.8* | 9.3* |
| DE index | 100 | | 36 | 47 | 47 | 18 |
| DE index below 10 | -- | No. tests | 1 | 0 | 1 | 2 |
| | | | Seed cotton quality (deviation from check) | | | |
| Gin turnout | 34.2 | % | 0.1 | 0.3 | -0.7* | -0.2 |
| Lint % | 36.4 | % | 0.7* | 0 | 0 | 0.3 |
| Trash % | 7.0 | % | 1.3* | 0.5 | 1.6* | 2.0* |
| | | | Seed quality (deviation from check) | | | |
| Seed weight | 10.8 | g/100 | 0.1 | 0.2 | 0.1 | 0 |
| Floaters | 21.3 | % | -2.0 | 0 | -1.6 | -2.8 |
| Emergence (greenhouse) | 92 | % | -11* | -1 | 1 | -23* |
| Emergence (field) | 77 | % | -15* | -1 | -8* | -27* |
| Days to emerge (greenhouse) | 5.6 | | 0.5* | 0.2 | 0 | 1.4* |
| Days to emerge (field) | 11.1 | | 0.5 | 0.3 | 0.1 | 1.2* |
| Dead seedlings (field) | 1.8 | % (seed planted) | -0.4 | -0.1 | 0.2 | -0.7 |

* Significantly different from untreated check at 0.05 confidence level. † Information on treatments and tests in Table 1.

Center, Phoenix. Fiber quality was determined on two replications per test in 1973 and on the treatment date test in 1974. Three replications were used in each of the remaining tests.

Seed samples were acid delinted and washed. The percentage of seed that floated during the wash was determined, and the floaters, as well as mechanical- or insect-damaged seed, were discarded. Weight of 100 undamaged seed was obtained. Germination percent (14 days at 17 C) was obtained from two replications of the 1973 tests. For the 1972 and 1974 tests, samples of 100 seed from all plots were planted in sand flats in the greenhouse, and also in the field during spring planting. Greenhouse emergence was counted to 14 days. Field emergence was counted to 28 days for 1972 seed and 42 days for 1974 seed. Average number of days for seedlings to emerge was calculated for all plots.

A second pick was made in the Yuma 1973 test only. Seed and fiber quality from the second pick were determined and included when calculating means.

## RESULTS

### Yield—Immature Bolls

In 1972 (Table 2), the 2,4-D plus chlormequat mixture was superior to either material applied alone or to chlorfurenol as indicated by average DE index and number of tests with DE index below 10. By the end of the season, it became apparent that the growth regulators could be divided into two groups: 1) fast acting, but not effective to the end of the growing season (2,4-D); and 2) slow acting, but persistent (chlormequat and chlorflurenol). The mixture of 2,4-D plus chlormequat gave the advantages of fast action and persistence.

Table 3. Chemical termination effects on lint yield, number of immature bolls at first harvest, and certain quality parameters of seed cotton, seed, and fiber in six tests on cotton in 1973.

| Characteristics measured | Value for check | Unit of measure | Chemical termination treatment† 2,4-D | Chlorflurenol | 2,4-D + Chlormequat | 2,4-D + Chlorflurenol |
|---|---|---|---|---|---|---|
| | | | Lint—immature bolls | | | |
| Lint yield | 1,208 kg/ha | % reduction | 10.6 | 6.4 | 11.2 | 12.1 |
| Immature bolls | 226,00/ha | % of check | 20.5* | 45.8* | 10.4* | 17.7* |
| DE index | 100 | | 31 | 52 | 22 | 30 |
| DE index below 10 | -- | No. tests | 2 | 0 | 3 | 1 |
| | | | Seed cotton quality (deviation from check) | | | |
| Gin turnout | 33.7 | % | -0.2 | -0.5 | -0.6 | -1.1* |
| Lint % | 37.5 | % | 1.0* | 0.1 | 0.5 | -0.1 |
| Trash % | 10.2 | % | 2.4* | 1.7* | 2.5* | 2.8* |
| | | | Seed quality (deviation from check) | | | |
| Seed weight | 11.0 | g/100 | 0 | -0.2 | -0.2 | -0.3 |
| Floaters | 10.2 | % | -0.7 | -0.5 | -0.5 | -1.8 |
| Germination | 93 | % | 1.5 | 2.8 | -0.1 | -0.6 |

* Significantly different from untreated check at 0.05 confidence level. † Information on treatments and tests in Table 1.

Table 4. Chemical termination effects on lint yield, number of immature bolls at first harvest, and certain quality parameters of seed cotton, seed, and fiber in a test on cotton with six treatment dates.

| Characteristics measured | Value for check | Unit of measure | Chemical termination treatment† 2,4-D | Chlorflurenol | 2,4-D + Chlormequat | 2,4-D + Chlorflurenol |
|---|---|---|---|---|---|---|
| | | | Lint—immature bolls | | | |
| Lint yield | 1,302 kg/ha | % reduction | 8.5* | 6.3* | 11.4* | 8.9* |
| Immature bolls | 35,000/ha | % of check | 13.1* | 31.8* | 13.7* | 20.3* |
| DE index | 100 | | 22 | 38 | 25 | 29 |
| DE index below 10 | -- | No. dates | 1 | 2 | 1 | 2 |
| | | | Seed cotton quality (deviation from check) | | | |
| Gin turnout | 33.4 | % | -0.3 | 0 | -0.6* | -1.0* |
| Lint % | 36.3 | % | 0.1 | -0.1 | -0.1 | -0.3 |
| Trash % | 7.9 | % | 1.1* | -0.2 | 1.4* | 2.1* |
| | | | Seed quality (deviation from check) | | | |
| Seed weight | 9.4 | g/100 | 0.2 | 0.2 | 0.2 | 0.2 |
| Floaters | 18.1 | % | -3.2* | -2.1* | -3.4* | -3.5* |
| Emergence (greenhouse) | 96 | % | -16* | -1 | -15* | -7* |
| Emergence (field) | 62 | % | -17* | -1 | -16* | -10* |
| Days to emerge (greenhouse) | 4.6 | | 0.7* | 0 | 0.8* | 0.6* |
| Days to emerge (field) | 25.3 | | 0.5 | 0 | 1.2* | 0.6 |
| Dead seedlings (field) | 1.3 | % seed planted | 0.3 | 1.3* | 0.2 | 1.0 |

* Significantly different from untreated check at 0.05 confidence level. † Information on treatments and treatment dates in Table 1.

In the 1973 tests (Table 3), 2,4-D plus chlorflurenol was evaluated instead of chlormequat alone. The 2,4-D plus chlormequat mixture was again superior to other treatments. In these tests, 2,4-D alone and the 2,4-D plus chlorflurenol mixture were about equal in effectiveness.

We recognized that treatment date could influence results. Therefore, in 1974 we established a test at Phoenix having six dates of treatment with the same treatments as used in 1973. Unfortunately, flowering and fruit set in this test dropped to a very low level in late August and remained low for the remainder of the season. This reduced treatment effects on lint yield and number of immature bolls (Table 4). The lowest DE indices and their application dates, respectively, were: 2,4-D alone, 10 on 26 August; chlorflurenol alone, 9 on 15 August; 2,4-D plus chlormequat, 10 on 30 August; and 2,4-D plus chlorflurenol, 8 on 26 August. These data indicated that there is little difference among treatments if they are applied at the proper time. However, it is our opinion that the relative performance of chlorflurenol alone and 2,4-D alone would not have been as favorable if flowering and fruiting had been at a higher level in the late summer.

Two changes were made in the remaining 1974 tests. Application rates of both growth regulators were reduced in the 2,4-D plus chlorflurenol mixture, and a mixture of TD 1123 plus chlorflurenol was substituted for chlorflurenol alone. The 2,4-D plus chlormequat mixture again was the most effective (Table 5). It was obvious from lint yield and immature boll data that reduction in application rates of 2,4-D plus chlorflurenol reduced treatment effectiveness. TD 1123 plus chlorflurenol was moderately successful as indicated by the DE index. The lint yield and immature boll data plus casual observations in the field indicated that TD 1123 was much faster acting than 2,4-D. We estimate that it should have been applied 10 to 14 days later than 2,4-D plus chlormequat for greatest effectiveness.

**Table 5. Chemical termination effects on lint yield, number of immature bolls at first harvest, and certain quality parameters of seed cotton, seed, and fiber in six tests on cotton in 1974.**

| | | | Chemical termination treatment† | | | |
|---|---|---|---|---|---|---|
| Characteristics measured | Value for check | Unit of measure | 2,4-D | 2,4-D + Chlormequat | 2,4-D + Chlorflurenol | TD 1123 + Chlorflurenol |
| | | | Lint—immature bolls | | | |
| Lint yield | 1,251 kg/ha | % reduction | 5.8 | 5.7 | 4.0 | 16.9* |
| Immature bolls | 130,000/ha | % of check | 16.7* | 7.2* | 23.5* | 7.4* |
| DE index | 100 | | 25 | 13 | 28 | 24 |
| DE index below 10 | -- | No. tests | 3 | 3 | 1 | 2 |
| | | | Seed cotton quality (deviation from check) | | | |
| Gin turnout | 34.5 | % | 0 | -0.4 | 0 | -0.5 |
| Lint % | 37.2 | % | 0.5* | 0.1 | 0.2 | 0 |
| Trash % | 7.4 | % | 1.2 | 1.1 | 0.5 | 1.4 |
| | | | Seed quality (deviation from check) | | | |
| Seed weight | 11.1 | g/100 | 0.1 | 0.1 | 0.1 | 0.3 |
| Floaters | 25.8 | % | -2.3 | -0.1 | -0.6 | 1.4 |
| Emergence (greenhouse) | 95 | % | -14* | -15* | -4* | 0 |
| Emergence (field) | 60 | % | -18* | -22* | -4 | -10* |
| Days to emerge (greenhouse) | 5.6 | | 0.6* | 0.8* | 0.2 | 0.2 |
| Days to emerge (field) | 26.4 | | 1.0* | 0.7* | -0.1 | -0.3 |
| Dead seedlings (field) | 1.6 | %(seed planted) | -0.2 | 0.3 | 0.4 | -0.1 |

* Significantly different from untreated check at 0.05 confidence level. † Information on treatments and tests in Table 1.

## Seed Cotton Quality

Trash in seed cotton from all treatments containing 2,4-D was higher than in the check treatments. In most cases, the difference was significant. The high trash content in seed cotton from plots treated with 2,4-D probably resulted from inhibition of abscission of squares, bolls, and leaves by 2,4-D (5). This is not a serious problem in desert areas, but could be in other climates. Chlorflurenol treatment also increased trash in lint in 2 of 3 years. There is no obvious explanation for more trash following chlorflurenol treatment. Percent gin turnout was decreased in several cases with this treatment. This apparently was the result of more trash in the samples. Lint percentages were higher when 2,4-D was used alone. This was not the result of smaller seed. We suspect it was the result of small trash particles not removed during cleaning.

## Seed Quality

Seed weight was not significantly affected by any of the treatments. The number of light seed that floated following acid delinting generally was greater for the check than for seed from treated plots. This could be expected as light seed frequently come from immature bolls and most of these develop late.

Seedling emergence from seed of plants treated with 2,4-D, whether alone or in mixture, generally was reduced in greenhouse and field plantings. The effect of 2,4-D on emergence of seed from treated cotton plants is well known (2, 5, 6). Emergence time was frequently longer for seed from 2,4-D treated plants. 2,4-D did not affect germination in 1973.

Seed from chlorflurenol-treated plants in 1 of 2 years and TD 1123 plus chlorflurenol-treated plants in 1 year showed significantly reduced emergence in the field, but not in the greenhouse. Data from other tests, not reported here, indicated that TD 1123 plus chlorflurenol usually reduced field emergence and that chlorflurenol alone occasionally reduced field emergence. No treatment seriously affected seedling mortality in the field.

## Fiber Quality

Fiber length (2.5 and 50% span) and uniformity ratio were not significantly affected by any of the treatments. Fiber strength was not significantly affected, except for a 3% decrease by TD 1123 plus chlorflurenol in 1974. Data from other unreported tests indicated that reduced fiber strength could be expected from TD 1123. However, if TD 1123 is applied later, as now appears desirable, there should be little effect on fiber strength.

Micronaire generally was higher (average of 0.12) from treated plants than from checks. This apparently resulted from more low Micronaire fiber from late maturing bolls in the checks. The differences obtained were not great enough to be economically important.

## DISCUSSION

Although new termination treatments replaced less promising treatments each year as they become available, 2,4-D plus chlormequat treatment was generally most effective each year. The 2,4-D plus chlorflurenol mixture was slightly inferior to 2,4-D plus chlormequat. When used alone, 2,4-D was less effective than either of the above mixtures and had greater adverse effect on seedling emergence. However, 2,4-D does have certain advantages over other treatments, which include low cost, low application rate, and a long history of safe, nontoxic use for food and feed production, but tolerances have not been established in cottonseed.

Chlorflurenol alone and chlormequat alone generally were less effective than other treatments for chemical termination. There remains a possibility that these treatments might be satisfactory if applied about 14 days earlier than treatments including 2,4-D.

TD 1123 plus chlorflurenol has not been adequately tested, but in 1974 tests, it apparently was superior to 2,4-D for chemical termination when all factors, such as seedling emergence, were considered. TD 1123 plus chlormequat was comparable to TD 1123 plus chlorflurenol (data not shown). TD 1123 was faster acting and less persistent than 2,4-D. We estimate that TD 1123 should be applied 10 to 14 days later than treatments with 2,4-D for best results. This later application date should reduce, and perhaps obscure, the adverse effects on seed viability and on fiber strength. In any case, the effects of TD 1123 on seedling emergence are less than for 2,4-D. Use of TD 1123 in place of 2,4-D would eliminate the problem of inhibited abscission of squares, flowers, and leaves. Further casual observations indicated that use of TD 1123 accelerates defoliation and may accelerate boll opening.

Temperature, species, and physiological condition of the plant apparently cause some differences in plant response. In particular, plant response to chemical termination treatments was slower at Safford (higher altitude and cooler). Chlormequat appeared to be more effective on Pima cotton than Upland cotton.

Three treatments, 2,4-D, 2,4-D plus chlormequat, and 2,4-D plus chlorflurenol, have reduced immature bolls on cotton plants at first harvest but have reduced lint yield only slightly. The reduction in immature bolls has given a proportional reduction in diapausing pink bollworms in the fall (8). Bariola et al. (4) have shown an average reduction of diapausing pink bollworm in the fall of 97% and an average yield reduction of 7% for the most effective chemical termination treatment in five tests. They also reported that pink bollworm emergence in the spring was reduced an average of 40% in two tests. More recent unpublished data showed an 80% reduction in spring emergence. Contamination of treated plots by midwinter leveling may account for lower reduction in the first two tests.

These data indicate that chemical termination is a workable technique and is ready for more extensive testing. Continued testing with small plots, as reported here, with a few tests having plots 0.5 to 1.0 ha in size (4) appears adequate for agronomic evaluations However, large scale testing is needed to obtain adequte entomological data, as pink bollworm moths can fly up to 55 km in sufficient numbers to reinfest a test area (3). Large scale testing presently is hampered since it requires registration of the plant growth regulators. Extensive data are needed (large scale testing) by manufacturers of plant growth regulators to justify the expense of registering their products.

Once registration is obtained, the decision on when to apply chemical termination treatments commercially most likely will be made by growers as a group and will be based mainly on economic considerations. The options will range from little or no yield reduction and limited control of pink bollworms to a high level of pink bollworm control and greater yield reductions. Effects on yield will vary with time of application, cultivar, crop management, elevation, other insects, and yearly climatic variations. The southeastern types of Upland cotton generally have less late fruiting than Acala or Pima cottons. Early planting, moderate nitrogen fertility, moderate plant population, adequate, but not excessive irrigation, and control of sucking insects during June and July will generally insure a larger early boll set and a smaller late boll set. Pink bollworm diapause is related primarily to day length and is not subject to alteration by crop management.

## REFERENCES

1. Adkisson, Perry L. 1962. Timing of defoliants and desiccants to reduce populations of pink bollworm in diapause. J. Econ. Entomol. 55:949-951.
2. Arle, H. F. 1954. The sensitivity of Acala 44 cotton to 2,4-D. West. Weed Control Conf. Proc. 14:20-25.
3. Bariola, L. A., J. C. Keller, D. L. Turley, and J. R. Farris. 1973. Migration and population studies of the pink bollworm in the arid west. Environ. Ent. 2:205-208.
4. ———, D. L. Kittock, H. F. Arle, P. V. Vail, and T. J. Henneberry. 1976. Controlling pink bollworm: effects of chemical termination of cotton fruiting on populations of diapausing larvae. J. Econ. Entomol. 69:633-636.
5. Cook, Elton D. 1955. Cotton defoliation tests in 1956. Ninth Ann. Cotton Defol. Conf. p. 9-12.
6. Goodman, V. H. 1953. The yield and progeny seedling responses to treatment with 2,4-D, 2,4-5-T, and M.C.P. Sixth South. Weed Conf. Proc. p. 47-56.
7. Kittock, D. L., Jack R. Mauney, H. Fred Arle, and L. A. Bariola. 1973. Termination of late season cotton fruiting with growth regulators as an insect-control technique. J. Environ. Qual. 2:405-408.
8. ———, L. A. Bariola, H. Fred Arle, and P. V. Vail. 1975. Evaluation of chemical termination of fruiting for pink bollworm control by estimating number of immature cotton bolls at harvest. Cotton Grow. Rev. 52:224-227.