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# Plant Growth Regulators for Cotton

**Gene Stevens**  
State Extension Agronomy Professor

## Note

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Several new plant growth regulators have come on the market for use in cotton in recent years. These plant growth regulators have given growers a new opportunity to influence cotton growth to their advantage. However, this opportunity goes only as far as the ability of the grower to understand and use them properly.

## Modifying cotton growth

Modifying cotton growth has become an essential component of cotton production, whether by making adjustments in fertility, water management or use of harvest aids. Applying plant growth regulators to modify early and midseason growth is similar to other management practices. There is potential to influence yield if they are managed properly.

The key to modifying growth is knowing what the plant needs at each stage of development to reach the final goal of higher yield and quality. The next step is to do everything possible to provide for these needs. Plant growth regulators have the potential to promote crop earliness, square and boll retention, higher nutrient uptake, and keeping vegetative and reproductive growth in harmony to improve lint yield and quality.

## Background

### Natural growth regulators

Several naturally occurring hormones work in the cotton plant to adjust plant growth. When plant growth regulators are applied to the cotton plant, they work in much the same way as the natural regulants already present. In many ways, they supplement or destroy the natural hormone. They often will work together in ratios and concentrations to regulate growth. Some naturally occurring hormones are auxins, gibberellins and cytokinins. Some of the more common plant growth regulators are composed of these hormones or combinations of them.

The auxin family serves a number of functions in plants, such as cell and stem elongation, leaf expansion, increased rooting and changes in fruit abscission. Some yield response has been noted when certain auxins have been applied to cotton, probably due to greater boll retention. Other reports have shown no yield response.

The gibberellins are associated with stem elongation and some leaf enlargement, but have been shown to increase fruit retention in cotton. Yield responses when applied alone to cotton have been mixed, with some data showing smaller bolls and no yield response.

Cytokinins can promote cell division and enlargement of stems, leaves and fruit. They have also been shown to reduce fruit abscission in cotton, but this is probably an indirect result of making the fruit a better competitor for nutrients. Cytokinins can also delay aging of leaves, allowing longer photosynthetic activity.

### **Synthetic growth regulators**

The number of synthetic plant growth regulators available to cotton growers is increasing. Pix has been the most widely used material due to its ability to reduce excessive cotton growth and put more emphasis on boll development. Mepichlor has more recently entered the market with the same active ingredient as Pix, Mepiquat Chloride. PGR IV is the first labeled plant growth regulator for cotton that promotes cotton growth. Maxxon has most recently followed in the same market track as PGR IV, with the same hormones. Cytokinin has also entered the market with a different hormone than PGR IV or Maxxon.

## **Pix and Mepichlor**

Pix (Mepiquat Chloride) is the first plant growth regulator in cotton production to make a significant impact on cotton growth and yield. Since its introduction by BASF Corporation in the early 1980s, it has been widely studied and frequently used in the major cotton growing areas. Pix is an anti-gibberellin, meaning that it reduces the production of gibberellin in the plant, which normally would enlarge plant cells.

Mepichlor is produced by Micro Flo and contains the same active ingredient as Pix; therefore it is used in much the same way. Research on the use of Mepichlor is limited, therefore this publication will focus primarily on Pix.

Pix applications are most successful when applied near the early bloom stage of development and again within 3 to 4 weeks on cotton that is subject to rapid and excessive vegetative growth. Not all cotton fields will benefit from Pix applications. It works best on healthy, nonstressed cotton when conditions favor rank growth. Many times, these conditions occur when water through irrigation and rainfall has been abundant, high nitrogen rates have been used, and large, indeterminate varieties have been planted.

The primary effect that Pix has on cotton production is that it takes energy away from leaf and stem development and directs it toward boll development and retention. For this reason, it is crucial for cotton growers to understand their individual field conditions and make or omit applications as conditions dictate. As a result of a Pix application at the appropriate times of development, lint is more efficiently produced due to decreased plant height, branch length and leaf size. This provides for a more open canopy that increases boll retention and reduces boll rot; consequently, bolls are given greater potential to produce. However, yield response will depend on the necessity of Pix in a particular field.

## **Pix management situations**

Several approaches to using Pix have been developed across the Cotton Belt. All have credibility and can be successful in reducing growth, yet a universal approach that is used on every farm has been slow in coming. Conditions vary widely throughout the cotton growing areas.

The most commonly used approach is to base application decisions on plant height at early bloom. The Pix label specifies that cotton should be between 20 and 30 inches tall near this growth stage before the first application is made. Usually, Pix applied at the 1/2 to 1 pint per acre rate is recommended, followed 3 to 4 weeks later by a second application if necessary. Growers should remember that the label restricts the total amount applied in one season to 1-1/2 pints per acre. Dr. David Guthrie with the National Cotton Council has suggested the following responses to different situations at early bloom (Guthrie 1993):

### **Situation 1**

Plant height is less than 20 inches at early bloom due to stress.

#### • **Response**

Relieve stress if possible. Avoid a Pix application. Treatment may be warranted later. Wait and see.

### **Situation 2**

Plant height is 20 to 24 inches at early bloom.

#### • **Response**

If bloom begins before July 5, then the crop is on schedule. Wait and see. Pix at 1 pint per acre may be required later, particularly if plant size exceeds 28 inches within one week of early bloom or 32 inches within two weeks of early bloom. If bloom begins after July 5, particularly after July 10, then apply 1/2 to 1 pint per acre to shorten the boll loading period if crop is not under a drought stress.

### **Situation 3**

Plant height is more than 24 inches at early bloom. Growing rapidly.

#### • **Response**

Apply 1/2 to 1 pint per acre to reduce shading and improve boll set. An additional 1/2 to 1 pint (depending on previous treatment rate) may be required if the plant size exceeds 28 inches one week after early bloom or 32 inches two weeks after early bloom.

### **Situation 4**

Plant height is approaching 20 to 24 inches prior to early bloom. Growth is rapid and the crop is well watered. Anticipated early bloom height is more than 24 inches.

#### • **Response**

If prebloom cotton is 16 inches tall, apply 1/4 pint per acre. If prebloom cotton is 20 inches tall prior to first treatment, apply 1/2 pint per acre. An additional Pix treatment at 1/2 to 1 pint per acre may be necessary if the plant height exceeds 24 inches at early bloom, 28 inches after early bloom, or 32 inches two weeks after early bloom.

## **Low rate multiple strategy**

A drawback to applying these recommended rates in one or two applications is the possibility of drought stress that may set in following an application, creating an adverse effect on the crop. In response to this concern, a low-rate strategy has been developed. This approach uses low-rate multiple (LRM) applications of Pix beginning at squaring and continuing as crop growth dictates. The difference is a more conservative approach to slowing crop growth where applications may be ceased during conditions of stress. If growth is naturally deterred prematurely, growers have less of an investment tied up in the crop than if they used higher rates.

Using LRM applications, up to four low-rate applications may be made to the crop with rates of 1/8 to 1/4 pints per acre. The first application should be made at match head square and subsequent treatments are made at 7- to 14-day intervals or when regrowth occurs. Crop growth and growing conditions will dictate application rates and timing. As long as favorable conditions occur, this is an acceptable measure for controlling cotton growth. Care should be taken to scout the crop to ensure that excessive growth does not require a more aggressive approach.

## Plant monitoring approach

A third approach to Pix management is currently being recommended in North Carolina and Arkansas (Bonner 1993). This approach is recommended for growers who are willing to employ plant mapping techniques in their management plan. It takes a systematic approach that is based on accumulated plant growth and the current rate of growth. Desired plant height and the assumed number of nodes at the end of the season are key ingredients in this recommendation.

Several physiological assumptions must be made that are applicable to cotton growth in a particular area. For Missouri, irrigated cotton should produce around 20 to 22 nodes during the season, while nonirrigated cotton may produce 17 to 18. These values may vary from year to year and field to field, yet they are still a good standard on which to base a decision. Growers using this system should establish final plant height goal. Under irrigated conditions, some threat of boll rot exists in Missouri conditions. For this reason, we suggest establishing a final plant height goal 2 inches greater than the row spacing. However, as a general recommendation that takes nonirrigated conditions into account, the following guidelines may apply. When on 30-inch rows, it is suggested that 30 to 35 inches is optimum. Those growers using 38-inch rows typically should strive for 40 to 45 inches.

Once a goal has been set for crop growth, a Pix threshold is derived by dividing the desired plant height by the expected number of nodes developed in the growing season. Next, during the first square stages or shortly after, a measurement is taken on plant height and nodes are counted on a representative sample obtained from a field. A grower should take five plants from 10 locations in the field to get an accurate measure. Again divide the plant height at the stage of sampling by the number of nodes. Compare this number with the Pix threshold.

If the number obtained during the measurement is less than the Pix threshold, Pix is not required. However, if it is greater than the threshold, further monitoring should be made. Since elongation is most pronounced in the top five nodes, measure the total length of the internodes between these nodes. Divide the inches of this active internode growth by three. A Pix application is suggested if the number exceeds the Pix threshold.

Pix should be applied at lower rates similar to the LRM approach if a treatment is warranted around match head square. As the plant develops into the early bloom stage, 1/2 to 1 pint may be needed to slow growth sufficiently. Remember, no more than 1-1/2 pints should be applied in one growing season, and the last application should be made no later than 30 days before harvest.

The approach that Missouri growers opt to use depends on the level of management they are willing to expend to reach a goal. We suggest that growers choose the method that they are most comfortable with. All the approaches discussed have credibility and have been successfully used on cotton. One Mississippi study comparing LRM and single applications found primarily physiological differences versus yield responses to the different treatments (Wallace et al., 1993). These researchers found that the early LRM approach made a greater impact on early season height, node number and internode length. The single early bloom application mostly impacted boll retention. In our observations, a more effective height control is gained when applications are started early. However, the effect the application will make on yield is the bottom line.

## PGR IV and Maxxon

Cotton producers have shown steady interest in PGR IV as a plant growth regulator since its introduction in 1991. Manufactured by Micro Flo Company, it contains gibberellic acid and synthetic indolebutyric acid. The material has shown consistent growth and yield responses in some university trials. The label allows for treatments in the seed furrow, during the 1-7 leaf stage, at match head square and at early bloom.

Maxxon is a plant growth regulator similar to PGR IV, but it contains different quantities of gibberellic acid and synthetic indolebutyric acid. Manufactured by Riverside, it is labeled to be applied on cotton at match head square and first bloom. University research on Maxxon has been limited.

The effects of PGR IV and Maxxon on cotton has been studied at the MU Delta Center near Portageville since 1992. Both plant growth regulators were applied at 4 ounces at match head square and 4 ounces at early bloom. Response of cotton to both PGR IV and Maxxon ranged from 10 to 15 percent in 1992 to no differences in 1993. Though not statistically significant in these studies, both showed potential for higher lint yields.

The University of Arkansas has studied PGR IV extensively for several years. Over an 8-year period, the material has averaged a 115 pound lint yield from foliar applications. Arkansas researchers have found that the optimum timing for PGR IV on cotton is at planting in the furrow, at the second true-leaf stage and at the match head square stage. They found that these applications had the greatest influence on cotton growth, leaf area and square retention. The manufacturer also promotes the material as beneficial with an early bloom application as well. Success may be made with this application if growth is not excessive.

The optimum rate was 1 ounce per acre at planting and 4 ounces applied in a split between the second true leaf and match head square stages. To obtain maximum benefit from PGR IV or Maxxon, use only when the crop is healthy and not stressed by heat, drought, insects or poor fertility.

## How does PGR IV affect cotton growth?

Most research on the material has reported earliness, increased leaf area, increased nutrient uptake and square and boll retention as factors leading to higher yields. In-furrow treatments have shown slightly earlier emergence and enhanced seedling vigor. Researchers at the University of Texas have noted a tendency for more bolls to develop on the first two fruiting positions and on the lower 10 reproductive branches following treatment (Robertson and Cothren, 1993). Research has shown that at least two-thirds of the total lint produced comes from the first two fruiting positions.

PGR IV or Maxxon may be options for growers who want to pursue high yields through a more intensive management approach. Continued research will give us a better handle on the use of these materials. Until then, many farmers may want to try a conservative approach with plant growth regulator applications. It would be advisable to apply the materials early in the growing season to promote early growth, such as in-furrow (PGR IV) or match head square treatments, then use Pix or Mepichlor after bloom to slow vegetative growth and force a timely cutout.

Until further research is conducted, growers are advised not to tank-mix with Pix or Mepichlor. Since the active ingredient in these products inhibits gibberellic acid synthesis, their use in combination with PGR IV or Maxxon in a tank mix results in parts of the plant growth regulators working against each other. One promotes vegetative growth while the other slows it. Some researchers suggest their applications be at least a week apart.

# Cytokin

Cytokin was recently released by Plant and Bioregulator Technologies, Inc. for cotton production. The primary component of Cytokin is cytokinin. The product has shown some favorable results in university trials across the Cotton Belt, particularly when used in combination with Pix.

MU research in southeastern Missouri has shown a yield advantage over the control treatment with the use of Cytokin applied at match head square and at early bloom. When applied in a tank mix with Pix, a greater lint increase was observed. This synergism was not noted with the combination of Pix and PGR IV or Maxxon.

Though university research on Cytokin is limited, the manufacturer recommends applying 2 to 4 ounces per acre beginning at match head square and applying weekly for a total of four applications.

The hormone cytokinin is produced in the roots of plants. Under periods of plant stress, especially stress affecting the roots, cytokinin is likely to be inhibited. Cytokin is believed to replenish the plant's cytokinin supply during these periods.

Unlike the other plant growth regulators mentioned, Cytokin may be most beneficial under stressed conditions to maintain proper boll set and retention, promote earliness and develop a better root system. Cytokin or combinations of Cytokin and Pix have the potential for higher cotton yields, though growers are encouraged to use most plant growth regulators judiciously and on a limited basis at first, testing them under their own field conditions.

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**Original authors: David W. Albers and C. Tim Schnakenberg**

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