New Plant Growth Regulators in Cotton

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Abstract

Over a four-year period a range of new plant growth regulators was tested. Of these only AVG showed any real promise - a detailed report on this product is available elsewhere in these proceedings. Work on Pix confirmed that short determinate cultivars such as S40 are particularly sensitive to the inappropriate program application of Pix, suffering yield losses of between 5 to 21% when Pix is used this way. It is strongly advised that growers use the vegetative index to decide on Pix applications especially when growing cultivars such as S40.

Keywords: Cotton, gibberellic acid, Glycinebetaine, PGR IV, AVG, Pix, PGR, Plant growth regulators.

Introduction

The use of plant growth regulators has been a common practice in the production of Australian cotton for at least two decades. The most common product has been Pix, which reduces plant height by stopping the production of the plant hormone (gibberellic acid) responsible for cell elongation. Many other plant growth regulators (PGRs) have been tested overseas, and some are commonly used in cotton production. A range of new PGRs (Glycinebetaine, GA_3, PGR IV and AVG) where tested under Australian conditions. The use of Pix was also tested on a range of new cultivars to examine cultivar sensitivity.

The compounds tested

1) Glycinebetaine

Glycinebetaine accumulates naturally in some plants when they are stressed and is thought to have an important role in protecting plants against these stresses. Cotton is exposed to water stress even under irrigated conditions and it was thought that foliar application of glycinebetaine may help plants withstand stress.

1.1 Methods

Four experiments were conducted to assess this compound. The first in the 1996/97 season (irrigated) and two experiments in the 1997/98 season (1 irrigated, 1 dryland) and a final experiment in the 1998/99 season (dryland).

The 1996/97 experiment was very detailed. Cotton cultivar Sicot 189+ was sown on the 9/10/96 on raised beds 1m apart and at a density of 13 plants m^{-2}. A randomised complete block design was used with two treatments (control and glycinebetaine) and five replicates. Plot size was 4m x 15m with 4m buffers between plots. Glycinebetaine was applied using a hand held spray rig on the 7/1/97 (90 days after sowing) using the manufacturers' recommended regime (3 kg ha^{-1} in 100 litres of water ha^{-1} with a wetting agent and oil). Crop management followed commercial practice. The numbers of squares (floral buds), open flowers and bolls (fruit) were measured on four occasions - 99, 133, 147 and 167 days after sowing. Photosynthesis was measured 99 days after sowing using an IRGA (LiCor 6400). A dry matter harvest was taken 121 days after sowing and partitioned into leaf, stem, boll wall, lint and seed. The concentrations of K, Ca, Mg, and Na were then determined in these plant parts using atomic absorption spectrophotometry. Final yield was determined on 30/4/97 by picking 15m from an inner row of the plots using a single row spindle picker. Standard analysis of variance was used.

In 1997/98 a second detailed experiment was carried out under dryland conditions. Cotton cultivar Sicot 189 was sown on the 16/10/97 on raised beds 1m apart and at a density of 13 plants m^{-2}. A randomised complete block design was used with two treatments (control and glycinebetaine) and four replicates. Plot size was 8m x 20m. Glycinebetaine was applied at first flower, 2/1/98, using a highboy spray rig, at 3.5 kg/ha with 125 ml of Superbuffa (a neutralising spreader). The water volume was 142 litres/ha. Crop management followed commercial practice.

Five dry matter harvests were taken (14/1/98, 27/1/98, 17/2/98, 9/3/98 and 20/3/98) based on a metre of row from each plot and partitioned into leaf, stem, boll and tap root fractions. Dry weights were recorded and cation concentrations analysed. Leaf photosynthesis and chlorophyll fluorescence (SPAD) were measured on 6/1/98, 4 days after application. Final yield was determined on 9/4/98 by picking 18m from an inner row of the plots using a single row spindle picker. Standard analysis of variance was used.

A further irrigated experiment was conducted in the 1997/98 season. A final dryland experiment was conducted the 1998/99 season. In this experiment 3.5 kg/ha was applied as in the other experiments, but multiple applications were also tested.

1.2 Results

In the 1996/97 season glycinebetaine did not affect any of the parameters measured.

In the 1997/98 season under dryland conditions glycinebetaine increased the dry weights of leaves, stems and tap roots soon after application (Figure 1). However, these effects disappeared after about one month. No effects on boll wall, seed or lint dry weights were found. Twelve days after application glycinebetaine had increased flower number (P=0.06) and boll number (P=0.08). However, as with dry weight these differences disappeared as the season progressed. Glycinebetaine did not influence any of the parameters of leaf photosynthesis when measured six days after application.

In the Irrigated experiment in 1997/98 glycinebetaine had no impact on yield as was the case in both other experiments (Table 1). Likewise in the multiple application date dryland trial in the 1998/99 season no impact on yield was found.

Table 1. Glycinebetaine did not affect cotton yield (lint kg/ha) either under irrigated or dryland conditions over four experiments.

	Irrigated		Dryland	
	96/97	97/98	97/98	98/99
Control	2236	2950	1699	1885
Glycinebetaine	2239	2918	1646	1797*
Significance	ns	ns	ns	ns

* averaged across the different multiple applications (1 x 3.5, 2 x 3.5, 3 x 3.5) as they did not differ.

1.3 Conclusion

Theory suggested that glycinebetaine may be valuable in protecting plants from stressed environments, however the detailed worked carried out at Narrabri over four years showed no yield benefit from this product and only transitory impacts on growth. One speculation as to why this product does not work is that unlike tomatoes, where there is some evidence of glycinebetaine being effective, cotton does not translocate the product when sprayed on foliage. Consequently glycinebetaine is unlikely to have a role in the Australian cotton industry. This will remain the case until the development of an effective method of getting gylcinebetaine into the cotton plant. If this development occurs further research may be required.

2. PGR IV and GA_3

The shedding of squares and bolls occurs even in high yielding crops. Plant growth regulators may provide an important tool in improving fruit retention in cotton. Also, other important gains in efficiency may occur with the use of the newer growth regulators. These include the possible setting of fruit at lower node positions, which in turn may improve earliness, reduce late season insect control costs and reduce late season water applications.

Substantial work has been carried out on the anti-gibberellin plant growth regulators such as Pix, however very little work has been carried out on the newer growth regulators. Some of these compounds are straight plant hormones (GA_3) or mixtures of plant hormones (PGR-IV). They are proposed to increase the stress tolerance of plants, improve the efficiency of carbohydrate mobilisation and enhance nutrient uptake. The shedding of both squares and fruit in cotton is related to carbon and nutrient supply. If these newer growth regulators can improve the efficiency of remobilisation and fruit retention then yield and earliness may be improved. These growth regulators are likely to be marketed to the Australian industry in the near future and it is important to have an unbiased assessment of their efficacy. Also, it is important to develop diagnostic methods to identify situations where the use of growth regulators is justified, so that the indiscriminate use of these compounds can be avoided.

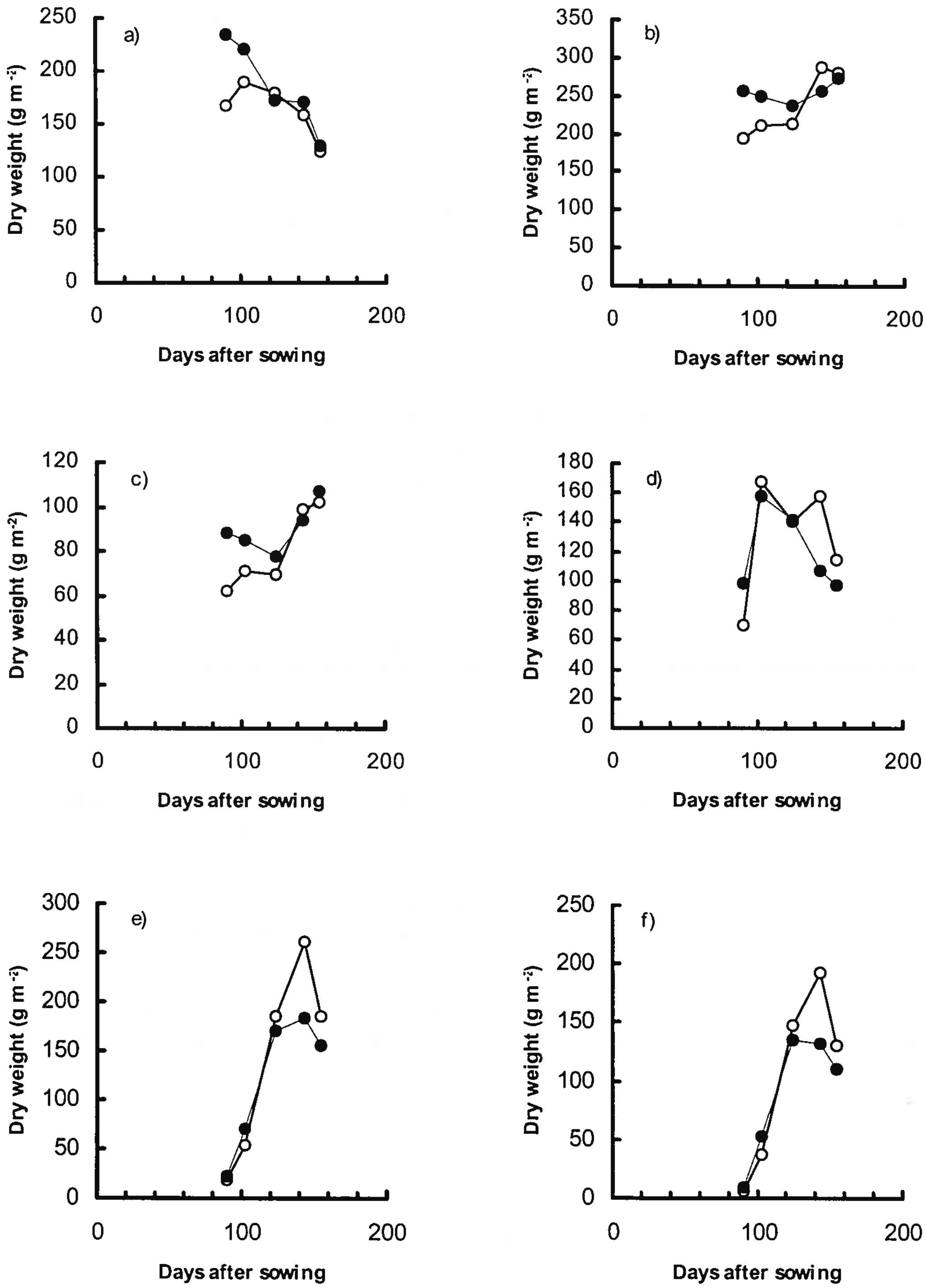

Figure 1. In the 1997/98 season glycinebetaine under dryland conditions increased the dry weight of a) leaves, b) stems, and c) tap roots after application but this difference declined with time, no effect was found on e) boll walls f) seed or g) lint (❍ control, ● glycinebetaine).

2.1 Methods

In the 1997/98 experiment the impact of four different plant growth regulators - gibberellic acid (applied at ten leaf stage (GA_3 E) or at early flowering (GA_3 L)), Glycinebetaine (Gb), PGR IV and Pix - were compared to untreated cotton plants (cultivar Sicot 189). Detailed measurements of plant growth, nutrition and physiology were made.

In the 1998/99 experiment the impact of 2 plant growth regulators - gibberellic acid, applied at ten leaf stage (GA_3 E) or at early flowering (GA_3 L), and PGR IV - were compared to untreated cotton plants.

2.2 Results

The 1997/98 experiment results have been reported at an earlier cotton conference (Wright and Shann, 1998). In summary, both the late applied GA_3 (GA_3 L) and Pix increased boll weights and boll numbers, but these effects had disappeared by the end of the season.

Analysis of the partitioning patterns of cotton plants treated with Pix and GA_3 L showed that immediately after application there was a substantial increase in partitioning to fruit, however, again with time the partitioning patterns returned to that of untreated plants. There was in fact weak evidence that both GA3 L and PGR IV caused a yield loss in this season (Table 2).

Likewise in the 1998/99 experiment no impact on yield (table 2) was found.

Table 2. None of the new PGR's tested had a positive affect on cotton yield

Treatments	97/98	98/99
Control	2960	2411
GA3 E	2936	2618
GA3 L	2787†	2399
Glycinebetaine	2919	
PGR IV	2787†	2825
Pix	2854	

† significantly different P<0.1

2.3 Conclusion

Neither GA3 or PGR IV provided any yield or management benefits in these experiments

3. AVG

AVG (aminoethoxyvinylglycine) is an inhibitor of ethylene production. It is perhaps the most promising of the new growth regulators being examined. A full report is available in these proceedings (Thongbai, Wright, Milroy, Bange, Rapp and Smith, 2000).

4. Pix

4.1 Methods

In 1998/99 a Pix experiment was conducted comparing two cultivars (Sicot 189 and S40) treated with or without 600mls/ha of Pix at first flower. Plot size was 18m x 8 rows with 4 row buffers between plots.

In 1999/00 two Pix experiments were conducted the first using Ingard cultivars (Sicot 189I and S40I) treated with or without either 600 or 1200 mls/ha at first flower. The second compared three cultivars (Sicot 189, S40 and a breeding line x442) treated with two different regimes (600ml/ha at first flower or 600 ml/ha at cut out).

4.2 Results

In the 1998/99 experiment Pix did not influence yield in Sicot 189, a cultivar reputed to be responsive to Pix, while in S40 Pix caused a yield decrease of 5% (Fig. 2). Maturity picks indicated that no advantage in maturity accrued to Sicot 189 treated with Pix, while in S40 the crop reached maturity 6 days earlier than untreated S40.

In the 1990/00 conventional cultivar experiment the first flower application on S40 caused a 12% reduction in seed cotton yield. No other treatment influenced yield (Fig 3).

In the 1990/00 experiment involving Ingard cultivars, Pix applied at 1200 mls/ha at first flower increased yield in Sicot 189i but decreased seed cotton yield by 21% in S40i. The 600 ml/ha rate did not influence yield in either cultivar (Fig 4).

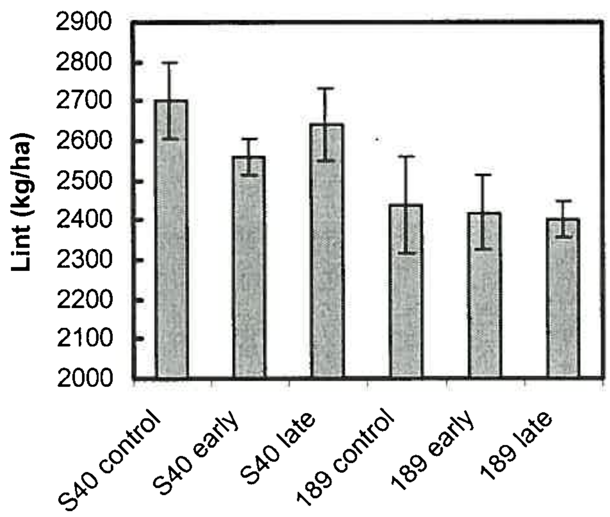

Figure 2. Pix (600 ml/ha at first flower) reduced lint yield in S40 by 5% and had no impact on the yield of Sicot 189.

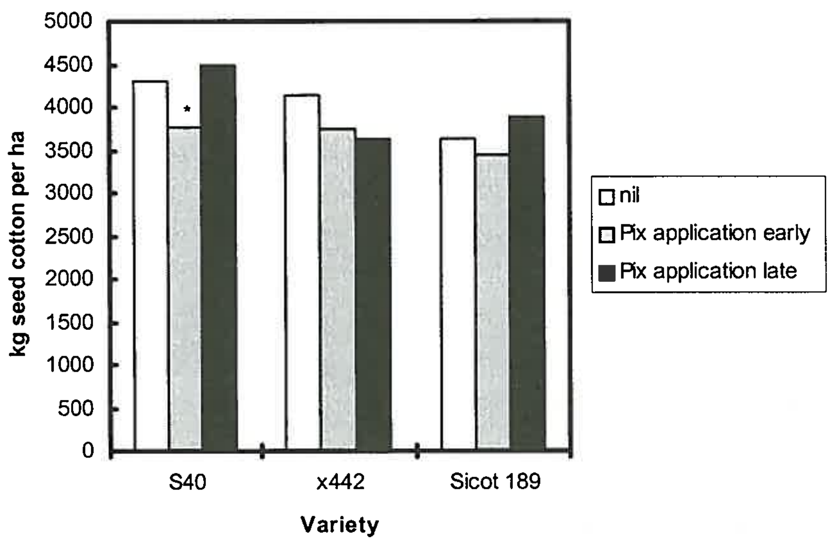

Figure 3. Pix did not influence yield except when applied at first flower to S40 where it caused a 12% reduction in seed cotton yield.

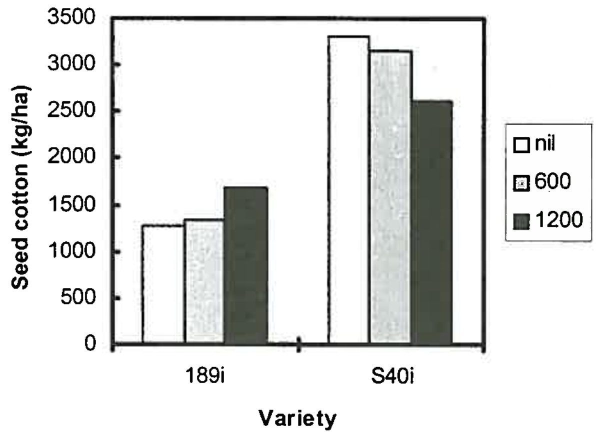

Figure 4. Pix (1200 mls/ha) caused a 21% reduction in seed cotton yield in S40 and a 32% increase in Sicot 189i.

4.3 conclusion

These experiments clearly show that care needs to be taken when Pix is applied to the short determinate cultivars like S40 as in these experiments it consistently suffered yield penalties. Growers should use the actual growth of the crop, as monitored by vegetative index, rather than applying Pix in a programmed manner.

References

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