Fashion or function? The pros and cons of PGRs

MICK FAULKNER, PRINCIPAL CONSULTANT, AGRILINK AGRICULTURAL CONSULTANTS

Plant Growth Regulators (PGRs) have been a fashionable topic in broadacre cropping for many years, but until recently there has been little understanding of how they might benefit dryland farmers.

Recent innovative research and farmer use has resulted in a greater understanding of the role PGRs can play in grain and pasture production, and interest in this technology has been stimulated by plans to make trinexapac-ethyl more available this year and the release of a new formulation registered for use in cereals in Australia. The new Syngenta product, Moddus Evo, will increase the availability and reduce the cost of a key PGR.

Broadacre cropping has been caught behind several other industry sectors in knowledge about PGRs and the skills involved in successfully using them.

Novel products, a greater understanding of how to best use 'old' PGR chemistry and research into application technologies and plant physiological response have resulted in recent significant gains in the areas of yield, quality and ease of management in a range of crops and pastures.

PGRs are classified according to how they influence plant growth. Five of the six main PGR groups are those with site activity on:

1. gibberellins and the gibberellic acid (GA) pathway
2. auxins and the cell division pathway
3. cytokinins and the cell division pathway
4. abscisic acid and the stomatal pathway
5. ethylene synthesis and the ethylene pathway

The sixth main group (Group 6) work by disrupting metabolic processes.

As part of the Green Revolution initiated by Norman Bourlag, wheat genetics were changed to increase the harvest index. A key method to achieve this was selection of varieties that possessed dwarfing genes. It is estimated that, along with genetic resistance to rust pathogens, the development of dwarf varieties using *rht* genes has been the largest contributor to wheat yield gain and stability internationally.

In a wheat plant, the action and impact of *rht* genes on gibberellins and the GA pathway are identical to that of a Group 1 PGR.

PGRs in cereals have mainly been used to prevent lodging, which reduces yield, causes quality problems and harvest difficulties and increases the severity of some diseases such as eyespot. Group 1 PGR products, in particular, are very effective at reducing or minimising lodging and have a role wherever there is a high risk of lodging. PGRs have also been used to successfully reduce the height of canola, resulting in a better harvest index, reduced lodging and greater ease of windrowing and harvest operations.


MICK FAULKNER

Plant Growth Regulators (PGRs) alter plant growth by impacting on cell division or cell elongation .

They are used routinely in modern turf, floriculture and amenity horticulture to meet consumer needs and to improve plant water use efficiency and nutrient use efficiency and the sugar and horticultural industries have also embraced PGR technology.

The use of PGRs in grass-based pasture systems is also increasing rapidly. In the pasture industry it is now relatively common to, for example, apply gibberellic acid (a common PGR) to increase grass biomass production in one paddock and a gibberellic acid inhibitor to increase seed production in another.

It can be difficult to distinguish between what have been categorised as 'snake-oil' products and proven PGRs, and if the grains industry is to capitalise on this potentially useful technology, growers and their advisers need to learn more about PGRs and where they are likely to produce the greatest benefits.

PGRs are far from new but there is still little understanding of how they work and how, when and where they should be used.

However, recent research by Agrilink indicates yield responses to PGR application in the absence of lodging, with combinations of products with different modes of activity on the GA pathway showing greatest promise as yield promoters.

Group 1 PGRs appear to have some ability to improve yield. There are hundreds of chemical compounds in Group 1 but most are used for other agricultural applications. Many fungicides, including most of the triazole group, have some degree of PGR activity and one, paclobutrazol, is used almost exclusively as a PGR.

Group 6 products are usually herbicides that are used at sub-lethal doses, and many farmers and advisers will have occasionally seen initial crop suppression from herbicide application result in higher yield.

The main Group 5 product has been ethephon, an ethylene-releasing compound, but increasing ethylene levels does not always have the desired outcome and there are as many instances of crop damage from using a Group 5 product as there are of positive responses.

MID NORTH HIGH RAINFALL ZONE SITE 2012 MACE WHEAT RESPONSE TO A RANGE OF PGR TREATMENTS.

Basics

In 2005, after 15 years of variable results and claims for and against PGRs, Agrilink decided to go back to basics in an effort to understand the use of PGRs.

After three years of research a screen trial of 360 treatments involving five products and three application timings was conducted in 2009 to assess yield responses in the absence of lodging.

The highest yield responses all resulted from combinations of two or more products. Only one product (Product A*) ranked in the five top-yielding treatments when used alone, and this response occurred only when it was applied at GS 30. When used later it was nowhere near as effective.

Timing was identified in this trial as being critical, with Product B having no useful activity when applied at GS 30-31but providing some benefit when applied marginally later in stem elongation. Product A and Product C were impressive in mixtures applied early in the stem elongation but gave no response when applied later during stem elongation. Product D in mixes was ineffective at GS 30, very effective at GS 31 and ineffective at GS 32. Product E had useful activity over a range of timings, depending on the product it was tank-mixed with.

In 2011 and 2012 Agrilink research concentrated on timing and application method, comparing seven products (five from Group 1 and two from other Groups).

In 2011 trials at Merilden, south-east of Clare, PGRs produced substantial yield responses in wheat, with one treatment resulting in a yield of 9.05 t/ha, an increase of 1.99 t/ha without any benefit from reduced lodging.

This trial reinforced the importance of timing of foliar applications. Figure 1 (below) shows the variation in response to trinexapac-ethyl (Moddus) plus chlormequat chloride when applied at GS 30 compared to GS 31. The time for wheat to progress from GS 30 to 31 in Australia varies from five days to 15 days depending on temperature, so depending on conditions, the window of opportunity to apply a PGR at the right growth stage for maximum benefit may be only a day or two.

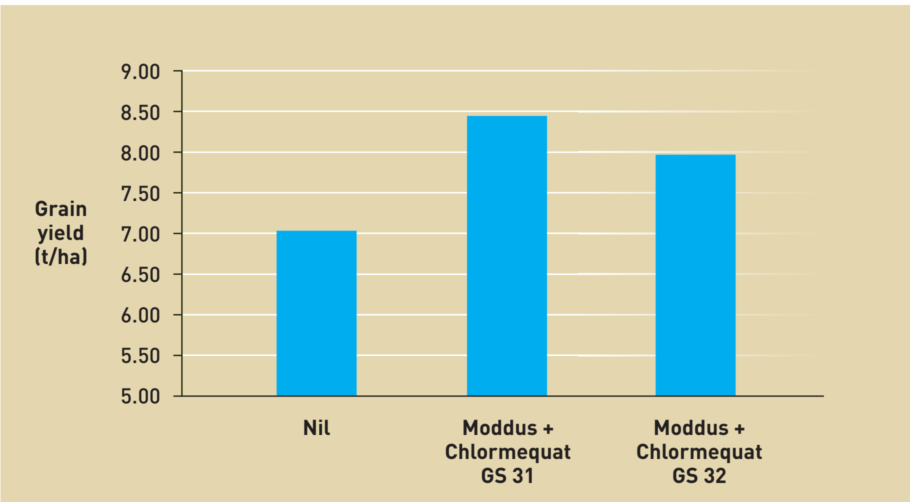

FIGURE 1. GRAIN YIELD RESPONSE TO MODDUS + CHLORMEQUAT FOLIAR APPLICATION (MERILDEN, 2011)

MID NORTH HIGH RAINFALL ZONE SITE 2012 MACE WHEAT WITHOUT PGR.

MID NORTH HIGH RAINFALL ZONE SITE 2012 MACE WHEAT WITH PGR COMBINATION.

Group 1 action

During stem elongation a substantial amount of water is used by the plant (around 110 mm for an average 4 t/ha wheat crop). The water is lost by transpiration as a result of photosynthesis that produces carbohydrates.

If the crop has access to unlimited nitrogen a substantial portion of this carbohydrate is used to create more plant parts (later-order tillers, bigger leaves and longer stems). When longer stems are created, most of the available water-soluble carbohydrates are transported to the growth sites and converted into stable fibre fractions such as lignin, so established stems, and leaves to a lesser extent, are left without stored carbohydrate. This means the main head-bearing tillers have lots of leaves, long stems of fibrous material with low stores of water-soluble carbohydrates and low levels of intermediate carbohydrates such as hemi-cellulose and cellulose.

Stored water-soluble carbohydrates and carbohydrates that are able to be

MID NORTH HIGH RAINFALL ZONE SITE 2012 ORION WHEAT WITHOUT PGR.

MID NORTH HIGH RAINFALL ZONE SITE 2012 ORION WHEAT WITH PGR COMBINATION.

MID NORTH HIGH RAINFALL ZONE SITE 2012 ORION WHEAT WITH 200 ML MODDUS.

re-mobilised by the plant for grain filling are extremely important if the plant is incapable of photosynthesising enough during this high-demand grain filling phase. This can occur in very high yielding situations, where the plant is entering terminal drought or as a result of a combination of high yield and dry conditions.

All Group 1 PGRs shorten the internodes but each chemical acts on a specific part of the GA pathway to produce that shortening. Chlormequat chloride is an early-stage GA inhibitor and acts before ent-Kaurene, while trinexapacethyl inhibits much later in the pathway (between GA_{53} and GA_1).

Decisions

Issues to be considered in determining whether or not PGR use is appropriate include:

1. What dwarfing genes are present in the crop and variety being grown and which PGR will the crop respond to?
2. Do seasonal conditions and yield projections suggest that storage of water-soluble carbohydrates, hemi-cellulose and cellulose will be important in achieving the yield potential?
3. Is water use during stem elongation resulting in large amounts of growth, with carbohydrate reserves not being replenished for grain filling?
4. Is the combination of variety, nitrogen status and plant population likely to result in lodging?

The dwarfing mechanisms in some crops and varieties mean there is little potential for benefit from applying certain PGRs.

If the answer to questions 2, 3 or 4 is 'yes' there may be potential to increase yield by use of an appropriate PGR at the right growth stage.

PGR application does not guarantee a yield increase, and in some circumstances can have a negative effect. Group 1 PGR use may be detrimental where photosynthesis is impaired by moisture stress or growth has been limited by moisture stress during stem elongation. Group 5 products can also be very damaging in those conditions. Application of trinexapac-ethyl can cause crop yellowing if the crop is under stress from frost, moisture or nitrogen stress.

* *Product names are not included because these results were obtained in private trials conducted without the involvement of the suppliers of the products.*