Plant growth regulator use in broad acre crops

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Abstract

There is little reliable information on how, why and on which crops plant growth regulators (PGRs) are currently used in Australia. Such information is needed to better link research and development with extension. Currently the four main classes of PGRs used in Australia include Ethephon (ETH), onium-types (chlormequat, CCC), and second and third generation PGRs; the triazoles (e.g. tebuconazole, TEB) and trinexapac-ethyl (TE), respectively. Of these, only CCC, TEB, TE are registered for use in cereals and none for canola. To better understand current usage of PGRs in grain crops, a telephone survey of 142 agronomists working across Australian grain growing regions was conducted. Participants provided information relating to PGR usage on the range of crops grown in their area, including, rates of application, reasons for use, response of crops/effectiveness, and a variety of other variables. The potential economic contribution of PGR to the grains industry was estimated from analysis of reported yield gains from application of PGR to wheat in the high rainfall zone (HRZ). Application of PGR with no change in yield from, for example, a 2.38 Mha area (representing 70% of the HRZ) would lead to a cost of around $70M. In contrast, there was an estimated net benefit of $35M and $138M for a 5 and 10% increase in grain yield in the HRZ. This research highlights the need to better understand use of and yield responses to PGRs under a range of climatic, regional and cultivation situations, through co-ordinated research and extension.

Introduction

Plant growth regulators (PGRs) were developed as a tool for growers to manage lodging risk in a range of grain crops. The most widely evidenced effect in the scientific literature for PGRs is the reduction of plant height when PGRs are applied at early stem elongation in cereals (Berry *et al*. 2004) or rosette formation in canola. Shorter plant height improves crop resistance to lodging and can improve harvestability and possibly grain quality where lodging is associated with increased sprouting. In some instances PGRs have been linked to an increase in stem strength (Tripathi *et al*. 2004) and number of roots (Emam and Shekoofa 2009). Research into the effect of PGRs on grain yield has generated inconsistent conclusions, which may reflect the complex interaction between crop species and variety, the type, rate and timing of PGR application with respect to plant phenology, and environmental conditions. Some improvement in yield has been reported in response to PGRs used on wheat but generally not for either barley or canola, although there are some exceptions (Berry and Spink 2009). Three PGRs are now registered for use in cereals in Australia, chlormequat (CCC), trinexapac-ethyl (TE) and ethephon (ETH) but the current use of PGRs remains unknown. To better understand current usage and perceptions of PGRs in grain crops, a broad ranging telephone survey of agronomists from across Australian grain growing regions was conducted. Potential economic contribution of PGRs to the grains industry was also investigated through economic analysis.

Methods

The survey instrument used in this study was designed to generate understanding of PGR usage across Australian grain growing regions, and reasons agronomists recommended use in their region. Both quantitative (scale and ordinal) variables were included, as well as open-ended qualitative questions to provide insight into perspectives and concerns of agronomists across the grain growing areas. A broad and inclusive sampling frame was employed to cover the growing areas and capture the diversity of perspectives on, and applications of, PGRs. Participants were recruited via internet searching and direct contact with agricultural stores in each Australian agro-ecological zone. The resulting list of 218 potential participants developed within the Tasmanian Institute of Agriculture (TIA) was provided to third-party Computer Assisted Telephone Interviewers (CATI) from the Central Queensland University Population Research Laboratory (PRL). PRL were also provided with the survey instrument and instructions on its application by the TIA research team. Of the 218 potential participants, 71 either declined to be involved, were ineligible or not contactable. In total, 142 agronomists were interviewed by telephone. Final survey data were analysed within TIA using descriptive and analytical statistical methods. Common rationales for specific actions or decisions in PGR use and perceived effectiveness were identified to the open-ended survey questions. Most of the open-ended questions elicited consistent responses across grain growing areas and were thus reclassified into nominal categories to assist with communication of results. Each participant was invited to discuss the four main crops that they managed, and data was collated by crop, resulting in data for 474 crop areas managed. This paper will report results from the PGR survey related to wheat, which was the main crop managed by participating agronomists. The study was approved by the UTAS Human Research Ethics Committee (reference number: H0013500).

Results

Why do agronomists recommend PGR use?

Of the 142 agronomists who participated in the survey, 29 (20%) reported recommending PGRs for application in wheat. The extent of use was low for these participants; 66% of respondents recommended PGR use on wheat for less than 5% of the hectares they managed, and only 10% of respondents recommended PGRs for greater than 40% of hectares under their management. The agronomists who recommended PGRs generally reported higher yields for wheat (4.0 t/ha) than those who did not recommend PGRs (3.1 t/ha), however, this appeared to be related to the region or rainfall zone the agronomists were working in. The larger biomass production associated with increased yield requires greater crop inputs and PGRs are well-recognised as one management strategy to manipulate canopy size to reduce lodging (Pinthus 1973; Berry et al. 2000; Berry and Spink 2009). The majority of respondents (69%) who recommend PGRs, recommended that growers apply a combination of two PGR products.

Only 10% of respondents reported two applications per season while the majority of respondents (86%) reported only one application of PGRs per season. There was some variation in the timing of PGR application (Table 1), however most agronomists (76%) applied PGR at the early stem elongation stage.

Table 1. Growth stages at which PGRs are generally recommended for wheat

Growth Stage	Number of respondents (%)
Booting	1 (3%)
Early stem elongation	22 (76%)
Late stem elongation	2 (7%)
Late tillering	3 (10%)
TOTAL	**29 (100%)**

Benefits of PGR use

When asked to explain the benefits from using PGRs in wheat, participating agronomists most frequently reported reduction in lodging risk and, related height reduction (Figure 1). Yield was also reported as an important benefit. Harvestability and straw strength/thickness may also relate to the observed benefit of height reduction, with those three rationales all indicating a more compact growth habit and improved harvestability.

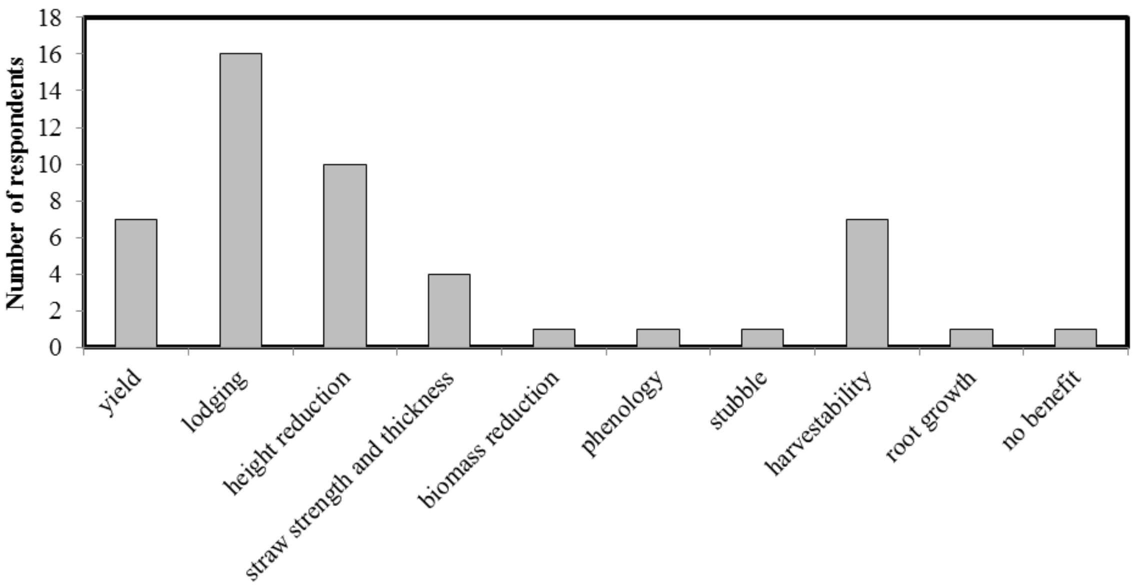

Figure 1. Benefits described by agronomists from the use of PGRs in wheat.

Why do agronomists not recommend PGR use in wheat?

Agronomists who did not recommend PGRs for application to wheat provided insights into the perception and experience of agronomists who had either tried these products previously, or were unconvinced by the evidence of their efficacy (Figure 2). The most frequent rationale was that PGRs were not needed in the area the agronomist managed. This was usually related to typical yields for the region or rainfall zone that the agronomist worked in, with agronomists in low yield areas most often mentioning the theme 'not needed'. The related theme of 'not suitable in the environment or area' was also mentioned by many of the participants. An important theme to emerge from this question was an economic one where agronomists said that the application of PGRs to the crops they managed did not provide a justifiable return on the cost of application, and related to this was the theme that the science or evidence of the effectiveness of PGRs was perceived to be weak or lacking.

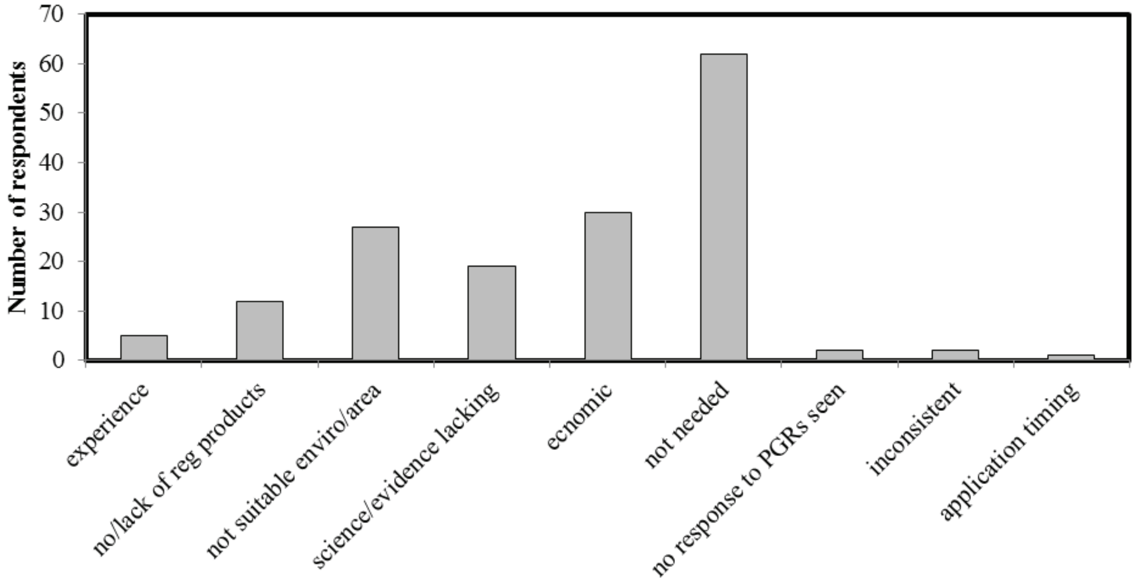

Figure 2. Agronomists' reasons for not recommending PGR use in wheat.

Economic analysis

The most certain economic benefit that was associated with PGR use was a reduction in plant height and an associated improvement in lodging resistance, leading to improved harvestability. This was perceived to reduce the loss of grain through shattering or poor quality. Indirect benefits included potentially reduced cost of harvesting, through reduced effort to harvest of crops with a high incidence of lodging, and through less expenditure on harvesting technologies to reduce grain losses. PGRs were also likely to improve dry-matter partitioning in grain, particularly in the high rainfall zone (HRZ). In the HRZ, a combination of higher rainfall and higher input can lead to greater relative production of vegetative matter.

As an example, the area planted to wheat in HRZ is ~2.38 Mha estimated as 70% of the total area of the high rainfall zone (3.4 Million ha) (ABS 2011). Average yields are around 4 t/ha (Sylvester-Bradley et al. 2012), which puts total annual wheat production from the high rainfall zone at around 9.52 Mt.

Table 2. Economic analysis for return on investment from use of the PGR Moddus® for a nil, 5 or 10% increase in grain yield in the HRZ. Assumptions are described in the text.

Item	Base line	Change in grain yield		
		0%	+5%	+10%
Area (Mha)	2.4	2.4	2.4	2.4
Yield (t/ha)	4.0	4.0	4.2	4.4
Total yield (Mt)	9.5	9.5	10.0	10.5
Return at $220/t ($M)	2094.4	2094.4	2200.0	2303.4
Cost at $30/ha ($M)	0	71.4	71.4	71.4
Net Return ($M)	2094.4	2023.0	2128.6	2232.0
Net Benefit ($M)	0	-71.4	34.2	137.6

The analysis in Table 2 shows the potential economic returns to the grains industry if PGRs return 0%, 5% and 10% increases in grain yields. A long term average wheat price of $220/t is assumed, along with the current price of the most expensive PGR (Moddus, $770 for 5L), which equates to $30/ha when applied at the recommended rate of 1.2 L/ha. As could be expected, application of PGR with no change in yield from a 2.38 Mha area would lead to a cost of around $70M. In contrast, there was a net benefit of around $35M and $138M for a 5 and 10% change in grain yield in the HRZ.

Conclusion

PGRs are generally reported and perceived to reduce plant height in grain cereals when applied at the appropriate stage of development; improvement in grain yield, however, tends to be inconsistent. A survey of 142 Australian agronomists found that only 20% recommend the use of PGRs in crop management of wheat, and their main rationale for recommending PGR use was improved lodging resistance, followed by height reduction and improved yield. Reasons why agronomists did not recommend PGR use in the crops they managed were because they were ‘not needed’ or unsuited to their region. Economic analysis showed that application of PGR to 70% of the HRZ with no change in yield would cost around $70M. In contrast, there would be a net benefit of ~ $35M and ~$138M if application of PGRs to wheat in the HRZ generated a 5 and 10% change in yield, respectively.

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