The effects of plant growth regulators on winter and spring canola (*Brassica napus* L.) types in the High Rainfall Zone of south-eastern Australia

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Abstract

European canola cultivars have shown potential to produce high grain yields in the High Rainfall Zone (HRZ) of southern Australia. However these crops grow tall and produce large amounts of non-grain dry matter resulting in harvesting difficulties and inefficiencies in the conversion of resource to grain. Plant growth regulators (PGRs) are a common tool used in the Northern hemisphere to control height, reduce lodging and manipulate the crop canopy to improve light penetration and increase grain yields. An experimental PGR was applied to winter and spring canola cultivars at Hamilton, Victoria in 2010 and 2011 and at Longford, Tasmania in 2011 to determine if crop morphology could be altered to improve grain yields in the HRZ. The grain yield, yield components, crop size and plant architecture of four late maturing European winter cultivars (Taurus, CBI206, CB3 at Hamilton and CBIW208 at Longford) and two mid maturing European spring cultivars (CBI8802 and CBI2610 at Hamilton) were compared with the Australian spring cultivars, Hyola 50 (Hamilton) and 45C75 (Longford). The PGR did in some instances alter flowering and final above ground dry matter (AGDM), pod density, canopy depth and branching and although differences between cultivars and crop maturity were detected, effects were often inconsistent. However changes in plant morphology had no significant affect on grain yield. The lack of yield response was attributed to no lodging in the experiments and the ability of crops in the HRZ to sustain larger canopies than in the Northern Hemisphere without reducing yield. Reducing plant height and improving resource conversion are still important targets in the HRZ and further work needs to be conducted to devise agronomic, chemical and genetic strategies (e.g. through the use of dwarf material) to increase the ease and efficiency of grain production in this environment.

Keywords

harvest index, lodging, canopy structure, GAI

Introduction

Late maturing canola cultivars from Europe have the potential to increase productivity in the HRZ of southern Australia through integration with livestock industries (Kirkegaard et al 2008) or through increases in grain production (Riffkin et al 2012). Experiments conducted during dry seasons at Hamilton, Victoria between 2005 and 2008 showed that grain yields from the later maturing European winter types were either greater or not significantly less than the spring types available to Australian growers. However, the European cultivars were taller and harvest indices were significantly less indicating inefficiency in the partitioning of biomass into grain. Plant growth regulators are typically

used in the management of canola in the Northern Hemisphere to reduce crop height, improve canopy structure, alter root partitioning and improve winter hardiness (Daniel and Scaribrock 1986; Berry and Spink 2009). Berry and Spink (2009) showed a positive response to PGR when applied to crops with moderate to large canopies at the bud stage of development with a green area index (GAI) greater than 1 but a negative effect when applied to crops with small canopies with a GAI of less than 0.8. An optimum GAI of 3.5 at flowering was proposed by Lunn et al 2001 to optimise light capture and penetration into the canopy. The performance of winter and spring types in response to PGR was compared in experiments at Hamilton, Victoria in 2010 and 2011 and at Longford, Tasmania in 2011 to determine if plant height and partitioning could be manipulated to increase grain yields in the HRZ.

Material and Methods

Locations

Experiments were conducted on the Department of Primary Industries research farm at Hamilton in Victoria (37°49’S, 142°04’E) in 2010 and 2011 and at Longford in Tasmania (41°59’S, 147°12’E) in 2011. Soil type at Hamilton is a chromosol (Isbell 2002) and the long term average (LTA) rainfall is 690 mm. The soil type at Longford is a dermosol (brown clay loam Isbell 2002) and the LTA rainfall is 620 mm.

Treatments and Experimental design

At Hamilton, five (2010) or six (2011) cultivars were grown with or without spring irrigation and either with or without an unregistered experimental PGR which inhibits the early stages of gibberellin biosynthesis. Cultivars included three European winter types, Taurus, CBI206 and CB3, one late maturing European spring type CBI8802, an Australian spring type, Hyola 50 and a winter spring cross CBI2610 (2011 only). The experimental design was either a split block design (2010) with irrigation as the main block and cultivar and PGR randomised within each block or a split-split block design (2011) with irrigation as the main block and cultivar maturity time (Early and Late) as the sub block. Cultivars (Early: Hyola 50, CBI8802 and CBI2610, Late: Taurus, CBI206 and CB3) and PGR treatments (+PGR, Nil PGR) were randomised within each sub block. There were three replicates in 2010 and four replicates in 2011.

At Longford, two canola cultivars, one winter (CBIW208) and one Australian spring type (45C75) were sown with and without the same PGR as applied at Hamilton. The experiment had a split plot design with cultivar as the main block and the PGR treatment randomised within each block with four replicates.

At Hamilton in 2010 the PGR was applied once when the stem had extended to 30 and 50 cm in height. Due to the lack of response to PGR in 2010, the PGR was applied twice in 2011, once at 4-5 leaf stage and again when the stem had extended to a height of between 30 and 50 cm. At Longford the PGR was applied twice at the 4-5 leaf stage and when the stem had extended to a height of 20 cm.

Management and measurements

The experiments were direct drilled on April 29 and 30 at Hamilton in 2010 and 2011 respectively and on May 4 at Longford Tasmania using a plot cone seeder with knifepoint tynes. Eight rows were sown per plot with a row spacing of 15 cm and plot dimensions of 15 m long by 6.8 m wide at Hamilton or 15 m long by 1.5 m wide at Longford. Sowing rate was for a target of 50 plants m⁻².
Weeds and pests were controlled as required. Quadrat cuts (0.5 m$^2$ per plot) were taken at the bud visible and 10% flowering stages to determine dry matter and green area. At final harvest plant height, grain yield, seeds m$^2$, seed weight, pods m$^2$, total above ground dry matter (AGDM) and harvest index (HI) were determined from 2 x 1 m$^2$ quadrats per plot. At Hamilton the number of primary and secondary branches, internode number and length and canopy depth were also measured from 10 representative plants per plot.

**Results**

**Plant height**

At final harvest, PGR treated crops were 10 and 20 cm shorter at Hamilton in 2010 and 2011, respectively and 10 cm shorter at Longford (treatment means). The height reduction was greater for the earlier maturing cultivars at both Hamilton and Longford in 2011. At Hamilton, height was reduced by 22 cm in the early maturing cultivars but by only 14 cm in the winter types. At Longford, PGR reduced the height of the spring cultivar by 30% but by only 10% for the winter type.

**Grain yield, yield components, harvest index**

There was no significant difference in grain yield between the PGR and nil treatments at any of the sites in either year (Table 1). The Early maturing cultivars treated with PGR at Hamilton in 2011 had significantly ($P<0.001$) more pods m$^2$ than the Nil PGR treatment (+PGR, 10070; Nil PGR, 8890 lsd, 575.6) but fewer seeds per pod ($P<0.05$) (+PGR, 16.3; Nil PGR, 17.6 lsd, 0.72). There was no significant effect of PGR on these traits for the Late maturing cultivars at this site. The PGR significantly ($P<0.001$) reduced seed weight and harvest index ($P<0.05$) at Hamilton in 2011 (Table 1). At Longford the PGR reduced pod density in the spring cultivar but increased pod density in the winter cultivar (data not shown). The PGR had no other effect on the other yield components or HI at this site.

**Canopy structure and size**

At Hamilton in 2010 and Longford in 2011 there were no differences in any measurement between PGR and nil treatments for GAI or AGDM at the bud visible, flowering or final harvest stages. At Hamilton in 2011, AGDM was greater at flowering and final harvest in the Nil PGR treatment (Table 1). The PGR significantly ($P<0.05$) increased the number of primary and secondary branches in both years at Hamilton. There was a significant ($P<0.05$) PGR x cultivar interaction for the depth of pods in the canopy with a reduction in depth in 4 of the 6 cultivars in 2011 (CBI206, Hyola 50, CBI2610 and Taurus) (data not shown).

**Table 1. Grain yield, seed weight (Wt), harvest index (HI), plant height (Ht) above ground dry matter (AGDM) and green area index (GAI) of canola with and without plant growth regulator (PGR) at Hamilton Victoria in 2011. Data is mean of cultivar and irrigation treatments.**

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<th>Grain Yield t ha$^{-1}$</th>
<th>Seed Wt mg</th>
<th>HI</th>
<th>Plant Ht cm</th>
<th>Final Harvest AGDM t ha$^{-1}$</th>
<th>Flower AGDM t ha$^{-1}$</th>
<th>Flower GAI cm$^2$ cm$^2$</th>
<th>Bud AGDM t ha$^{-1}$</th>
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<td>Hamilton 2011</td>
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Discussion

The PGR significantly reduced crop height at all sites as expected but only altered the partitioning of assimilate into grain (HI) at Hamilton in 2011. In some instances the PGR did alter flowering and final AGDM, pod density, canopy depth and branching and, although differences between cultivars and crop maturity were detected, effects were often inconsistent. For example, the PGR increased pod density in the early maturing cultivars at Hamilton in 2011 whereas at Longford the PGR reduced pod density in the early maturing cultivars but increased densities in the late maturing cultivars. However, any changes in plant morphology (plant size, architecture and partitioning) had no significant affect on grain yield.

The positive effect of PGRs in other studies have been attributed to reduced lodging (Armstrong and Nicols 1991; Berry and Spink 2009) and improved light penetration through the canopy by reducing plant size in large crops (Lunn et al 2003). Lodging did not occur at any of the sites in either year so the benefits of improved stand ability through the use of the PGR were not realised in these experiments.

Canopy sizes were often large with a GAI more than 3 by the bud visible stage and more than 5.6 at flowering for the Nil PGR treatment at Hamilton in 2011. Even with the application of PGR, canopy sizes were generally larger than the GAI of 2 at bud visible stage and the 3 to 4 just prior to flowering identified by Lunn et al 2001 as optimum. Previous studies in the HRZ of southern Australia have shown grain yield to be positively associated with plant height and AGDM at flowering and final harvest (Riffkin et al 2012). These studies also indicated that crops in the HRZ are able to support larger canopy sizes than those in the Northern Hemisphere without adverse effects on grain yield possibly due to higher incidence of solar radiation with subsequent greater penetration of light deeper into the canopy and milder temperatures around flowering and grain fill. This suggests that grain yield benefits may not be as readily achieved in this environment by reducing canopy size or that an insufficient reduction was achieved to capture the reported benefits.

Conclusion

The anti-gibberellin plant growth regulator altered plant height, yield components and canopy architecture but did not improve efficiency of dry matter conversion into grain or grain yields. The lack of yield response was attributed to no lodging in the experiments and the ability of crops in the HRZ to sustain larger canopies than in the Northern Hemisphere without reducing yield. Reducing height and AGDM and improving HI are still important targets to increase the ease of harvesting operations and for a more effective use of inputs through better partitioning of resources into grain. Further work needs to be conducted to devise agronomic, chemical and genetic strategies (e.g. through the use of dwarf material) to increase the ease and efficiency of grain production in this environment.

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References


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