Is gibberellic acid application a useful tool for increasing oat production?

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Abstract
Oats are an important enterprise diversity option for north-west Victoria due to traditional pasture grasses (ryegrass, cocksfoot and phalaris) not suiting the region. Gibberellic acid (GA) may have the potential to assist in filling the early Autumn feed gap by shifting the peak in the growth curve forward (increasing early growth), due to its ability to boost biomass shortly after application in a number of pasture grasses. The response of cereal oats to GA however is not well understood. This research was conducted to give growers a better understanding of the effects of GA on oats in terms of changes to production, plant recovery following grazing for hay and grain yields and likely economics. Oat biomass showed no response to GA application throughout the season, however biomass was decreased in response to a single grazing event. Similarly, application of GA had no effect on oat feed or hay quality. Average grain yield was 4.2t/ha with no interaction between any treatment (GA timing or grazing) on protein or moisture. However, test weight increased as a result of grazing independent of GA application or timing.

Keywords
Grazing, feed value, biomass, oat grazing, biomass recovery.

Introduction
Oats are a versatile crop with many applications. Despite this, planting of oats in the region has been limited due to a lack of in crop herbicide options and marketability. However, in recent years, high export hay prices have seen oats being reintroduced into many farming operations. In this region, dry, cold conditions early in some seasons result in a lack of early pasture growth. In these instances the use of gibberellic acid (GA) could potentially assist in early biomass production. GA is a naturally occurring plant hormone. Plants begin to produce GA in warmer months (Wingler and Hennessy 2016), boosting biomass production mainly by increasing plant cell elongation and replication. GA is used on perennial pastures and horticultural crops to stimulate biomass production, flowering and fruit set, but the effects of GA in annual cereal crops is relatively unknown. When GA is applied to established perennial winter pastures in the colder months, biomass production is stimulated, shifting the growth to occur earlier (Ghani 2014; Arnold et al. 1967). It was hypothesised that the use of GA would increase biomass and consequently lower feed value with a visual yellowing effect indicating changed crop nutrient status (Hermans et al. 2006; Poorter and Nagel 2000). This paper outlines findings from an experiment focussing on the effect of applying GA and grazing on oat biomass quantity and quality, and grain yield.

Methods
Site Description
The trial was established in 2016 at Warmur in the Victorian Mallee, a predominantly mixed cropping and sheep production area with a winter dominant average annual rainfall of 375 mm, 250 mm falling on average within the growing season. The soil at the site was a clay loam with a starting plant available water of 59 mm and 76 kg N/ha available to 70 cm depth prior to sowing. Sowing occurred on 21 April 2016 into a fallow paddock.

Crop Management
At sowing, Granulock Supreme Z + Impact was applied at 50 kg/ha with a following 50 kg/ha and 60 kg/ha of urea applied on 9 July and 29 July respectively to ensure N was not limiting.
Weeds, pests and diseases were all managed to best practice.

Experimental Design
The trial was established as a randomised block design (plot size was 0.00252 ha) with four replicates of six treatments (1) No graze ; (2) Graze ; (3) Graze + GA before graze,15 June; (4) Graze + GA after graze 21 July; (5) No graze + GA before graze 15 June; (6) No graze + GA after graze 21 July. The grazing event,

simulated through defoliation by a whipper-snipper, occurred on 21 July with GA applied immediately following the relevant treatments. Gala growth regulator (2016), was applied at a rate of 80 ml/ha using a hand wand 50 cm above crop height.

Measurements and monitoring

Biomass measurements were made by taking two 1m lengths of crop row cut at ground level from either end of each plot and dried at 70°C for 48 hours. Subsamples were taken from these samples for feed quality assessment. Feed quality was assessed using NIR to give measurements of: crude protein, dry matter digestibility, neutral detergent and acid detergent fibre, metabolisable energy and water soluble carbohydrates. The timing and purpose of assessments are outlined in Table 1.

Table 1. Timing and purpose of biomass and feed quality testing through the trial.

Biomass Cut Timing	Purpose of assessment
15 June	Measure initial biomass prior to treatment applications.
27 June	Monitor biomass response 2 weeks after 15 June GA application
21 July	Monitor biomass response 4 weeks after 15 June GA application – at grazing
16 August	Monitor dry matter recovery of all treatments following grazing.
9 October	Hay yield and quality evaluation.

Treatment effects were analysed using a general analysis of variance (ANOVA) in Genstat software (17th ed.)

Results

Biomass

2016 was an above average rainfall season for Warmur with 371 mm of the 471 mm total annual rainfall falling within the growing season. Moisture levels were maintained throughout the season, temperatures were mild. These factors contributed to adequate growth and biomass throughout the season.

Table 2. Dry matter (DM) (t/ha) average of treatments at various times in season.

Treatment	15 June DM^ (t/ha)	27 June DM$^{\#}$ (t/ha)	21 July DM (t/ha)	16 August DM (t/ha)	9 Oct DM (t/ha)
1 No Graze, Nil				5.89^{a}	13.33^{a}
2 Graze, Nil		1.37	2.58	3.67^{b}	9.92^{b}
3* Graze, GA Before	0.45	1.82	2.67	3.14^{b}	11.33^{ab}
4* Graze, GA After				3.78^{b}	9.12^{b}
5* No Graze, GA Before	0.45			5.59^{a}	11.60^{ab}
6* No Graze, GA After				5.67^{a}	13.22^{a}
P Value	-	NS	NS	P<0.001	P=0.036
LSD (P= 0.05)	-	0.93	1.02		2.86
CV%	-	25.8	17.3	1.01	16.6
				14.4	

* Samples with GA applied.

^ Cuts taken prior to treatment application (15-June) were not statistically analysed (n=2).

\# Note: Samples taken prior to grazing.

There was no effect of GA application on biomass at any time of sampling, but a main effect of defoliation was observed on 16 August with no interaction between grazing and GA timing factors (Graze P<0.001, Graze x GA timing P = 0.701). Similarly there was lower biomass in grazed treatments (2 and 4) with no interaction between treatment factors (Graze P = 0.004, Graze x GA timing P = 0.133), suggesting the biomass removal in a grazing event could not be recovered by the time of hay cut (9 October).

Seasonal conditions were conducive to increased biomass production. As a result the trial experienced widespread and severe lodging prior to hay cut and harvest. Lodging scores were taken just prior to harvest, based on a visual assessment of plot percentage that had bent over/lodged due to rain, wind or the impact of its own weight. Lodging scores ranged from 30% to 90% of the plot area however there was no correlation between treatments and lodging scores.

Feed Value
There were no treatment effects on feed quality throughout the trial based on a number of quality parameters (Figure 1).

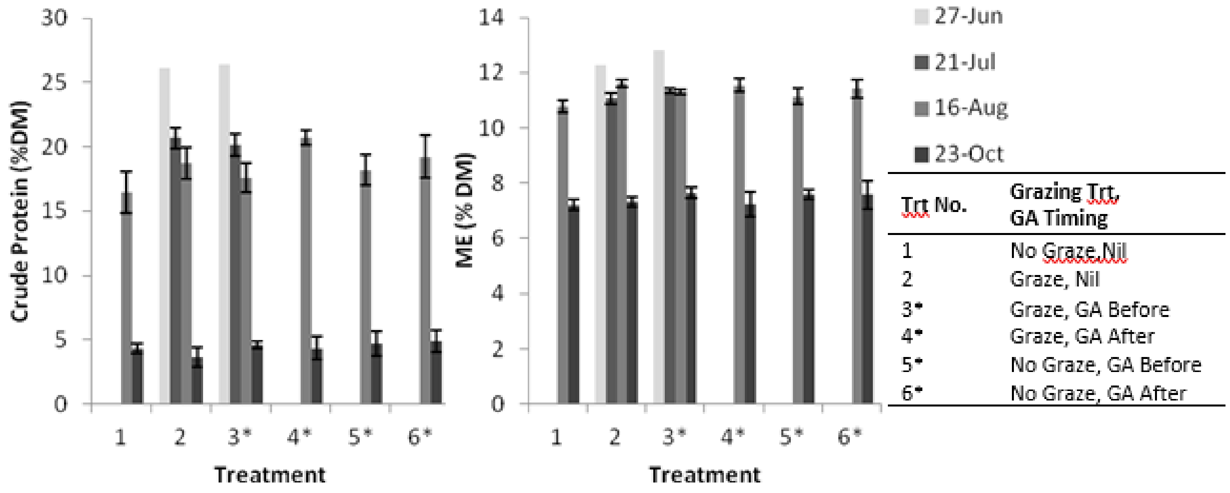

Figure 1. Feed quality on four dates during 2016. Left) CP (%Dry matter (DM)), Right) ME (%DM) (*treatments with GA applied). Error bars are standard error of the mean of each treatment (n=4 except 27 June n=2).

Hay Quality and Grain Yield
Hay quality across all treatments was poor with very low CP and high fibre content. However, this result was not affected by GA application, grazing or GA application x grazing at either of the two application timings.

Table 3. Grain yield and quality by treatment and statistical analysis

Treatment Number	Grazing tmt/ GA Timing	Yield t/ha	Protein (%)	Screenings (%)	Test Weight (Kg/hL)
1	No Graze,Nil	3.5	12.4	6.9	49.1[a]
2	Graze, Nil	4.8	12.2	5.1	51.8[b]
3*	Graze, GA Before	4.6	12.1	4.4	51.3[b]
4*	Graze, GA After	4.4	11.9	5.4	51.1[b]
5*	No Graze, GA Before	3.9	12	5.3	50.5[a]
6*	No Graze, GA After	4.2	12.3	5.1	50.1[a]
P Value		NS	NS	NS	P=0.025
LSD (P=0.05)		1.44	0.502	2.017	1.55
CV%		22.4	2.7	24.8	2.0

There was no difference in grain yield across any treatments with the trial averaging 4.2 t/ha. Similarly there was no difference seen between quality parameters of protein or screenings. However, there was a difference in test weight between treatments due to grazing (Graze P = 0.003, GA timing P = 0.613, Graze x GA timing P = 0.158).

Conclusion

There has been very little research done into the effect of GA application on annual cereal crops in Australia. It was hypothesised that there would be an observed increase in oat biomass following GA application compared to nil treatments due to the known ability of GA to increase cell elongation and replication in plants (Hamayun et al. 2010; Gupta and Chakrabarty 2013). This was not the case and has raised a number of questions as to what contributing factors may have led to these results. While crop nutrient requirements may change in the event that GA application successfully altered biomass accumulation, it is suggested that in this instance, oat response to GA was not limited by nitrogen as sufficient fertiliser was applied during the season. A decrease in biomass was measured two weeks after grazing. However, this did not have an impact on grain yield or quality as grazed plants were able to recover sufficiently by harvest and developing heads were not impacted.

There was no change in feed or hay quality from the analysis of a number of quality parameters. The 2016 season was not an average season generally experienced in north-west Victoria and much of Australia. Mild temperatures experienced in 2016 may have played a role in reducing the effects of GA application as thermal receptors in plants are known to stimulate the synthesis of GA within plants (Wingler and Hennessy 2016; Atwell et al. 1983; Sawhney 1983) . In July 2016 daily minimums were warmer than average, thus GA applications in a colder year could be to an advantage in terms of increased crop growth. Feed quality and biomass were both unaffected by either timing of application of GA, indicating that in this situation, application of GA would not have been economically viable on oats in the 2016 season. If future research were to be carried out, the addition of other variables (urea and GA rate and timing) and oat varieties may be able to answer some of the questions raised in this trial around factors and conditions that may result in a response from application of GA.

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