Dry matter production of winter wheat, cultivars ‘Brennan’ and ‘Revenue’, does not increase after application of gibberellic acid

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Abstract

Winter wheat is often grown as a dual-purpose crop in the High Rainfall Zone (HRZ) of Australia. To help fill the winter feed gap there is grower interest in increasing winter dry matter production for feed without adversely affecting yield. Gibberellic acid (GA) has been used to increase pasture production in winter by stimulating shoot and cell elongation. GA has the potential to be used in dual-purpose winter wheat to increase dry matter production following initial grazing and thereby increase feed supply for subsequent grazing. Adding nitrogen (N) at the time of treatment has been shown to increase dry matter production. Experiments on winter wheat cultivars ‘Brennan’ and ‘Revenue’ were conducted over three seasons (2010 – 2012) in northern Tasmania. Crops were treated with varying rates and combinations of GA and nitrogen (N). Experiments evaluated the individual and combined effects of GA and N on dry matter production and grain yield. Treatments did not increase dry matter yield in these experiments, nor did they adversely affect yield.

Keywords

Nitrogen, yield, Bayesian.

Introduction

Maintaining feed supply in mixed farming systems throughout winter in Tasmania and the HRZ requires careful management. To help manage overall farm feed supply, winter wheat is often sown early as a dual-purpose crop. However, with low temperatures during winter, growth rates are slow and strategies to increase winter feed production would be useful.

Gibberellins are plant hormones that regulate growth and morphogenesis. Gibberellic acid (GA) when applied exogenously has been shown to increase feed supply in grass pasture species (e.g. Bryant et al. 2016). Early experiments in pasture used high rates of GA for example 105 g/ha (Biddiscombe et al. 1962) and treatments tended to increase dry matter (DM) but then had a detrimental effect after a period of time when growth rates were slowed, a ‘bounce down’ effect. More recent experiments have used lower application rates (e.g. 8 g/ha; Matthew et al. 2009), which still increase DM yield without the residual bounce down effect. Together with smaller application rates and a decrease in the price of GA, GA is now used in pasture-based systems to strategically stimulate out of season growth.

GA has the potential to be used in dual-purpose wheat, as it is in pasture, during winter to increase feed production when overall feed supply on farm is low. Experiments in wheat have shown GA to increase leaf blade length when applied to GA-sensitive cultivars (Evans et al. 1995). Preliminary work by Dean and Botwright Acuna (2008) demonstrated GA to be useful in increasing early dry matter in dual-purpose wheat, cultivar ‘Tennant’. This study follows on from that work and was designed to evaluate the efficacy of GA application on dual-purpose wheats commonly grown in Tasmania, ‘Revenue’ and ‘Brennan’, to increase dry matter production in winter for grazing and grain yield.

Methods

Experiments were located in commercial paddocks of wheat grown in northern Tasmania (41°31′S, 146°54′E) over three growing seasons (2010-2012). ‘Revenue’ was sown 3 May 2010 and 6 April 2011 at 105 kg/ha and ‘Brennan’ was sown 1 May 2012 at 100 kg/ha. Weeds and pests were controlled as per commercial practice. Each trial was a randomised complete block, with four replicates. Plot were 1.85 m wide and 8 or 10 m in length. At mid-tillering (GS25) and four weeks later, at late tillering, the trial area was mown to simulate grazing and then foliar treatments of GA alone and in combination with nitrogen (N) were applied. N treatments used were soluble N products, one containing only soluble, ‘Easy N®’, labelled N in the treatments and one containing N plus trace elements, 'Winter Crop Boost', labelled WCB in the treatments. Treatments were: Nil (no GA or N application), GA 4, GA 8, GA 16 (GA at 4, 8, 16 g/ha), N (N at 15 kg/ha), WCB (N at 15 kg /ha), GA 8 + N (combination of GA and N at 8 and 15 kg/ha), GA 8 + WCB (combination of GA and N at 8 and 15 kg /ha). Plants were sampled from 0.6 m^2 quadrats at 0, 7, 14, 21, 28, 56 days post treatments and also at flowering and physiological maturity. In 2011 and 2012 height was also measured when dry matter cuts were taken. A plot harvester was used to measure grain yield.

Statistical analysis

Plant heights were analysed by ANOVA at each sampling time separately. Grain yields were analysed by ANOVA for each year separately. ANOVAs were conducted in Genstat 18 (VSN International Ltd) and least significant differences (l.s.d.) at P = 0.05 were used to test differences between means. To describe the change in dry matter over time a Gompertz model was adopted, given by;

$$d = e^{a+b(1-e^{-ct})}$$

in which t is time (thermal time (GDD, base temperature = 0°C)), d is the log of the predicted dry matter, and a, b, c are parameters to be estimated. It was assumed the observed log dry matter was Gaussian distributed, DM ~ N (d, τ), where τ is the precision (reciprocal variance). The above model was fitted within a Bayesian framework. Bayesian model require priors to be specified. We used non-informative Gaussian priors for the parameters, $a \sim N(-3.168, 0.001)$, $b \sim N(4.606, 0.001)$, $c \sim N(1.48e^{-3}, 10^{-6})$, where the means were approximate estimates obtained from exploratory work. A non-informative Gamma prior was assigned to the observation precision, $\tau \sim$ Gamma (0.001, 0.001). Inference was obtained in the form of posterior means and variances obtained via Markov chain Monte Carlo (Brooks 1998) (MCMC) simulation. Parameters were updated using Metropolis-Hastings updates. Convergence was easily attained with 10^6 iterations and thinning ratio of 10^{-3}.

Results

Grain yield was not affected by treatments in any year with mean grain yield of 8.6, 8.1 and 9.9 t/ha in 2010, 2011 and 2012, respectively.

When height was measured, for example, at 14 days post treatment in 2011, GA treatments increased height of the plants ($P \leq 0.001$, Figure 1). This height effect tended to be consistent when measured, though the height effect did not last, with all treatment plants the same height at flowering (data not presented).

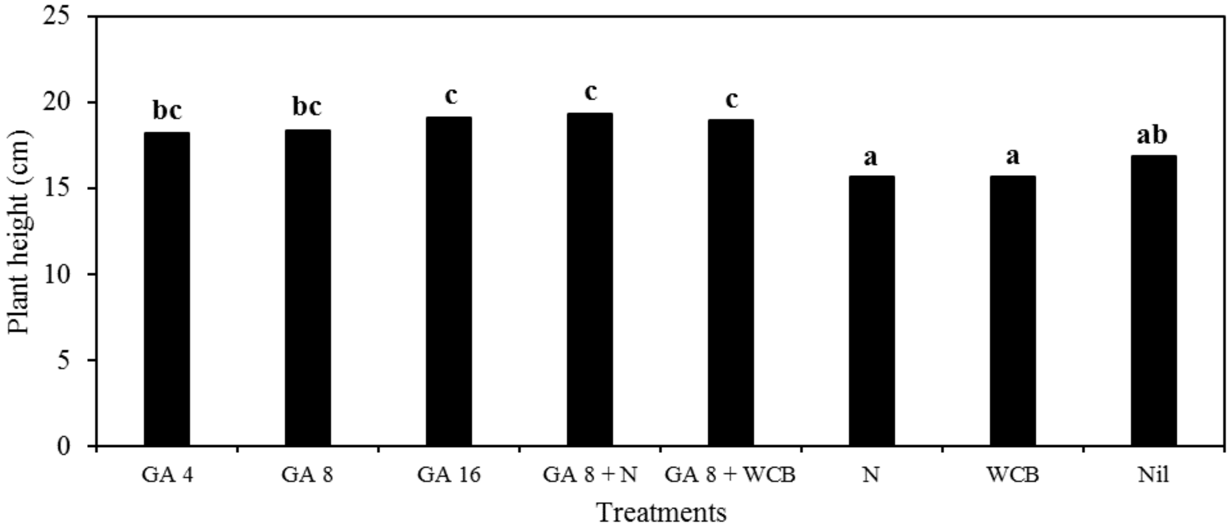

Figure 1. Mean plant height of treatments 14 days post treatment in 2011. A different letter above each bar indicates that height differed significantly (P = 0.05) between treatments.

The Bayesian model gave a good fit for all treatments (Figure 2). There was however, no treatment difference in any of the parameters, a, b or c (data not presented) indicating a common relationship with thermal time between levels of GA treatments.

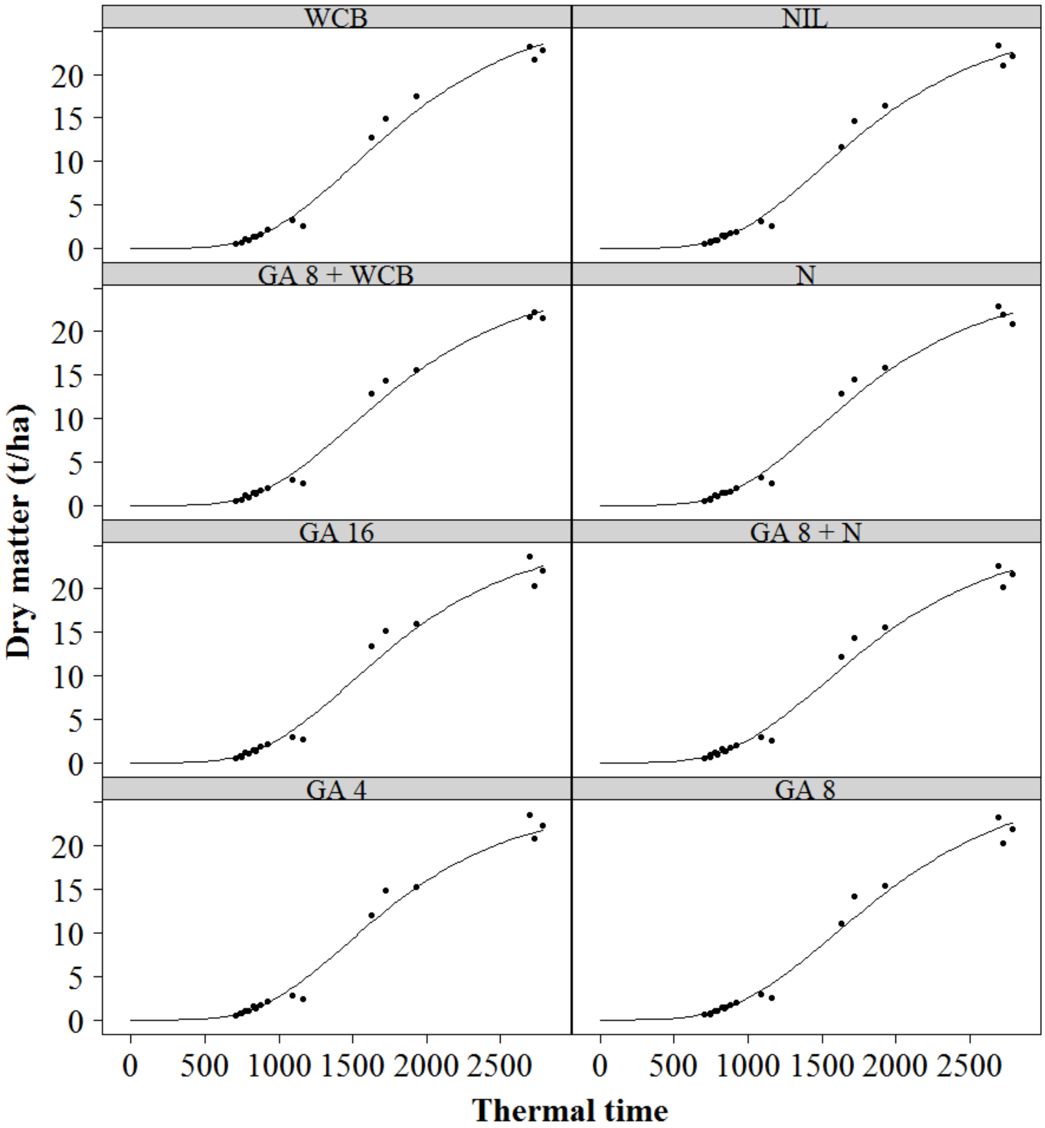

Figure 2. Observed data (●) and fitted values (–) from the Bayesian Gompertz model for dry matter (t/ha) over thermal time (GDD, base temperature = 0°C) from planting. There was no difference between parameters used for the model for any treatment.

Discussion

In contrast with previous work with wheat cultivar ‘Tennant’ (Dean and Botwright Acuna 2008), GA did not increase early dry matter of cultivars ‘Revenue’ and ‘Brennan’. ‘Tennant’ has slower early vegetative growth and the growth habit is more prostrate. It is possible that the effect of GA with ‘Tennant’ (Dean and Botwright Acuna 2008) was more pronounced due to better ability to capture the DM while cutting. GA did have an effect on height on both ‘Revenue’ and ‘Brennan’, indicating the cultivars are GA-sensitive (Evans et al. 1995) and either increased blade length or affected the growth habit to be less prostrate. Altering the growth habit to upright more erect form, would be an advantage with dual-purpose wheat, as grazing animals would be able to graze the crop more efficiently.

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