Grain yield of winter feed wheat in response to sowing date and sowing rate

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Abstract

Most feed wheat grown in New Zealand is sown in April or May, although some growers plant in late March. The aim of this research was to determine if there are potential yield gains from sowing earlier to increase productivity and profitability. Three field experiments over three seasons from 2012-13 to 2014-15 examined the effects of sowing dates in February, March and April and four to five sowing rates on the growth and yield of irrigated feed wheat crops at Leeston, Canterbury. Grain yields ranged from 9.7 t/ha to 15.9 t/ha. The highest grain yields were obtained from late March sowings in all of the trials. For the late March sow date target plant populations of at least 150 plants/m^2 were optimal for highest grain yield. There was an interaction between sowing date and sowing rate in the second and third trials. For later sown crops there was a greater yield response from higher sowing rates compared with earlier sown crops. Disease (*Zymoseptoria tritici*) and lodging were problematic in the second season. Earlier sow dates were more affected by lodging. Earlier sowing of feed wheat crops into March gave growers a higher yield potential compared with April. Further gains in yield could be possible from even earlier planting but this would need more appropriate cultivars, particularly with more resistance to disease and lodging. Also, with early sown crops reaching stem extension in autumn more knowledge on how to best manage the crop canopy is needed.

Additional keywords: time of sowing, plant growth regulator, plant population, *Triticum aestivum*

Introduction

Extending canopy duration in a wheat (*Triticum aestivum* L.) crop increases its radiation interception, therefore potentially increasing dry matter and grain yield (Hay and Porter, 2006). There are two ways the grower can influence wheat development to achieve a longer leaf area duration. Firstly, selecting late maturing cultivars gives a longer canopy duration (McKenzie *et al.*, 2000). Secondly, early sowing of winter wheat extends the duration of the vegetative phase and the subsequent duration of the canopy (Hay and Kirby, 1991). Advancing the sow date from mid-May to mid-April has given yield increases from 0.5 to 2 t/ha depending on cultivar (FAR, 2002). Winter wheat is mostly sown from early April to mid-May in New Zealand, although in recent years some crops have been sown in late March. Research to assess the potential yield advantage of sowing earlier than mid-

April is limited. Crop modelling by the authors of this paper has shown a wheat grain yield of 19 t/ha could be possible from a February sow date. Plant population is an important aspect of potential yield and production costs. Plants sown earlier have more time to tiller and therefore the plant population may be able to be reduced while maintaining head population and yield potential. Also, lower plant populations with a less dense canopy may have less disease build up and lower susceptibility to lodging.

This paper reports on trials in three successive years that assessed the impact of different autumn sowing dates and sowing rates on wheat grain yield.

Materials and Methods

The three trials were at Leeston, Canterbury (43° 45' S, 172° 15' E) and were conducted in the 2012-13, 2013-14 and 2014-15 seasons. The previous cropping history for the respective trials were peas before the 2012-13 and 2014-15 trials, and clover before the 2013-14 trial. The soil type for all trials was a Temuka silt loam (Kear *et al.,* 1967). This soil is deep, stoneless, poorly drained with a very high plant available water capacity. A weather station was on site and recorded daily soil temperature and rainfall.

Individual plots (12 x 1.65 m) were drilled with cv. Wakanui winter wheat into a top worked seed bed. The experimental design was a split plot with sow date as main plots and population as sub-plots with four replicates (Tables 1, 2 and 3).

Soil moisture was measured in each sow date weekly by neutron probe in the 0-1.0 m profile of soil in 10 cm increments. Irrigation was available but was only needed in the 2014-15 season when 30 mm was applied. Agrichemicals were applied to ensure that weeds, pests and disease were not a limiting factor. Plant growth regulators were applied in all trials at Zadoks growth stage 30 and 32. The soil mineral nitrogen content was measured in August of each trial year to enable calculation of applied nitrogen. Fertiliser N applications totalled 300 kg/ha of urea (2012-13 season), 270 kg/ha of urea (2013-14 season) and 410 kg/ha of urea (2014-15 season) and were applied in two split applications during September and October in each trial.

Canopy reflectance data was measured fortnightly in the 2013-14 and 2014-15 seasons for each treatment using the Trimble Greenseeker crop sensing system (Trimble Agriculture Division, 10368 Westmoore Drive, Westminster, CO 80021, USA). The greenseeker unit is a handheld module designed to be raised 600 mm above the top of a crop canopy. It has a light source that produces light in the visible (red, 660 nanometre) and near-infrared (NIR, 770 nanometre) wavelengths and a sensor that measures the amount of reflectance of these wavelengths which is recorded at 10 readings per second.

For each measurement date, the average reflectance values from approximately 45 measurements were obtained from a 5 m x 0.6 m area of each plot and a normalised difference vegetation index (NDVI) was calculated using the formula:

$$\text{NDVI} = \frac{\text{NIR - red}}{\text{NIR + red}}$$

The last measurement for the earliest sow date was taken on the 28 November before bird netting was installed for this sow date only.

The experimental crops were harvested with a Sampo plot combine at approximately

14% moisture content. Plot yields were weighed on board using a load cell bin and grain moisture was measured at the same time using a whole grain moisture probe. A sample of approximately 1 kg grain from each plot was retained for later quality testing. The harvest dates were 13 February 2013, 31 January 2014 and 3 February 2015. Grading tests included: screenings (%), thousand grain weight (g), and test weight (kg/hl).

Grain yield data were tested by analysis of variance (ANOVA) and where significant effects were observed ($P<0.05$), differences were compared using the least significant difference (LSD) procedure ($P=0.05$) using GenStat (15th Edition, VSN International Ltd, UK).

Results

Grain yield

The highest grain yields were from the late March sow dates in each of the trials (Tables 1, 2 and 3). For each successive trial year the highest yields were respectively 15.1, 12.3 and 15.9 t/ha at actual plant populations of 156 to 205 plants/m^2. Bringing the sow date forward from April into late March only gave an increased ($P<0.001$) yield in the 2012-13 season. The lowest ($P<0.001$) yields were from the February sow dates in the 2013-14 and 2014-15 seasons but the April sow date in the 2012-13 season. This may have been because the April sow date in 2012 did not establish well with a mean plant population of 82 plants/m^2 compared with 119 and 101 plants/m^2 for the latter two trials.

An early March sow date was added in the most recent trial to test how sensitive the crop was to yield drop off as the sow date was brought forward from late March. The yield dropped by 1.2 t/ha from late to early March (comparing the two highest yielding plant population treatments).

There was an interaction between sowing date and sowing rate in the two more recent trials. For later sown crops there was a greater yield response from higher sowing rates compared with earlier sown crops. For example, in the 2014-15 season trial there was no yield increase from increasing plant population from 50 to 200 plants/m^2 in the 20 February sow date but a 3.3 t/ha increase for the 23 April sow date.

Head population

In the 2013-14 and 2014-15 seasons there was a strong relationship between plant and head population for the highest yielding sow date treatment (the late March sow date) (Figure 1a). The head population was higher (600 heads/m^2 and above) for plant populations of 150 plants/m^2 and above compared with 50 and 100 plants/m^2. In the 2012-13 season there was only a weak relationship between plant and head population, possibly because there was a much smaller difference between the highest and lowest plant populations in the 2012-13 season than in the other two seasons.

The relationship between head population and grain yield followed the same pattern as for plant and head population. In the 2013-14 and 2014-15 seasons there was a strong relationship between head population and grain yield (late March sow date) (Figure 1b). The grain yield increased as head population increased to about 600 heads/m^2 and then plateaued.

Crop canopy reflectance

The Greenseeker was used to measure the NDVI (normalised difference vegetative index) of the crop canopy. The NDVI is influenced by the amount of chlorophyll and biomass of the canopy. A high NDVI indicates a healthy canopy that can intercept more radiation. In the 2014-15 season NDVI increased more quickly with late February and early March sow dates compared with later sow dates but then decreased below the NDVI of the later sow dates until the end of October (Figure 2 shows data for the 150 plants/m^2 treatment). This decrease in NDVI was not observed in the February sow date crop in the 2013-14 season and was not measured in the 2012-13 season.

Table 1: The effect of three sowing dates and four plant populations on the grain yield (t/ha) at Leeston, Canterbury in the 2012-13 season. Actual plant population in brackets.

Target plant population (plants/m^2)	Time of sowing (TOS)			
	27 February	21 March	18 April	Mean
50	12.1 (42)	13.2 (46)	11.1 (35)	12.2
100	13.8 (74)	14.2 (97)	12.0 (67)	13.3
150	14.0 (98)	14.9 (130)	13.4 (106)	14.1
200	14.3 (151)	15.1 (156)	13.7 (119)	14.4
Mean	13.5	14.4	12.6	
	Yield	Plant population		
Sig (TOS)	***	*		
Sig (Population)	***	***		
Sig (TOS x Population)	NS	*		
$LSD_{0.05}$ (TOS)	0.43	17.5		
$LSD_{0.05}$ (Population)	0.35	10.3		
$LSD_{0.05}$ (TOS x Population)	0.60	22		
CV%	3.1	12.3		

*** = P<0.01, * = P<0.05, NS = not significant at P<0.05.

Table 2: The effect of three sowing dates and five plant populations on the grain yield (t/ha) at Leeston, Canterbury in the 2013-14 season. Actual plant population in brackets.

Target plant population (plants/m^2)	Time of sowing (TOS)			
	20 February	26 March	15 April	Mean
50	10.8 (62)	10.1 (63)	9.74 (47)	10.2
100	11.3 (120)	11.4 (112)	11.1 (114)	11.2
150	11.1 (136)	11.7 (141)	11.6 (148)	11.5
200	10.9 (209)	12.3 (188)	11.6 (167)	11.6
250	10.7 (211)	12.1 (241)	11.9 (245)	11.6
Mean	10.9	11.5	11.2	

	Yield	Plant population
Sig (TOS)	NS	NS
Sig (Population)	***	***
Sig (TOS x Population)	***	NS
$LSD_{0.05}$ (Population)	0.25	18.2
$LSD_{0.05}$ (TOS x Population)	0.57	35.5
CV%	2.7	15

*** = P<0.01, NS = not significant at P<0.05.

Table 3: The effect of four sowing dates and four plant populations on the grain yield (t/ha) at Leeston, Canterbury in the 2014-15 season. Actual plant population in brackets.

Target plant population (plants/m^2)	Time of sowing (TOS)				
	20 February	10 March	28 March	23 April	Mean
50	12.8 (58)	14.1 (57)	14.4 (68)	12.3 (36)	12.9
100	13.0 (83)	14.6 (113)	15.6 (123)	14.2 (82)	14.4
150	13.1 (139)	14.5 (156)	15.9 (205)	15.0 (128)	15.4
200	12.8 (192)	14.5 (198)	15.9 (227)	15.6 (156)	14.2
Mean	13.4	14.3	14.6	14.7	

	Yield	Plant population
Sig (TOS)	***	***
Sig (Population)	***	***
Sig (TOS x Population)	***	*
$LSD_{0.05}$ (TOS)	0.51	24.3
$LSD_{0.05}$ (Population)	0.22	11.3
$LSD_{0.05}$ (TOS x Population)	0.61	29.7
CV%	2.2	12.4

*** = P<0.01, * = P<0.05, NS = not significant at P<0.05.

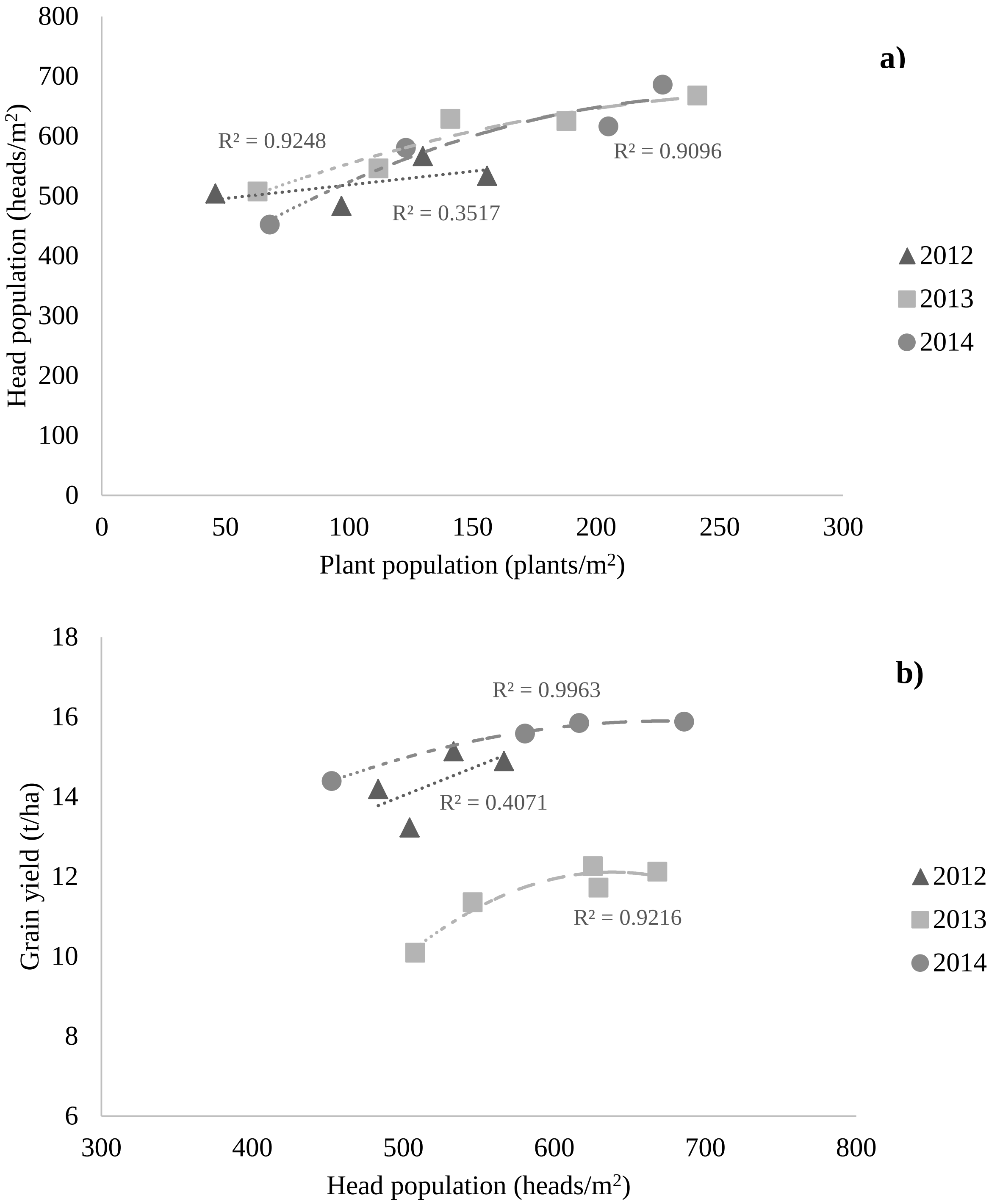

Figure 1: a) Relationship between plant population and head population for late March sown treatments and b) relationship between head population and grain yield for late March sown treatments at Leeston, Canterbury in the 2012-13 to 2014-15 seasons.

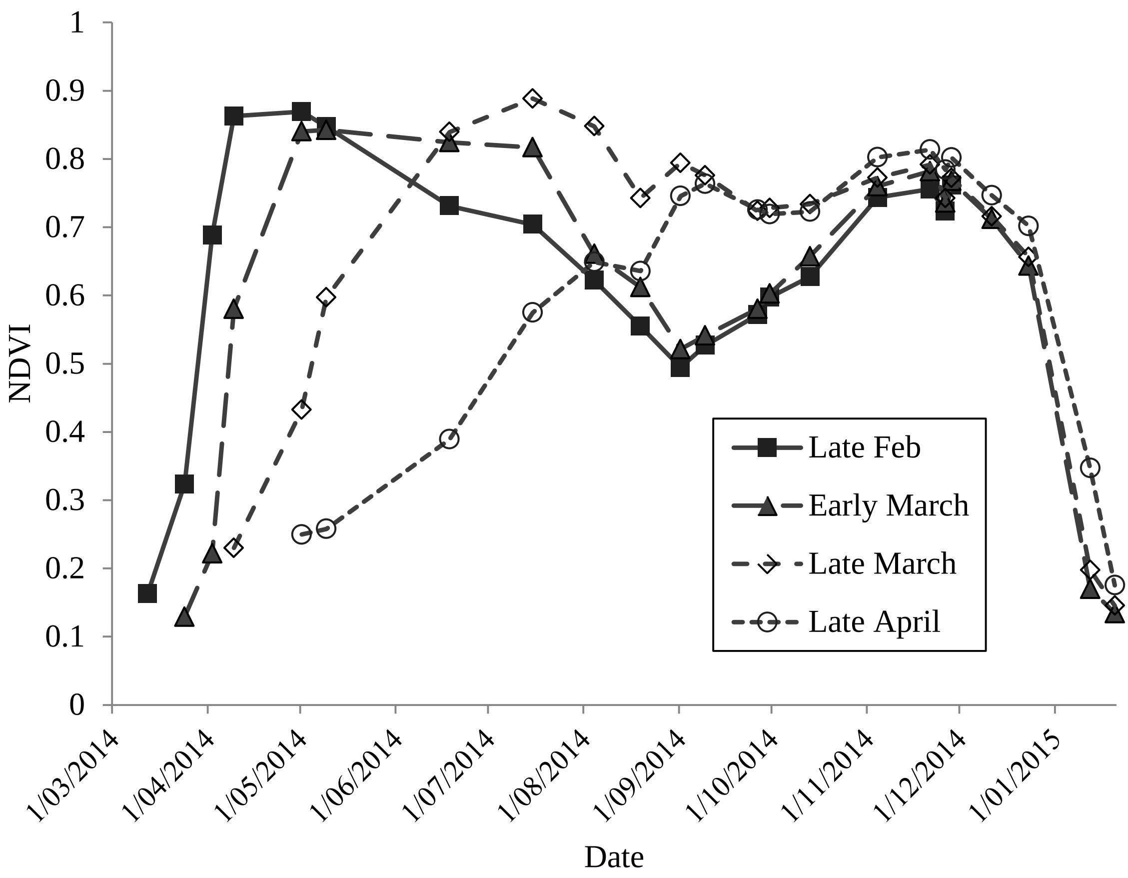

Figure 2: Normalised difference vegetative index (NDVI) for the 150 plants/m^2 treatment for the 2014-15 season at Leeston, Canterbury.

Discussion

The sowing date for winter wheat has gradually come forward over time and a small proportion of the wheat crop is now drilled in late March as farmers perceive there is a yield advantage from earlier sowing. Although there could be a clash between early drilling and the harvest of other crops if there is a yield and profitability gain to be had farmers will consider how to make it work. In these trials the highest yields were from the late March sow date.

Drilling cereals early in warmer conditions can increase the risk of pest, disease and lodging problems (Dennett, 2000). Winged aphid activity may be higher increasing the chance of barley yellow dwarf virus (BYDV) transmission from volunteer cereal plants. The risk of infection by rusts, eyespot and *Zymoseptoria tritici* are increased. For example, *Zymoseptoria tritici* incidence was high in the 2013-14 season exacerbated by a wet spring. Therefore, additional crop management inputs will be required in some years.

Early sown crops can be more prone to lodging. Lodging occurred in the February sow date treatment in the 2013-14 season. Crop development is brought forward so that, for example, the February sown crop was at GS30 when plant growth regulator was applied in early winter. Knowledge of plant growth regulator efficacy going in to cooler temperatures is very limited as they are usually applied in spring. Earlier drilled crops may also need irrigation for seed germination and seedling growth and to activate pre-emergent residual herbicide.

With current agronomic knowledge there was not a further yield gain from sowing before late March. Much of the increased dry matter potential with late February/early March sowing appears to be lost as the crop stalls, and senesces for a period in the winter and early spring. This collapse and early spring senescence reduces light interception in the early spring through reductions in the area of the green crop canopy. This was recorded as differences in NDVI in the 2014-15 season.

The cultivar used in this series of trials Wakanui has late maturity but intermediate resistance to *Zymoseptoria tritici* and lodging. It also has a prostrate leaf habit which causes shading and tiller death in the lower canopy when the crop is sown early. At present even with its limitations Wakanui is considered to be the best suited cultivar for early sowing. Further progress may be made with germplasm with higher resistance to *Zymoseptoria tritici*, BYDV and lodging, combined with very late maturity and a more erect leaf habit.

The highest yields for the late March sowing date were from plant population treatments of 150 plants/m^2 and above with resulting head populations of 600 heads/m^2 plus. This head population corresponds to the desired target head populations of 600 to 800 heads/m^2 previously reported (White *et al.*, 2000). Standard grower practice for April sown crops is to use seeding rates to establish between 100 and 150 plants/m^2. Results from these trials suggest to maximise yields from late March to April sown crops growers need to consider increasing the seeding rate to give 150 to 200 plants/m^2.

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