Wheat grain yield and protein in response to sowing date, nitrogen and variety

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Key findings

- Grain yield responded to the interaction between season, variety, N rate and sowing date.
- The dry finish to the 2015 season meant sowing later reduced yield. Nitrogen application did not affect yield regardless of sowing time.
- The end of 2016 was characterised by a wet and cool finish and yield increased with N, but there was no sowing time effect.
- Nitrogen application generally increased protein. Only in 2015 did late sowing increase protein further.

Why do the trial?

Nitrogen management remains one of the most important and risky decisions for farmers. Breeding for yield over the past five to six decades (and continuing) has resulted in varieties that take up and use more nitrogen. This means that nitrogen management of new varieties needs to continuously be assessed and adjusted. In addition, there is increasing interest in adjusting sowing time to stretch the time window for completing all sowing operations on farm. Early sowing of some varieties (e.g. Trojan) was also shown to increase yield under low frost risk. To improve yield and maintain protein content under adjusted sowing times, it is important to consider which varieties are most suited, and if N management needs to be adjusted.

Here we present results of a 2-year scoping study aimed at unravelling the combined effects of variety, sowing time and N, on yield and its components.

How was it done?

Plot size	1.75 m x 10.0 m	
Seeding dates 2015	30th of April ("early") and 26th of May ("late")	
Seeding dates 2016	17th of May ("early") and 2nd of June ("late")	
Seeding rate	210 plants / m^2	
Fertiliser (urea N)	0 kg N/ha	
	60 kg N/ha split between seeding and beginning of tillering (GS20)	
Initial mineral soil N 2015	30th of April:	89 kg N/ha
(in 0-100 cm soil layer)	26th of May:	123 kg N/ha
Initial mineral soil N 2016	22nd of April:	84 kg N/ha
(in 0-100 cm soil layer)	31st of May:	89 kg N/ha
Wheat varieties	Axe, Cobra, Mace, Scout, Spitfire and Trojan	

Methods

The trial was repeated over the 2015 and 2016 seasons, and had a randomised block design with two sowing dates, six wheat varieties, two N rates and three replicates. Soil samples were taken the day before, or on the day of sowing for each sowing date. Soil cores were taken to a depth of one metre, separated into 20 cm layers and analysed for initial soil moisture and N content.

Biomass was sampled in two (inner) rows of 50 cm at anthesis and two (inner) rows of one metre at maturity. The biomass was oven dried at 60°C and weighed. The anthesis samples were separated into leaf, ear and stem, and weighed separately to assess biomass distribution in the plant. A whole shoot subsample was analysed for total shoot N. The maturity samples were separated into ears and remaining shoot. The remaining shoot was analysed for N content and the ears were used for determination of yield and yield components: 1000-grain weight, number of ears per m^2, harvest index (i.e. grain weight / total biomass), screenings and protein content.

Results and Discussion

Please note that in this section, we refer to “early” and “late” sowing as relative to each other. The “early” sowing treatments were actually conventional sowing dates, not ‘early in the season’. See the actual sowing times in the “how was it done” section.

Seasons

The 2015 and 2016 growing seasons were markedly different in terms of rainfall and end of season temperature. In 2015 the overall growing season rainfall (April-October) was below the long-term average of 300 mm with 230 mm. At the end of the 2015, the crop experienced a warm and dry finish with consecutive days of temperatures great than 30°C-35°C in early October. In contrast, 2016 had consistent rainfall early in the season and well above average rainfall in September. Overall, growing season rainfall reached 356 mm and conditions in October and November were cooler for grain fill.

Biomass

In 2015, for Mace, Cobra, Spitfire and Trojan, there was no difference in biomass at anthesis with early or late sowing. In 2016 however, later sowing resulted in significantly higher total biomass at anthesis for all varieties. Interestingly, this did not result in higher yield. A possible explanation could be that for the late sown crops, rainfall, temperature, and related N mineralisation and N uptake, was better synchronised with critical growth stages, resulting in an increase in biomass compared with the early sown treatment. When comparing the total N uptake of the crops in the early and late sown treatment of 2016, the late sown treatment indeed has a higher total amount of N taken up. However, at maturity the early sown treatment appeared to have caught up and biomass and total N taken up did not differ among the sowing time treatments at harvest time. Only Mace had significantly higher yield in the late sowing treatment of 2016 (Table 1).

Grain yield

Grain yields were significantly higher in 2016 (3.5 t/ha) than 2015 (2.7 t/ha). Figure 1 shows the average yields and protein, averaged over all treatments, among the varieties for 2015 and 2016. Most varieties (except Axe and Mace) had higher yields when sown early compared with late in 2015. Furthermore, N application did not affect yield in 2015, except for Trojan. For Trojan, N application decreased yield in 2015, but only in the late sowing treatment. The lack of effect from time of sowing and N on grain yield for any varieties tested implies that water was the yield limiting factor this season.

The opposite was observed in 2016, where N application significantly increased yield for all varieties, but there was no sowing time effect (except for Mace). In the wet 2016, the lack of effect from sowing time implies that water was not limiting. Instead, N was the limiting factor for yield, resulting in the increase of yield with N application, regardless of sowing time. We found no differences in N requirements among the varieties tested here (measured by the correlation between total N taken up by the crop, and yield (data not shown)).

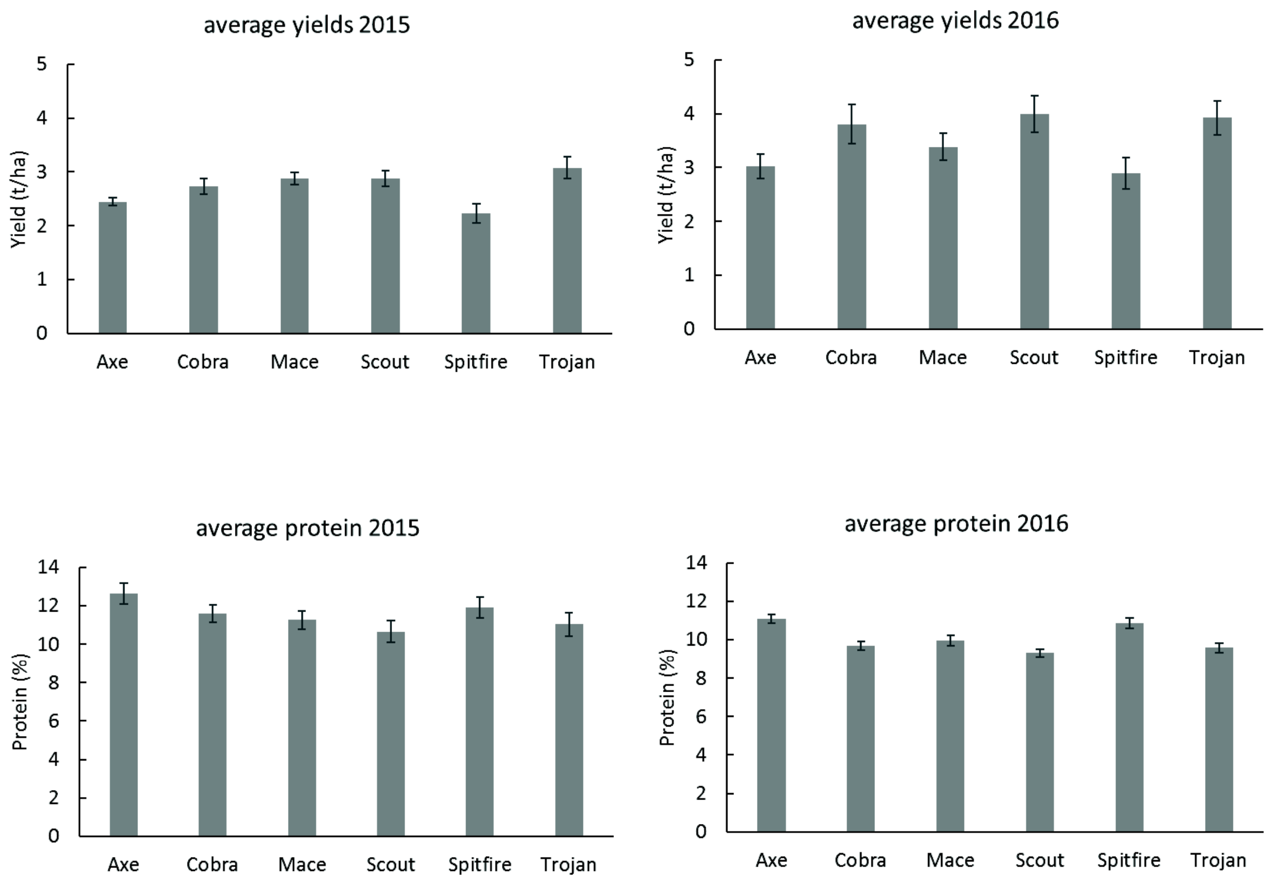

Figure 1. Yield (top graphs) and protein (bottom graphs) for each variety in 2015 and 2016. Bars indicate the average of the 2 N rate x 2 time of sowing treatments with 3 replicates (i.e. average of 12 samples). Error bars indicate two standard errors.

Protein

Among the varieties tested, in both years, protein generally increased with N application (though not always significantly, see Table 1). In 2015, late sowing increased protein further, though only significantly so for Axe and Scout. The increase in protein correlated with a decrease in 1000-grain weight (data not shown).

Table 1. Average yield and protein, affected by sowing time and N application in 2015 and 2016. Different letters indicate significant differences within a variety only.

2015		Yield (t/ha)		Protein (%)	
	sowing time	0 kg N/ha	60 kg N/ha	0 kg N/ha	60 kg N/ha
Axe	early	2.3	2.6	12.3 b	13.2 b
Axe	late	2.4	2.4	10.1 a	15.0 c
Cobra	early	2.8 a	3.2 a	10.3 a	11.8 ab
Cobra	late	2.3 b	2.6 b	10.4 a	13.8 b
Mace	early	2.7	3.2	11.0 ab	12.6 b
Mace	late	2.7	2.9	9.5 a	12.2 ab
Scout	early	3.0 ab	3.6 b	9.4 a	10.5 a
Scout	late	2.5 a	2.7 a	9.9 a	14.0 b
Spitfire	early	2.2 b	2.9 b	10.5 a	12.7 ab
Spitfire	late	1.7 a	1.9 a	10.2 a	14.2 b
Trojan	early	3.3 bc	4.0 c	9.9 a	11.3 ab
Trojan	late	2.6 ab	2.4 a	9.2 a	13.8 b
2016		**Yield (t/ha)**		**Protein (%)**	
	sowing time	**0 kg N/ha**	**60 kg N/ha**	**0 kg N/ha**	**60 kg N/ha**
Axe	early	2.2 a	3.3 b	11.1	11.5
Axe	late	2.9 a	3.6 b	11.0	10.7
Cobra	early	2.6 a	5.0 b	9.4	10.5
Cobra	late	2.8 a	4.8 b	9.2	9.6
Mace	early	2.4 a	3.9 b	9.5 a	11.4 b
Mace	late	2.9 a	4.4 b	9.5 a	9.4 a
Scout	early	2.8 a	5.2 b	8.9 a	10.2 b
Scout	late	3.1 a	4.8 b	8.8 a	9.4 ab
Spitfire	early	1.8 a	3.7 b	10.7	11.7
Spitfire	late	2.3 ab	3.7 b	10.5	10.5
Trojan	early	3.3 a	4.5 ab	8.8 a	10.3 b
Trojan	late	2.9 a	5.1 b	9.3 a	10.0 b

Conclusions

Sowing time and N rate affected yield and protein, but was dependent on variety and season.

The timing of rainfall and related N availability plays an important role. In the dry 2015 season, N application did not increase yield. There was a sowing time effect for most varieties, with early sowing increasing yield relative to late sowing. Nitrogen application did increase protein, and late sowing increased protein further due to lower yields. In contrast, in the wet 2016, yield increased with N, but there was no sowing time effect on yield or protein. The varieties tested did not differ in N requirements.

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