Strobilurins increase production in high-yielding wheat crops

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Abstract

The strobilurin azoxystrobin applied to a high-yielding wheat crop in Mid Canterbury in 1998 resulted in significant yield increases. The increase was independent of any fungicidal effect, and increased linearly with the amount of strobilurin applied. There was weak evidence that later applications (GS59, anthesis) were more effective than earlier ones (GS39, flag leaf fully emerged). The main reason for the yield increase was that a larger green leaf area was maintained during senescence, and hence more radiation was intercepted. Because these effects occurred late in grain filling, they resulted in larger grain.

Additional key words: *fungicide, azoxystrobin, leaf area, senescence*

Introduction

The application of fungicides containing strobilurins has been reported to increase yields in cereals and other crops, even without disease pressure (Grossmann and Retzlaff, 1997). Reports from the UK suggest that the yield increases are associated with crops staying green for longer (Rund, 1998), so that higher yields may be associated with a higher growth rate near maturity and a longer grain fill duration. A negative side-effect has been that green straw has made harvest more difficult. However, the increases in yield have apparently been sufficient that most UK farmers are now using such products despite the difficulties at harvest time.

The purpose of this study was to test whether the use of a fungicide containing a strobilurin (Amistar, a.i. 250 g/l azoxystrobin) would increase winter wheat yield and, if so, to identify the physiological changes that led to the increase. In addition, the study sought to quantify the response to rates and timings of strobilurin application.

Materials and Methods

The experiment was in a winter wheat crop (cv. Hussar) sown late April 1998 and managed for high yield on the property of Dean Pye at Dorie in mid-Canterbury. The crop received a total of 275 kg N/ha in four applications, and was irrigated from early October to late December with 25 mm applications at 7-10 day intervals. Irrigation and rainfall were sufficient to ensure no water stress was experienced. Plots (5 m x 1.35 m) were marked out on 4 November (GS39) and the first applications applied (GS39). The second applications were on 1 December (GS59). The experiment was a randomised complete block design with four replicates of 14 treatments (Table 1). All treatments except number 14 were sprayed with epoxycanizole (Opus) at a rate of 250 g/ha to suppress foliar diseases so that the effect of azoxystrobin could be assessed in the absence of disease. Treatment 14 received no fungicide at GS39 or later. Treatments 4, 9 and 13 substituted tebuconazole (Folicur) for Strobilurin at GS39.

Immediately after the GS39 treatment was applied, a 0.1 m^2 sample was taken from each plot. The area of each leaf, counting from the top, was determined on a 10 tiller subsample to obtain the initial leaf area profile. Sample and subsample were dried and weighed. Further samples were taken at anthesis, 20 days after anthesis, then about twice per week until maturity. In these later samples a count was made on a 10 tiller subsample of the number of live leaves from the flag leaf down to the last live leaf. A leaf was assumed still to be alive if it was more than half green; otherwise it was considered dead. For the last two samples, when the flag leaf was dying, the percent green area on each leaf was assessed. Leaf areas were then calculated from the state of each leaf down the profile from the top and the initial leaf area profile. The samples were then dried and weighed.

The crop was harvested with a plot combine on 17 February 1999. The straw was dry and there were no harvesting difficulties. Sample mass, thousand grain mass and moisture content were measured. Results were adjusted to 15% moisture content. Grain number was calculated from yield and thousand grain mass.

Table 1. Treatments applied at GS 39 and GS59.

Treatment	GS39 (flag leaf ligule)	GS59 (anthesis)	Units of Strobilurin[1]
1	Strobilurin (1.0)[2] + Opus[3]	-	1.00
2	Strobilurin (1.0) + Opus	Strobilurin (0.25)	1.25
3	Strobilurin (1.0) + Opus	Strobilurin (0.5)	1.50
4	Strobilurin (1.0) + Opus	Folicur (0.5)	1.00
5	Strobilurin (0.75) + Opus	-	0.75
6	Strobilurin (0.75) + Opus	Strobilurin (0.25)	1.00
7	Strobilurin (0.75) + Opus	Strobilurin (0.5)	1.25
8	Strobilurin (0.75) + Opus	Strobilurin (0.75)	1.50
9	Strobilurin (0.75) + Opus	Folicur (0.5)	0.75
10	Opus	-	0.00
11	Opus	Strobilurin (1.0)	1.00
12	Opus	Strobilurin (0.5)	0.50
13	Opus	Folicur (0.5)	0.00
14	Untreated		0.00

[1] one unit of strobilurin was equivalent to 1000 ml/ha or 250 g/ha Azoxystrobin.
[2] units of strobilurin applied; [3] Opus was applied at 250 g a.i./ha

Leaf area index (LAI, leaf area per unit ground area) results for each treatment were used together with solar radiation data from Lincoln, about 30 km from the experiment, to calculate the amount of radiation intercepted by the crop between anthesis and maturity. Calculations were on a daily basis and intermediate values of LAI were interpolated linearly. Biomass accumulated during this time was then calculated assuming a radiation use efficiency (RUE) of 1.1 g of biomass per MJ of intercepted solar radiation (Monteith, 1977; Jamieson *et al.*, 1998).

Tests for the effects of the rate and timing of application of strobilurin, and the effects of Opus and Folicur were done using analysis of variance. An assessment was also made for any trends across the field, but none were found. In addition, linear regression of means was used to determine the quantitative effect of strobilurin, and to test hypotheses on the causes of this effect.

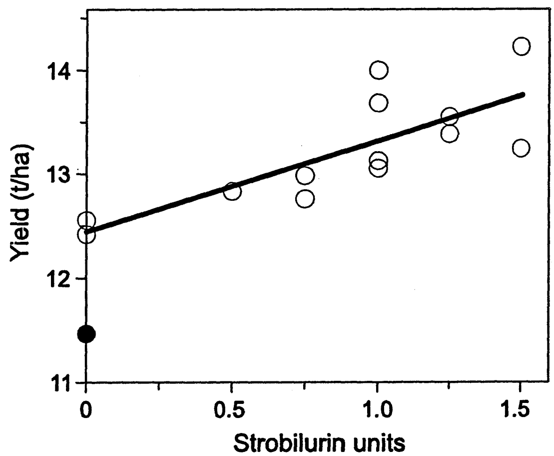

Figure 1. The effect of total strobilurin applications (timing effects not considered) on grain yield (15% moisture). The filled symbol is for no fungicide at GS39. The slope of the line is 0.9 t/ha per strobilurin unit (l/ha).

Results and Discussion

Yields were very high and uniform across the trial (CV 5.3%). There was a strong linear relationship between yield and the total amount of strobilurin applied (Fig. 1). The slope of the regression (excluding treatment 14) was 0.9 t/ha per strobilurin unit, and the regression explained 61% of the variation in yield means. Application of Opus at GS39, without the addition of strobilurin, increased yield by about 1 t/ha. Folicur had no effect in addition to Opus. There was weak evidence that timing of strobilurin application was important, with the late application having marginally more effect on yield than the early one. Grain masses varied from a minimum of 38.5 mg to a maximum of 43.7 mg. There was a significant linear relationship between grain mass and total strobilurin applied, but no significant effect of the treatments on grain number.

Strobilurin had a significant effect on the rate of senescence of individual leaves, although the timing of the death of the flag leaf was little affected. Differences in LAI (Fig. 2) between treatments were associated mainly with longer retention of lower leaves. Calculations of the biomass accumulated after flowering showed that the differences in radiation interception caused final biomass variations that were similar to the grain yield differences. This meant that a regression of yield means on calculated biomass accumulated after flowering (Fig. 3) was highly significant, had a slope not significantly different from 1, and explained 65% of the variation in yield. The measurements of biomass from anthesis onwards were similar to the calculated values, but the small size and variability of the samples meant that treatment differences were not detectable.

Analysis of the time course of biomass accumulation showed that differences did not occur until early January (Fig. 4). Hence the yield differences were generated in about the last 18 days before grain fill ended. The use of Opus alone caused an increase in the amount of radiation intercepted, an increase in final biomass, and hence a grain yield increase. The yield differences were associated entirely with changes in grain size, and grain number was unaffected by the treatments.

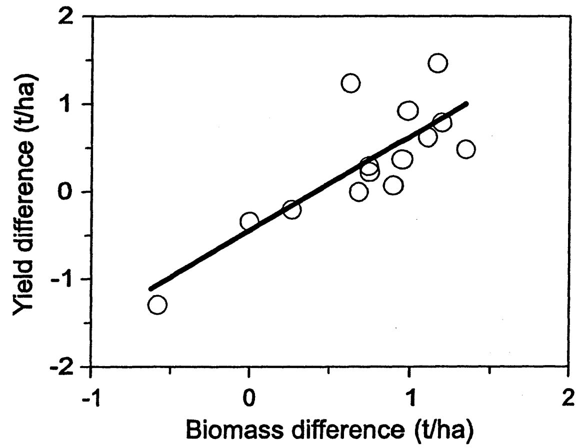

Figure 3. Relationship of the grain yield difference to biomass difference with respect to treatment 10 (no strobilurin).

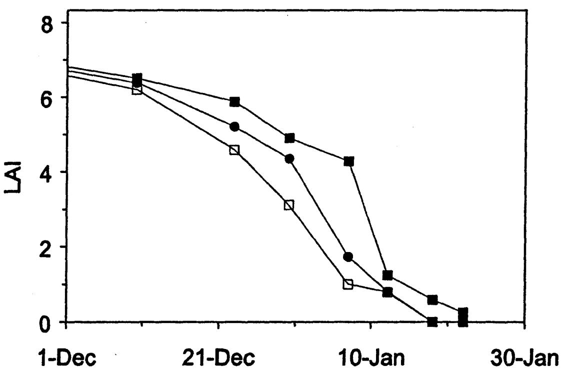

Figure 2. LAI response to strobilurin and fungicide. No fungicide (□), Opus without strobilurin (●), Opus plus 1.5 l/ha strobilurin (■).

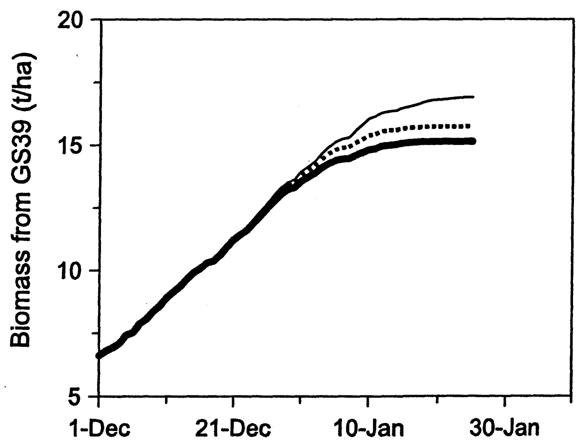

Figure 4. Biomass accumulation during grain filling for no fungicide (▬▬), no strobilurin (▪ ▪ ▪ ▪) and 1.5 l/ha of strobilurin (——).

Biomass differences did not appear until early January even though LAI differences were apparent by early December. This occurred because LAI changes have little effect on radiation interception when LAI is high, and therefore do not affect the growth rate. When LAI falls below about 4, then growth rate changes with LAI become evident. For instance, a change in LAI from 8 to 7 reduces radiation interception from 97 to 96%, whereas a change from 4 to 3 reduces interception from 83 to 74%. Changes in biomass as a result of differences in LAI accumulate very slowly at first.

Conclusions

Strobilurin significantly increased yield in a very high yielding wheat crop. The reasons for the increase are uncomplicated. Leaves below the flag leaf senesced more slowly, so that more radiation was intercepted during late grain filling, despite there being little change in final senescence date. The analysis showed that the extra biomass produced because of increased radiation interception during late grain filling was sufficient to cause yield increases by increasing grain mass. There was no evidence that grain fill duration or RUE were affected by the treatments. Green straw did not cause harvesting difficulties in the experiment.

This experiment has confirmed the effectiveness of strobilurin application in a high yield situation. It did not indicate the effect it would have when crops experience more stress, how N uptake and grain N content are affected, or whether all strobilurin products have a similar effect. More work is needed with experiments designed specifically to answer these questions. The experiments would need to include measurements of leaf area and biomass accumulation similar to those in this experiment to determine whether the mechanism is the same.

Acknowledgements

This project was funded by the Foundation for Arable Research. Our thanks to Ross Hanson for marking out the trial and harvesting the plots, Alan Upritchard of Crop Care for applying the treatments and supplying the Amistar, Myles Rea for grain weight measurements, and Dean Pye for the use of his land.

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