ECONOMIC POTENTIAL OF MONITORING PROTEIN CONTENT AT HARVEST AND BLENDING WHEAT GRAIN

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ABSTRACT

Precision agriculture has been primarily focused on the management of inputs but recently developed technologies that monitor grain quality at harvest create the opportunity to manage outputs spatially. Provided specific product qualities achieve higher prices, monitoring, separation and blending may be economically justified. This paper analyzes the potential economic effects of blending different grain qualities at the farm level.

We estimated sub-field specific crop yield and quality response to nitrogen fertilizer based on field experiments with winter wheat (*Triticum aestivum* L.) in Germany and then used these responses to simulated yield and quality for a hypothetical field. We analyzed the economically optimal fertilization and blending strategy for different price scenarios. Quality specific fertilizer and blending strategies are subject to the premiums paid for higher qualities. For most price scenarios, the highest net returns were generated with fertilizer rates that resulted in premium quality for all harvested wheat. However, if fertilizer rates were too low to achieve premium quality for all wheat, separation and blending of different qualities provided an economic advantage of up to € 100 per ha. The potential benefit is subject to the level of premium paid for higher quality and the level of fertilizer applied.

Keywords: site-specific nitrogen management, winter wheat, baking quality, separation and blending

INTRODUCTION

Technological solutions, which monitor grain quality during harvest have been developed and are been implemented on combine harvested for some years but the analysis of the economic potential of using this information is comparably rare (Taylor et al., 2005). In an economic analysis, Long et al. (2002) found scant evidence of economic profitability for spring wheat production under site-specific management with the consideration of quality specific prices. Instead of managing the variability by controlling the input an alternative approach may be to appropriately manage the output with heterogeneous qualities. The aim of this paper is to demonstrate the economic potential to separate grain qualities according to a given price structure to maximize farmer's profit. Therefore we used data from N fertilizer response experiments, which monitored the impact of N fertilizer on crop yield and grain quality.

METHODS AND MATERIAL

To analyze the economic effect of separating different grain qualities during harvest, we used field trial data on the response of grain yield and grain protein content to nitrogen fertilizer. The field trials were conducted in the year 2000 with the wheat cultivar *Contur* on four locations in Northern Germany (Link and Jasper, 2003). The field trials had seven different N fertilizer treatments ranging from 0 to 360 kg/ha N. Each treatment had four replications; however, our data set only included the average for each treatment. For the purposes of examining site-specific management options, we constructed a model field, assuming the field response from the different location represent the different response within a field. The wheat grains of the cultivar *Contur* can be sold as baking wheat provided that the protein level is beyond 12 %.

Yield ($Y = \beta_0 + \beta_1 \cdot N + \beta_2 \cdot N^2$) and quality ($Q = \alpha_0 + \alpha_1 \cdot N$) response to nitrogen fertilizer can be described as quadratic and linear production function, respectively. The coefficients and the t-statistics for the coefficients are provided in Table 1.

The model calculations were based on wheat prices for two qualities (feed quality and baking quality). Wheat prices were based on annual averages in Germany from 2002 to 2010 which ranged from 83.90 to 207.30 € Mg^{-1} for feed wheat, and from 90.20 to 219.10 € Mg^{-1} for baking wheat (LFL, 2008). The premiums for higher quality ranged from 3.20 to 11.80 € Mg^{-1} with the highest premium in the year 2007 and the lowest premium in 2003. The average premium was 7.80 € Mg^{-1}. The nitrogen fertilizer price was assumed constant at 0.90 € kg^{-1}.

Table 1. Yield and Quality response coefficients from four locations.

Location	Yield Response Function			Protein Response Function	
	β_0	β_1	β_2	α_0	α_1
1	4.376	0.0518	-0.00012	7.14	0.018
	(15.0)[1]	(16.0)	(-13.7)	(12.8)	(7.6)
2	7.027	0.0372	-0.00010	8.57	0.012
	(7.9)	(3.7)	(-3.7)	(17.1)	(5.4)
3	7.523	0.0386	-0.00009	9.89	0.009
	(56.2)	(26.5)	(-24.4)	(13.5)	(3.0)
4	5.478	0.0479	-0.00010	8.26	0.016
	(23.7)	(18.5)	(-14.0)	(12.2)	(5.5)

[1]t-ratio

The model calculations involved a modeling of the net return above fertilizer costs as a function of N fertilizer with respect to the different qualities. According to the quadratic yield function profit increases until a maximum, where marginal costs meet marginal revenues and decreases with further N fertilizer supply. With the consideration of a premium for quality the profit function jumps to another level, when the threshold protein quality is achieved. We modeled two scenarios. A reference scenario without quality separation. In this situation yield and profit response is the result of the average response from the model field. When the threshold protein level is achieved on average the price for baking quality applies. In the case of quality separation, we suppose that the farmer can blend the different qualities such that one fraction is sold as baking quality, the other is sold as feed quality. We used a solver to find the net return maximizing blending of all fractions of feed quality wheat to be blended into the theoretical baking quality bin so that the requirements for baking quality are just met.

The different profit functions provide the base to discuss the blending potential of different qualities. We did not include costs for grain separation into our analysis. So all economic potentials are gross potentials, which have to be compared with the technological costs and other costs that apply, if grain separation is applied.

RESULTS

According to the premium paid for quality fertilizing for protein quality can be economically justified even if the protein threshold can only be achieved with fertilizer rates beyond the yield maximizing fertilizer rate. The left illustration in Figure 1 shows that with uniform harvest (solid line) highest net returns above fertilizer cost can be obtained with a fertilizer rate at about 260 kg ha^{-1} N. This is about 40 € ha^{-1} higher than the maximum net return for feed quality. However, as can be seen from the graph there is only a small window of fertilizer rates, which result in a higher net return than the maximal net return with feed quality at a fertilizer rate of 185 kg ha^{-1}. Furthermore a marginal fertilizer reduction from the highest net return providing fertilizer rate results in a profit drop of more than 100 € ha^{-1}. With the possibility to separate different qualities at harvest part of this profit loss can be compensated by selling a fraction of the harvest as quality

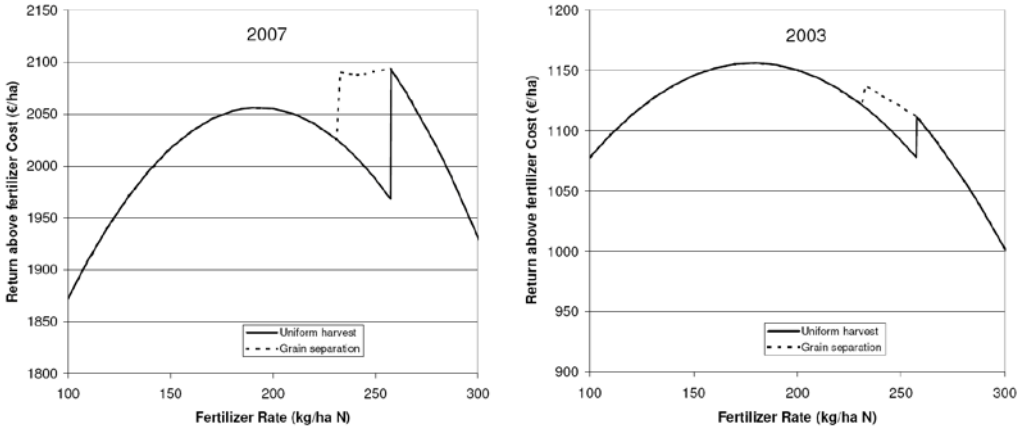

Fig. 1. Returns above fertilizer costs with uniform and separate harvest with price expectations for different qualities from 2003 and 2007

wheat, which is illustrated with the dotted line in Fig. 1. Even though net return above fertilizer cost with separate harvest does not exceed the maximum of net return with uniform harvest the window with fertilizer levels which result in higher net returns is substantially bigger. Fertilizer levels below 232 kg ha^{-1} do not result in baking quality in any of the locations (see Table 1). That is why the shape of the dotted and the solid line are the same for fertilizer rates below 232 kg ha^{-1} N. The right graph in Figure 1 shows the effect of grain separation when the premium is low, as it was the case in the year 2003. With the price expectations from that year fertilizing for protein quality was not profitable and highest net returns above fertilizer costs were achieved with feed quality at fertilizer rates of 179 kg ha^{-1} N.

DISCUSSION AND CONCLUSIONS

Separating different grain qualities at harvest can assure high profits even when the protein requirements for the whole plot is not achieved. This may reduce the producers risk not to achieve the required protein quality on the whole field. However, to be economically justified some requirements needs to comply with. First, there needs to be an incentive for higher quality normally expressed in higher prices for premium qualities. In some years the demand for higher qualities may be lower, so will the premium be. Any investment in crop quality separation has to take into account that a return to the investment applies only in years with a high premium for quality. Furthermore, the variability within the field needs to be high enough to ensure, that on parts of the field the required quality can be achieved.

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