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Risk premiums due to Fusarium Head Blight (FHB) in wheat and barley

Bruce Dahl[1], William W. Wilson*,[1]

Dept. of Agribusiness and Applied Economics, North Dakota State University, NDSU Dept. 7610, P.O. Box 6050, Fargo, ND 58108, United States

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ABSTRACT

Fusarium Head Blight (FHB) is an important problem to the agricultural production and marketing system, and has led to major economic losses for wheat and barley producers in the United States, Canada and many other countries. Deoxynivalenol (DON) is a mycotoxin associated with FHB. Grain products and feed grain contaminated with DON (commonly known as vomitoxin) are subject to FDA advisory limits and as a result end-users place restrictions on this factor. This has led to steep price discounts, as well as higher risks for producers and grain merchandisers. Research has led to development of varieties that are resistant to moderately resistant to FHB. Also, studies indicate combinations of genetic resistance, fungicides and some management practices (combine settings, tillage practices, etc.) can be used to decrease losses due to FHB. This increases cost to the industry and imputes a value related to reduced FHB. The purpose of this paper is to analyze risk and determine risk premiums necessary to induce growers to adopt risk reducing technologies in the case of wheat and barley grown in the United States.

1. Introduction

Fusarium Head Blight (FHB or commonly termed scab) and the resulting mycotoxin deoxynivalenol (DON or also termed vomitoxin) has major implications for wheat and barley supply chains in the United States, Canada and many other countries. FHB has implications throughout the agricultural system including crop breeding, technology development and applications, disease forecasting, harvesting and post-harvest technologies, as well as post-harvest pricing and handling practices. It raises costs and risks for growers, inducing them to use more costly management practices and/or shifting to other crops. It reduces the quantity produced, raises prices and increases premiums for non-FHB wheat and malting barley, meaning higher costs, risks and more complicated logistics for domestic processors and importers, and finally, it raises costs of breeding. These effects would be further exacerbated by recent CODEX proposals to measure and limit fusarium on raw materials instead of products (Bianchini et al. (2015), U.S. Industry Response (2014)).

FHB has resulted in growers shifting production to less risky crops and crop rotations. While changes in cropping patterns have been influenced by many factors (Government Farm Program changes, rise of importance of ethanol and increased demand for corn, soybeans and canola, increased profitability of alternative crops, and the more recent impacts of growth in cereals production and exports from FSU countries and the EU, etc.), increased risk of FHB is crucial. Ali and Vocke (2009) indicated concern for the impact of FHB has affected planting decisions by farmers since the 1990s. Wilson et al., 2017 (in addition to Wilson, 2018 and Wilson et al., 2018) documented the evolution of FHB on cereals, and particularly costs of the disease to the system. Similarly, much of the durum and malting barley production has shifted out of eastern, central and north-eastern counties in North Dakota into more westerly counties in North Dakota and eastern Montana. The incidence of FHB may be increasing due to larger corn plantings and the switch toward minimum or reduced tillage practices, which increases host presence for FHB development when environmental conditions are favorable. Near similar problems related to FHB have been evolving in Canada.

Taken together this disease has important impacts on the agricultural system. It has the impact of increasing risks related to vomitoxin content, and its impact on yield and price (discount) risk. In response growers either adopt risk reducing technologies (e.g., use of fungicide, Moderately Resistant (MR) varieties or both) and/or earn risk premiums to grow products that are risky. This increases cost to the industry and imputes a value related to reduced FHB. In addition, several technologies have been and are being developed to reduce the risks of FHB. The purpose of this paper is to analyze risks and determine risk premiums necessary to induce growers to adopt risk reducing technologies in the case of wheat and malting barley grown in the United States. Results are useful to the entire agricultural system, including growers, technology developers, marketers, processors and

* Corresponding author.
E-mail addresses: bruce.dahl@ndsu.edu (B. Dahl), william.wilson@ndsu.edu (W.W. Wilson).
[1] Authors are Research Scientist and CHS Endowed Chair in Risk Management and Trading, and University Distinguished Professor at North Dakota State University.

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educators. Though the analysis uses data from the United States, the problem, methodologies and results are applicable for many other countries confronting like problems.

2. Previous and related studies

Earlier studies by Johnson et al. (2003) and Nganje et al. (2004a, 2004b) estimated the value of economic losses due to FHB. Hollingsworth et al. (2008), examined economics of growing Moderately Susceptible (MS) vs MR cultivars with application of fungicides at different stages and various levels of infection of FHB. They evaluated the effect of control for different varieties, fungicide application combinations and applied a direct comparison for Net Revenue, with discounts for levels of DON and market prices obtained in the post-harvest period. McMullen et al. (2012) reviewed effectiveness of fungicide and agronomic management practices (changing combine settings, cleaning grain post-harvest, etc.) and noted that while these can be effective in decreasing levels of DON in grain, they can become quickly uneconomic depending on the price of wheat, premiums/discounts, costs of application, etc.

Recent studies indicated combinations of genetic resistance, fungicides and some management practices (combine settings, tillage practices, etc.) can be used to decrease FHB losses (Salgado et al., 2014; Hollingsworth et al., 2008). The most effective of these is genetic, however, limited genetic resistance has been incorporated into wheat/durum/barley varieties (McMullen et al., 2012). In addition, the effects of genetic resistance and fungicide application tend to be additive (Hollingsworth et al., 2008; McKee et al., 2013; McMullen et al., 2012; Salgado et al., 2014, and Willyerd et al., 2012).

The economic benefit of FHB management practices depends on several variables. Statistical estimates of the relationship among these variables provide an indication about the economic benefits. Madden and Paul (2010) modeled the relationship between six fungicide treatments, including a control; FHB intensity, as measured by percentage of diseased spikelets; and test weight effects for soft winter and spring wheat varieties. Madden and Paul (2009) show a statistical relationship between yield and FHB intensity, with a mean 4.10 MT/ha yield for Hard Red Spring wheat when the disease is not present and a reduction of 0.038 MT/ha for each unit increase in the presence of FHB. Salgado et al. (2014) and D'Angelo et al. (2014) find a negative relationship between a FHB index and yield. Other studies, including Paul et al. (2007), Paul et al. (2005, 2006), show statistically significant correlations between a FHB index and DON content. Finally, Wiesrma (2016) showed that fungicide impacts multiple diseases, including FHB, leaf rust and leaf spotting disease. Results indicated favorable impacts of fungicide applications on each of these diseases in the case of Hard Red Spring wheat (HRS) in the Red River Valley.

2.1. Background and related analysis

Concurrent with the emergence of DON has been the impact on production of cereals within North America. It is important that area planted to wheat in the United States decreased from 70 to 50 million acres and that for HRS wheat decreased from 10 million acres to 6 million acres between the mid-1990s to current; and in 2017, it is expected that wheat plantings will fall to their lowest level in over 50 years, at 49 million acres (AgResource, 2016) in 2016, and the recent USDA Baseline has wheat falling to 48.5 million acres for 2017 and forward. In addition to the effect of DON, there were other factors impacting these shifts as indicated above. Similar problems exist in Canada and are discussed in Canadian Grain Commission (2017) and Clear and Patrick (2017).

These issues are important to the industry due to costs and risks, but, also due to the reduced production particularly in traditional regions. DON affects the processing sector having the impacts of increasing risk and costs for wheat, and for testing etc., changing procurement regions, etc. Indeed, the advent of DON has impacted the food market, the feed market, the pet food market, the marketability of crops offshore, and the food market, e.g., Oreos (Levine, 2015).

2.1.1. Evolution of scab

DON was identified in wheat and barley in 1993 and later described as vomitoxin (Bianchini et al., 2015). Since then it has evolved and has become very important throughout the wheat and barley sectors in the United States, and in many other countries (Chumak, 2017, and Bianchini et al., 2015)). Taken together DON has increased risk and cost throughout the agricultural system. This has impacted the entire supply chain including inputs, farm production practices, marketing and handling, in addition to processing and distribution; and has induced the technology industry to develop chemicals and varieties to mitigate risks related to DON. Vomitoxin is not only a problem in wheat and barley in many countries, but also in corn. Of interest, the 2016 corn crop in the United States had vomitoxin and the Andersons tested every delivery of corn at its ethanol plant in central Indiana (Thomson Reuters, 2016 and 2017).

2.1.2. Scab severity

Bianchini et al. (2015) provides a summary of the data on DON. Average DON levels were typically < 0.67 (mg/kg) and in many years, were < 0.35. Only in 2014 was the DON level greater at 0.85 mg/kg. However, the variability was large and in some years, the deviations approached 2 mg/kg. In further detail, they reported that 1.7% of hard wheat samples showed DON > 2 mg/kg; while > 30% of soft wheat had levels exceeding 2 mg/kg (1 ppm is equivalent to 1 mg/kg).

US Wheat Associates publishes data on DON in wheat which varies by class (US Wheat Associates, 2004–2016). The data for HRS show that the average level of DON varies across origins, and was large in the mid-2000s. Since then, there has been a notable decline in the DON level, and, in recent years including 2016 with exception of a few origins, it was nil for North Dakota (U.S. Wheat Associates, 2016a,b) vs 0.2 ppm in 2015. For Soft Red Winter (SRW) wheat the results showed increases due to spikes in 2009 and for selected states in 2013–2015. High DON levels were indicated in Arkansas, Missouri, Illinois, Ohio, Kentucky and Maryland during the 2013–2015 period, and Ohio, Kentucky and Missouri in 2009.

2.1.3. Breeding and scab

Breeding for reduced DON became a high priority following the 1993 epidemic. This entails disease screening and testing of advanced breeding lines and cultivars which escalated following 1993 (Bianchini et al., 2015; Rudd et al., 2001). By the early 2000s HRS cultivars were released for wheat and barley with improved FHB resistance and reduced DON. The observed level of DON was reduced by 50% compared to susceptible checks. This was led by the HRS varieties which over time were adopted for the vast majority of planted areas. Planting is now dominated by Moderately Resistant (MR) and Moderate (M) varieties, capturing about 70% of the plantings.[2] For other classes including SRW and Hard Red Winter (HRW) wheat, the development and adoption of MR varieties has lagged. There is no scab resistance in current Durum varieties.[3]

Conventional breeding and alternatives are being explored to further improve scab resistance. Dahl et al. (2004a, 2004b) illustrated the tradeoffs and values of fusarium resistant varieties in breeding

[2] This value can be deduced from a combination of the annual variety survey (http://www.ndwheat.com/uploads/resources/1009/whtvr17.pdf) and the variety trial data and selection guide (https://www.ag.ndsu.edu/publications/crops/north-dakota-hard-red-spring-wheat-variety-trial-results-for-2017-and-selection-guide/a574-17.pdf).

[3] Scab resistance in durum wheat is very limited. Newer durum cultivars may have less disease severity than older cultivars. However, this low level of resistance is not similar to that of the hexaploid wheat Sumai 3 (as pointed out by Dr. Elias, North Dakota State University 2017).