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The economics of foliar fungicide applications in winter wheat in Northeast Texas

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ABSTRACT

Among plant pathogenic organisms, fungi are a major reason for crop losses around the world and have a significant impact on yield and quality. Previous studies suggest that up to 42% yield loss caused by fungal diseases can be prevented by applying foliar fungicides to winter wheat. Local wheat production data on fungicide application, yield, and disease severity for four soft-red winter wheat cultivars (Magnolia, Terral LA841, Pioneer 25R47, Coker 9553) for two years (2011 and 2012) in three locations in Northeast Texas (Royse City, Howe, and Leonard) were analyzed to study the economics of one foliar fungicide (TebuStar® 3.6L). A preventive application of the fungicide resulted in a relatively conservative 9.41% overall yield gain and a net return (from investing in tebuconazole) of $107.7/ha in 2012, which lead to an overall positive (two-year average) net returns of $52.09/ha. A probability analysis indicated that positive overall net returns are likely and that most of the cultivars considered have the potential to produce a yield gain necessary to at least break even with or exceed the cost of applying tebuconazole.

1. Introduction

The U.S. is the world's largest wheat producing and exporting country. World wheat trade is expected to increase as the population grows in Egypt, Algeria, Iraq, Brazil, Mexico, Indonesia, Nigeria, and other developing countries (USDA ERS, 2012). Wheat is the third largest crop planted in the U.S., behind corn and soybean, and is expected to remain an important agricultural commodity for years to come. It generates about 198,000 jobs and accounts for $20.6 billion to the U.S. economy (Richardson et al., 2006). In 2007, Texas ranked as the 4th largest wheat producing state with about 3.84 million acres in production (Census of Agriculture, 2007). Wheat is the third most planted crop behind forages and cotton in Texas. In 2005, the wheat industry generated 11,273 jobs and contributed with $658.8 million to the Texas economy (Richardson et al., 2006).

Among plant pathogenic (disease-causing) organisms, fungi are the number one reason for crop losses around the world and have a significant impact on yield and quality in wheat production (McGrath, 2004). According to Wegulo et al. (2012), the most prevailing foliar diseases in winter wheat in the Great Plains of the U.S. are leaf rust (*Puccinia triticina*), powdery mildew (*Blumeria graminis* f. sp. *graminis*), tan spot (*Pyrenophora tritici-repentis*) (anamorph: *Drechslera tritici-repentis*), Septoria tritici blotch (*Mycosphaerella graminicola*) (anamorph: *Septoria tritici*), spot blotch (*Cochliobolus sativus*) (anamorph: *Bipolaris sorokiniana*), and Stagonospora nodorum blotch (*Phaeosphaeria nodorum*) (anamorph: *Stagonospora nodorum*). Stripe rust (*Puccinia striiformis* f. sp. *tritici*) and stem rust (*Puccinia graminis* f. sp. *tritici*) are sometimes considered less common (Wegulo et al., 2012), and sometimes considered the most frequent in the wheat producing regions of the U.S. (Kolmer, 2007).

In the U.S., foliar fungicides used in wheat are usually grouped in two categories: strobilurins and triazoles. Strobilurins are highly effective when applied preventively (Wegulo et al., 2012) while triazoles are highly effective and reliable against early fungal infections (Hewitt, 1998). Examples of strobilurin fungicides include azoxystrobin, pyraclostrobin and trifloxystrobin; while examples of triazoles include metconazole, propiconazole, prothioconazole, and tebuconazole.

Fungicide costs and wheat prices influence the decision of spraying or not spraying. To be effective, most fungicides need to be applied before the disease occurs or at the appearance of the first symptoms. When the fungicide is applied to wheat before the flag leaf emergences, it generally results in less disease control on the upper leaves during grain development and smaller yield benefits (De Wolf et al., 2012). In general, fungicides primarily protect plants

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from getting infected and just few fungicides are effective in plants that have already been infected (McGrath, 2004). The benefits from fungicide applications in crop production are reflected in returns of up to three times the cost involved (McGrath, 2004). However, Hershman (2012) and McGrath (2004) explained that when the disease severity is low and there is minimal yield loss, applying a fungicide will not result in either a yield or an economic advantage.

Northeast Texas has traditionally being a region of moderate to high disease pressure. Leaf rust infection levels of susceptible cultivars are typically moderate or high, frequently reaching above 16% and every so often above 50% (Personal Communication, Texas A&M AgriLife Extension Representative in Commerce, TX). According to several wheat trials conducted by Texas A&M AgriLife Extension Representative in Commerce, TX in six locations in Northeast Texas (Leonard, Fairlie, Royse City, Greenville, Celeste, and Bailey) during 2005–2013, leaf rust infection levels for three common susceptible varieties (Pioneer 25R49, Pioneer 25R54, and Syngenta Jackpot) averaged 1% for plots treated with tebuconazole at 280 g/ha and 63% for untreated plots (with a median of 70%).

Several regional studies (Reid and Swart, 2004; and frequent technical reports by Swart, 2014) report yield increases greater than 30% of the treated plots over untreated plots. Studies in neighbor states (i.e., Thompson et al., 2014) have also reported yield increases close to 20% in recent years (i.e., 2012). Chen (2012) explained that yield losses of up to 60% due to stripe rust have been documented in experimental fields. Wegulo et al. (2009) showed that up to 42% yield loss was prevented by applying foliar fungicides to winter wheat. O'Brien (2007) showed that potential average wheat yield losses of 30% are common in Kansas when leaf rust is not controlled at flowering. From 1991 to 2002, the U.S. Department of Agriculture, Agricultural Research Service (USDA ARS, 2013) reports winter wheat yield losses in Texas from stem rust, leaf rust, and stripe rust averaging approximately 0.02%, 2.4%, and 0.4% per year respectively; while in the U.S. they average 0.14%, 2.1%, and 0.5% per year respectively. Clearly, fungal diseases have a significant economic impact on wheat yield and quality. Higher net returns may be obtained by carefully managing fungal diseases. “The formula for success in growing wheat in Northeast Texas is quite simple. Plant several high yielding resistant varieties in a timely manner, manage for optimum yet realistic yields, and use an inexpensive foliar fungicide [TebuStar® 3.6L] to protect yourself against a leaf rust race change or late season glume blotch infection” (Swart, 2014).

Unlike previous studies, this study conducts an analysis of four soft-red winter wheat cultivars (Magnolia, Terral LA841, Pioneer 25R47, Coker 9553) for two years (2011 and 2012) in three locations in Northeast Texas (Royse City, Howe, and Leonard). The general objective of the study is to analyze the effect of foliar fungicides on wheat yields and net returns, and to assist wheat growers in Northeast Texas with economic tools that may allow them to assess the economic benefits from foliar fungicide applications. The specific objective is to evaluate yield and net return from using the foliar fungicide tebuconazole (TebuStar® 3.6L) in Northeast Texas wheat production. The hypothesis examined is whether a preventive application of a relatively inexpensive foliar fungicide (TebuStar® 3.6L) to winter wheat in Northeast Texas is likely to result in a yield gain necessary to at least break even with or exceed the fungicide application cost.

2. Materials and methods

2.1. Wheat field trials, prices, and costs

Winter wheat (*Triticum aestivum* L.) data on fungicide treatment, location, yield, and disease severity for four soft-red winter wheat cultivars (Magnolia, Terral LA841, Pioneer 25R47, Coker 9553) was obtained from the Texas A&M AgriLife Extension Representative in Commerce, TX. Those are common cultivars in Northeast Texas and are considered to be moderately resistant to fungal diseases according to the agency's wheat trials over the last several years. Table 1 also summarizes the responses of these four cultivars to some common diseases and pests according to the agronomic assessments made by the companies that produce them. Specific environmental conditions, plant development stages, other disease and pest pressures, and disease resistance over time, among others, influence each cultivar's disease and pest response.

Wheat field trials for the four cultivars were conducted in 2011 and 2012 in three locations in Northeast Texas: a location in Royse City (32°58′27″N, 96°19′58″W), a location in Howe (33°30′18″N, 96°36′51″W), and a location in Leonard (33°22′59″N, 96°14′43″W). The corresponding elevations at each of these locations are 167 m, 256 m, and 219 m. The soil types in all three locations are either Houston Black Clay (calcareous clays and marls) or Leson Clay (alkaline shale and clays). Both soil types are very deep, moderately well drained, and very slowly permeable soils. Those are typical soils characteristics where wheat is grown in Northeast Texas.

Each wheat trial was replicated six times in a randomized complete block design. Each plot was 1.22 m wide and 6.06 m long and 15.24 cm row spacing. The treated plots were sprayed with the foliar fungicide TebuStar® 3.6L at 280 g/ha (diluted in 93 L of water per hectare) when the plants were approximately at Feekes Growth stage 10 (Large, 1954). The CO_2 powered backpack sprayer was equipped with a three-nozzle boom with 8002VS stainless steel tips 48 cm apart and flat-fan nozzles at 2.11 kg/cm^2.

Each experimental unit was evaluated one month after the foliar fungicide was applied. Ten plants per plot (subsamples) were randomly selected. Flag leaves on each plant were visually assessed for the presence of Septoria, barley yellow dwarf (BYD), leaf rust, and strip rust.

The harvest was done with a research Kincaid combine (Kincaid Manufacturing, Haven, Kansas). After weighing the grain and correcting to 13% moisture, grain yield in bushels per acre was recorded. Table 2 summarizes the three locations where the trials were conducted, their soil types, the weather conditions, and the planting, spraying, and harvesting dates.

Wheat prices per bushel were obtained from Texas A&M AgriLife Extension–Extension Agricultural Economics (2011, 2012). The average wheat price regardless of variety and location over the two years analyzed was $0.25/kg. The tebuconazole cost ($12.36/ha) and its application cost ($4.94/ha) were obtained from fungicide companies in Northeast Texas. When wheat prices are high relative to fungicide treatment costs, positive net returns are more likely (Thompson et al., 2014; Wegulo et al., 2011; Wiik and Rosenqvist, 2010).

Table 1
Disease and pest response.

	Disease and pest ratings			
	Magnolia[a]	Coker 9553[a]	Terral LA841[b]	Pioneer 25R40[c]
Stripe rust	3	2	9	7
Leaf rust	6	4	8	7
Septoria leaf blotch	5	5	7	n.a.
Powdery mildew	8	4	7	4

[a] Ratings according to AgriPro (2014a,b) numeric scale from 1 (good/resistant) to 9 (poor/susceptible).
[b] Ratings according to Terral Seed (2014) disease resistance numeric scale from 1 to 9, where 1–3 (below average), 4–6 (average), and 7–9 (above average).
[c] Ratings according to DuPont Pioneer (2014) numeric scale from 1 (poor) to 9 (excellent). The abbreviation n.a. stands for not available, which means that the authors were unable to find a rating.