Foliar Fungicide Application in Northeast Texas Wheat: Yield Response and Net Returns

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Outline

1. Introduction

2. Data

3. Methods and Procedures

4. Results and Discussion

5. Conclusion

Introduction

- Fungal diseases
  - are the number one reason for crops losses around the world (McGrath, 2004)
  - have a significant impact on wheat yield and quality
- Up to 42% yield loss caused by fungal diseases can be prevented by applying foliar fungicides (Wegulo et. al 2009)
- Managing fungal diseases is essential when growing crops

Objectives

- To evaluate yield and net return from using the foliar fungicide tebuconazole in wheat production.

- To assist wheat growers in Northeast Texas with economic tools that may allow them to assess the economic benefits from foliar fungicide applications.

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Texas Wheat

- Texas ranks as the 4th largest wheat producing state with about 3.84 million acres in production (2007 Census of Agriculture).

- In Texas, wheat is the third most planted crop behind forages and cotton (2007 Census of Agriculture).

- In 2005, the wheat industry generated 11,273 jobs and contributed with $658.8 million to the Texas economy (Richardson, Outlaw and Raulston, 2006).

Foliar Diseases

- Most prevailing foliar diseases in winter wheat in the Great Plains of the United States (Wegulo et al. 2012)
    - 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)
    - Stagonospora nodorum blotch (Phaeosphaeria nodorum; anamorph: Stagonospora nodorum)
    - Stripe rust (Puccinia striiformis f. sp. tritici)
    - Stem rust (Puccinia graminis f. sp. tritici)

Foliar Fungicides

- Usually grouped in two categories:
  - Strobilurins
  - Triazoles
- Triazoles slow fungal growth through the inhibition of sterol biosynthesis (Horst, 1987).
- Sterols are essential building blocks of fungal cell membranes and are inhibited at a single site by triazoles.
- Triazoles are highly effective and reliable because of their curative activity against early fungal infections and their ability to redistribute in the crop (Hewitt, 1998).
- Examples of triazoles used in the U.S.
  - Metconazole, propiconazole, prothioconazole, and **tebuconazole**

Reasons to Use Fungicides Products (McGrath, 2004)

- Control the disease during the establishment and development of the wheat crop.

- Increase productivity and reduce leaf and seed damage.

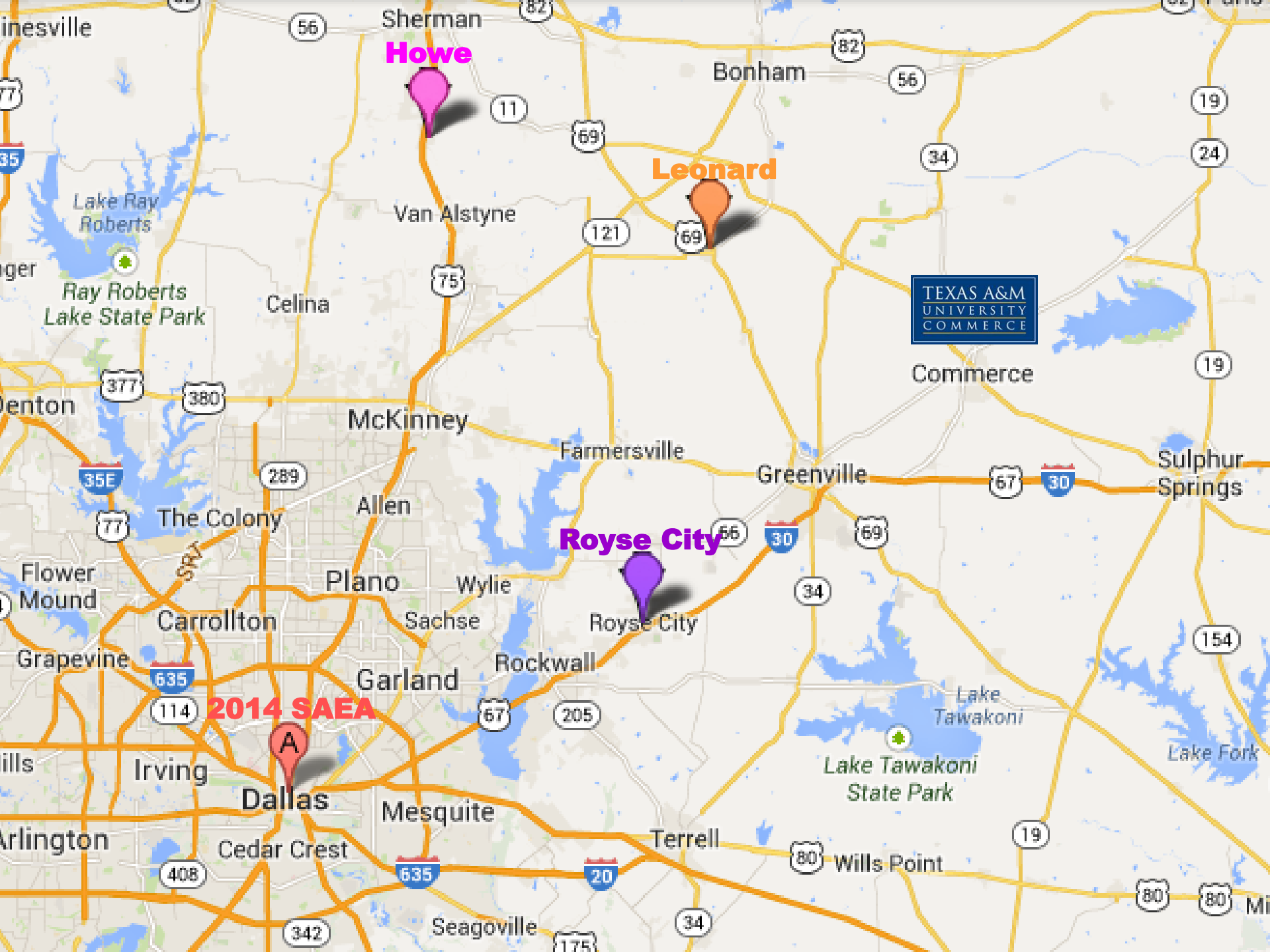- Improve the storage life and quality of harvested products.

Fungicides

- Fungicide 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 before 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 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).

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Data

- Data from wheat yield trials was obtained from the Texas A&M AgriLife Extension Representative in Commerce, TX.
  - Two years
    - 2011
    - 2012
  - Three locations
    - Royce City
    - Howe town
    - Leonard city
  - Four soft-red winter wheat cultivars
    - Magnolia
    - Terral LA 841
    - Pioneer 25R47
    - Coker 9553
- Wheat prices per bushel were obtained Texas A&M AgriLife Extension-Extension Agricultural Economics.
- Data on the cost of tebuconazole and its application were obtained from fungicide companies in Northeast Texas.

Soil Types

- Are either Houston Black Clay (calcareous clays and marls) or Leson Clay (alkaline shale and clays).

- Are very deep, moderately well drained, and very slowly permeable soils.

- Are typical soils characteristics where wheat is grown in Northeast Texas.

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Methods and Procedures

- Effects of tebuconazole applications on disease severity, net returns, and wheat yields response were evaluated by analyses of variance using the GLM procedure in SAS.

- Several linear models were used to test treatment interactions with location, cultivar, and year.

Model

- The general form of the linear model is

- $Y_{ijklmn} = \mu + \alpha_i + \beta_j + \gamma_k + \delta_l + \lambda_m + \alpha\gamma_{ik} + \varepsilon_{ijklmn,}$

- μ = the overall yield mean from the treated group
- α_i = the effect due to the ith treatment
- β_j = the effect from the jth block
- γ_k = the effect from the kth cultivar
- δ_l = the effect from the lth location
- λ_m = the effect from the mth year
- $\alpha_{\gamma ik}$ = the interaction effect of the ith level of treatment depending on the kth level of cultivar
- ε_{ij} = the error term.

Procedures

- Tukey means separation tests at 5% significance levels were used to perform means comparisons between sprayed and non-sprayed treatments for yield gain and net returns.

- A profitability analysis was conducted based on Bayesian inference (Bestor 2011, Munkvold et al. 2001, De Bruin et al. 2010, and Esker and Conley 2012)

Profitability Analysis

- $Rn = P * (Y_t - Y_c) - (C_f + C_a)$

- $(Y_t - Y_c) = \dfrac{Rn - (C_f + C_a)}{P}$

- $\beta_0 = \dfrac{Rn - (C_f + C_a)}{P}$

- Substitute Rn with desired ERn

- $t(\beta_0) = \dfrac{\beta_0 - (Y_t - Y_c)}{Sp^2\left(^1\!/_{n_t} + ^1\!/_{n_c}\right)^{1/2}}$

- $S_p^2 = \dfrac{(n_t - 1)S_1^2 + (n_c - 1)S_2^2}{(n_t - 1) + (n_c - 1)}$

- $P = 1 - Prob\ t[t(\beta_0), df]$

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Overall Yield

- Overall (treated + untreated) average yields (kg/ha) in 2011 and 2012 were found to be statistically different at the 5% significance level.

Table 2. Yield Response (kg/ha) to Fungicide Applications per Year

Year	N	Mean (kg/ha)*
2012	144	5,750.36a
2011	144	4,632.10b

* Means represent averages across three locations and four cultivars. Means with the same letter are not statistically different at α=0.05 significance level.

Fungicide Application

- Fungicide application was found to have a statistical significant effect ($P<0.05$) on the overall yield.

Wheat Yield in 2011

- In 2011, there was no significant difference on overall yield between the treated and untreated plots.

- Several studies have found statistical differences in yield between fungicide treated and untreated plots (Reid and Swart 2004; Wiik and Rosenqvist 2010).

- Our unexpected findings in 2011 may be attributed to the infection of barley yellow dwarf in the Howe location in 2011.

- Wiik and Rosenqvist (2010) explain that uncontrollable factors such as the emergence of new diseases can affect yield gain.

Wheat Yield in 2011 (Cont.)

Table 6. ANOVA for the Wheat Yield Response (kg/ha) to Fungicide Applications in 2011

Source	DF	F Value	Pr > F
Location	2	93.94	<0.0001
Treatment	1	0.83	0.3629
Location*Treatment	2	0.25	0.7792
Cultivar	3	23.57	<0.0001
Location*Cultivar	6	3.50	0.0034
Treatment*Cultivar	3	0.34	0.7941
Location*Treatment*Cultivar	6	0.62	0.7131
Rep(location)	15	1.31	0.2119

Wheat Yield in 2012

- Unlike 2011, in 2012, there was statistical difference on overall yield between the treated and untreated plots.

- Our findings in 2012, although conservative, are consistent with previous studies.

- The difference in wheat yield in 2012 represented an 8.6% increase of the treated group over the untreated group.

Wheat Yield in 2012 (Cont.)

Table 7. ANOVA for Wheat Yield Response (kg/ha) to Fungicide Applications in 2012

Source	DF	F Value	Pr > F
Location	2	40.76	<0.0001
Treatment	1	80.59	<0.0001
Location*Treatment	2	13.12	<0.0001
Cultivar	3	35.62	<0.0001
Location*Cultivar	6	27.00	<0.0001
Treatment*Cultivar	3	5.08	0.0025
Location*Treatment*Cultivar	6	1.95	0.0802
Rep(location)	15	5.86	<0.0001

Other Results

- There were statistical differences in yields and net returns
  - among locations during each year
  - among cultivars during each year

Net Returns

- **Table 12.** Net Return ($/ha) from Fungicide Applications per Year

Year	N	Mean ($/ha)*
2012	72	107.70a
2011	72	-3.53b

* Means represent averages across three locations and four cultivars. Means with the same letter are not statistically different at α=0.05 significance level.

Table 13. Net Returns Increase ($/ha) from Tebuconazole Applications at Various Wheat Prices and Fungicide Costs

		Tebuconazole Cost ($/ha)*							
		24.21	22.48	20.75	19.02	17.29	15.56	13.83	12.10
Wheat Price ($/kg)	0.15	18.76	20.49	22.22	23.95	25.68	27.41	29.13	30.86
	0.18	25.92	27.65	29.38	31.11	32.84	34.57	36.30	38.02
	0.20	33.08	34.81	36.54	38.27	40.00	41.73	43.46	45.19
	0.23	40.24	41.97	43.70	45.43	47.16	48.89	50.62	52.35
	0.25	47.41	49.13	50.86	52.59	54.32	56.05	57.78	59.51
	0.28	54.57	56.30	58.02	59.75	61.48	63.21	64.94	66.67
	0.30	61.73	63.46	65.19	66.91	68.64	70.37	72.10	73.83
	0.33	68.89	70.62	72.35	74.08	75.80	77.53	79.26	80.99
	0.35	76.05	77.78	79.51	81.24	82.97	84.69	86.42	88.15

* Tebuconazole cost includes fungicide cost plus application cost.

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2011

- During the first year (2011) the net return was estimated to be negative, -$3.53/ha, but wheat yield from the treated plots were not statistically different from the untreated plots at the 5% significant level.

- The emergence of a disease in one of the locations after the fungicide was applied may have affected yield in 2011.

- Unlike 2011, the net return from spraying tebuconzole in 2012 was estimated to be $107.70/ha, and wheat yield from the treated plots were statistically different from the untreated plots.

2012

- Several studies have found statistical differences in yield between fungicide treated and untreated plots (Reid and Swart 2004; Wiik and Rosenqvist 2010).
- Our findings in 2012, although conservative (an 8.6% increase of the treated group over the untreated group), are consistent with previous studies.
- Reid and Swart (2004) reported yield increases of 34% to 41% of treated plots over untreated plots.
- Our conservative 8.6% yield gain resulted in a positive return from investing in tebuconazole.
- In fact, the positive net return of $107.7/ha in 2012 offset the relatively small negative net return of -$3.53/ha in 2011, resulting in an overall positive net return.

Contribution

- The study contributes with additional findings related to the economic effect of fungicide applications to prevent fungal diseases on wheat production.

- The study considers an approach in evaluating net returns from fungicide applications that is based a Bayesian inference.

- The study may assist wheat farmers in Northeast Texas, who regularly use fungicides to control foliar fungal diseases, with economic tools to make educated decisions about their fungicide selection and expectations.

Thank You!