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# THE INFLUENCE OF PROPICONAZOLE FUNGICIDE APPLICATION ON HARD RED SPRING WHEAT CULTIVARS

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## Abstract

The effect of foliar applied systemic fungicide propiconazole (1-[[2-2,4 dichlorophenyl) on the agronomic, seed quality, and economic response of hard spring wheat (*Triticum aestivum* L.) was investigated under rain-fed conditions. Propiconazole applied at Feekes growth stage (GS) 10 suppressed leaf spot disease but had no effect on grain yield or other traits measured. Percent reflectance of 800 nm wavelength radiation increased as the visually estimated leaf spot disease severity decreased following fungicide treatment, indicating that foliar reflection may be an efficient and reliable assessment of foliar disease. The use of propiconazole to control foliar diseases and maximize spring wheat production is not economically feasible under other similar enviromental conditions.

## Introduction

The current trend toward intensive cereal management (ICM) systems to achieve maximum potential yields using high nitrogen fertility levels and increased seeding densities result in a dense plant canopy that favors leaf disease occurrence (Oplinger *et al.*, 1985). Consequently, substantial economic yield losses frequently result. Genetically managed crop resistance is the method of choice to combat major crop diseases. However, genetic resistance may not be available and/or permanent due to changing pathogenecity of disease causal organisms. The major wheat (*Triticum aestivum* L.) disease problems in North Dakota are leaf rust (*Puccinia recondita* Rob. ex. Desm. f. sp. *tritici*), stem rust (*P. graminis* Pers. f. sp. *tritici*. Ericks. and E. Henn.), tan spot (*Pyrenophora tritici repentis* (Died.) Shoemaker), and leaf blotch (*Septoria* spp).

Whereas hard red spring wheat (HRSW) cultivars are generally resistant to rust infection, but none are completely and/or parmanently resistant to all prevailing diseases. Tan spot, a major wheat disease can cause an yield loss upto 40% in North Dakota (McMullen & Hosford, 1989). Septoria may cause 10 to 30 % loss in heavily-infested high yielding fields of susceptible wheat and barley (*Hordeum vulgare* L.) cultivars (Lamey & Timian, 1981). Fungicides are widely used on winter cereals in Europe (Jenkins & Lescar, 1980) and in North America (Guy *et al.*, 1987; Oplinger *et al.*, 1985) and the response from fungicide applications depends on cultivar reaction and disease infection levels (Harms *et al.*, 1989). The fungicide propiconazole (1-[[2-(2,4 dichlorophenyl) 4-propyl1,3-dioxolan 2-yl] methyl]1H 1,2,4-triazole) was recently cleared for use on wheat in the USA and is effective against leaf diseases in cereals (Guy *et al.*, 1987; Mayfield, 1985) that are favoured by microclimatic conditions with

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high management inputs (Oplinger *et al.*, 1985). Propiconazole is a translocated systemic fungicide that is therapeutic and serves as a protectant to manage leaf diseases in cereals. The present report describes objective of this research was to evaluate the agronomic, seed quality and economic responses of HRSW cultivars to propiconazole fungicide application in rain-fed conditions of spring wheat growing environments.

## Materials and Methods

Field trials were conducted at Prosper and Casselton, ND, in 1987 and 1988. The soil type at Prosper was Perella (fine silty mixed, frigid Typic Haplaquolls) - Bearden silty clay loam, while Casselton was Bearden silty clay (fine silty, Aeric Calciaquolls). Details of soil test analyses performed by the North Dakota State University Soil Testing Laboratory Fargo from samples taken to a depth of 120 cm at planting time from each experimental site (environment) and the common agronomic practices used are presented in Table 1. Soybean (*Glycine max* (L.) Merr.) was the previous crop in all environments. The experimental arrangement was a split-plot in a randomized complete block design with 4 replications. Main plots were HRSW cultivars - Era, Stoa, Len and Nordic. Sub plots were fungicide treatments - foliar applied propiconazole (1-[[2-(2,4-dichlorophenyle) 4-propyl 1,3-dioxalan2-yl]methyl]1 H1,2,4-triazole) vs control. All seeds were previously treated with carboxin (5,6-dihydro-2-methyl-N-phenyl-1,4-oxathiin-3-carboxamide) + thiram (bis(dimethylthio-carbamoyl) disulfide) (Vitavax 200) 0.4 + 0.4 g a.i. kg$^{-1}$ seed each to control loose smut (*Ustilago tritici*) and other seedling diseases.

**Table 1. Summary of soil analyses and plot management at four North Dakota environments in two years.**

| | Environment | | | |
|---|---|---|---|---|
| | 1987 | | 1988 | |
| Variable | Prosper | Casselton | Casselton | Prosper |
| Soil water, kg kg$^{-1}$ | 0.25 | 0.33 | -c | --- |
| Soil pH | 6.7 | 7.0 | 7.8 | 8.2 |
| NO3N, kg ha$^{-1}$ | 239 | 441 | 329 | 231 |
| Available P, kg ha$^{-1}$ | 47 | 43 | 87 | 59 |
| Exchangeable K, kg ha$^{-1}$ | 605 | 907 | 1445 | 1568 |
| Organic matter, g kg$^{-1}$ | 28 | 55 | - | - |
| Seeding date | 22 Apr. | 22 Apr. | 05 Apr. | 11 Apr. |
| Row spacing, cm | 15 | 15 | 14 | 14 |
| Plot size, m2 | 5.6 | 5.6 | 5.2 | 5.2 |
| Harvested area, m2 | 3.7 | 3.7 | 3.3 | 3.3 |
| Harvest date | 04 Aug. | 04 Aug. | 29 July. | 22 July |

Total water content, Watersoluble NO3N (0120 cm), Data missing

The propiconazole fungicide was foliar applied @ 125 g a.i. ha$^{-1}$ in a water solution at 276 kPa pressure from a tractor mounted compressed air sprayer adjusted to deliver 187 l ha$^{-1}$ at Feekes growth stage (GS) 10 (Large, 1954). A shield was attached on the sprayer, which served as a barrier to avoid spray drift to neighbouring plots. Canopy reflectance was measured before and after the foliar disease development at GS 67 (jointing), and GS 11.2 (soft dough stage), respectively, in 1987. Percent sunlight reflectance values from each wheat plot canopy was measured in the 800 nm wave length, using a hand-held multispectral radiometer (CROPSCAN, Inc., Fargo, ND). Reflectance readings were taken during cloud-free periods between 0900 and 1300 CST. All trials were seeded with a 10-row plot drill in 15 or 14 cm row spacing at 400 seeds per m$^2$.

Agronomic traits determined were plants per m$^2$, plant height, lodging score, days-to-heading (HD), physiological maturity (maturity), leaf spot, grain yield, spikes per m$^2$, kernel per spike, kernel weight, protein concentration and test weight (TW).

Plants per m$^2$ were calculated as an average number from a random half meter section of two rows in each plot. Leaf spot rating was a combination of tan spot (*Pyrenophora tritici repentis*) and *Septoria* spp. Infection levels were visually estimated using a scale of 0 (zero) = no lower leaves infection to 9 (nine) = severe upper leaf infection as detailed by Couture (1980) recorded at GS 11.2. Before harvest, plant height was measured and lodging was scored according to the Belgium rating system (Oplinger *et al.*, 1985). Spikes per m$^2$ were computed by counting a random 625 cm$^2$ section of each plot. Nine spikes were randomly handpicked and threshed with a single head thresher to determine kernels per spike and weight per kernel (KW). Kernels were counted and weighed. Weight per kernel was calculated as the sample weight divided by number of seed. The number of kernels per spike were averaged from 9 spikes. Days to heading (HD) were counted from planting date to when 50% of the spikes had emerged half way from boot. Maturity was considered when the peduncle turned to straw color. Ends of plots were trimmed to eliminate border effects. Harvest was with a plot combine and the grains were dried 2d at 38$^0$C in a force air drier, cleaned and then weighed. Grain test weight and grain protein concentrations were determined from random subsamples of each plot using a standard test weight scale and NIR analyzer, respectively. Economic returns following fungicide treatments were determined based on grain yields and protein percentages. The cost of propiconazole was US $29.19 ha$^{-1}$ (product price US $23.00 plus application cost $6.19). Market price was calculated at US $0.135 kg$^{-1}$ of wheat grain and a protein premium or discount of $0.0011 g$^{-1}$ above or below 140 g kg$^{-1}$, respectively.

Data of traits determined for each environment (year-location) was analyzed separately and combined across environments after determining the error variances were homogeneous. LSD was used when F test of the ANOVA Table was significant ($P<.05$).

The trial at prosper 1987, was hail damaged prior to harvest. This precluded the inclusion of grain yield, yield components and test weight data in the combined analyses.

**Table 2. Average temperatures and total monthly precipitation at four North Dakota environments, in 1987 and 1988.**

| | | Temperature | | | | Precipitation | |
|---|---|---|---|---|---|---|---|
| | | Avg | | | Dev. from | | Dev from |
| Environment | Month | Max. | Min. | Avg. | Avg. | Total | Avg. |
| | | | --- (°C) --- | | | -- mm -- | |
| Casselton, 1987 | April | 18.7 | 1.0 | 9.8 | +4.2 | 0 | 47 |
| | May | 23.1 | 8.1 | 15.6 | +2.4 | 79 | +23 |
| | June | 28.2 | 12.4 | 20.3 | +1.9 | 58 | 18 |
| | July | 29.9 | 15.7 | 22.8 | +1.3 | 77 | 06 |
| Prosper, 1987 | April | - | - | - | - | - | - |
| | May | 23.9 | 16.2 | 16.5 | +3.4 | 57 | +01 |
| | June | 28.2 | 12.4 | 20.3 | +1.8 | 55 | 21 |
| | July | - | - | - | - | - | - |
| Casselton, 1988 | April | 16.3 | 4.2 | 10.3 | +4.7 | 4 | 44 |
| | May | 25.9 | 9.4 | 17.7 | +4.6 | 29 | 26 |
| | June | 31.4 | 14.4 | 22.9 | +4.5 | 33 | 44 |
| | July | 32.9 | 14.7 | 23.8 | +2.4 | 8 | 75 |
| Prosper, 1988 | April | 15.9 | 2.4 | 6.8 | +1.2 | 22 | 25 |
| | May | 25.9 | 9.0 | 17.4 | +4.3 | 37 | 19 |
| | June | 32.2 | 14.0 | 23.1 | +4.7 | 34 | 43 |
| | July | 32.6 | 15.5 | 24.1 | +2.6 | 16 | 67 |

Dev (Deviation) from average is given in reference to 30year average at Fargo (19541989).

Data for April and July in Environment Prosper, 1987 are not included due to some missing values.

## Results and Discussion

Climatological data are given in Table 2. Casselton 1987 environment was 48 mm below normal for rainfall with 4.2, 2.4, 1.9 and 1.3$^{0}$C above normal for April, May, June and July, respectively. The 1988 season was exceptionally hot and dry. Casselton and Prosper received 189 and 154 mm less rainfall respectively, than average. Thus, environmental conditions were not favourable for crop growth, lodging or foliar disease infection.

Great differences among experimental conditions were evident from means of agronomic traits for cultivar and fungicide treatments (Table 3). Casselton 87 environment produced the maximum grain yield of 5624 kg ha$^{-1}$ followed by Casselton 88 and Prosper 88 environments with 2728 and 1814 kg ha$^{-1}$, respectively. Conversely, protein concentration was lowest in Casselton 87 (141 g kg$^{-1}$), compared to prosper 88 and Casselton 88. Leaf spot disease and lodging scores were higher in Casselton 87 environment than in Prosper 87 environment as would be anticipated with relatively better crop conditions. Differences in maturity were mainly due to different planting dates, but hot and dry conditions of 1988 hastened maturity. Nordic and Stoa were the

Table 3. Influence of environments, cultivars, and foliar fungicide (propiconazole) on agronomic traits and economic net return of hard red spring wheat in North Dakota (1987-88).

| | | | | | | | | | | | | | Reflectance (800 nm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | Plants per m2 | Plant height | Lodging index | Leaf spot | Grain yield | Spikes per m2 | Kernels per spike | Weight per kernel | Test weight | Protein conc. | HD | PM | GSç 6-7 | GS 11.2 | Net income |
| | no | cm | 0.2-9 | 0-9 | kg ha$^{-1}$ | no. | no. | mg | kg m$^{-3}$ | g kg$^{-1}$ | —d— | -----%------ | | | --US ha$^{-1}$-- |
| **Environment** | | | | | | | | | | | | | | | |
| casselton, 87 | 381 | 91.1 | 4.4 | 5.3 | 5624 | 580 | 34.4 | 32 | 732 | 141 | 58.8 | 98.3 | 59.0 | 59.0 | 722 |
| Prosper, 87 | 201 | 71.2 | 2.4 | 2.4 | -- | -- | -- | -- | -- | 137 | 58.7 | 95.5 | 35.7 | 25.7 | -- |
| Casselton, 88 | 203 | 56.4 | -- | -- | 2728 | 390 | 32.5 | 20 | 722 | 154 | 64.1 | 94.2 | -- | -- | 359 |
| Prosper, 88 | 208 | 44.1 | -- | -- | 1814 | 315 | 26.9 | 32 | 761 | 148 | 69.7 | 103.3 | -- | -- | 223 |
| **Cultivar** | | | | | | | | | | | | | | | |
| Era | 216 | 63.0 | 3.9 | 4.0 | 2902 | 395 | 34.1 | 29 | 711 | 141 | 64.2 | 99.0 | 46.0 | 34.6 | 355 |
| Stoa | 265 | 71.8 | 2.7 | 3.9 | 3690 | 449 | 38.2 | 28 | 752 | 148 | 61.8 | 96.5 | 47.3 | 35.8 | 492 |
| Len | 237 | 65.1 | 3.0 | 4.4 | 3271 | 454 | 25.7 | 33 | 746 | 153 | 62.4 | 98.4 | 45.0 | 32.8 | 449 |
| Nordic | 274 | 63.0 | 4.1 | 4.1 | 3691 | 417 | 27.1 | 30 | 744 | 137 | 62.8 | 97.4 | 51.1 | 33.9 | 441 |
| LSD (0.05) | 21 | 1.9 | 0.4 | \|NS | 76 | 50 | 2.7 | 2 | 10 | 2.4 | 0.5 | 0.6 | 1.9 | 1.1 | 31 |
| **Fungicide** | | | | | | | | | | | | | | | |
| Control | 248 | 65.4 | 3.4 | 4.8 | 3571 | 428 | 31.2 | 31 | 736 | 145 | 62.8 | 97.8 | 47.3 | 33.1 | 445 |
| Propiconazole | 249 | 66.1 | 3.4 | 3.4 | 3406 | 429 | 31.3 | 31 | 740 | 146 | 62.8 | 97.9 | 47.3 | 35.4 | 424 |
| LSD (0.05) | NS | 0.6 | NS | 0.3 | NS | NS | NS | NS | NS | NS | NS | NS | NS | 0.7 | NS |
| X | 248 | 65.6 | 3.4 | 4.1 | 3489 | 428 | 31.2 | 31.2 | 738 | 145 | 62.8 | 97.8 | 47.3 | 34.2 | 434 |

Denote, days to heading (HD), and physiological maturity (PM), respectively, Loging index = SxIx0.2, where S= Area of surface lodged (1=non to 9= total), I= Intensity of lodging (1=Upright to 5 =flat), GS = Feekes growth stage. NS = Not significant.

highest yielding cultivars followed by Len and Era. Nordic was lowest in protein concentration (137 g kg$^{-1}$) and Len was highest (154 g kg$^{-1}$). Stoa produced the maximum economic yields and seemed to be the most promising cultivar in similar environments. A significant environment x cultivar interaction existed for all characters when averaged across fungicide treatment, except plant per m$^2$, grain yield, spikes per m$^2$ and kernel weight, indicating that environment had a differential influence on cultivar performance (data not reported).

Averaged across environments and cultivars (Table 3), the foliar-applied propiconazole increased plant height, however, the response of plant height was too small (0.7 cm) to be practically significant. Guy *et al.*, (1989) reported no effect from propiconazole application on plant height whereas, Wulster *et al.*, (1987) observed that small rates of propiconazole increased plant height in lily (*Lolium longiflorum* Thunb.) which decreased when higher rates were used.

**Table 4. Physiological maturity (PM), leaf spot, and percent reflectance as affected by environment x propiconozale (P) and cultivar x P in North Dakota (1987-88).**

| Environment | Treatment | PM | Leaf spot | Reflectance (800 nm) GS 11.2 |
|---|---|---|---|---|
| | | (d) | (09) | --%-- |
| Prosper, 87 | Control | 95.1 | 3.4 | 25.1 |
| | P | 95.8 | 2.3 | 26.3 |
| Casselton, 87 | Control | 98.3 | 6.2 | 41.1 |
| | P | 98.4 | 4.1 | 44.5 |
| Prosper,88 | Control | 103.4 | -- | -- |
| | P | 103.1 | -- | -- |
| Casselton, 88 | Control | 94.1 | -- | -- |
| | P | 94.3 | -- | -- |
| | LSD (0.05) | 0.3 | 0.4 | 1.5 |
| **Cultivar** | | | | |
| Era | Control | | 4.4 | 33.4 |
| | P | | 3.5 | 35.8 |
| Stoa | Control | | 4.6 | 35.0 |
| | P | | 3.5 | 36.5 |
| Len | Control | | 5.1 | 31.2 |
| | P | | 3.1 | 34.4 |
| Nordic | Control | | 5.1 | 32.8 |
| | P | | 3.4 | 35.0 |
| | LSD (0.05) | | 0.5 | NS |

GS = Feekes growth stage; NS = Not significant.

Foliar-applied propiconazole significantly reduced foliar disease levels, particularly in Casselton 87 environment, where disease infection was greatest, causing significant fungicide x environment or cultivar interactions (Table 4). Percent reflectance increased correspondingly in Casselton 87 environment following fungicide. Guy & Oplinger (1989) also reported larger effects of propiconazole in foliar diseases under favourable infective environments. Radiometer assessment supported the visual estimation of foliar disease. Percent reflection (800 nm) from crop canopies of fungicide treated plot increased due to decreased foliar infection. This agrees with the results of Nutter *et al.*, (1990), Khan & Spilde (1992), who reported increased percent reflectance as visually estimated leaf spot disease severity decreased following fungicide treatment. However, despite disease suppression, foliar applied propiconazole did not significantly increase grain yield. In contrast Buechley & Shaner (1983); Guy & Oplinger (1989); Guy *et al.*, (1987) and Mayfield (1985) found that propiconazole effectively decreased foliar diseases accompanied by improved grain yield indicating that disease levels were not severe enough to cause significant grain yield reduction in these environments. This agrees with Harms *et al.*, (1989), who found that fungicide applications suppressed foliar disease development on susceptible cultivars but the disease susceptibility and control was not related to yield response from fungicides. Other workers reported that yields are clearly related to disease control (Guy *et al.*, 1987; Guy *et al.*, 1989; Mayfield, 1985)). Morris *et al.* (1989), observed an effective control of foliar diseases with propiconazole application on a hard winter wheat cultivar but the increase in grain yield, kernel weight or test weight was obtained at one or two out of three locations. In the present study propiconazole application did not influence lodging, number of kernels per spike or kernel weight and test weight whereas, an increasing kernel weight (Guy & Oplinger, 1989; Guy *et al* 1987) and test weight (Guy & Oplinger, 1989; Mayfield, 1985) with no effect on kernels per spike and kernel weight (Buechley & Shaner, 1983) has been reported. When averaged across environments and cultivars, fungicide application did not increase HRSW grain yield, protein concentration, test weight, or net economic return, suggesting that the use of fungicide is not economical under low disease conditions. More research is needed to isolate the economic implications of disease management under conditions of higher incidence of disease attack.

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