Fungicide Spray Decision for Wheat Leaf Rust

Glen Statler and Gary Helgeson

Leaf rust incited by *Puccinia recondita* Rob. ex. Desm. f. sp. *tritici* can reduce wheat yields when susceptible cultivars are grown and weather conditions favor rust development. Leaf rust is normally controlled by fungicides or resistant cultivars, but resistance is not permanent since the fungus has the ability to change and attack previously resistant cultivars. This ability of the pathogen to change makes leaf rust a constant potential threat to wheat production.

Yield losses caused by this disease have been demonstrated by comparing yields of plots in which leaf rust was controlled with fungicides to yields of unsprayed plots (Statler, 1974). Grower estimates of yield losses are also useful in loss estimations. The USDA Cereal Rust Laboratory provides useful loss estimates for the rust diseases (Roelfs, 1978). Yield losses up to 30 percent have been reported, depending on the susceptibility of the cultivar and rust severity (Samborski and Peturson, 1960; Statler, 1974).

Epidemics can occur when susceptible cultivars are grown on large acreages and environmental conditions favor rust development. Rust epidemics have caused widespread losses. In 1965, Samborski (1966) estimated a 20 percent yield reduction in late planted fields of Selkirk in Canada. That same year, losses were estimated at 6.8 percent for North Dakota (Roelfs, 1977). Dubin and Torres (1981) reported several thousand hectares of wheat destroyed by the 1977 leaf rust epidemic in Mexico even though there was large scale use of fungicides.

Leaf rust was severe in 1985 with estimated statewide yield losses ranging up to 27 percent in Texas with an average loss of 7.4 percent on winter wheat in the U.S. (Long et al., 1986). This was the largest loss ever reported for leaf rust in the United States. A lack of moisture limited leaf rust development in the southern U.S. during early 1986, but leaf rust was severe and losses occurred in much of the northern winter wheat area. Losses were estimated at 10 percent on winter wheat in 1986 for North Dakota (Cereal Rust Lab USDA St. Paul, MN Rept #6).

Fungicides can be used to control the disease when resistance is not available. However, changing environmental conditions make spray decisions very difficult. A decision to spray is based on yield loss due to disease development. Fungicides must be applied before rust is present on the top leaf, so disease development must be estimated prior to a decision to spray. Disease development is based on varietal resistance, environmental conditions, and biological factors (Eversmeyer and Burleigh, 1969).

We have proposed a flow chart as an aid for a fungicide spray decision (Fig. 2). The chart is based on the fact that rust moves up the plant and increases in amount during the season if all conditions are favorable and that severe infection causes yield loss. We have also developed a computer software program, "Wheat Leaf Rust Spray Decision Aid." This program is available from the NDSU Extension Service. The following discussion is to help answer the questions in Figure 2 and the Wheat Leaf Rust Spray Decision Aid.

1. Susceptible cultivar?

Refer to North Dakota Small Grain and Flax Variety Performance and Descriptions (Extension Service Circular A-574) for current varietal descriptions. Resistant cultivars do not need protection by fungicides unless new races develop.

2. Rust observed?

If rust is not observed when fields are monitored, spray is not recommended.

3. Growth stage.

Plant growth stage at onset of rust.

Early is preheading. If plants are past heading, it is probably too late to spray. If the disease is found early, e.g. 10 percent on the lower leaves at the boot or jointing stage, and weather conditions favor disease development, fungicide applications may be advisable. This is based on the fact that rust moves up the plant during the season and we are protecting the top two leaves, since most of the photosynthate for kernel fill is derived from those leaves.

4. Top two leaves infected?

If the top two leaves have more than about 5-10 percent rust at heading, it is probably too late to spray. If the disease is first discovered at the late milk or dough stage and the disease level is low, it is unlikely that the disease will progress to a point that would make fungicide application economically feasible.

5. Disease severity.

Disease severity on lower leaves of 5-20 percent; consider spraying. Wheat leaf rust is evaluated by percent severity and infection type (Fig. 1). The percent severity is the amount of rust on the leaves. The infec-

Statler is professor and Helgeson is former research assistant, Department of Plant Pathology.

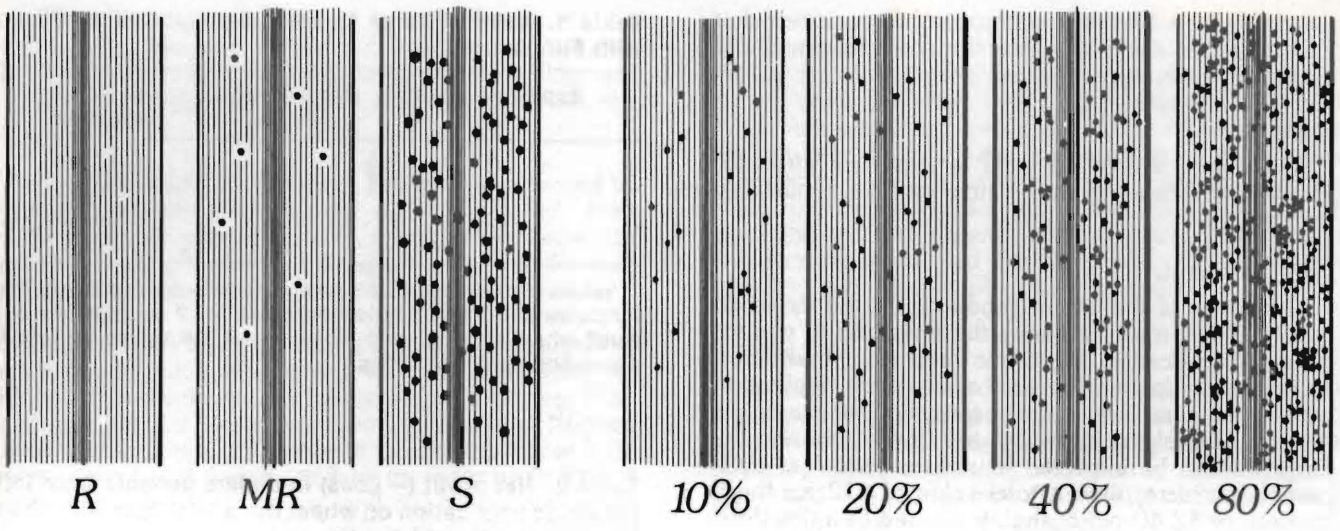

Figure 1. Infection Type and Percent Severity for Wheat Leaf Rust.

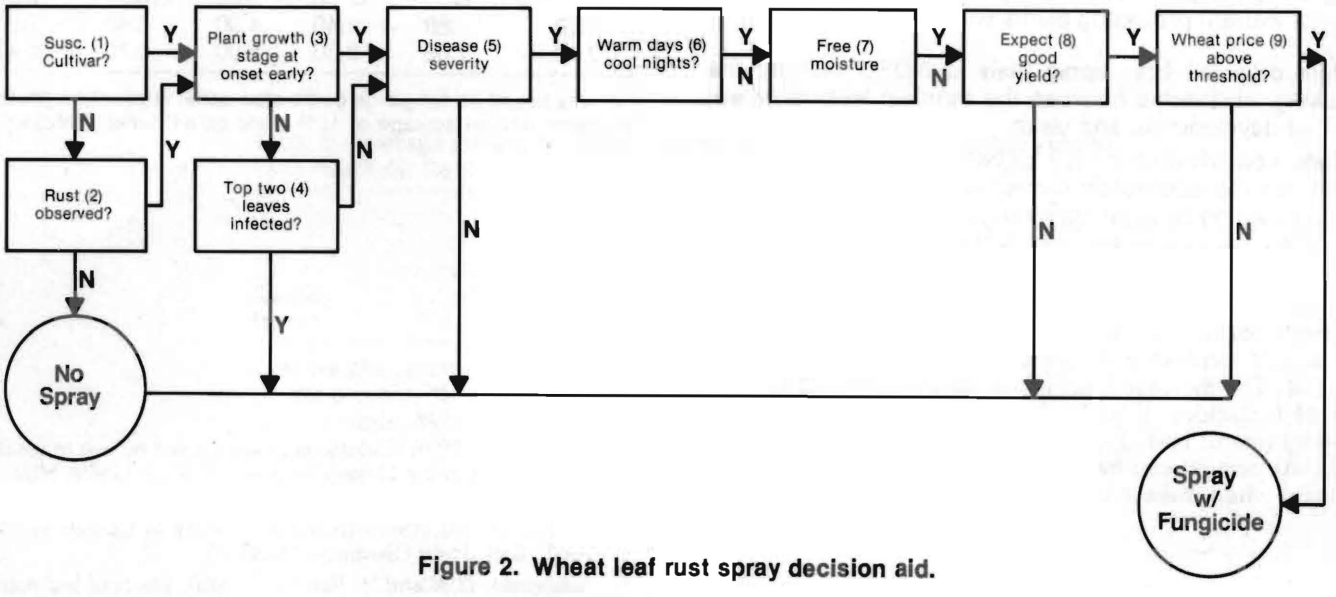

Figure 2. Wheat leaf rust spray decision aid.

tion type indicates if the variety if resistant or susceptible. Couple this reading with the plant growth stage to determine whether the disease is capable of developing to a level that will negatively affect yield.

6. Temperature.

Warm days and cool nights favor rust development. Dry, cold, or hot weather retards rust development.

If the disease is first discovered at a preheading stage of plant growth and severity is above 5-10 percent, then we need to be able to estimate how quickly the disease will spread. Research indicates that along with growth stage and rust severity, the most significant factors related to yield loss from wheat leaf rust are daily minimum temperatures and hours of free moisture on leaves (Statler, 1974).

7. Moisture.

Free moisture on the leaves (4-6 hours) is necessary for germination and penetration by the rust fungus.

The conditions which are conducive to the spread of rust infection are similar to those which promote good development of wheat plants and the attendant high yields. Warm days and cool nights (temperatures ranging from 60-80°F) with 4-6 hours of free moisture on the leaves are conducive to rust development. If any one environmental factor is not conducive, if the plants are not susceptible, or if rust is not present, then rust

development will be delayed, possibly to the extent that damage to yield will fall below the economic threshold to pay for spraying.

8. **Yield.**

   Spray only if a good yield is expected (probably above 40 bushels per acre). Increased yield must pay for spraying.

9. **Price of wheat.**

   The value of the wheat produced by the expected yield increase must be above the threshold to pay for the spray application. Economic threshold can be determined by comparing the cost of fungicide application with the potential loss from not spraying. For example if the cost of applying fungicides is $12 per acre and the fungicide can be expected to reduce yield loss by 5 bushels per acre, then a total value of $12 for the 5 bushels, or $2.40 per bushel, is needed as a threshold to break even. Thus, a cost of 5 bushels per acre will trigger additional marginal profit and spraying is recommended (see cost return tables).

It is commonly accepted that *P. recondita* increases in amount as the season progresses and that the amount of rust is generally correlated with yield loss (Roelfs, 1978). Therefore, if the variety is susceptible, leaf rust can quickly progress to the point where the yield loss from rust is sufficient to warrant protecting plants with fungicides.

Data collected from spray trials at NDSU indicate the following relationship between the terminal level of wheat leaf rust development and yield:

Yield = 64.54600392 – [(0.19392029) × (%leaf rust)]
for the moderately susceptible cultivar Manitou and

Yield = 62.77780304 – [(0.23003216) × (%leaf rust)]
for the susceptible cultivar Thatcher.

If all biological and environmental conditions are favorable for rust development, one may estimate a rapid rate of rust increase ending the season with 80-90 percent leaf rust. The increased yield from spraying should pay the cost of fungicides. If any factor such as hot dry weather severely retards rust, a slow rust increase with final severity of 15-20 percent can be expected. Spraying is not recommended when disease progress is slow.

Table 1. Net Profits or (– Loss) for Controlling Disease with Fungicides.

Expected Loss %	(50 bu crop) Bu/A	Net Return Dollars/A
0	0	(– 12.00)
10	5	1.25
20	10	14.50
30	15	27.75

Values are estimates of severe rust on a susceptible cultivar, fungicide and aerial application costs for 2 applications of $6 each, wheat at $2.65, and 50 bu wheat. All values will change depending upon conditions.

Table 2. Net profit (– Loss) in dollars per/acre from foliar fungicide application on wheat (for a 10% loss with changing prices and yields).

Crop Price ($ Bu)	Potential Yield (Bu/A)				
	40	45	50	55	60
$2.60[1]	– 1.60	– .30	1.00	2.30	3.60
2.80	– .80	.60	2.00	3.40	4.80
3.00	0.0	1.50	3.00	4.50	6.00
3.20	.80	2.40	4.00	5.60	7.20
3.40	1.60	3.30	5.00	6.70	8.40

[1]Values based on fungicide costs plus aerial application costs of $12/acre, and an average of 10% yield gain (Statler & McMullen, 1986).

References

1. Dubin, H.J. and E. Torres. 1981. Causes and consequences of the 1976-1977 wheat leaf rust epidemic in northwest Mexico. Ann. Rev. Phytopathol. 19:41-49.
2. Eversmeyer, M.G. and J.R. Burleigh. 1969. A method of predicting epidemic development of wheat leaf rust. Phytopathology 60:805-811.
3. Long, D.L., J.F. Schafer and A.P. Roelfs. 1986. Virulence and epidemiology of *Puccinia recondita* f. sp. *tritici* in the United States in 1985. Plant Dis. 70:1107-1110.
4. Roelfs, A.P. 1977. The 1977 stem rust situation - wheat, durum, and oats. Crop Production Conference Report. Crop Quality Council. Minneapolis, MN. p. 56-61.
5. Roelfs, A.P. 1978. Estimated losses caused by rust in small grain cereals in the United States - 1918-76. USDA Misc. Pub. No. 1363. 85 p.
6. Samborski, D.J. 1966. Leaf rust of wheat in Canada in 1965. Can. Plant Dis. Surv. 46:33-35.
7. Samborski, D.J. and B. Peturson. 1960. Effect of leaf rust on the yield of resistance wheats. Can. J. Pl. Sci. 40, 4, pp. 620-622.
8. Statler, G.D. 1974. The relationship of leaf rust infections and wheat yields. North Dakota Farm Res. 31:24-26.
9. Statler, G.D. and M. McMullen. 1986. Wheat Leaf Rust. N.D. Extension Service Bull. PP-589.