Fig. 1. The four dark strips running up-and-down in the center of this infra-red aerial photo show the extra growth effect of fungicidal treatment by air on this experimental wheat field.

Applying Fungicides For Greater Profits

E. H. Lloyd, Jr., and Robert E. Nowatzki

Reviews have been published on the efficacy of fungicides for controlling leaf and stem rust of cereals (2, 3, 8). More recently, tests have shown that fungicides will protect wheat foliage from leaf spotting diseases (1, 4, 5, 6, 7, 9). Airplane sprayed field trials have shown that yield increases of 28 per cent (1), and 31 per cent (10) are possible with two fungicide applications to control leaf spotting diseases and leaf rust, respectively. For economic reasons these applications begin when the wheat is in the boot stage on fields having a high yielding potential (1); i.e., adequate water, nutrients, weed control, soil tilth and planted to varieties with ade-

Dr. Lloyd is extension plant pathologist. Nowatzki is superintendent, Langdon Branch Experiment Station.

Thanks to Jim Symons, Vernyl Pederson, Glen Statler and Lee Darlington who cooperated during investigations.

quate stem rust resistance. One or more of the leaf diseases (septoria blotch, pyrenophora tan spot, leaf rust or spot blotch) may be present (1, 5, 6, 9).

Even with guidelines and economic benefits demonstrated, many investigators have questioned the validity of cereal leaf disease chemical control, because much of the data was accumulated on either (1) small plots sprayed by hand or modified ground applicators, or (2) large field plots sprayed by airplane. No randomization nor replication was implemented in these large trials; therefore, statistical evaluation of the results was not possible.

In view of these objections, field and small plot tests made in 1971 near Langdon, North Dakota had these objectives: (1) to substantiate the validity of fungicide applications to wheat and barley to protect potential yielding ability, (2) to evaluate untried fungicides as controls for leaf rust and leaf spot diseases, and (3) to evaluate the use of an additive for prolonging the functional period of a fungicide on the leaf surface.

FIELD TEST

Because of the need to show that aerial applied fungicides are useful for controlling cereal leaf diseases, evaluations of four fungicides applied by airplane to strips 165 feet wide by 1/2-mile long of Bonanza spring wheat and Dickson spring barley were made on the Jim Symons farm located about six miles east and two miles south of Langdon. Three replications of each treatment and non-sprayed check strip were measured and staked on June 28. Chemicals used in this and the small plot test were provided by Cities Service Corporation, Niagara division of the FMC Corporation, Chemagro division of Baychem Corporation, Occidental Corporation, and Kennecott Copper Corporation.

Bonanza spring wheat was grown on summer-fallow soil and Dickson barley on soil planted the previous year to durum. About 182 pounds of residue per acre were on the fields planted to barley, but the fields planted to wheat were essentially bare.

Recordings on leaf diseases were made at weekly intervals. Infra-red photographs were taken August 11.

Aerial applications of one and one-half pounds of Manzate 200 and Kocide 101 and one-half gallon of Cit Cop 4E and Copper Count N were made July 15 or 16, and 7 days later on July 23. A Pawnee 235 equipped with 40 T-jet nozzles each having a 45 core and a number 8 orifice was used. The fungicides were applied in five gallons of water per acre under 48 psi pressure. The wind varied from 3-10 mph on the spray dates.

Harvesting barley began August 21 and wheat August 30. Cuts were made with a 20-foot self-propelled swather. After swathing, 100 heads were randomly collected from each treatment and non-sprayed strip. Four swaths were harvested with a self-propelled combine from the center of each treatment and non-sprayed strip and the grain weighed at the Easby Elevator.

Results and Discussion

By July 15, half of the fifth leaf (third leaf from the top) of Bonanza wheat was dried and shriveled due to the combined effects of **Septoria avenae** f. sp. **triticea** and **Pyrenophora trichostoma.** The fifth leaf of Dickson was equally diseased and the sixth leaf showed some yellow flecking. **Septoria passernii** was predominately present on the barley, but **S. avenae** f. sp. **triticea** and **Helminthosporium teres** were present also.

The flag leaves remained non-diseased on barley. This was principally due to the lack of moisture during the period from August 1 through August 16, although Dickson has some field resistance to leaf diseases. The lack of moisture at this time also affected the growth potential of Dickson and the plants matured early, alleviating any advantage from the use of fungicides. Leaf diseases, however, developed on the sixth and flag leaf of Bonanza spring wheat after August 16 when rains resumed intermittently.

The data in Table 1 show that two applications of Manzate 200 applied at seven-day intervals significantly protected the yield potential of Bonanza wheat. Treated field strips yielded significantly better than did non-sprayed strips, and the wheat test-

Table 1. Effectiveness of four fungicides applied twice at seven-day intervals to protect the growth potential of Bonanza spring wheat.

	Non-treated	Manzate 200	Kocide 101	Cit Cop 4E	Copper Count N
Grains/head (No.)[1]	28.87[2]	29.61	27.95	27.93	26.81
Wt of grain/head(g)[1]	0.92	0.97	0.86	0.89	0.82
1,000 (kernel) wt(g)	32.0	32.4	30.8	31.8	30.4
Protein (%)[3]	10.77	11.27	10.70	10.57	10.70
Test wt (lb)	61.5	61.25	61.25	61.5	61.25
Yield (bu/A)[4]	57.34	63.18	58.13	55.68	53.52

[1]Average of 100 heads per treatment.
[2]Average of 3 replications per treatment.
[3]Adjusted to 14% moisture.
[4]LSD .05 equals 5.36 bu.

ed slightly higher in protein. The test weight in this trial was no better than the non-sprayed check.

Yields from the wheat receiving applications of Kocide 101, Copper Count N or Cit Cop 4E were not significant at the rates tested. Kocide 101, however, might perform satisfactorily at the 2- to 3-pound per acre rate as it did in barley spray trials in 1969 (unpublished data).

The better yield obtained on Manzate 200 treated strips was at least partially due to the increase in individual kernel weight as evidenced by the 1,000 kernel weight, and also to the increase in number of kernels per head (Table 1). There was nearly one more kernel per head on strips of grain treated with Manzate 200 than on non-treated strips. These results support those of Shipton (7).

Results on the barley were not significant (Table 2). This was attributed to insufficient moisture for the barley to complete growth. In contrast, the fields planted to Bonanza spring wheat were fallowed and had enough stored soil moisture to complete growth of the crop. Plumpness of grain from fungicide treated strips tended to be greater than non-treated grain. Manzate 200 and Copper Count N were six per cent greater than the non-treated strip.

Table 2. Effectiveness of four fungicides applied twice at seven-day intervals to protect the growth potential of Dickson barley.

	Yield (Bu/A)	Test Weight (lbs)	Plumpness (%)
Non-treated	59.68[1]	49.16	70.0
Manzate 200	59.98	49.33	76.0
Kocide 101	57.22	48.66	69.3
Cit Cop 4E	61.38	48.16	72.3
Copper Count N	59.27	47.83	76.0

[1]Average of three replications per treatment.

SMALL PLOT TEST

Several chemicals were tested for their effectiveness to control leaf spot diseases and leaf rust in an experiment made at the Langdon Experiment Station during 1971. The effectiveness of Pinolene to extend the residual life of fungicides on the leaf surfaces was also evaluated.

Manitou spring wheat and 50 pounds of 10-40-10 fertilizer were drilled in three replicated blocks on summer-fallowed soil May 19. The planting rate was 75 pounds per acre. Waldron spring wheat residue, infected with **Septoria** spp. and **Pyrenophora trichostoma,** was uniformly scattered on each plot at the rate of 500 pounds per acre to insure an adequate supply of fungal inoculum. Three replications were divided into 11 plots, four feet wide by 42 feet long. Ten fungicidal treatments and a non-sprayed check were randomized within each replication. Applications of the fungicides were made with a John Bean ground sprayer traveling three miles per hour. Two-hundred psi pressure was used; and at this rate approximately 50 gallons spray per acre was applied. The fungicidal treatments, per-acre rate of application, number of applications, interval between applications, and whether the special spreader-sticker Pinolene was added or not are listed in Table 3. The first fungicidal application was made July 9 when the wheat was in the boot stage. The second application was made either seven days later on July 16, or 14 days later on July 23. One pint per acre of Pinolene was added to the spray on plots receiving the spreader-sticker.

Notes were taken July 15, July 20, and August 10. Leaf rust readings were made August 10 when the wheat was in the soft dough stage. The plots were harvested August 30.

The data were statistically analyzed with an analysis of variance and treatments either compared orthogonally, or with the LSD or Duncan's multiple range tests. Mean yield, test weight and leaf rust readings are recorded in Table 3.

Results and Discussion

Leaves on plants receiving Copper Count N treatments developed a yellowish hue. Hinosan treated foliage also had a yellowish color, but of less intensity than that induced by the Copper Count N fungicide. Both Hinosan treatments caused minor leaf margin burning. Manzate 200, Polyram, and the non-sprayed check treatments created no yellowing of the foliage.

Minor leaf spotting developed by July 9, the date of first spraying, although good development of **Septoria** and **Pyrenophora** fruiting bodies occurred on the crop residue initially distributed on the plots. Leaf rust occurred in the plots and on winter wheat spreader rows.

Septoria and pyrenophora leaf diseases did not develop enough for measurement by August 10. However, leaf rust was extensive. The data in Table 3 show that spraying with fungicides controlled leaf diseases and, moreover, wheat leaf rust. More rust showed on the non-treated check than on any of the fungicide treatments. Rust readings made were mostly of the susceptible reaction type. The data show that Manzate 200 provided good control of leaf rust, and that Polyram and Hinosan have rust control potential, even though less effective than Manzate 200. Copper Count N was only partially efficient in controlling rust of wheat.

Table 3 summarizes yield and test weight results. All treatments included in the test, except Copper Count N applied twice at seven-day intervals and once with no Pinolene, were significantly

Table 3. Mean yield, test weight and leaf rust readings of Manitou spring wheat that received a fungicide applied at various rates and intervals and with or without Pinolene.

Chemical	Rate Applied Per Acre	Number of Applications	Added Pinolene[1]	Days Interval Applied	Mean Yield (Bu/A)[2]	Range Test	Mean Test Weight[2] (lbs)	Range Test	Mean Leaf Rust[2] (%)
Manzate 200, 80%	1 1/2 lb	2		7	53.87	a[3]	59.83	ab	8.3[4]
Hinosan EC, 30%	1 1/2 pts	2		7	50.40	ab	60.33	a	26.7
Polyram, 80%	2 lb	1	+		50.40	ab	60.33	a	21.7
Hinosan, EC 30%	2 pts	1	+		49.70	ab	60.67	a	38.3
Polyram, 80%	1 1/2 lb	2		7	48.23	b	60.00	a	16.7
Copper Count N, 8%	3/4 gal	1	+		47.53	b	60.00	a	35.0
Copper Count N, 8%	1/2 gal	2		14	47.53	b	60.17	a	36.7
Manzate 200, 80%	2 lb	1	+		47.50	b	60.00	a	5.0
Copper Count N, 8%	3/4 gal	1			46.83	bc	60.87	a	45.0
Copper Count N, 8%	1/2 gal	2		7	46.80	bc	60.00	a	31.7
Non-sprayed check		0			43.20	c	58.67	b	48.3

[1]Used 1/2 pint per acre.
[2]Readings are average of 3 replications.
[3]Means followed by same letters are not significantly different at 5% level.
[4]Average per cent severity.

greater than the nonsprayed check. Two applications of Manzate 200 applied at seven-day intervals was significantly better than comparable applications of either Polyram or Copper Count N, but no better than two applications of Hinosan. All treatments except that which included the two applications of Manzate 200 gave a significantly better test weight than the nonsprayed check.

There was no significant difference in yield among treatments receiving a single application of a fungicide including Pinolene and comparable treatments receiving two applications but with no additional Pinolene spreader-sticker. However, two applications of Manzate 200 were significantly better than one application with Pinolene added.

SUMMARY

These data show that significant yield reductions are prevented with foliar applications of fungicides to wheat to control leaf rust and leaf spotting diseases. A 5.84 bu/A yield potential was saved by protecting Bonanza spring wheat foliage from infection with **Septoria** and **Pyrenophora.** At $1.40/bushel this is $8.18 gross return. The average cost of two applications of Manzate 200 to Bonanza is $5.20 per acre, for a net return on the investment of $2.98 per acre.

Two applications of most fungicides tried were required to obtain maximum benefit, but one application with the addition of Pinolene gave substantial protection. The data suggest that Hinosan and Polyram have merit for use to control leaf rust and leaf diseases. Also, because Hinosan is a liquid, applicators would be better able to handle it. The 2.9 bushel yield difference between one application of Manzate 200 + Pinolene in comparison with one application of Polyram + Pinolene is not explainable at this time.

Results obtained with Dickson barley emphasize the need for growers to consider available soil moisture on re-crop land before using a fungicide to protect against disease. However, plump barley demands a premium for malting. A greater percentage of plump kernels means less clean-out and therefore greater profit. A producer using fungicides on barley can realize returns that are measured in other terms besides yield per acre.

References

1. Bissonnette, H. L. 1966. **Why Not Control Plant Diseases in Wheat.** N. D. Seed Journal 35:2.
2. Buchenau, G. W. 1970. **Forecasting Profits from Spraying for Wheat Rusts.** S. D. Farm and Home Research Bul. 21(1):31-34.
3. Dickson, J. G. 1959. **Chemical Control of Cereal Rusts.** Botan. Rev. 25:486-513.
4. Hosford, R. M., Jr. 1971. **Wheat Diseases.** 1970 Wheat Newsletter 17:112-114.
5. Hosford, R. M. Jr. 1971. **Wheat Leaf Blight and Blotch —Losses and Control.** N. D. Farm Research Bull. 29:1, 5-8.
6. Lloyd, E. H., Jr. 1968. **Cereal Diseases — 1968.** N. D. Seed Journal 37:3.
7. Shipton, W. A. 1968. **The Effect of Septoria Diseases on Wheat.** Australian Journal of Experimental Agric. and Animal Husbandry. Vol. 8:89-93.
8. Rowell, J. B. 1968. **Chemical Control of the Cereal Rusts.** Ann. Rev. Phytopathology 6:243-262.
9. Statler, G. D. 1971. **The Virulence and Potential Destructiveness of Wheat Leaf Rust in N. D.** N. D. Farm Res. Bull. 29:2, 7-10.
10. Weihing, J. L., D. S. Wysong and Robert Brambl. 1969. **Controlling Leaf Rust Can Increase Winter Wheat Yields.** Farm, Ranch & Home Quarterly.