Some Progress Being Made in Rust Control with Fungicides[1]

By W. E. Brentzel[2]

Although some screening of fungicides and antibiotics for rust control was done in 1955 in the greenhouse, usually the tests included materials which previously had showed merit. Materials showing promise in the screening trials were included in field trials, ranging from a few rows to larger plots, depending on the amount of each material available and its indicated merits. Some trials were carried out on 40th acre plots replicated several times. Fungicides which had previously shown value were, in a few cases, applied in fields, either by ground sprayers or airplanes.

In 1955 the rust epidemic was much less severe than in 1954. Much of the hard wheat escaped with only slight stem rust damage. On the other hand, leaf rust appeared to be more destructive.

In 1955 it was clearly shown that the severity of stem rust development depends not only upon many local factors but also upon conditions prevailing in other states. Severe drought in the winter wheat belt reduced the intensity of spore showers. Rust spores which were blown into North Dakota did not cover the state in general but appeared to be concentrated in certain areas, depending upon southern spore sources and weather conditions.

Estimates of the rust damage in 1955 for North Dakota are:

Stem rust on wheat	**6%**
Stem rust on durum	**20%**
Leaf rust on wheat	**5%**
Leaf rust on durum	**Trace**
Stem rust on barley	**Trace**
Stem rust on oats	**10%**

The cereal crop yields for North Dakota estimated by the United States Department of Agriculture as of December 1, 1955, were:

Durum	**13,770,000 bu.**
Wheat	**99,712,000 bu.**
Oats	**55,104,000 bu.**
Barley	**82,064,000 bu.**

Thus it appears there was considerable rust damage even in 1955.

The time of spray application of chemicals is important both with respect to injury of plants and control of rust. Close attention was given to the stage of grain development when the sprays were applied. Some applications were applied early, some in midseason, some when the grain was almost mature.

[1]Third annual progress report on Bankhead-Jones offset Project No. 102, control of rust with fungicides.

[2]Plant Pathologist. To the many chemical companies who furnished chemicals and assistance in this work, due credit is hereby acknowledged.

Before using any material one should know just what is to be accomplished. Many fungicides are protective. That is, if applied ahead of spore showers they ward off infection by destroying the spores as they come in contact with treated plants. When this is intended, the chemical obviously should be applied in advance of the spore shower. Another objective may be rust eradication; that is, the rust may be allowed to develop to a greater or less degree and the chemical applied as an eradicator. This type of material might possibly be the most desirable, as one could then wait to see if rust was going to be a problem. However, to eradicate rust after it once becomes established requires a strong fungicide and this may be harmful to the plant. Much work has dealt with the eradicative type of material. In these tests calcium sulfamate has often been used as a standard for comparison with other materials.

A third type of chemical is one which might possibly condition the plant by absorbing the material and translocating it to all its parts to prevent penetration of the rust fungus. That is, the material might be applied well in advance of the time when spore showers are expected, allowing the plant to absorb the chemical before rust inoculation occurs. Unfortunately, a satisfactory material which can be taken up either through the roots or leaves and thus ward off rust infection has not yet been found.

Greenhouse Trials

Fungicides and antibiotics for this series of trials were selected according to previous performance on grain crops or on some other kind of plants. Durum wheat was used in all of the tests. Plants were grown in pots. When they grew to the second leaf stage rust spores were applied and allowed to develop on the leaves. The chemicals were applied after the rust had developed for about 10 days and after spores were formed. Effects of the treatments were noted and recorded two or three days later.

Many of the treatments show considerable reduction in the rust severity. Quite a few were injurious to the plant. No doubt the injury in some cases could be reduced by lowering the concentration of the solution. Just how much reduction in the strength of solution could be made and still obtain rust control has not been learned.

The performance of treatments under greenhouse conditions was not always duplicated under field conditions. Quite a few chemicals that appeared promising in the greenhouse seemed to have little value in the field. All materials, however, that gave good results in the field also showed promise in the greenhouse trials.

Field Trials in Small Plots

Wheat was sown in plots consisting of four rod rows. These trials included chemicals not included in previous tests and additional tests of materials on which more information is desired. The

value of these chemicals for rust control is unknown although many of them have some merit for controlling other kinds of plant diseases.

Each chemical was applied as a spray to a block of four rod rows of either durum or hard wheat, using compressed air and a small portable sprayer. The first application was July 25, followed by a second on August 10. Rust was not severe in any of the plots but hot dry weather seemed to be causing considerable damage.

The severity of rust in these trials was relatively low, ranging from about 50 per cent in the non-sprayed plots down to 20 per cent in some of the sprayed plots. The yields of grain, although not subjected to statistical analysis, seemed to be correlated with the severity of the rust. Test weights in all lots ran low, due more to dry weather than to rust damage. However, as much as four pounds per bushel difference was obtained with some of the sprays. Acti-dione, when used properly so as not to injure the plants, seemed to be quite effective. This was noted especially in the early season while leaf rust was active. Sodium sulfanilate also appeared to have some value and caused no damage from burning or reduction in the germination of the seed. Some of the other preparations also seemed to have merit.

Trials in Larger Field Plots

Wheat was sown in 50 plots each measuring about 1/75 acre. These were sprayed with a few of the better known and more commonly used fungicides. Liquid Parzate, Dithane D-14, Acti-dione and calcium sulfamate were prepared in the field. Zinc sulfate was added to liquid Parzate and to Dithane D-14 to obtain Zineb. Lime was added to sulfamic acid to make calcium sulfamate. Preparing these materials in the field reduced the cost considerably below materials fully prepared at the factory. Acti-dione was emulsified by mixing with a purified light oil to increase penetration of the wheat foliage. The cost of Acti-dione, although high by the pound, would be low to the grower because only 30 parts of the chemical per million are used in the spray. The sprays were alternated one with another and applied on three different dates during the season.

Experiments have shown that calcium sulfamate applied late in the season, adversely affects the germination of the seed and the baking quality of flour made from sprayed plants. However, when applied early in the season, and followed by less injurious sprays, calcium sulfamate was not injurious.

Each spray was applied at the rate of 40 gallons per acre and was prepared as follows:

A.—Acti-dione—30 parts per million + Spreader Sticker
C.—Calcium sulfamate—1 pound in 4 gallons water + Spreader Sticker
D.—Dithane D-14—1 quart in 20 gallons + $ZnSO_4$ + Spreader Sticker
P.—Parzate, liquid—1 quart in 20 gallons + $ZnSO_4$ + Spreader Sticker
S.—Sodium sulfanilate—1 pound in 6.6 gallons water + Spreader Sticker

TABLE I.—**The effects of five chemical sprays on rust when applied to wheat in field plots.**

Three treatment[1] combination	Stem rust		Ave. Yield (grams)	Test wt. lb./bu.	Germination % in soil
	% severity	On necks			
AAA[2]	Trace	Trace	408	53	84
ASA	8	Trace	403	53	81
ACS	3	Trace	403	53	63
CAS	2	Trace	401	53	82
CAC	Trace	Trace	395	51	31
OOO	40	Some	380	53	84
CDD	3	Trace	385	53	87
SSS	7	Trace	384	53	82
CCC	Trace	Trace	383	51	18
OOO	30	Some	388	53	84
CAA	Trace	Trace	379	53	84
CPP	3	Trace	371	52	86
SAA	3	Trace	349	53	84
SAC	5	Trace	333	52	27
ACC	2	Trace	325	52	11
SCS	3	Trace	315	53	45

[1]Indicates order of three sprays—June 27, July 23 and August 1.
[2]Indicates the chemical and the order of application. A—Acti-dione, P—Parzate liquid, C—Calcium sulfamate, S—Sodium sulfanilate, D—Dithane, liquid, O—Check, no spray.

The first spray was applied June 27 when the wheat was about 12 inches tall with no boots showing. Leaf rust severity was five per cent and there was only a trace of stem rust. The second application was made July 23, having been delayed considerably by rains. The grain was in the early dough stage and leaf rust severity was 40 per cent while stem rust severity was only five per cent. The third spray was applied August 1, followed by one-half inch of rain during the night. The wheat was in the hard dough stage with most of the leaves dead, due to leaf rust and dry weather. The heads were still green. Most of the leaf rust had disappeared but stem rust severity was 40 per cent.

Although stem rust appeared early, about June 14, it was slow to develop, due perhaps to a lack of subsequent spore showers and because of dry weather in the early season. Leaf rust developed faster than stem rust in these plots. The rainy period which delayed the second application of sprays was followed by more extremely warm dry weather, which checked development of rust and also growth of the wheat plants. Under these conditions, the third spray did little or no good.

Results indicate that Acti-dione was the most effective spray, especially when applied three times in succession. Zineb (Parzate and Dithane) appeared to be valuable in reducing the rust somewhat and improved the quality of the grain. Sodium sulfanilate, as in previous tests, appeared to have value also.

Calcium sulfamate applied early, when the wheat was about 12 inches tall and in the preboot stage, appeared to cause no injury to the germination of the seed produced on sprayed plants (Table I). When calcium sulfamate was used as the second spray, germination was reduced. When used as a third spray it reduced the germination

severely. This material is an excellent eradicator of rust and could perhaps be used safely in the early season, followed by less injurious sprays such as Acti-dione, Sodium sulfanilate or Zineb.

Practical Applications

Rust has been a major problem ever since wheat has been grown in this region. No control of the blight in a really effective manner has been devised. Losses have been reduced considerably by breeding new varieties of wheat, but the new varieties have been relatively short lived because new races of rust have appeared. The frequent change of varieties that is necessary in order to deal with this problem causes much work and expense. Wheat is grown in large acreages, on a production basis, without cultivation and has not had the protection from fungicides that many other crops have had. Economy of production has not been favorable for extensive spray programs. But spray trials carried out here and elsewhere during the past three years seem to indicate that fungicides may become profitable. Wheat rust generally can be reduced and held under a measure of control, and other plant diseases are also curbed. The Acti-dione spray appeared to be quite effective against leaf rust in 1955.

A number of growers in North Dakota used fungicidal sprays for rust control during the year. In this work they were guided largely by recommendations from the Experiment Station, County Agricultural Agents and interested chemical companies. Liquid Parzate was applied to several fields. The results obtained by five growers who used Parzate follows:

	Yield (bu./acre) average	Test weight (pounds/bu.) average	% Germination in soil
"Parzate" sprayed	21.18	59	75
Unsprayed	16.08	56	70
Increase due to spray	5.10 bu.	3	5

Not all of the cooperators in these farm field trials were successful in increasing the yield and quality of the grain. Several factors often enter into this problem, such as dry weather and lack of rust development. In general the sprays were effective.

Reports from 17 growers who used Dithane D-14 show that some obtained increases of as much as 10 bushels per acre. Others were less successful. For an average of 17 growers the increase was 4.9 bushels per acre and the test weight per bushel was increased about three pounds. The extra 4.9 bushels in yield of durum wheat more than paid the cost of the chemicals. The increase in bushel weight in some cases placed the grain in a higher grade.

The cost of liquid Parzate or Dithane D-14 plus the zinc sulfate, with which these materials are mixed to produce Zineb, will depend on the number of applications. Two quarts of the chemical

per acre were used in each case, costing about one dollar. All of the grower cooperators sprayed three times, a few four times. The cost in these instances would be about three or four dollars per acre for the materials, plus cost of application.

There are fungicides other than Zineb which are effective against rust but Zineb is available and not priced excessively high. It is used extensively as a fungicide for other crop diseases, especially fruit and vegetable diseases, including blight on potatoes.

Zineb sprays are definitely protective fungicides. It is essential that the leaf surface be covered thoroughly if adequate protection is to be obtained. It is also necessary to combine a spreading and sticking agent with the material. Zineb sprays should be applied at the rate of from 25 to 40 gallons per acre to obtain good coverage of the plants. Two quarts of the liquid Dithane or Parzate are generally mixed with ¾ pound of zinc sulfate along with about ½ ounce spreader-sticker. This amount of chemical in 25 to 40 gallons of water is sufficient to cover one acre of grain. In the early season while the plants are small a little less material might be adequate, although in the late season a full dose is required for good protection.

Equipment

Low volume sprays such as two to five gallons per acre do not give adequate coverage of the plants when Zineb is used. It is often difficult for an airplane to apply much more than these low rates without making several passes over the field. Ground driven sprayers used for spraying potatoes and weeds may be adapted for using Dithane or Parzate. Most of the weed sprayers have low volume nozzles. A change to nozzles that will give a higher volume of spray per acre may be required. Also it may be necessary to change the screens in the weed sprayer to prevent plugging. Generally a 50-mesh screen will permit the spray to pass through without difficulty. It is necessary to keep the solution agitated while spraying.

The usual procedure for preparing the solution is to fill the tank about half full of water. Start the agitator or by-pass and add the correct amount of Dithane or Parzate liquid. Stir thoroughly and slowly add the zinc sulfate, keeping the agitator running all the time. The spreader sticker should then be mixed with a few gallons of water and added to the tank after which the tank may be filled and made ready for spraying.

Experimental trials up to this time have been limited largely to wheat but some oats has been included in tests the last two years. Further experimentation will include both oats and barley sprays, not only for rust but for control of other diseases as well.