The Fight Against Flax Rust[1)]

THAT LONG ROAD OF SCIENTIFIC RESEARCH, PROTECTING MAN'S FOOD AND FIBER CROPS, HAS NO ENDING

By H. L. Walster[2]

All crops are subject to plant disease. With the exception of those alterations in crops caused by purely unfavorable physical conditions, all plant diseases are caused by the invasion of the crop plant by microorganisms or small forms of plant life commonly spoken of as fungi and bacteria.

In North Dakota we are all familiar with the plant diseases of wheat, the rust fungus. One of the rust fungi causes black stem rust, another causes leaf rust and still another fungus species causes stinking smut. Flax, too, has its diseases. We have the fungus which causes flax wilt, another which causes pasmo and still another which causes flax rust.

The wheat producers of North Dakota and surrounding territory became suddenly aware of what, to them, was a new phase in the behavior of black stem rust of wheat in 1950. All of the hitherto rust resistant varieties of wheat, particularly the durums, were attacked by rust. Careful investigation of the cause showed that the rust epidemic of 1950 was largely due to the invasion of Race 15B of black stem rust, a strain not hitherto found in this immediate territory.

Many strains of black stem rust are known. By a strain of a fungus we mean that certain lots of fungus, looking just exactly like any other lot under the microscope, will nevertheless behave differently when tested against different varieties of a given crop. In other words, one race of rust may infect a dozen varieties of wheat and fail entirely to infect another dozen varieties of wheat. Over 200 physiological strains of black stem rust have been identified.

Flax rust also shows this characteristic of being subdivided into physiological races or strains. We sometimes call them strains, sometimes races. It means the same thing.

Up to 1941, we thought we had made pretty good progress in getting a high-yielding, rust resistant variety of flax in the well-known Bison variety. It wasn't until 1941 that rust hit hard, causing extensive damage to many varieties of flax. In the variety trials of the North Dakota Experiment Station, Bison was particularly damaged at Fargo and on the irrigated fields at Williston. Again in 1942, Bison was very susceptible to flax rust. Flax rust spread

[1]Second in a series of two articles.
[2]Former dean, School of Agriculture, and director of Experiment Station, North Dakota Agricultural College.

much more widely in 1942 than it did in 1941, heavily infested fields being reported from all parts of the state. In the variety trials at Fargo in 1942, the named varieties rated as susceptible to rust were Redwing, Biwing, Bison, Koto, Zenith.

Some 15 years ago plant scientists began to realize that we must be more careful in the use of the term "resistant." The question is complicated by the fact that there are degrees of resistance, or conversely, degrees of susceptibility. From the practical point of view the word we want to hear is resistance, but perhaps we would do straighter thinking if we dropped the word resistance entirely and talked about "less susceptibility." J. C. Walker, author of a textbook on plant pathology published in 1950, uses the term "suspect" which he applies to a plant which is subject to a given disease brought about by a given causal complex.

In order that a disease may spread there must be, in the case of these fungi, a crop of spores to serve as the inoculum. In the case of flax rust, the annual spread of infecting spores is from the germination of the black stage of the rust which lives over on the flax straw.

For a disease to become established it first must penetrate the crop. After it penetrates, it must start up a growth inside the plant, thus causing the typical disease development with the appearance of the symptoms which are commonly recognized on the outside of the plant. In the case of flax rust, the whole life history—that is, all stages of the development of the rust plant—go forward on flax straw and leaves. We are not concerned with any intermediate host. This means, of course, that both the male and female parts of the flax rust fungus are found on the flax plant. Wherever male and female exist, whether in the case of microorganisms or in the case of higher flowering plants, we have an opportunity for the creation of hybrids or new races.

In his years of work with flax rust here at the North Dakota Agricultural Experiment Station, Dr. H. H. Flor, plant pathologist of the United States Department of Agriculture, has collected many races of flax rust from the flax growing areas in North Dakota and surrounding states. He has also created by hybridization new races of flax rust in his greenhouse work.

Dr. Flor uses some 24 varieties of flax in differentiating the different stages of flax rust. In 1949 he made 55 rust collections from flax fields in Iowa, Minnesota, North Dakota, and South Dakota. Forty-seven of these were sufficiently alive so that degrees of susceptibility of the 24 test varieties of flax to each lot of rust in the collection could be determined.

One important conclusion was reached from these 1949 studies; namely, that there was a rapid spread of races attacking Dakota flax at that time. This spread began in 1948, when T. E. Stoa, agronomist, and Dr. Flor called attention to the appearance of rust on Dakota flax in an article which appeared in the November-

December 1948 issue of the Bimonthly Bulletin of the Experiment Station. They published a second article on this subject in the Bimonthly Bulletin in November-December 1949 issue. Late seeded fields of Dakota flax were attacked in 1948. Up to 1948 Dakota had been called immune to the races of flax rust in the midwest flax growing region.

Where did these new races of flax rust come from? Stoa and Flor advanced three possible explanations in 1949:

(1) **"That in the original search for the races of flax rust, the one which attacks Dakota flax might have been overlooked because at best a plant disease survey can only cover a small part of the area."**

(2) **"The races attacking Dakota may have been recently introduced. Such races were known to exist in Oregon on the West Coast and in South America in the years before rust appeared on Dakota flax in North Dakota."**

(3) **"New races of flax rust may have arisen by mutation. Flax rust is reestablished each year in the midwest by the processes of sexual reproduction. In that sexual reproduction a more virulent sport or mutant could easily arise thus accounting for a new race of flax rust."**

Relation of Rust Resistance to the Breeding of the Variety

In their 1948 article Stoa and Flor pointed out that Dakota is a cross of Renew and Bison varieties. Such rust resistance as Dakota flax had was derived from the Renew parent. Rust resistance of the Renew parent was derived from one of its parents, Newland. Stoa and Flor pointed out in 1948 that all varieties which get their resistance from Newland were attacked by the rust collected on Dakota flax in eastern South Dakota. These included, besides Dakota, Renew, Arrow and Custer. About 40 percent of the genetic mixtures known as Victory flax were also attacked.

The appearance of new races which attack hitherto rust resistant varieties of flax is not a new thing. In his 1949 rust collections Flor obtained a race from the South Dakota Experiment Station, at Brookings, which attacks the hitherto non-commercial resistant variety he has been using in his collection of 24 test varieties; namely, C. I. 1188 and C. I. 194. The race which attacks these two does not attack Williston Brown. Incidentally, this is only the second time in 18 years that Flor has identified a race from midwest collections of flax rust which does not attack the usually very susceptible Williston Brown. All midwest rust collections made in 1949-50 attacked either Koto or Dakota or both. In 1950 most of them attacked both. Heavy rust infections were not general in North Dakota in 1950 but there was a heavy rust infection in the Minot area in north central North Dakota, in southern Manitoba, and in southeastern South Dakota. Infections on Dakota and Koto were in most cases relatively light in the Red River Valley in 1950 probably because of the drought.

A Bit of Flax Rust History

The North Dakota Agricultural Experiment Station has been making investigations about flax rust for 50 years. The earliest published reference to flax rust occurs in the 12th Annual Report of the director, Feb. 1, 1902 when Professor H. L. Bolley called attention to the fact that for the crop of 1901 there was "a rust on flax which produced a considerable amount of damage this season."

In the 17th Annual Report of the director published Feb. 1, 1907, Bolley wrote "Culture experiments conducted in culture cages seem to disprove the theory that (flax) rust can be transmitted by the seed. Again early spring studies of straw and volunteer plants on our plots in cooperation with the aid given by Professor J. C. Arthur of the Indiana Station allow us to make known the fact not previously known that the fungus of flax rust passes on its different known spore stages upon the cultivated flax. The disease is thus ready to attack the new crop at once in the spring, the infecting spores coming direct from the old flax straw and stubble to the young plants. This seems to fully explain the great loss from the rust in our experimental plots, and allows us to announce a new reason for proper rotation of flax soil and handling of the old flax straw."

In this same report Bolley announced two farm plans regarding flax as related to rust:

(1) **"All rusty flax straw not thoroughly composted should be burned in order to destroy rust spores. Composting or burning will also destroy wilt fusaria and other detrimental fungi."**

(2) **"Rotation of soil must be practiced in flax culture in order to escape excessive rust infection, as the rust spores spread from the old straw and stubble to the new crop."**

Few people today realize the importance of the emphasis which Professor Bolley always placed upon soil sanitation. Note that he early realized that the flax straw was a source of infection. T. E. Stoa, station agronomist, has repeatedly called attention to the fact that in standard variety trials conducted on the main Experiment Station at Fargo there usually is less rust than is reported from the farms in the surrounding territory. The reason is quite evident. At the Experiment Station all flax straw is promptly removed from the fields. Early fall plowing, which completely covers the stubble, is uniformly practiced. Flax is never placed on blocks of land which raised flax the previous year nor near any blocks of land or waste piles of flax straw or stubble. In other words, the station has been practicing reasonably good sanitation farming from the point of view of not exposing the young flax plants at any stage in their growth to local infection. It does not mean, of course, that they may not subsequently be exposed from a wind borne infection that might have come in from quite a distance; in fact it is quite likely that our late season infections of flax rust are such wind borne infections.

Resistance to Flax Rust

As early as 1912 Bolley recognized that some of his wilt resistant flaxes were not resistant to rust. He calls attention to this fact about NDR 22 in his Press Bulletin 53 published March 12, 1912. In that same Press Bulletin, commenting upon the rather widely grown NDR 52, Bolley stated "It rusts slightly at times but seems to be largely resistant to rust." In the same Press Bulletin he says that NDR 73 is less wilt resistant than NDR 52 and 22 but is very strongly resistant to rust, seldom showing any rust under ordinary conditions.

When I came to North Dakota in 1919 I found that the principal rust resistant varieties being grown were NDR 52 and NDR 114. The first large distribution of NDR 114 was made by the Experiment Station in 1919. In Press Bulletin 53 published on March 12, 1912, Bolley stated concerning NDR 114, "Few, if any rust spots appear upon the plants even when surrounded by other rusty plants." He stated that the NDR 114 selection was made "especially with view of retaining wilt resistance and rust resistance." NDR 114 continued to show a general rather high degree of rust resistance even when some plants were rather heavily infected. In 1928 there was generally moderate to heavy infection of rust on flax, particularly on NDR 114 and Winona. It is of interest that only traces, that is from one to three per cent, of rust appeared on Buda and Bison in 1928. **It wasn't until 1941 then that Bison was struck down by the quite apparently new strain of rust which had been built up to a high degree of prevalence by that time.**

Besides the battle against wilt and rust, this Experiment Station's plant pathologists and plant breeders have been endeavoring to learn more about the new pasmo disease which hit hard for the first time in 1943. Some progress is already being made in getting some degree of resistance to pasmo but apparently there still is not any such degree of resistance as there is to wilt and rust.

Protecting the Reputation of the Flax Crop

There has been a notion for years that flax is hard on the land, the presumption being that it withdraws more fertility from the soil than the cereal grains. To get at the facts, the departments of Agronomy and Agricultural Chemistry began a series of careful experiments in 1947 in which Dakota flax and the three cereals, Mida wheat, Marion oats, and Manchurian barley were grown on the Station farm at Fargo under identical soil conditions, in each case seeded at timely dates for the seeding of each crop.

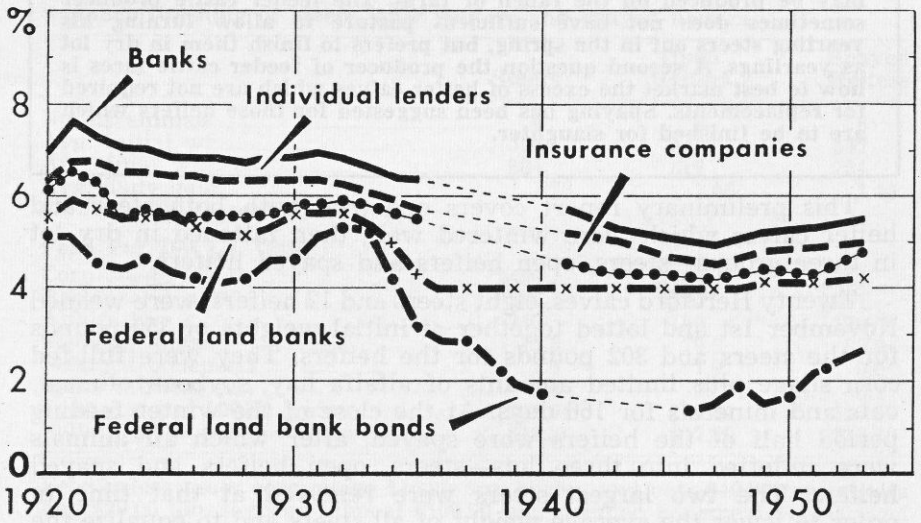
Actual yield of each crop was determined and the grain and straw analyzed for the essential nutrients taken from the soil. The amount removed by the grain is the important thing because that is ordinarily sold and removed from the farm. Under the best practical managerial conditions all straw can be returned to the soil, so let us look at the nitrogen removal by flax in each of these three years as compared to the nitrogen removal by grains.

In each of the three years at Fargo the flax crops produced removed less nitrogen per acre than either wheat, oats, or barley. The same was true of the phosphorus removal and also of the potassium removal. The amount of the essential elements removed by flax and other crops, of course, varies with the yield and with the season. Similar data, including additional figures obtained in 1950, confirm the conclusion that flax removes less fertility per acre under ordinary conditions than do the cereal crops.

On Newly Recorded Farm Mortgages

INTEREST RATES CHARGED FARMERS

Compared with Yields of Representative Federal Land Bank Bonds



U. S. DEPARTMENT OF AGRICULTURE NEG. 54 (2) - 154 AGRICULTURAL RESEARCH SERVICE

This graph shows that interest rates fell during the early twenties, increased in the late twenties to a peak in 1932, then fell to a low point in 1946 or 1947 and increased after that through 1951 and 1952. Federal land banks charge the lowest rates, as they were created to transfer funds from money markets to farmers as cheaply as possible. Next lowest rates are charged by insurance companies. They are in the market as investors. To use their funds fully they must invest a large part of them in open-market securities.

Banks and individuals charge the highest rates. They make smaller loans than those made by insurance companies and Federal land banks. The rates individuals charge on mortgage loans are affected by the rates they can obtain on other types of local loans, which are subject to less competition from lenders outside the local community.

Until 1947 interest rates charged by farm mortgage lenders drew more closely together because of the growing competition of low-rate lenders (insurance companies and Federal land banks) in local markets for loans. This was also due to surplus lending power which forced down charges. The widened spread since 1947 is due to the policy of Federal land banks of keeping their rates low, despite increases in rates of other lenders.