GROWERS who plant two new varieties of pinto beans and use sulfur dust as a control measure have less need to fear the ravages of bean rust caused by the fungus *Uromyces phaseoli typica* Arth.

The rust, like the cereal rusts, can ruin a crop in a few weeks if the weather is right. It did tremendous damage in 1927 and 1928 in northeastern Colorado. It appeared again in 1938; in 1942, in epidemic proportions, it caused a loss of a million dollars in a county where 50,000 acres of pinto beans are grown and heavy losses also in other parts of Colorado. Severe and costly outbreaks occurred in 1944 and 1945 in fields of Great Northern beans in Wyoming and Montana.

The losses were particularly bad because they came when there was heavy demand for dry beans by the armed services and farmers were expanding their acreages—in Colorado, from 421,000 acres to 595,000 acres in 1943; in Wyoming and Montana, from 49,000 and 21,000 acres, respectively, to 124,000 and 66,000 acres. Plant diseases are usually more severe where a concentration of acreage of any crop occurs, especially if environmental conditions favor the development and spread of the causal organisms. Because of the increase in acreage, farmers did not follow crop rotation as carefully as they did in previous years, and the rust was more destructive in fields that had grown beans the previous year than where another crop had been grown.

The two rust-resistant varieties became available to growers in 1946. They were developed by the Department of Agriculture in 8 years of breeding and selection at Beltsville and the Department's Field Station at Greeley, Colo. They are called Pinto No. 5 and Pinto No. 14.

As with the cereal rusts, races or strains of the bean rust occur. Before 1937 little was known about them, but since then scientists in the De-
partment have identified 24 races. Because there are so many races and they show different degrees of infecting ability, the problem of breeding resistant plants is complicated. Before making crosses for the ultimate production of a rust-resistant pinto bean, a variety that resisted as many of these races as possible had to be found. After several years of testing, a white-seeded Kentucky Wonder type that could withstand most of the races of rust was found. In 1937 it was crossed with several pinto varieties. Pinto No. 5 and No. 14 were both derived from a cross between Idaho Pinto, an early, rust-susceptible type, and the resistant white-seeded Kentucky Wonder.

The early generations were tested in greenhouses at Beltsville by inoculation with practically all the rust races. Only the resistant plants were saved. These were grown in Colorado, where selections were made for an ideal pinto type. This process of elimination was continued until 1943, when we conducted a large field test and grew 110 different hybrid lines under commercial conditions. Rust was widespread, and all the commercial varieties of pinto in the test proved to be completely susceptible, but most of the hybrid lines were resistant. Sixteen lines were chosen for commercial tests at six locations in 1944. Rust was again widespread, but the two new sorts were immune.

Besides resisting rust, the two varieties are tolerant to common bean mosaic, a virus disease that causes considerable loss in the present commercial pinto beans. No. 5 and No. 14 are also highly tolerant to a bacterial blight of beans known as halo blight (*Pseudomonas phaseolicola* Dow.), which is rather widespread in many western areas.

They resemble commercial pintos in most characteristics. They are less viny and about 2 weeks earlier in maturity than the old Colorado strain, but are slightly more viny and a little later in maturity than the Idaho and Wyoming strains. Their seed-coat pattern is practically identical with that of the commercial varieties, except that it is somewhat brighter and has a clearer white background and darker brown markings. The new pintos require approximately 96 days to reach maturity, a few days later than the Idaho and Wyoming Pintos, but about 10 days to 2 weeks earlier than the Colorado strain. Thus in many western areas they can be threshed before other row crops, like sugar beets, are harvested.

Like the Idaho and Wyoming commercial strains, Pinto No. 5 and No. 14 are primarily adapted to irrigation. Under dry-land conditions they may not yield quite so well as the Colorado strain, which is primarily a dry-land type, but No. 5 and No. 14 are fairly well adapted to those conditions, and dry-land farmers may want to grow them in preference to the Colorado strain because they mature earlier.

When we started the breeding work we realized that we would need several years to produce a rust-resistant pinto. Besides, rust was becoming a serious menace to the Great Northern beans in Wyoming and Montana,
and no variety or strain resisted the disease. So it seemed desirable to devise chemical spraying or dusting methods of control. We tried many different chemicals, both sprays and dusts, with success; but in cost, ease of obtaining materials, and efficiency, sulfur dust appeared to give the best results under field conditions in Colorado.

Bean rust overwinters as resistant black spores which germinate in the spring about the time the beans are planted. Each spore produces four smaller spores, which are spread by the wind and may infect the young bean plants. If a smaller spore lights on a bean plant, and conditions are right, it germinates and grows into the leaf. In about 10 days, small white flecks appear on the under side of the leaf; soon they break through the leaf surface, and the rust spots or pustules appear. Each pustule contains hundreds of a third kind of spore, the brown summer spores, the ones that farmers first notice. They also are blown about by the wind and spread infection to other beans. Each single spore may produce another rust spot with hundreds of spores. If the humidity is high enough, from either rain or dew or irrigation, the rust fungus produces a crop of spores in 10 days from first infection. Unless something is done to control the disease, a severe epidemic may occur.

Tests under field conditions in Colorado have proved that when sulfur is applied to beans fairly early in the season, before rust spots become visible, the control is excellent. The sulfur destroys the comparatively few rust pustules that are present at that time. The secondary spread from these spots is stopped and the formation of other infection centers is prevented. If dusting is done after the rust is rather advanced and widespread throughout the field, more applications of sulfur dust are needed and the control is not so complete. If rust is widespread in an area, two or three dustings are usually necessary, even though the first one was applied early in the season, because spores from undusted fields may later be blown to fields that were dusted. Since sulfur is effective for only about 10 days, another application is necessary if viable rust spores are present.

The ideal time to dust is when the atmosphere is quiet and the plantings are not wet with rain or dew. The sulfur should be applied at the rate of 20 to 25 pounds to the acre. If two dustings are made, 15 pounds can be applied the first time, when the plants are small, and approximately 20 pounds at the second dusting. Naturally, care should be exercised in getting as good a coverage as possible.

In parts of Colorado the Mexican bean beetle (Epilachna varivestis Muls.) is frequently a serious pest. Entomologists have found that basic copper arsenate controls this insect in Colorado and does not injure beans. A mixture of 25-percent basic copper arsenate and 75-percent sulfur dusted on beans at the rate of 20 to 25 pounds to the acre is recommended to control both rust and the Mexican bean beetle at the same time.

The cost of the materials is relatively low. The basic copper arsenate
and sulfur mixture costs about $2 an acre for materials for a single dusting. The sulfur alone costs about 75 cents per acre, and the cost of application is about $1 an acre for each dusting. We consider this to be reasonably cheap insurance for a crop, even in years when rust is not a menace.

In northeastern Colorado most growers of pinto beans have been dusting their fields with sulfur alone or the basic copper arsenate and sulfur mixture. In 1944, even though rust was serious, many farmers controlled it in excellent fashion. Some did not apply control measures until the disease was widespread; even then it was fairly well controlled, but two and sometimes three applications of sulfur were necessary. Some undusted fields were so severely damaged that they yielded only 6 to 10 bushels an acre, while most of the sulfur-dusted fields yielded 30 to 35 bushels an acre. By using sulfur the farmers reduced the production of overwintering spores, thus lessening the chances of a heavy rust infestation the following year. In 1945, although conditions were ideal for rust, only a single dusting in most cases was necessary for almost perfect control. The percentage of overwintering spores was so reduced that one thorough sulfur dusting early in the season killed the few rust infection centers and no secondary spread occurred. With cooperation from growers, the disease was nearly eliminated in 2 years.

In Wyoming and Montana, control measures for rust were not applied in 1944, and the disease was serious. In 1945 only a small proportion of farmers dusted with sulfur. Where this was done, the yield increases were outstanding.

In Wyoming, fields dusted twice yielded on an average of 1,600 to 1,800 pounds of seed to the acre; undusted fields averaged 800 to 1,000 pounds.

In Montana, dusting with sulfur was extremely successful. The fields dusted twice produced almost 1,000 pounds more seed to the acre than the undusted fields, and 610 pounds more than those dusted once. The best producing field, which was dusted twice, yielded 2,369 pounds an acre; the poorest undusted field gave only 380 pounds.

Several new disease-resistant snap beans have been developed by workers in the Department and State experiment stations.

Pioneer, released to growers in 1943, resists curly top and common bean mosaic. Its pods are dark green, short, round, straight, and stringless in the early stages. It is recommended only as a home-garden variety in sections where curly top usually causes severe injury to standard varieties.

Florida Belle is a green-podded snap bean that is adapted to the South, especially to Florida. It was introduced in 1943. It resists rust, powdery mildew, and common bean mosaic, and is tolerant to heat and drought. The plants are of the bush type, large and sturdy, and produce
long, almost flat, light-green pods. It is used principally as a market or shipping variety.

Logan is another new green-podded snap bean, somewhat like Tendergreen. It withstands powdery mildew and common bean mosaic. It is hardy and can set pods under adverse conditions, such as hot weather at blooming time. Its pods are round, long, straight, and stringless. It is well adapted to most bean-growing sections.

Several disease-resistant bush wax beans also have been released to growers since 1943. Florida White Wax is resistant to mildew, common bean mosaic, and some forms of rust. Cooper Wax, a market-garden type, resists common bean mosaic and tolerates powdery mildew. Ashley Wax, a canning type, is somewhat similar to the Refugee varieties, but has a shorter bush. It is resistant to common bean mosaic and tolerates powdery mildew.

Work on the production of varieties resistant to common and halo bacterial blights of beans is under way. Before long we can expect varieties resistant to these diseases.

THE AUTHOR

W. J. Zaumeyer, a pathologist, joined the Department in 1928 and since that time his work has dealt particularly with bacterial blights, rust, and virus diseases of beans, and root rot and leaf-spotting diseases of peas. At present his main job is to develop bean varieties that are resistant to disease and to find other ways to control certain diseases of this crop. Dr. Zaumeyer is a graduate of the University of Wisconsin.

FOR FURTHER READING


Wade, B. L.: New Wax Beans Have What it Takes, Southern Seedsman, volume 5, pages 9, 18, and 26, 1942.

Wade, B. L.: Logan, A New Hardy Snap Bean, Seed World, volume 53, pages 12, 13, 40, and 41, 1943.

ALSO, IN THIS BOOK

Genetics and Farming, by E. R. Sears, page 245.