OBSERVATIONS CONCERNING DISEASES OF IRIS AND TULIPS.[1]

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The season of 1928 was very favorable for the development of diseases among ornamentals at Lafayette, Indiana. Especially during the period of blossoming of iris and tulips, considerable rainy weather occurred. As has been previously noted[2], a garden of ornamental plants with its variety of species under more or less intensive cultivation offers unusual opportunities for the development of a large number of diseases. In the writer's garden, nearly all of the major diseases of iris, soft rot, leaf spot, sclerotial rot and rust occurred, and the principal disease of tulips, botrytis blight or fire disease, was especially virulent.

Iris Diseases.

Soft Rot. The soft rot of Iris is generally considered as caused by *Bacillus carotovorus*. Richardson finds that it differs slightly from the typical *Bacillus carotovorus* and it may be a special form of this species. *Bacillus carotovorus* causes a soft rot of a wide variety of plants such as carrot, cabbage, cauliflower, turnip, rutabaga, lettuce, cucumber, muskmelon, potato, tomato, pepper, egg plant, hyacinth, onion, etc. In the writer's garden it caused a severe rot of carrots in 1927.

In 1928, it was first noted on iris about blossoming time. Infection usually occurs either in the rhizome or at the base of the leaves. Attention is usually first attracted to the disease by the occurrence of leaves which show wilting at the tips. The bases of such leaves show considerable areas with a water soaked appearance (fig. 1). As the disease progresses, the rot develops up the leaf blade. In this way whole fans may rot off at the base, fall over, and die (fig. 2). The infected portion is reduced to a soft slimy mess. In a similar way the flower stalks may be invaded. The rotting and collapse of the tissue of the lower part of the stalk finally causes it to break over. In the rhizomes, the rot often affects only a portion of the clump. The rhizome is reduced to a soft slimy mess except for the persistent epidermis. Eventually the interior of the rhizome dries up, changing into a granular brown powder surrounded by the persistent epidermis. The rotting plants have a strong unpleasant odor resembling decaying flesh.

The way in which infection occurs is not clear. Probably infection occurs through any wound. In 1928 a whole clump of an unknown

[1] Contribution from the Department of Botany, Purdue University, Agricultural Experiment Station.

[2] Mains, E. B. Plant Diseases in a Home Garden. Proc. Ind. Acad. Sci. 37:341-353. 1928.

Fig. 1—Soft Rot of Iris. Fans showing infection at the base. These leaves were rapidly reduced to a soft, slimy, ill-smelling mess.

variety of the Germanica group died. An examination showed that this was due to a combination of borer infestation (fig. 3) and soft rot, the rot probably entering through the wounds caused by the borer. This was usually the case when infection occurred in the beardless Iris. In every instance where rot occurred in an Iris of the beardless groups, it was associated with borer infestation. Such was not usually the case in varieties of the bearded Iris. An examination of the clump illustrated in figure 2 showed no evidence of borer attack. It is probable that any injury may open the way for infection. The prevalence of the organism and its omnivorousness account for the wide distribution of the trouble.

During 1928 a clump of the Germanica type so commonly grown in gardens a generation ago was completely rotted. Of the bearded Iris the varieties, Blue Jay, Nibelungen, Quaker Lady, Queen Caterina, and Purple King were most severely infected. A number of bulbs of the variety Rosa Bonheur, an English Iris, were completely destroyed. The species *Iris laevigata, I. spuria, I. halophila, I. setosa* showed considerable rotting associated with borer infestation. Although a number of varieties and species showed no infection, no conclusion can be drawn concerning relative susceptibility since such plants probably were not exposed to infection.

Fig. 2—Soft Rot of Iris. Clump showing several fans rotted off and broken over in the foreground.

Very little is known concerning the control of this disease. The control of insects attacking the rhizomes will probably help to reduce this disease. For this reason, burning during the winter of all plant debris and weeds which harbor the eggs of the Iris borer is to be recommended. If the rot of the rhizome has not progressed too far it may be controlled, according to Hoare, by digging infected plants, cleaning away the rotted portion and then dipping in a pink solution of permanganate of potassium. The plants should then be reset in a new location which has received a dressing of lime. A number of the organic mercury compounds which are now on the market are probably well worth trying, both for the treatment of diseased rhizomes and infected soil.[3]

[3] Hoare, A. H. Iris Diseases. Jour. Min. Agr. Great Britain **32**:454-458. 1925. Soft Rot p. 457.

Richardson, J. K. A Study of Soft Rot of Iris. Ann. Rep. Quebec Soc. Prot. Plants. **15**:105-121. 1922-1923.

Van Hall, C. J. J. Das Faulen der junger Schlosslinge und Rhizome von Iris florentina und Iris germanica, verursacht durch einige andere Bacterienarten. Zeit. f. Pflanzenkrank. **13**:129-144. 1905.

Fig. 3—Soft Rot of Iris. Borers often afford entrance for the disease. This clump was almost completely destroyed by it. Note the borers among the rotting rhizomes.

Sclerotial Rot. This disease has usually been referred to as *Sclerotium Rolfsii.* A culture of the organism sent to Prof. H. H. Whetzel in 1927 was determined by him as *S. Delphinii* Welch. In a letter Professor Whetzel states that "It is certainly not *S. Rolfsii.* That species does not in my opinion occur as far north even as Lafayette, besides the sclerotia are too large for *Rolfsii.*"

This disease attacks principally the base of the leaves. Attention is usually attracted to the disease by leaves showing brown tips. When this is caused by Sclerotium (several diseases may produce a similar effect) the base of the leaves and the rhizome are covered with the white mycelial growth of the fungus on which numerous light brown sclerotia occur. As the disease progresses the leaf bases collapse and the leaves fall over on the ground and die. They usually become covered with the mycelium and sclerotia of the fungus. In the writer's garden, this disease has not been specially destructive. The damage has been limited to leaves destroyed and in most cases, only a relatively few leaves are killed. This disease, however, is undesirable, since it not only will reduce the vigor of the plants if operative over a period of years but it makes the plants unsightly.

In 1928 the disease was most severe on the varieties Lent. A. Williamson, Blue Boy, Dalila, and Pallida Dalmatica. The varieties Othello, Mithras and Albert Victor were moderately infected and Her Majesty, Dorothea K. Williamson, Blue Jay and Violacea grandiflora showed a slight infection. It is doubtful if this represents differences in relative susceptibility. To obtain information concerning varietal susceptibility to this disease it will be necessary to study varieties under conditions of uniform infection.

Very little is known concerning the control of this disease. Sulphur is apparently of little effect. In 1927 severely infected plants of the variety Pallida Dalmatica were divided and part of the divisions dusted with sulphur and planted in a new location. In 1928 this showed as much infection with Sclerotium as those which were not treated. The organic mercury compounds are well worth trying. It would be desirable to treat both the rhizomes and infested soil with these.

Leaf Spot. This disease is caused by the fungus *Didymellina Iridis (Heterosporium gracile)*. It is first noticeable as yellowish spots, which finally are surrounded by a brown margin. The whitish center finally becomes more or less covered with the black conidiophores and spores. As the infection spreads the spots coalesce and finally the leaves are entirely killed. This disease is seldom of such severity that plants are killed. The defoliation over a period of years probably reduces the vigor and multiplication of the plants and may accentuate winter-killing in the case of the less hardy varieties. The unsightly condition produced by the dead leaves is also very undesirable in an ornamental plant.

Early in the spring of 1928 all of the dead leaves of Iris varieties were removed and destroyed, following the recommendation of Tisdale. This resulted in much less of the disease during 1928. It did not appear in any amount until late in the summer. By late fall, however, it had reached a moderate development on susceptible varieties. The varieties Florentina alba, Monsignor, Fairy, Ballerine, Queen Caterina, Queen Alexandra, Quaker Lady, Violacea grandiflora showed only a slight infection. Sherwin Wright, Mrs. Neubronner, Lent. A. Williamson, Loreley, Dr. Bernice, Her Majesty, Parc de Neuilly, Purple King, Madame Chereau, Flavescens, Aurea, Rhein Nixe, Parisana, Lohengrin, Gypsy Queen, Mithras and James Boyd showed a fair amount of infection. Blue Jay, Jacquesiana, Lohengrin, Mrs. Darwin, Iris King, Mary Garden, May Queen, Storm Cloud, Honorable, and Nine Wells were moderately infected. Of the species *Iris dichotoma* and *I. tectorum* showed a slight to moderate infection. *Iris versicolor, I. halophila, I. pumila cyanea, I. siberica, I. fulva, I. pseudacorus, I. xiphium, I. xiphioides, I. Kaempferi, I. lacustris, I. cristata, I. orientalis, I. ensata, I. Bulleyana, I. setosa,* and the variety Dorothea K. Williamson showed no infection.

As mentioned above, Tisdale recommends the destruction of dead leaves in early spring. The fungus lives over winter in the dead diseased leaves and spreads from these to the young leaves in the spring. Such leaves should be destroyed before new growth starts. Some growers practice burning over their beds during the first dry period in the spring. This should be done before growth starts. The dead leaves should be dry and there should be enough wind so that the fire will travel rapidly over the plants without injuring the shallowly planted rhizomes and buds. Hoare states that vigorous plants are less likely to attack and recommends fertilizing with lime and phosphates.[4]

[4] Hoare, A. H., Iris Diseases. Jour. Min. Agr. Great Brit. 32:454-458. 1925. Leaf Spot p. 455.

Tisdale, W. B. Iris Leaf Spot Caused by Didymellina Iridis. Phytopath. 10:148-163. 1920.

Rust. The rust of Iris was introduced into the writer's garden in 1928 for the purpose of obtaining data concerning the relative susceptibility of the various varieties and species in connection with a detailed study of this disease. This disease is caused by *Puccinia Iridis*. On susceptible varieties abundant brown uredinia are produced (fig. 4), and if the infection is severe the leaves are finally killed. This disease probably is seldom very destructive. Like leaf spot and sclerotial rot it weakens infected plants and makes them unsightly. In North America this rust has been collected on *Iris Douglasiana, I. fulva, I. longipetala, I. missouriensis, I. tenax, I. tuberosa, I. versicolor, I. xiphium* (Arthur & Fromme, North American Flora 7:379). In addition, it has also been listed as occurring in other countries on *I. aequiloba, I. caucasica, I. decora, I. dichotoma, I. ensata, I. filifolia, I. flavescens, I. flavissima, I. florentina, I. foetidissima, I. fumosa, I. fuscata, I. germanica, I. gracilis, I. graminea, I. Hartwegi, I. iberica, I. Kingii, I. ochroleuca, I. Pallasii, I. pallida, I. pseudacorus, I. pseudopumila, I. pumila, I. ruthenica, I. spuria, I. tectorum, I. xiphium,* and *I. xiphioides* (Sydow Monographia Uredinearum 1:598-600. 1904). During 1928 the rust infected *I. halophila, I. xiphioides* (Royal Blue), *I. Missouriensis,* and *I. setosa* (several plants) severely. *I. dichotoma, I. spuria, I. lacustris, I. versicolor* (few plants), *I. setosa* (several plants), and *I. Bulleyana* were moderately resistant. *I. ensata, I. stylosa, I. graminea, I. pseudacorus, I. orientalis, I. sibirica, I. tectorum, I. versicolor* (several plants), *I. fulva,* and *I. Kampferi* either showed no signs of infection or a slight brown flecking. Of the bearded Iris none of the varieties showed any sign of infection. The varieties Mrs. Neubronner, Iris King, Mrs. Darwin, Lent. A. Williamson, May Queen, Nine Wells, White Knight, Gypsy Queen, Perfection, Honorable, Blue Boy, Sherwin Wright, Storm Cloud, Mary Garden, Loreley, Dr. Bernice, James Boyd, Her Majesty, Mithras,

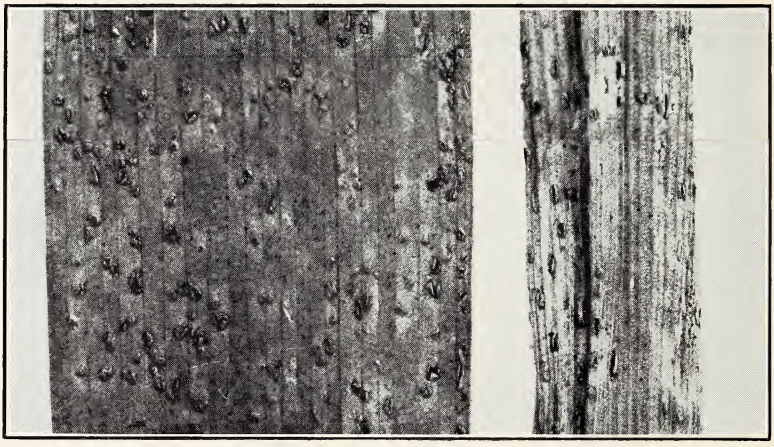

Fig. 4—Rust of Iris. Portion of leaves showing uredinia.

Blue Jay, Queen Alexandra, Quaker Lady, Parc de Neuilly, Carthusian, Albert Victor, Purple King, Madame Chereau, Jacquesiana, Flavescens, Aurea, Rhein Nixe, Parisiana, Lohengrin, Celeste, Florentina alba, Violacea grandiflora, Caprice, Monsignor, Fairy, Pallida dalmatica, Ballerine, Queen Caterina, and Georgia were repeatedly dusted with the spores of the rust without any sign of infection developing.

The lack of infection on such species as *I. fulva*, *I. ensata*, *I. graminea*, *I. pseudacorus*, *I. tectorum* and the Germanica types which have been listed as hosts indicate that either there are strains within these species of different susceptibility or races exist in the rust differing in ability to infect these species. Investigations now in progress are showing that both suppositions are true.

Apparently in the eastern part of the United States teliospores very seldom are formed. The rust probably survives the winter in the uredinial stage on the living leaves of infected plants. Destruction of leaves as soon as uredinia appear in the spring should greatly reduce this rust. Judging from the results obtained with other rusts, dusting with sulphur should control this disease.

TULIP DISEASES.

Botrytis Blight or Fire Disease. This disease of tulips is caused by *Botrytis Tulipae*. This is probably the most important disease of tulips. It is often very destructive in the tulip-growing areas of Europe and has been reported as severe in various parts of the United States. The springs of both 1927 and 1928 at Lafayette were wet and very favorable for the development of this disease. It spread rapidly and several varieties, especially those in partially shaded places, were very severely affected.

The disease usually is first indicated by yellowish to reddish contorted leaves in early spring (fig. 5). Under moist conditions these soon become covered with the grayish mass of conidiophores and spores (fig. 8). Infection rapidly spreads by means of these spores to neighboring plants. Upon these infection first is evident as small water-soaked spots (fig. 6) which increase in size, becoming yellowish or reddish, coalescing and finally involving most or all of the leaf. The flower buds may be infected before they emerge. In such cases they are blasted (fig. 6) and soon become covered with a mass of conidiophores and spores (fig. 7). Sometimes infection develops rapidly when the plant first starts to develop in the spring and oftentimes the plants are killed before they emerge from the ground (fig. 9). When infection takes place, after the flower stalks have reached their full development, the stalks and buds may show a number of brownish spots (fig. 8). The buds are often contorted, either not opening or producing imperfect flowers. Otherwise perfect flowers may be disfigured by numerous brown spots on the petals.

When infection is severe the parts affected are eventually killed and, if under moist conditions, abundant, small, black sclerotia are formed on the infected parts (figs. 9 and 10). These sclerotia serve to carry

the fungus over winter and start the disease the next spring. The dead leaves and stems are oftentimes covered with these sclerotia (fig. 10), and if they are allowed to decay in the soil the sclerotia remain to start infection the following spring. Sclerotia often develop at the

Fig. 5—Botrytis Blight of Tulips. Showing contortion of the leaves characteristic of this disease.

Fig. 6—Botrytis Blight of Tulips. Showing blasted flower buds and secondary infections on upper leaf. The lower leaf has been killed by the fungus.

Fig. 7—Botrytis Blight of Tulips. Showing sporulation of the fungus on early infected flower buds.

Fig. 8—Botrytis Blight of Tulips. Showing effect of late infection on flower buds.

base of the old flower stalks (fig. 9), on the outer brown scales and in lesions on the white scales beneath (fig. 11). These are transported with the bulb and start infection in the spring. In the fall of 1928 sclerotia were found on a number of bulbs which had been received

Fig. 9—Botrytis Blight of Tulips. Showing killing of stems and the production of sclerotia.

Fig. 10—Botrytis Blight of Tulips. Showing the development of sclerotia on debris from diseased tulips.

from Holland (fig. 11). These bulbs were otherwise in good condition, and if they had not been examined specially the sclerotia would have been overlooked. In this way the disease is introduced into gardens which have been free from it.

This disease is difficult to control since the sclerotia carry it over adverse conditions and the abundant production and dissemination of

Fig. 11—Botrytis of Tulip. Showing sclerotia on outer brown scale (left, near top) and lesion on inner white bulb scale (right) on bulbs received from Holland. The disease is introduced into plantings in this way.

conidia in the spring rapidly spread the disease. Care should be taken to plant bulbs free from the disease. Bulbs should not be planted in soil containing debris from diseased plants. As soon as the first signs of disease appear in the spring all diseased parts should be removed and destroyed before spores are produced in order to prevent the disease from spreading.[5]

[5] Hopkins, E. F. The Botrytis Blight of Tulips. Mem. Cornell Uni. Agr. Exp. Sta. 45:311-361. 1921. Review of the literature given.