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Agricultural Bulletin

THE FOOT-ROT DISEASE OF CEREAL CROPS

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It has been shown that certain species of fungoid organisms, which occur free-living in the soil and on diseased grain, may cause a diseased condition in cereals, known as "Foot-Rot." The name "Foot-Rot," which is in no way connected with the animal disease of the same name, has been given to this cereal disease because the soil fungi live as parasites on the root and lower stem and cause rotting of these lower portions. All varieties of wheat are susceptible to attack but oats appear to be resistant. Severe outbreaks of this disease in barley crops are not common.

Symptoms

Four phases of the disease may be observed throughout the crop-growing season.

(1) **Seedling Blight.**—When wheat fields are examined just before the plants begin to tiller, i.e., in winter, they may be found to contain numbers of dead or wilted seedlings, distributed irregularly throughout the coulter rows, among healthy plants. These dead seedlings may be pulled from the ground easily when it is noticed that the underground stem has been rotted through. Plants so affected are shown in the Plate below.

(2) **Spring Yellows.**—In early spring, the presence of stunted, yellowish tip-withered plants indicates another phase of the disease. Such plants when pulled are found to have a poorly developed root system and the underground stem has rotted through as in the case of Seedling Blight. At this season, however, growth is rapid and new roots are formed above the "foot-rotted" area. These enable the plant to survive and if the season is favourable for growth such plants may recover and give satisfactory yields. Typical Spring-Yellow seedlings are also shown in the Plate below.

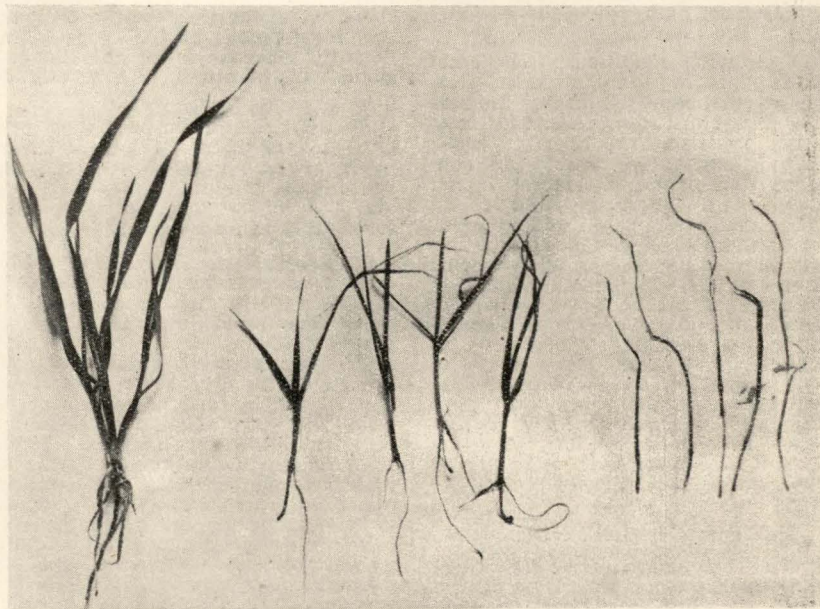
Undoubtedly in the past, these two phases of the disease, viz. Seedling Blight and Spring-Yellows, have in many instances been mistaken for Take-all, but the latter is a disease occurring in well defined circular patches and is more evident about the time the crop is coming into ear.

(3) **Whiteheads.**—Farmers frequently observe numbers of bleached empty ears in a green crop just after flowering time. This condition arises as a result of the stems being broken at the ground level. In some cases of severe foot-rot infection, this breaking

of the stems is due to the presence of the same fungi as cause the stem and root decay in Seedling Blight. In Bulletin No. 71, another condition of Whiteheads caused by a native weevil was described.

(4) **Scab.**—The last phase of the disease may be observed on mature ears at harvest time. Pinkish-brown patches on the chaff and empty florets containing a pink fungus growth or shrunken and bleached grain indicate scab infection. The fungi so far as

some serious proportions. During the 1934 season in Canterbury, the plant losses due to Seedling Blight were as high as 22 per cent. in some of the crops examined. In 1935 two fields were examined in which there was over 40 per cent. loss of seedlings. Further, it has been shown at the Canterbury Agricultural College that these soil fungi also attack germinating seeds and in some cases 25-30 per cent. of the seed sown may fail to germinate. The Spring-Yellow con-



Left: Normal healthy seedlings.

Centre: Spring-yellow seedlings. Note development of adventitious roots above the point where underground stem has rotted through.

Right: Typical examples of seedling blight; all specimens gathered from one field of Tuscan wheat about six weeks after sowing.

is known do not cause this phase of the disease by growing up the stem from infected seed or soil, but the reproductive bodies or spores of the fungus are blown on to the green ears. Here they germinate and the resulting fungus growth sets up the scab condition just described.

Economic Importance

The disease is responsible for plant mortality and reduction in yield, which, in England, North America, and Australia, has been shown to as-

dition does not cause plant mortality, but the surviving plants are stunted and produce little or no grain. Yield losses are increased further by the Whitehead and Scab effects.

Predisposing Factors

The disease is more prevalent in some seasons than in others and this suggests that there are field and growing conditions which influence the incidence of the disease.

(1) **Other host plants.** In all fields where there is a heavy infestation with

old man twitch, the degree of Seedling Blight is high. The twitch roots are carriers of the fungi and provide another means of allowing these organisms to persist in the soil. Old stubble of previous diseased crops also harbours the foot-rot organisms. Other grasses have been shown to act as carriers of the disease. For example, the disease organisms have been isolated from the roots of barley grass, brome grass and even ryegrass.

(2) Soil fertility. Foot-rot in wheat is more severe in soils rich in organic matter. The fungi live naturally on organic matter so that even when there is no cereal crop grown, the organisms still persist in the soil. Artificial fertilising seems to have little direct effect on the presence or absence of the disease. Severe attacks have been recorded in both manured and unmanured crops. Acidity measurements have shown the disease is more severe where the acidity is high, as a result of water-logged and poorly drained soil.

(3) Crop rotations. In 110 wheat crops examined by Canterbury Agricultural College only 13 were completely free from Seedling Blight. These 13 had been sown after either wheat, grass, mangels, rape, red clover or peas. On the other hand, there are instances of badly diseased wheat crops sown after each of the above-mentioned crops. The foot-rot disease is, therefore, likely to occur at any stage in the rotation.

(4) Growing conditions. The chief factors appearing to influence the presence or absence of the disease are seasonal and cultivation ones. The foot-rotting organisms are really weak parasites and thrive under soil conditions detrimental to vigorous plant development. Where growing conditions encourage a rapid and vigorous growth in the seedling stages, the degree of seedling blight and spring yellows is low. On the other hand, if, as a result of a cold, wet season or of poor cultivation, the crop is at a standstill in the seedling stage, heavy infestations of footrot are likely to occur. The fungi are more severe in their attack of the roots and stem when growth is dormant. This is further demonstrated by the fact that the disease is more evident in winter sown than in spring sown crops.

Control of the Disease

It has been shown above that there are several factors which predispose a crop of wheat to attack by foot-rotting organisms. If soil conditions encourage the activity of these organisms severe attacks of the disease will be observed. Control methods must aim at providing ideal conditions for the growth of the plant. This is influenced by seasonal conditions, but there are a number of cultural practices all of which assist plant vigour and thereby increase disease resistance.

(1) American workers have shown that under the continuous wheat cropping characteristic of their country. Foot-rot is reduced by burying the stubble deeply after harvest. They consider that the practice of skim ploughing perpetuates the disease.

Therefore, if wheat is to follow wheat, and if foot-rot is a limiting factor, deep ploughing is desirable immediately after harvest. If wheat is not being grown on the same area in the succeeding year, there is no objection to skim ploughing.

(2) The land should be made as free as possible from old man twitch and weed grasses which are carriers of the disease fungi.

(3) It has been noticed that heavy infestations occur on land that has not been sufficiently consolidated, this possibly being due to the fact that the seed has been sown too deeply. The preparation of the seed bed should be commenced early, and if at the time of sowing it is very firmly consolidated underfoot, the degree of infection is likely to be low.

(4) Water-logging, which produces acidity, must also be avoided. Therefore, liming and draining help the plant to withstand attack.

(5) The farmer should bear in mind the effect of time of sowing on the incidence of the disease. Sowings made at fortnightly intervals in heavily infested soil proved that wheat sown from the end of May until the middle of July was more severely affected than where wheat was drilled early in May or in the spring. This is bound up with growth conditions. In mid-winter germination and growth are slow, but in the early winter or spring the development of the crops is sufficiently vigorous to be able to withstand foot-rot attack to a greater degree.

(6) Seed should not be drilled deeper than two inches. Depth of sowing is important for the deeper the seed is sown the longer it takes to emerge and the longer it is in a condition susceptible to attack.

(7) Crop rotations have been considered as a possible factor influencing the disease. In view of the fact that the disease occurs after all crops, ordinary rotations cannot be altered to any great extent. The severest outbreaks of the disease in Canterbury have been recorded where wheat has been sown after Italian ryegrass and summer fallow. It must be emphasised that this does not decry the established practice of summer fallowing after grass, before sowing wheat. In the particular cases where such heavy infections occurred after fallow, it was because cultivation had not secured a firm hard seed bed. The soil was very loosely consolidated, a condition which does not promote vigorous development of seedlings and which results in sowing seed too deeply.

Consequently the crops concerned were more predisposed to attack and severe outbreaks of foot-rot were recorded. The disease is severe also after a wheat crop badly affected in the preceding year, or on a twitch infested area. The rotation should be adjusted so that wheat is not sown after these. Oats can be sown without any fear of infection.

Attention to the above practices is the first step towards prevention of foot-rot. They provide a means of ensuring a vigorous growth in the sus-

ceptible seedling stage. Seed treatment is an additional precaution, but seed treatment without good preparation of a firm seed bed, is ineffective. Dusting the seed with the dry dusts, copper carbonate, ceresan, or agrosan, at the usual rate of two ounces a bushel, has given better germination than unpickled seed on infected areas. The seed dusting, however, does not prevent foot-rot attack at the seedling stage, though it reduces mortality between the sowing and seedling stages.

The above are numerous methods of preventing the disease before sowing, but there is only one known method of reducing the loss once the disease appears in a crop, and that is by manurial top-dressing. An autumn-sown crop affected with the spring-yellows condition was top-dressed in September with a mixture of equal parts of superphosphate and sulphate of ammonia applied at the rate of two cwt. an acre. The spring-yellow plants responded remarkably to the stimulus of the top-dressing and the increases in yield more than paid for the cost of the manure. Affected plants in the non-top-dressed area succumbed later in the season or developed into stunted plants failing to produce ears. Thus by encouraging the early development of susceptible or slightly affected plants, they "outgrow" the period of susceptibility and the effect of the foot-rotting fungi.

Conclusion

Foot-rot is the name given to a disease caused by certain soil fungi which attack the roots and underground parts of wheat plants. As a result of attack during the season different conditions, described as seedling blight, spring-yellows, whiteheads, and scab, are all associated with the disease. The organisms occur also on twitch, many of the grasses, and can persist in the soil or aftermath of diseased crops. They are also seed borne. The organisms have the character of weak parasites, which become serious in effect when the plant is weakened by such adverse growing conditions as poor tilth, winter sowing, deep sowing, acidity, etc. Such growing conditions must be avoided by sound cultivation. Growing conditions, however, are influenced by season and foot-rot attack therefore fluctuates with seasons. In the 1934-35 season the disease was widespread and severe when a bad winter was experienced. During the 1935-36 season, growing conditions at the seedling stage were much more favourable, and severe attacks of foot-rot were not nearly so common, except where land was twitch infested, water-logged, or where cultivation had not produced a firm seed bed.

Copies of this Bulletin may be obtained from the Secretary, Canterbury Chamber of Commerce, P.O. Box 187, Christchurch.