Paper 10

DISEASES OF MAIZE IN NEW ZEALAND

M. Fowler
Plant Diseases Division, DSIR,
Auckland.

INTRODUCTION

There are about 120 pathogens causing significant diseases of maize (*Zea mays* L.) worldwide (Shurtleff, 1980). These include over 70 fungi, 40 viruses, 7 bacteria and 2 mycoplasmas.

Twenty-eight pathogens have been recorded from maize in New Zealand (Table 1). Only 4 diseases (some caused by more than one pathogen) are of economic importance at present — northern leaf blight, head smut, stalk and ear rots and root rot. In general, disease can be reduced by growing resistant or tolerant cultivars, using good field husbandry and using fungicidal seed treatments.

Many important diseases of maize have not yet been recorded in New Zealand (Table 2). If some of these diseases became established, losses due to disease could be increased, so all sections of the maize industry should be careful not to introduce them.

This paper updates the review of Fullerton (1978). The four major diseases are reviewed in turn, and a brief description is given of several of the minor diseases.

NORTHERN LEAF BLIGHT

Northern leaf blight is caused by the fungus *Setosphaeria turcica* (Luttrell) Leonard & Suggs; anamorph: *Exserohilum turcicum* (Passerini) Leonard & Suggs (Syn. *Drechslera turcicum, Helminthosporium turcicum*). It occurs in all maize growing areas of New Zealand and is particularly common in the Waikato. Losses due to northern leaf blight are variable, depending on both climate and cultivar. Weather conditions conducive to severe outbreaks occur about once every three seasons.

Spores of *S. turcica* persist in debris from the previous crop, and are carried by rain splash into the whorls of seedlings where they may germinate and cause lesions. Subsequently, spores produced on infected leaves can be spread by wind and rain splash, but a minimum of 1-2 days of continuous warm rain is required for the disease to spread extensively in this way. Leach, Fullerton and Young (1977a, b) showed that spore formation occurred during nights when the relative humidity remained high (>90%) for 10-12 hours. Light inhibited spore formation, and the optimum temperature was 20-26 °C. Spore release, as distinct from spore formation, was induced by bright sunlight and falling relative humidity, or by wind, or by rain.

The first signs of the disease appear within 24 hours of infection, as pale green flecks on the leaves. The lesions, which are typical of northern leaf blight, appear 10-14 days later. These lesions are elliptical, measure up to 15 cm x 4 cm, and are grey-green in colour but later become light brown or tan in the centre with grey-green margins. Under moist conditions, spores are produced on the dead tissue giving the lesion a black tinge. The lesions continue to enlarge and coalesce, and up to 70% of the leaf area may be killed (Fullerton, 1978).

Losses depend on the extent of leaf damage, and the stage of plant development. Severe damage soon after pollination can cause yield losses of up to 40%. Extensive leaf destruction later in the season causes negligible direct losses but predisposes plants to stalk rots and lodging (Fullerton, 1978).

Control

Fungicide sprays protect against initial infection, but by the time visible symptoms appear the fungus is well established within the tissue, and there is no evidence that subsequent development of lesions is inhibited by fungicides (Fullerton, 1978). Therefore their use is not economically justified.

Most of the commercial hybrids which are currently grown in New Zealand have a high level of resistance. In some hybrids the resistance if polygenic, while in others the resistance is conferred by a single 'Ht' gene.

Genetic resistance, combined with early incorporation of stubble to reduce the number of spores carried to the following season, is the most effective and economical way of controlling northern leaf blight.

HEAD SMUT

Head smut is caused by the fungus *Sphacelotheca reiliana* (Kühn) Clinton. It occurs in all the areas where maize is grown in New Zealand, but is most prevalent in the Poverty Bay region where it consistently causes significant losses averaging about 5% and up to 10%. Elsewhere losses are unimportant (Fullerton, 1975).

Spores, present in the soil or on contaminated seed, infect only during seed germination and early seedling

Table 1: Diseases of maize in New Zealand.

Pathogen	Disease	Reference
Fungi		
Ascochyta sorghi	Leaf spot	Boesewinkel (1982)
Aureobasidium zeae (=*Kabatiella zeae*)	Eye spot	Dingley (1973)
* *Botrytis cinerea*	Ear rot	Dingley (1969)
* *Chaetomium* sp.	Seedling root rot	Falloon (1982)
Colletotrichum graminicola	Leaf spot	Hill (1979)
Cochliobolus heterostrophus (=*Drechslera maydis*)	Southern leaf blight	Anon (1981)
Diplodia maydis (=*Diplodia zeae*)	Stalk rot, ear rot	Dingley (1969)
Fusarium avenaceum	Seedling root rot	Falloon (1982)
F. culmorum	Seedling root rot	Falloon (1982)
F. moniliforme (=*Gibberella fujikuroi*)	Stalk, ear, sheath, and seedling root rot	Neill and Brien (1935)
F. oxysporum	Root rot, adult plants	Fowler, M. unpublished
	Seedling root rot	Falloon (1982)
F. roseum	Root rot, adult plants	Fowler, M. unpublished
F. solani	Seedling root rot	Falloon (1982)
Gibberella zeae	Stalk rot, root rot	Brien & Dingley (1955)
Nigrospora oryzae (=*Khuskia oryzae*)	Stalk rot, ear rot	Dingley (1957)
* *N. sacchari*	Kernel blemish	Boesewinkel (1982)
* *Periconia macrospinosa*	Seedling root rot	Falloon (1982)
Puccinia sorghi	Rust	Cunningham (1931)
Pythium afertile	Seedling root rot	Robertson (1973)
Pythium monospermum	Seedling root rot	Robertson (1973)
Rhizoctonia solani (=*Pellicularia filamentosa* =*Thanatephorus cucumeris*)	Root rot	Laundon (1978)
Sclerophthora macrospora	Crazy top	Fullerton (1975)
Setosphaeria turcia (=*Drechslera turcia*, *Helminthosporium turcicum*, *Exserohilum turcicum*)	Northern leaf blight	Brien & Dingley (1955)
Sphacelotheca reiliana	Head smut	Cunningham (1945)
Trichoderma koningii	Seedling root rot	Falloon (1982)
Bacteria		
Erwinia chrysanthemi pv. *zeae*	Stem rot	Watson, D.R.W. unpublished
Virus		
Maize dwarf mosaic virus	Mosaic, stunting	Laundon, G.F. unpublished
Maize leaf fleck virus	Leaf fleck	Laundon, G.F. unpublished

* Pathogenicity not confirmed

stages (Shurtleff, 1980). Infection does not occur after this and there is no spread from plant to plant during the season. Spores on infected plants can be dispersed by wind, on grain, by contaminated machinery and in soil. Spores in the soil are the major source of infection (Fullerton *et al.*, 1974) but spores on seed or machinery provide a means of introduction of the disease to new areas.

The fungus grows systemically within developing plants. During formation tassel and ear tissues are invaded and may become almost completely replaced by a mass of dark brown or black spores. Infected ears rarely produce grain, so yield is reduced by a proportion equal to the proportion of smutted plants in the crop.

Control

Standard seed treatment fungicides (e.g. captan, thiram) effectively kill seed borne spores (Kruger, 1962) but do not prevent infection from spores in the soil. Systemic

Table 2: Some important diseases of maize not yet recorded in New Zealand.

Pathogen	Disease
Fungi	
Helminthosporium carbonum	Helminthosporium spot
Phyllosticta maydis	Yellow leaf blight
Physoderma maydis	Brown spot
Puccinia polysora	Tropical rust
Sclerospora saechaei	Downy mildew
S. sorghi	Downy mildew
Ustilago maydis	Boil smut
Bacteria	
Corynebacterium nebraskense	Goss's wilt
Erwinia stewartii	Stewart's wilt
Mycoplasma	
Spiroplasma sp.	Corn stunt
Virus	
Maize Rayado Fino virus (MRFV)	Fine striping disease
Synergistic interaction of Maize Chlorotic Mottle Virus (MCMV) with either Maize Dwarf Mosaic Virus (MDMV-A and B) or Wheat Streak Mosaic Virus (WSMV)	Corn lethal necrosis

seed treatment fungicides (e.g. carboxin, benomyl) control soil borne infections and Fullerton *et al.* (1974) recommended that seed planted in smut infected areas should be treated with both protective and systemic fungicides. The standard seed treatment in use at present contains carboxin and thiram.

Spores are known to survive in soil for several years so it would be necessary to spell infected ground for several seasons to reduce soil borne inoculum. Seed produced in smut infected districts should be treated before being moved to smut free areas. Machinery should be thoroughly cleaned, preferably by steam cleaning, before being shifted from infected to non-infected areas.

STALK ROTS AND EAR ROTS

Several fungi are commonly associated with both stalk rots and ear rots of maize in New Zealand. The four of most importance are *Diplodia maydis* (Berkeley) Saccardo [Syn. *Diplodia zeae* (Schweinitz) Leveille], *Fusarium moniliforme* Sheldon var. *subglutinans* Wollenweber & Reinking [Teleomorph: *Gibberella fujikuroi* (Sawada) Wollenweber var. *subglutinans* Edwards], *Gibberella zeae* (Schweinitz) Petch, and *Nigrospora oryzae* (Berkeley & Broome) Petch (Teleomorph: *Khuskia oryzae* Hudson). In addition, *Nigrospora sacchari* (Spegazzini) Mason was reported by Boesewinkel, 1982, causing a minor kernel blemish.

Stalk and ear rots occur in all the maize growing areas of New Zealand. The incidence is usually low, although severe localised outbreaks occur at times. Losses due to stalk and ear rots are usually small.

The causative fungi are common on grasses, in debris and in soil. Infection occurs mainly as the crop matures, particularly in prolonged wet autumns. However, infections sometimes occur earlier in the season. Cobs may become infected through the silks, and sometimes occasional plants in a green crop may turn brown and dry off prematurely due to infection with stalk rot 2-3 nodes above the ground.

Stalk rot causes the stalk to become soft and pulpy at the lesion, and the plant lodges readily. Extensive lodging can cause harvesting difficulties. Ear rots usually occur in plants which have lodged due to stem rot, particularly if the ear comes in contact with the ground. In wet conditions and in late harvested crops, undamaged plants may also be affected. Ears which have been damaged by birds or caterpillars are particularly susceptible. Ear rots may cause significant loss of grain, especially where lodging is extensive.

Control

There is little the grower can do to control outbreaks, however all commercial hubrids have been bred to strongly resist stem and ear rots. Early ploughing encourages breakdown of debris and reduces carry over of spores, and early harvesting helps to avoid losses from lodging in affected crops. Continuous cropping with maize should be avoided in areas where stalk and ear rots are prevalent.

ROOT ROT

Root rot is caused by the fungus *Rhizoctonia solani* Kühn (Teleomorph: *Thanatephorus cucumeris* (Frank) Donk, Syn. *Pellicularia filamentosa* (Patouillard) Rogers). Also usually associated are *Fusarium oxysporum* Schlechtendel: Fries, and *F. roseum* sensu Snyder & Hansen (Fowler, M. unpublished).

Isolates of *R. solani* which have been tested are all anastomosis group 2 of Parmeter *et al.* (1969).

The disease is common wherever maize is grown, although less prevalent in southern districts. It is consistently severe in much of the Waikato (Fowler, 1980). It causes lodging, which leads to harvesting difficulties and rotting of ears which come in contact with the ground. A reduced root system in severely affected plants causes yield losses up to 30% especially in drought conditions. The disease occurs in discrete patches within a crop; loss of yield of up to 5% in the crop as a whole may be attributed to root-rot (Fowler, M. unpublished data).

Sclerotia and viable mycelium persist from season to season on debris and in the soil. The pathogen occurs on the roots of grasses and clover, which are likely to provide the initial source of infection where maize is grown in fields originally in pasture. Severe root rot may occur in maize grown in fields the first season after pasture.

Profuse basidiospore production by the perfect stage of the fungus occurs at about silking stage some seasons in humid conditions, where it appears as a dull white felt-like coating on the stem near ground level. Evidence for the role of basidiospores in disease transmission is lacking.

Initial infection may occur any time from early seedling stage, but substantial root destruction mainly occurs after tassel formation. Brace roots are destroyed and otherwise apparently healthy plants lodge readily. All commercial cultivars are susceptible.

Elsewhere in the world *Rhizoctonia* in maize is of little importance and is generally associated with minor root and stem infections of seedlings and with some ear rots (Shurtleff, 1980). Recently, however, Sumner and Bell (1982) have reported in Georgia, U.S.A., severe root destruction in large, mature plants, similar to that occurring here, and caused by *R. solani* anastomosis group 2.

Control

There is no effective control. Treatment of seed with fungicide is ineffective. Careful crop management can, however, reduce losses:

- in high risk areas avoid the larger, heavier cultivars which lodge more readily under their own weight;
- avoid continuous cropping in affected areas; rotate for one or more seasons with alternative crops, but not with pasture;
- plough early to encourage breakdown of crop debris;
- harvest early to avoid lodging.

Future prospects for control of root rot by breeding resistance into new hybrids for New Zealand conditions appear hopeful. Segregating generations from crosses involving the inbred line BSD (Eagles and Hardacre, 1985) have been successively screened and selected in a *R. solani* disease nursery at Pukekohe since 1980 (M. Fowler, unpublished). Root rot resistance present in these lines appears to be associated with root form. Plants in which the brace roots are initiated at or below ground level, and which extend into the ground at a steep angle, tend to remain free of root rot, whereas those in which the brace roots are initiated well above ground level and which splay out widely are the most severely affected. Test crosses of some 108 partially inbred seed lines which have resistance to *Rhizoctonia* are being evaluated (Eagles and Hardacre, 1985).

DISEASES OF MINOR IMPORTANCE IN NEW ZEALAND

Seedling Root Rots

Fungi found associated with seedling root rots of maize in New Zealand include *Chaetomium* sp., *Fusarium avenaceum* (Corda:Fries) Saccardo, *F. culmorum* (W.G. Smith) Saccardo, *F. moniliforme* Sheldon var. *subglutinans* Wollenweber & Reinking, *F. oxysporum* Schlechtendal:Fries, *F. solani* (Martius) Saccardo, *Periconia macrospinosa* Lefebvre & A.G. Johnson, *Pythium afertile* Kanouse & Humphrey, *P. monospermum* Pringsheim, and *Trichoderma koningii* Oudemans. These pathogens are widely distributed but their incidence is usually low and they are rarely of much economic importance. The normal practice of oversowing by 10-15% to allow for losses caused by pests and diseases generally achieves the desired harvest population.

Falloon (1982) found in trials at Palmerston North, that emergent seedling numbers were increased 37-50% by several fungicide seed treatments, including thiram and carboxin, the standard seed treatment in use at present. *Fusarium oxysporum* and *Trichoderma koningii* were the most commonly isolated pathogens, and seedlings were more susceptible to these fungi at 15 °C than at higher temperatures.

Germinating seedlings are infected by soil-borne or seed-borne spores, particularly when there is cold wet weather and waterlogging after planting. Infection may result in germination and emergence failure, or wilting and death of early seedling stages. Almost all seed is treated with carboxin plus thiram which gives adequate control.

Rust

Rust is caused by the fungus *Puccinia sorghi* Schweinitz. Although widely distributed, the incidence is usually low but with occasional severe localised outbreaks. Its economic importance is negligible. Transmission is by air borne spores, which infect the leaves causing small brown or black pustules. Pustules may occur singly or in groups, or in severe cases extensive areas of leaf may be covered and killed. Control measures are unnecessary.

Sheath blotch

A variety of saprophytic and weakly pathogenic fungi, especially *Fusarium moniliforme*, are associated with sheath blotch. This disorder is very common and widely distributed, but is of no economic importance. Air-borne fungal spores colonise plant debris, especially anthers and pollen, which collect in the leaf axils. Adjacent leaf sheath tissue is then invaded to a limited extent, causing brown or black patches up to several centimetres in diameter. Control measures are unnecessary.

Crazy top

Occasional maize plants in the Waikato and Northland, are found infected with crazy top, but it is rare and of no economic importance. It is caused by the fungus *Sclerophthora macrospora* (Saccardo) Thirumalachar, Shaw & Narasimhan (Syn. *Sclerospora macrospora* Saccardo).

The fungus has a wide host range, including common weed species. Mobile zoospores are produced which infect the susceptible seedling stage of maize during periods of flooding. Infection results in stunting, leaf distortion, excessive tillering, dense leafy proliferation of tassells and developing ear.

Control measures are unnecessary.

Grey mould

Grey mould caused by the fungus *Botrytis cinerea* Persoon:Fries, has been recorded from an ear husk, and is of incidental interest only.

Eyespot

Eyespot is caused by the fungus *Aureobasidium zeae* (Narita & Hiratsuka) Dingley ex Hermanides-Nijhof (Syn. *Kabatiella zeae* Narita & Hiratsuka). Although common and widely distributed, it occurs usually in small localised outbreaks and is of little economic importance. Occasionally it may cause extensive leaf damage but is unlikely to affect yield.

Spores are produced on leaf lesions in wet weather and are spread by rain splash. Lesions develop in the form of circular spots 1-2 mm, with a light tan centre and an outer dark ring, and are surrounded by a pale green or yellow halo, scattered over the leaves. Lesions may coalesce causing extensive leaf scorching in severe cases, but control measures are unnecessary.

Leafspot

The fungi *Ascochyta sorghi* Saccardo and *Colletotrichum graminicola* (Cesati) Wilson have both been recorded causing leaf spot on maize, but these are minor diseases of no economic importance, and control measures are not needed.

Southern leaf blight

There is only a single record in New Zealand of this potentially serious disease, caused by the fungus *Cochliobolus heterostrophus* (Drechsler) Drechsler [con. stat. *Drechslera maydis* (Nisikado) Subramanian & Jain]. It is likely that temparatures are too low for it to establish and spread.

Soft rot

Soft rot, caused by the bacterial pathogen *Erwinia chrysanthemi* Burkholder, McFadden & Dimock pv. *zeae* (Sabet) Dye, is widely distributed but occurs only at a very low incidence. Consequently it is of no economic importance at present, and no control measures are needed. The disease is spread by rain splash, and usually first appears when plants are elongating but before tassels emerge. A soft slimy rot destroys leaves while still within the whorl and invades the stem resulting in collapse of the plant. The disease is associated with wet conditions. Under dry conditions, the affected tissues dry out and bind together the developing leaves, preventing or inhibiting their emergence. Such plants may grow out of the disease but are recognisable by their tattered, distorted leaves.

Virus diseases

Two diseases caused by viruses, maize dwarf mosaic virus and maize leaf fleck virus, have been recorded in New Zealand. Both appear to be minor diseases of no economic significance at present.

CONCLUSION

Growers in New Zealand are fortunate in having to contend with only a limited number of important maize diseases. Their impact is minimised by avoidance of disease prone areas, good management practices, use of resistant cultivars, and use of fungicide treated seed. Yields are high by world standards, and there is every reason to believe this may continue.

REFERENCES

Anon. 1981. *Commonwealth Mycological Institute Distribution Maps of Plant Diseases.* Map 346, Edition 4.

Boesewinkel, H.J. 1982. A list of 142 new plant disease recordings from New Zealand and short notes on three diseases. *Australasian Plant Pathology 11:* 40-43.

Brien, R.M., Dingley, J.M. 1955. Second supplement to "A revised list of plant diseases recorded in New Zealand", 1952-1955. *N.Z. Journal of Science and Technology A37:* 27-35.

Cunningham, G.H. 1931. *The Rust Fungi of New Zealand.* John McIndoe, Dunedin. 261 pp.

Cunningham, G.H. 1945. Additions to the smut fungi of New Zealand, 1. *Transactions of the Royal Society of N.Z. 75:* 334-339.

Dingley, J.M. 1957. New records of plant diseases in New Zealand. *Commonwealth Phytopathological News 3:* 10-11.

Dingley, J.M. 1969. Records of plant diseases in New Zealand. *DSIR Bulletin 192.* 298 pp.

Dingley, J.M. 1973. Eye spot disease of maize in New Zealand. *N.Z. Journal of Agricultural Research 16:* 325-328.

Eagles, H.A., Hardacre, A.K. 1985. Prospects of breeding maize cultivars specifically for New Zealand conditions. In: *Maize: Management to Market. Agronomy Society of N.Z. Special Publication 4:* 73-77.

Falloon, R.E. 1982. Fungicide seed treatment of maize to improve establishment and control seedling pathogens. *N.Z. Journal of Experimental Agriculture 10:* 197-202.

Fowler, M. 1980. Root rot — maize growers must live with it. *N.Z. Journal of Agriculture 141:* 45-47.

Fullerton, R.A. 1975. Seed and seedling diseases of maize and their control. In *Cereal Seed Diseases and Their Control.* Proceedings of a seminar held at Lincoln College, 8 July 1975, Ed. R.C. Close: 15-22.

Fullerton, R.A. 1978. Diseases of maize. *N.Z. Journal of Agriculture 136:* 42-46.

Fullerton, R.A., Scott, D.J., Graham, G.J. 1974. Effect of fungicides on the control of head smut of maize, and the relationship between infection level and crop yield. *N.Z. Journal of Experimental Agriculture 2:* 177-179.

Hill, C.F. 1979. New Plant disease records in New Zealand. *N.Z. Journal of Agricultural Research 22:* 641-645.

Kruger, W. 1962. *Sphacelotheca reiliana* on maize. I. Infection and control studies. *South African Journal of Agricultural Science 5:* 43-56.

Laundon, G.F. 1978. New host records of plant disease fungi in New Zealand. *N.Z. Journal of Agricultural Research 21:* 705-707.

Leach, C.M., Fullerton, R.A., Young, K. 1977a. Northern leaf blight of maize in New Zealand: release and dispersal of conidia of *Drechslera turcica*. *Phytopathology 67:* 380-387.

Leach, C.M., Fullerton, R.A., Young, K. 1977b. Northern leaf blight of maize in New Zealand. Relationship of *Drechslera turcica* airspora to factors influencing sporulation, conidium development, and chlamydospore formation. *Phytopathology 67:* 629-636.

Neil, J.C., Brien, R.M. 1935. Experiments on the control of pink cob-rot of maize. *N.Z. Journal of Agriculture 51:* 65-69.

Parmeter, J.R. (Jr.), Sherwood, R.T., Platt, W.D. 1969. Anastomosis grouping among isolates of *Thanatephorus cucumeris*. *Phytopathology 59:* 1270-1278.

Robertson, G.I. 1973. Occurrence of *Pythium* spp. in New Zealand soils, sands, pumices and peat, and on roots of container-grown plants. *N.Z. Journal of Agricultural Research 16:* 357-365.

Shurtleff, M.C. (ed.) 1980. *Compendium of Corn Diseases*. 2nd Edition, American Phytopathological Society. 105 pp.

Sumner, D.R., Bell, D.K. 1982. Root diseases induced in corn by *Rhizoctonia solani* and *Rhizoctonia zeae*. *Phytopathology 72:* 86-91.