BLIND-SEED DISEASE OF RYEGRASS.

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There is no need to stress the economic importance of blind-seed disease of ryegrass. Its severity in districts such as Southland has resulted in such areas in a serious decline in ryegrass seed production, but even the so-called “safe” seed-producing localities such as Hawke’s Bay may in certain seasons have many low-germinating seed crops.

Foy (1) in 1927 realised that the poor germination of perennial ryegrass in districts such as Manawatu and Southland could not always be blamed on to unfavourable harvesting weather. By 1932 Hyde (2) had discovered a fungus mycelium in the tissues and spores on the surface of ryegrass seed of low germination. He also demonstrated the transmission of the disease. The first detailed work on its identification was published in New Zealand by Neill and Hyde (3) in 1939. In this historic- paper these workers showed that the condition was caused by a specific fungus and they described the disease as blind-seed disease. They found the fungus on ryegrass seed of English, Welsh, Scotch, Irish, Swedish, Tasmanian, and Victorian origin. Their work was quickly followed by Noble (4) in Scotland, by Wilson, Noble, and Gray (5) in England, and by Muskett and Calvert (6) in Ireland in 1939 and 1940, but it was not until 1943 (7) that the first record of the disease was made in the United States, in the State of Oregon.

DESCRIPTION OF THE CAUSATIVE FUNGUS

Neill and Hyde (8) in 1942 first suggested that the causative fungus was *Phialea temulenta,* an organism which had been described by French workers in 1891 as affecting rye. The life cycle of this fungus has to be clearly understood for an appreciation of possible control measures.

Infected seed may not differ outwardly from healthy seed, though if infection has taken place at an early stage of seed development, seed may be small and shrunken. Such shrivelled seed is usually removed in machine dressing. Late-infected seed can, however; be detected only by microscopic examination after removal of the outer husks (paleae). If seed is fully formed when infected, the fungus seems unable to penetrate deeply and the seed may germinate normally.

Infected seed which either falls to the ground during harvesting or is sown in a low-germinating line of seed remains dormant until the following summer. When moisture and temperature conditions are favourable-a time usually coinciding with the flowering of the ryegrass-the fungus sends out small mushroom-like growths (apothecia) which are about Qin. in diameter. These produce spores (ascospores) which are forcibly ejected into the air when ripe and are able to infect flowering heads of ryegrass plants. This stage is called primary infection.

The next stage is the production of slime spores (conidial stage). The ascospores on the flowering ryegrass heads germinate and attack the developing seed and the fungus then produces masses of conidial spores which are encased in a slime readily soluble in water. Rain spatters the slime on to neighbouring florets and secondary infection takes place. As this secondary infection occurs nearer to the ripening stage of the seed, seed so infected is usually more nearly normal in size and is therefore less liable to be removed in machine dressing. Such blind seed reaching the ground is the source of further ascospore infection the following year.

RESEARCH INTO CONTROL OF DISEASE

In 1941 research workers investigating the disease met for the first time in Wellington and set up the Blind-seed Disease Committee. This informal committee is still meeting regularly. On the committee are representatives of the Grasslands Division, Plant Chemistry, Laboratory! and Plant Diseases Division of the Department of Scientific and Industrial Research; Canterbury Agricultural College, and the Extension Division of the Department of Agriculture. The committee pools information from all- sources; co-ordinates work, and plans the lines of research for the coming year.

1. **Control by Breeding for Resistance.** In 1945 Corkill and Rose (9) described their observations on the susceptibility of perennial ryegrass to blind-seed disease. They found that apparent susceptibility to the disease was lower in plants from four Southland old pasture lines than in plants of certified origin and that resistance and susceptibility appeared to be inherited. As a result the Grasslands Division began a comprehensive breeding programme in an endeavour to produce a resistant strain of perennial ryegrass equal in productivity and desirable agronomic characters to perennial ryegrass of pedigree origin. I understand, however, that refinements of inoculation technique have revealed that so-called resistant plants are not normally infected because of some features associated with the time and length of the flowering period. Mr Corkill will give you more details of this matter at the conclusion of this paper.

Breeding for disease resistance or "escape" in most cases is the best way of counteracting plant diseases. Italian ryegrass and to a less extent short-rotation ryegrass are normally less severely affected than perennial ryegrass. Neill and Hyde (3) suggested that the relative immunity of Italian ryegrass might be due to its later flowering, which caused it to miss the main discharge of ascospores.

2. **Control with Fungicidal Treatments:** Hair (10) at Plant Diseases Division, Auckland, tried several fungicides as sprays or dusts applied at the time of flowering. He found that Bordeaux mixture 10-8-100, Phygon, Dithane D14, and copper carbonate dust all gave a measure of control of the disease. The Extension Division of the Department of Agriculture followed up this work with 3 field trials in the 1947-48 season and 5 trials in 1948-49. Results were inconclusive in 1947-48, but in the following year Phygon spray was the most effective treatment. In a trial at Marton in 1947-48 application at the flowering stage gave significantly better results than at pre-flowering or pre-harvest. In one of the 1948-49 trials application at a late stage of flowering was more effective than application at earlier stages. The best control secured in any trial would not, however, have paid for the cost of treatment and

until more effective fungicides are available this 'does not appear to be a promising method of controlling blind-seed disease.

3. Control by Fertiliser Treatment: Noble and Gray (11) considered that the fungus attack was less in crops which had been grown under conditions of good husbandry. Gorman (12) of the Grasslands Division in this country found that crops with a dense bottom growth of white clover had lower infection. These results suggested that fertiliser treatments to stimulate crop growth might give both seed yield increases and seed of better germination. The Extension Division therefore conducted 13 replicated fertiliser trials in the seasons 1947-48 to 1950-51. In these trials the most outstanding feature was the marked increases in seed yields with the use of nitrogenous fertilisers. On the other hand no clear-cut effect from either nitrogenous or phosphatic fertilisers could be detected on seed germination or on the percentage of diseased seeds. In a trial at Levels' (out of 3 in 1947-48) significantly better germinating seed was produced on the nitrogen treated plots, but the difference was small. Similarly one trial at Balclutha (out of 7 in 1948-49) showed better germinations with increasing rates of nitrogen, though no significant effect could be detected on the percentage of blind-seed infected seed. In trials at Marton in 1949-50 and 1950-51 nitrogenous fertilisers gave marked increases in seed yields, but did not reduce the percentage of diseased seed.

In 'general, therefore, nitrogenous fertilisers on seed crops can be strongly recommended as a means of increasing seed yields, but there is, no evidence that they will affect the incidence of blind-seed disease.

4. Control by **Farm Management Practices.**

(a) Clean-seed Production. Noble and Gray (11) found that it was possible to prevent blind seed developing apothecia by immersing it in a hot solution of a mercurial seed dressing, but that though this resulted in "clean" seed, it was no guarantee that the crop would not be infected from old. seed in the ground before sowing or by. spores. blown from neighbouring areas. The fungus also lost its viability after two years' storage of infected seed.

Blair (13) at the 1948 meeting of 'the Grassland Association suggested clean seed production as a means of eliminating blind-seed disease. He has instituted at the Canterbury Agricultural College a project for the production of disease-free seed by sowing hot-water treated seed and by eliminating sources of infection from roadsides, headlands, etc. This experiment will be watched with interest.

Hardison (7) gives details of the methods adopted to control blind-seed disease in Oregon, U.S.A. In that State perennial ryegrass is primarily grown for seed production. Control is based on the elimination of badly infested fields through a programme of seed inspection and advice to growers. Clean seed is planted. Seed is sown ½in. deep and covered completely to prevent emergence of apothecia. Badly infested fields are ploughed up before the apothecia emerge. Good drainage is stressed, Straw and stubble are burnt after harvest. These methods give some idea of what is involved in a policy of clean seed production.

(b) Effect of Time of Closing: Gorman (12) found that early crops tended to have high germinations. Late crops were susceptible both to blind-seed disease and to ergot infection.

The Department of Agriculture conducted 5 trials in the 4 seasons 1947-48 to 1950-51 to investigate the effect of time of closing on blind-seed disease. Four of these trials were at Marton and one at Winchmore. In all cases seed yields and germination percentages were much reduced by closing after the end of October. In 3 trials the incidence of blind-seed disease was higher in the late-closed areas: in one trial it *was* not affected and in one disease counts were not made. The crops from late closing were usually thin and upright and some of those in early closed areas were sufficiently heavy to lodge. Factors such as this probably affected blind-seed disease incidence, but the practical importance of reasonably early closing to give good seed yields and good germinating seed has been demonstrated.

SURVEY OF FIELD CROPS

In the seasons 1948-49, 1949-50, and 1950-51 instructors of the Department of Agriculture, when making field inspections of Certified ryegrass crops, prepared information covering the growing conditions of the crops. Subsequently the yields and germinations of machine-dressed seed were secured. This information was secured from about 2500 perennial ryegrass and 1100 short-rotation ryegrass crops. It has been statistically analysed in an endeavour to isolate those factors affecting seed germination. As the main cause of low germination of ryegrass seed is blind-seed disease, it was reasonable to use germination as an indication of that disease.

For a start all crops were considered, but it was found that districts with a large percentage of high-germinating crops were obscuring the analysis. The data were therefore reanalysed and only those localities with mean germinations of about 85 per cent. or less were used. The crops were grouped into localities each of which was defined as being served by a "most representative meteorological station."

EFFECT OF LOCALITY AND SEASON

Table 1 shows the mean germinations for South Island crops. North Island crops have not been considered, as over the years in question Hawke's Bay and Poverty Bay crops greatly outnumbered others and average germinations have been high in those districts.

District and season are two of the most important factors associated with the incidence of blind-seed disease. For example, the effect of season is shown by the low germinations of South Canterbury crops in 1950-51 compared with those of the two previous seasons. The effect of district is shown by the low germinations in most seasons in South Otago and Southland.

An endeavour was made to find some factor associated with these seasonal effects. The number of rain days in 10-day periods' was selected as a measure of humidity and rainfall frequency, a rain day being one in which a measurable amount. of rain falls. The rain days at the appropriate meteorological stations were examined over the October-January period.

During the second week in December for perennial ryegrass and the second and third week for short-rotation ryegrass the number of rain days per 10-day period in districts. with high-germinating crops was not more than half the number of rain days in districts with low-germinating crops. Before and after these periods no such differences occurred. These times would be just after the main flowering of each ryegrass strain.

STATISTICAL ANALYSIS OF RYEGRASS SEED CROPS

The blind-seed disease survey considered the following factors:-.

Condition of crop (very heavy ; heavy ; medium ; thin ; very thin).

Lodging (severe (100 per cent.) ; heavy (75 per cent) ; medium (50 per cent.) ; slight (20 per cent.) ; nil).

Bottom growth (very dense; dense; medium, thin; nil).

Percentage of grass in the sward.

Number of grass crops in the surrounding fields.

Yield of machine-dressed seed.

These were examined against percentage germination. Crops were first assembled into groups each served by the same "most representative meteorological station." Those finally selected for analysis averaged about 85 per cent. or less germination in these meteorological station groupings. To get sufficient numbers of crops it was sometimes necessary to consider some adjacent "meteorological station" groupings together.

The analysis separated the effect of each factor independently of the others and made allowance for differing numbers in each class. For example, the factor "lodging" was studied with the effects of "condition of crop", 'bottom growth", "percentage of grass in the sward", "number of adjacent grass crops", and "yield" all stabilised. No allowance was made for possible interactions or correlations among these factors.

Table 2 summarises the results of the analysis and shows the following points;

Condition of crop: In most cases crop growth was not significantly related to germination. With perennial ryegrass at Temuka in 1950-51 germination was lower in the heavier crops, but at Pleasant Point, it was higher. With, short-rotation ryegrass, however, a highly significant relationship was established in two cases, germination being higher in the heavier crops., One of these was Ashburton in 1949-50 and the other Christchurch in 1950-51.

Lodging: In 4 cases, 2 with perennial ryegrasd and 2 with short-rotation ryegrass; a significant relationship was found between lodging and germination, the more lodged crops having the better germination. This amounted to a difference of about 20 per cent. germination between upright crops and those completely lodged. The effect of lodging on germination appeared to be more consistent with short-rotation than with perennial ryegrass.

Bottom Growth: With short-rotation ryegrass in no case did the amount of bottom growth affect significantly the subsequent germination. With perennial ryegrass the evidence is conflicting. In two cases germination decreased with increasing density and in two cases it increased. As, however, both of the former cases were in Ashburton and both the latter in parts of South Canterbury, one suspects that the observers in question had a different conception of what was meant by "bottom growth."

Number of Grass Crops in Surrounding Fields: In no case was this factor significantly related to germination,

Percentage of Grass in the Sward : In only 3 comparisons was a significant relationship established. In these the effect was such that an increase of 10 per cent. of grass in the sward was associated with an improvement of 5 per cent. of germination of the seed produced.

Yield of Seed: In practically all cases high-yielding crops are better germinating crops. The effect is more marked with perennial ryegrass than with short-rotation ryegrass. Consideration of all crops analysed in the survey shows that an increase of 10 bushels per acre of perennial ryegrass was associated with a 5 per cent. increase in germination: with short-rotation ryegrass the increase was only 2 per cent.

It is probable that this effect is correlated with the other factors considered. Many high-yielding crops are lodged, very heavy, and have a high percentage of grass in the sward. Nevertheless it can be stated with confidence that efforts to increase seed yields are likely to bring a worth-while bonus in the form of seed of better germination.

SUMMARY

The problem of blind-seed disease has been tackled vigorously for many years. One of the most pleasing features has been the co-operative effort of different

Government organisations and the agricultural colleges. Real progress has been made in defining the disease and its causative organism, in isolating the factors associated with heavy infection, and with breeding strains less likely to contract the disease.

Unfortunately we have little to offer the farmer in the immediate future in the shape of a practical means of avoiding the disease. No magical chemical has been discovered to defeat it. If seasonal conditions are against the seed grower, there is little that can be done to counteract the disease. Its effects can be minimised by the adoption of those practices that will in most cases give good seed yields--early closing, adequate fertiliser (especially nitrogenous), and saving seed from vigorous crops. Nevertheless I think I have shown that there is reason to hope that the future will bring a means of overcoming blind-seed disease more successfully than has been possible in the past.

REFERENCES

(1) Foy, N. R.: N.Z. Journal of Agriculture (1927): vol. 34, p. 188.

(2) Hyde, E. O. C.: N.Z. Journal of Agriculture (1932) : vol. 44, p. 316.

(3) Neill, J. C. and Hyde, E. 0. C.: N.Z. Journal of Science and Technology (1939): vol. 21, p. 281A.

(4) Noble, M.: Annals of Applied Biology (1939) : vol. 26, p. 630.

(5) Wilson, M., Noble, M., and Gray, E. G.: Nature (1940): vol. 145, p. 783.

(6) Muskett, A. E. and Calvert, E. L.:. Nature, (1940) : vol. 146, p. 200.

(7) Hardison, J. R.: Phytopathology (1948) ; vol. 38, p. 404.

(8) Neill, J. C. and Hyde, E. O. C.: N.Z. Journal of Science and Technology (1942) : vol 24, p. 65A.

(9) Corkill, L. and Rose, R. E. R.: N.Z. Journal of Science and Technology (1945) : A: vol. 27, p. 14.

(10) Hair, J. B.: N.Z. Journal of Science and Technology (1952): A: vol. 34, p. 11'7.

(11) Noble, M. and Gray, E. G.: Scottish Journal of Agriculture (1945): vol. 25, p. 94.

(12) Gorman, L. W.: N.Z. Journal of Science and Technology (1940) : vol. 22, p. 79A.

(13)' Blair, I. D.: Proceedings 10th Conference N.Z. Grassland Association (1948): p. 8.

TABLE 1-Continued.

Average Percentage Germination of Ryegrass Crops to Various Localities.

"Most Representative Meteorological Station"	Perennial Ryegrass						Short-rotation Ryegrass					
	1948-49		1949-50		1950-51		1948-49		1949-50		1950-51	
	No. of Crops	Average Germination	No. of Crops	Average Germination	No of Crops	Average Germination	No. of Crops	Average Germination	No. of Crops	Average Germination	No. of Crops	Average Germination
Timaru	61	87	41	79	160	64	40	92	22	73	57	80
Temuka	32	94	20	78	86	80	12	90	8	88	29	84
Geraldine	11	93	7	77	28	86	12	91	9	91	6	87
Pleasant Point	14	92	9	77	61	77	11	94	5	91	25	88
Fairlie	4	80	3	69	16	66	13	90	8	72	8	86
Maungati	4	88	—	—	—		1	85	—	—	—	—
Waimate	38	78	15	77	101	63	46	91	14	64	31	77
Oamaru	17	82	5	84	47	92	32	83	7	85	25	77
Waipiata	4	73	1	46	—	—	2	51	—	—	—	—
Alexandra	29	88	29	90	7	82	7	91	—	—	2	83
Queenstown	11	88	6	89	19	84	2	92	—	—	10	86
Ophir	—	—	4	86	9	80	1	64	—	—	—	—
Roxburgh	—	—	2	92	2	93	1	90	—	—	—	—
Hawea	—	—	—	—	20	83	—	—	—	—	—	—
Balclutha	—	—	1	68	-		5	76	—	—	11	66
Gore	—	—	—	—	—		14	63	7	63	30	78
Lumsden	—	—	1	83	—	—	—	—	14	66	1	79
Wendon	1	36	—	—	—	—	3	77	—	—	—	—
Invercargill	3	58	8	53	—		7	75	11	69	25	86
Milton	—	—	—	—	—		—	—	—	—	5	61
Tapanui	—		—	—	—		—	—	11	64	1	41

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	No. of Crops	Average Germination	No. of Crops	Average Germination	No of Crops	Average Germination	No. of Crops	Average Germination	No. of Crops	Average Germination	No. of Crops	Average Germination
Eyrewell	12	89	—	—	46	87	8	88	1	94	19	82
Ashley	—	—		—	2	83		—	—	—	11	76
Amberley	19	88		—	48	93	2	77	—	—	9	91
Loburn	22	85	—	—	25	85	25	88	—	—	—	—
Rangiora	15	84	—	—	37	85	6	83	—	—	10	80
Balmoral	23	90		—	12	93	1	72	—	—	—	—
Oxford	—	—	—	—	2	94			—	—	2	67
Hanmer	6	92	—	—	—	—	—	—	—	—	—	—
Culverden	4	92	—	—	21	92	2	91	—	—	2	90
Happy Valley	6	92			5	86			—	—		—
Waiau	16	95		—	31	86	—		—	—		—
Cheviot	19	91		—	22	93	1	95	—	—	—	—
Rotherham	—	—	—	—	7	95	—	—	—	—	3	92
Christchurch	14	83	25	88	94	88	22	91	15	90	75	84
Wigram	4	74		—	4	90	—	—	—	—	2	89
Lincoln	3	79		—	16	91	—		—	—	31	90
Kirwee	—	—	2	94	—	—	—		—	—	5	92
Darfield	—	—	18	71	30	84	—		12	84	16	84
Hororata	—	—	9	51	18	85				—	4	89
Ashburton	88	80	57	84	161	83	57	93	67	81	103	86
Methven	5	81		—	17	88	13	91	—	—	1	95
Rudstone	2	82	2	25	8	71	—	—	1	96	20	81
Winchmore	—	—	—	—	22	80	—	—	—	—	12	87
Geraldine	—	—		—	5	92			—	—	—	—

TABLE Z-Continued.

Results of Survey of Ryegrass Seed Crops.

NOTE: N.S. : No significant relationship between factor and germination.
* : Relationship significant at 5 per cent level.
** : Relationship significant at 1 per cent level.

Condition of crop : Positive means germination increases with heaviness.
Lodging : Positive „ „ increases with lodging.
Bottom growth : Positive „ „ increases with density.

Per cent. grass and yields: Positive figures mean germination increases with more grass and higher yield.

Met. Station District Grouping	Type of Ryegrass	Season	No. of Crops	Mean Germination %	Condition of Crop	Lodging	Bottom Growth	No. of Grass Crops Surrounding	% Germination per % Grass in Sward	% Germination per Bushel Yield
Waimate	Perennial	1950-51	101	63.3	N.S.	Positive**	N.S.	N.S.	N.S.	0.8**
Central Otago	Perennial	1950-51	57	84.9	N.S.	N.S.	N.S.	N.S.	N.S.	0.1
Ashburton	Short-rot	1949-50	75	79.4	Positive**	Positive*	N.S.	N.S.	N.S.	0.2**
Timaru-Fairlie, Waimate	Short-rot	1949-50	42	70.2	N.S.	N.S.	N.S.	N.S.	N.S.	0.2
Gore	Short-rot	1949-50	43	82.5	N.S.	N.S.	N.S.	N.S.	N.S.	0.2
Eyrewell, Ashley, Rangiora, Oxford	Short-rot	1950-51	42	79.4	N.S.	N.S.	N.S.	N.S.	N.S.	0.2
Christchurch	Short-rot	1950-51	75	84.5	Positive**	N.S.	N.S.	N.S.	N.S.	-0.2*
Ashburton	Short-rot	1950-51	103	86.3	N.S.	N.S.	N.S.	N.S.	N.S.	0.2**
Timaru-Waimate	Short-rot-	1950-51	88	78.8	N.S.	N.S.	N.S.	—	0.5*	0.3
Gore-Southland	Short-rot	1950-51	71	79.1	N.S.	Positive*	N.S.	N.S.	0.3*	0.3

TABLE 2.

Results of Survey of, Ryegrass Seed Crops.

NOTE: N.S.: No significant relationship between factor and, germination.
:* Relationship significant at 5 per cent level.
** : Relationship significant at 1. per cent level.

Condition of crop :	Positive means germination	increases with heaviness.
Lodging :	Positive „ „	increases with lodging.
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Ashburton	Perennial	1948-49	88	79.5	N.S.	Positive*	**N.S.**	**N.S.**	N.S.	**0.5****
Timaru	Perennial	1948-49	59	87.2	N.S.	N.S.	N.S.	N.S.	N.S.	**0.1**
Waimate	Perennial	1948-49	38	78.0	N.S.	N.S.	Positive*	**N.S.**	**0.6***	0.1
Ashburton	Perennial	**1949-50**	57	83.4	N.S.	**N.S.**	Negative*	N.S.	N.S.	**0.4***
Timaru, **Temuka**, Geraldine, **Pleasant** Pt., Waimate	Perennial	**1949-50**	97	78.3	N.S.	N.S.	N.S.	N.S.	N.S.	**0.2****
Ashburton	Perennial	1950-51	161	82.6	N.S.	N.S.	Negative**	N.S.	N.S.	**0.5****
Darfield-Hororata	Perennial	**1950-51**	57	84.4	N.S.	N.S.	N.S.	N.S.	N.S.	**0.7****
Loburn-Rangiora	Perennial	1950-51	62	84.8	N.S.	N.S.	N.S.	N.S.	N.S.	**0.5****
Timaru	Perennial	1950-51	**160**	64.2	N.S.	N.S.	N.S.	—	N.S.	**0.8****
Temuka	Perennial	1950-51	86	79.6	Negative*	N.S.	N.S.	—	**N.S.**	**0.7****
Pleasant Point-**Fairlie**	Perennial	**1950-51**	77	f4.9	Positive*	N.S.	Positive*	—	N.S.	**0.5****

DISCUSSION.

L. Corkill: Mr Lynch has mentioned the work of Grasslands Division in attempting to breed a strain of ryegrass resistant to blind seed disease. It may be of interest to review the position to date.

As far back as 1939 we had located a number of plants which appeared to be resistant to the disease, but unfortunately they were of poor agronomic type. We therefore set out to try to combine this resistance with good agronomic characters.

The method was to cross the resistant plants with plants of pedigree origin, select for resistance and improved type in the progeny plants, cross these again to pedigree plants, and repeat the process for a number of generations.

To determine whether plants are really resistant to the disease it is essential to have a technique of infection which will ensure that susceptible plants will always be infected. In our work the problem of consistently getting high infection in susceptible plants has been a very real one.

We have tried putting plants out in the field to allow them to become naturally infected, both at Palmerston North and Gore, but the results have been very inconsistent.

We have also tried various methods of artificial inoculation. The standard method we adopted was to hold the plants under fairly humid conditions in cool frames and inoculate during flowering by spraying with a water suspension of spores.

Results from this method were much more reliable than those from natural field infection, but in some seasons inconsistent results were obtained.

It was therefore decided last season to obtain more precise information on those factors which affect the success of artificial inoculation. Many factors would be concerned-for example, humidity, temperature, and stage of flowering at the time of inoculation.

It was this last factor which proved to be all-important.

A single head of perennial ryegrass has about 100 individual florets. Flowering proceeds systematically throughout the head. About one week elapses from the blooming of the first to the last floret. During flowering the glumes of each floret remain open for about one hour.

An experiment was carried out to determine the importance of the exact stage of flowering at the time of inoculation.

A group of clonal plants known to be susceptible was inoculated by spraying with a water suspension of spores about 20 minutes after pollination and while the florets that bloomed that day were still open. Another group of the same plants was inoculated 1¾ hours later when all the florets had closed. Both groups had been flowering for some days and records had been kept of the flowering dates of individual florets. It was therefore possible to calculate the effect of inoculation on florets which were inoculated when open, or just closed, or 1, 2, 3, and 4 days after flowering.

A duplicate series of the same plants was inoculated at the same times by dusting the florets with ascospores, the spores which cause the primary stage of the disease.

The results showed that with both ascospores and macroconidia (i.e., primary and secondary spores) high infection (over 90 per cent.) was obtained only if inoculation was carried out when the florets were actually open. If inoculation was delay& until the florets had just closed! the percentage infection was greatly reduced. With **macroconidial** inoculation it fell to about SO per cent., and with ascospore inoculation to less than 5 per cent. Inoculation. at later stages resulted in very low infection.

It was quite obvious that to get really high infection inoculation had to be carried out when the florets were actually open.

It was also found that if inoculation were made at this stage, neither high humidity nor damp conditions was necessary to obtain high infection. Under ordinary glasshouse conditions very high infection could be obtained. The important point was to inoculate when the florets were open.

It was **decided** to apply this critical test to plants which previously had appeared resistant.

Twelve of these plants and two supposedly resistant Italian **ryegrass** plants were inoculated.

Only one showed a significantly lower infection than the susceptible control plant.

It is clear that our supposedly resistant plants are not resistant if inoculated at the appropriate time, i.e., when the florets are actually open.

But there is a lot of evidence that certain strains are leas severely attacked in the field than the Certified strain of perennial ryegrass. I' could quote some of the Canterbury old-pasture lines and Southland old-pasture lines. Italian and short-rotation **ryegrass** also are not usually as severely attacked as Certified perennial ryegrass.

It seems likely that these strains escape the disease rather than that they have any definite physiological resistance, The escape mechanism is probably associated with differences in flowering characteristics associated with different strains.

For instance, it is known that some -of the old-pasture South Island lines are normally about a week earlier flowering than Certified perennial **ryegrass** while Italian **ryegrass** is **about a** fortnight later.

Between individual plants there are differences not only in date of flowering but also in the daily rhythm of flowering. In some plants the florets open earlier **and** stay open longer than in others.

These flowering characteristics may be the contributing factor in determining whether a plant will escape primary infection by ascospores. For remember, primary infection takes place practically only when the florets are open during flowering.'

The degree of escape will be determined by the degree to which flowering does not coincide with the main period of **asco**spore production.

It is realised that high infection in a crop could be obtained with only a small amount of primary infection, if the conditions for secondary infection were favourable, but, other things being equal,. the lower the primary infection, the lower the ultimate infection.

This season an experiment is being carried out to determine the effect of date of flowering in the field *on* infection.

One hundred and twenty plants known to be susceptible and in which we have a range in flowering extending from 30 September ‘to about the end of December have been put out in an area sown with a highly infected ryegrass line. This area should be a good source of primary infection.

With such a wide flowering range we should be able to determine whether primary infection in the field takes place over a wide season or is restricted to a narrow period. Of course, such an experiment will have to be repeated for some seasons.

Work is also being carried out to determine the concentration of ascospores in the air throughout the season.

For this work Mr J. C. Neil1 is using an ingenious machine designed by the Chemical Engineering Section of the Dominion Laboratory to sample the air for spores over an extended season at different times of the day and in various locations.

Results from such work should provide information which will assist in assessing the possibilities of breeding for escape to the disease.

Apart from plants which produce high germinating seed because they escape the disease, there may be plants somewhere which are truly resistant. We should continue to search for such plants. Now that we have a reliable artificial inoculation method we can readily distinguish them.

Q. Did you find less evidence of blind seed in first harvest crops ?

A. This was not specifically examined but it may have been a factor.

Dr. I. D. Blair advocated the production of disease free seed. by securing seed from pastures that are known to have a history of producing ‘disease free seed. This had been accomplished in Oregon. The essential features are the sowing of clean seed in clean land ensuring the reduction of infection by cutting out infected material in the vicinity.

Q. Dr. Hardison has controlled blind seed in Oregon since 1945 and I feel that an attempt should be made-to *follow* up this work in New Zealand. Its success of course depends on the co-operation of the farmers;

A. In Oregon ryegrass is grown almost entirely for seed production. Growers there can therefore take more drastic measures than we can in New Zealand where ryegrass is grown chiefly for grazing. Because we have experimental evidence that the distribution of spores is extremely widespread very large scale farmer- co-operation would be essential.