Effect of powdery mildew (Erysiphe graminis f.sp. tritici) on spring wheat in Finland

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Abstract. In 1970—72 the effect of powdery mildew on Finnish spring wheats with different field resistance was studied. For the mildew control 1 kg/ha Karathane WD (22.5 % Dinocap) was used. These investigations showed that mildew control increased grain yields in susceptible varieties by 2.4 to 6.6 %. The 1000-grain weight increased by 2.2 to 5.3 %, respectively. On the more field resistant spring wheats mildew control had no particular effect. Mildew control evened out the relative yield differences between the varieties.

The paper includes notes on the occurrence of mildew in Finland while the need for resistance breeding is also discussed.

Reports from various Scandinavian countries indicate that powdery mildew is considered a very important plant disease, which causes great yield losses in wheat and barley (HERMANSEN 1968, JOHANSEN 1963, LEIJERSTAM 1962, 1965, 1972b, SVENSSON 1971). In Finland the amouts of yield losses caused by mildew are not known. Mildew is, however, frequent in most wheat fields every year, and many varieties display a high percentage of infection (NISSINEN 1969).

In the present paper an attempt is made to clarify the effect of powdery mildew on spring wheats and to discuss the importance of mildew resistant varieties in Finnish conditions.

Material and methods

The tests were carried out at The Hankkija Plant Breeding Institute. The trial fields and the varieties used in the tests are presented in Table 1.

The method used was split plots with 4—6 replicates. Each plot measured 8 sq.m. The plots were fertilized with 1000 kg/ha of compound fertilizer. Thus 150 kg N, 88 kg P and 126 kg K were applied per hectare.

Table 1. Effect of mildew control (spraying with Karathane 1 kg/ha) on the yields of some spring wheats in 1970–1972 in Finland.

Trial field and year	Treatment	Variety	Mildew %	Grain yield kg/ha	Grain yield Ratio	Grain yield Change	Yield increase kg/ha	Yield increase %	1000-grain weight g	1000-grain weight Change	1000-grain weight Increase (%)
	Unsprayed	Ruso	9	2945	100	2760–3055			38.4	37.8–38.9	
	»	Touko	9	2896	98	2740–3062			36.3	35.5–37.0	
Tammisto (60°)	»	Veka	4	2658	90	2603–2731			33.7	32.5–34.9	
1970	Sprayed	Ruso	5	3017	100	2940–3180	+72	+2.4	40.1	38.2–41.8	+4.4
	»	Touko	5	3020	100	2755–3261	+124	+4.2	37.4	36.3–38.1	+3.0
	»	Veka	1	2661	88	2472–2830	+3	+0.1	33.7	33.1–34.2	+0.0
	Unsprayed	Ruso	12	4728	100	3840–5270			46.7	45.7–47.7	
	»	Hja a376	13	4610	94	4040–5120			48.4	47.0–50.7	
Tammisto (60°)	»	Hja a145	5	4912	104	4560–5320			43.2	43.0–43.7	
1971	Sprayed	Ruso	7	4925	100	4150–5560	+200	+4.2	48.3	47.1–49.2	+3.4
	»	Hja a376	7	4742	96	4550–5120	+132	+2.8	51.0	50.3–52.1	+5.3
	»	Hja a145	1	4895	99	4060–5350	–17	–0.3	42.7	42.1–43.5	–1.1
	Unsprayed	Ruso	25	3950	100	3187–5425			45.8	45.0–46.9	
	»	Hja a376	30	3727	94	3325–4887			46.5	45.6–48.0	
Nikkilä (61°)	»	Hja a145	5	4300	109	3562–5875			42.3	41.7–43.0	
1971	Sprayed	Ruso	10	4212	100	3437–5100	+262	+6.6	47.6	46.8–48.5	+3.9
	»	Hja a376	12	3919	93	3287–4650	+192	+5.1	47.8	46.1–50.4	+2.8
	»	Hja a145	3	4360	103	3212–5362	+60	+1.4	43.0	42.9–44.8	+1.6
	Unsprayed	Ruso	10	4700	100	4312–5150			40.8	40.5–41.0	
	»	Hja a1416	10	4796	102	4500–5075			36.2	35.9–36.5	
Anttila (60°)	»	Hja a145	3	5158	109	5050–5275			36.7	36.0–37.1	
1972	Sprayed	Ruso	6	4881	100	4575–5225	+181	+3.8	41.9	41.5–42.2	+2.6
	»	Hja a1416	5	4933	101	4500–5212	+137	+2.8	37.0	36.9–37.2	+2.2
	»	Hja a145	1	5062	103	4500–5300	–96	–1.8	36.7	36.0–37.1	+1.6

F-values for grain yields in 1972	
Karathane spraying	2.073°
Variety	5.146*
Variety–Karathane spraying	1.018°
	($LSD_{5\%}$ 217 kg/ha)

t-values for grain yields in 1972	Unsprayed	Karathane spraying
Ruso–Hja a145	3.129***	1.224°
Ruso–Hja a1416	<1	<1
Hja a145–Hja a1416	2.449*	<1

For mildew control, 1 kg/ha Karathane WD (22.5 % Dinocap) in 1000 liters of water was used (Crosier and Szkolnik 1956, Smiljakovic 1966). Spraying was repeated three times with two weeks intervals, as from the appearance of mildew pustules, on June 21—26.

The incidence of mildew was estimated at the time when it reached its maximum. The persentage of the leaf area covered by mildew on the upper four leaves was calculated.

Results

Karathane spraying increased the grain yields of Ruso, Touko, Hja a 376 and Hja a 1416, changing 2.4 to 6.6 %. The 1000-grain weight increased by 2.2 to 5.3 %, respectively. The mean increases in grain yield and 1000-grain weight in the Ruso variety were 4.2 and 3.6 %. On more field resistant varieties, Veka and Hja a 145, the effect of mildew control was not particularly noticeable (Table 1).

The relative yield differences between susceptible varieties were same in both treatments. On the other land, the field resistant line Hja a 145 yielded 4—9 % more than Ruso on unsprayed plots. However, Karathane spraying increased the grain yields of Ruso so that the ratio of Hja a 145 was not more than 99—103 (Table 1). Owing to drought, there were some difficulties in shooting, and that may explain the great differences in yields between the replications. The occurrence of mildew was not very intensive in these years, perhaps because of the rather late occurrence and drought which retarded the vigorous growth of the wheat stands. Karthane was not able to keep the stands completely free from mildew.

Discussion

In most years, high incidence of mildew in spring wheat is due to abundant mildew pustules on winter wheats in spring and early summer. Winter wheat is the main source of mildew infection on spring wheat. In South Finland the first traces of mildew in spring wheats occur around mid-June and the heaviest contamination takes place from the end of June to the end of July.

Usually the best crops are most severely attacked. In many cases, however, mildew exhibits greatest damages with crop yields that are below average (Pollhamer 1965). For instance, drought increases the injuriousness of mildew because the fungus increases the transpiration and adds to the need for water.

Finnish varieties are susceptible to mildew and show in many years a relatively high level of infection (Nissinen 1969, Fig. 1). The marked yield increases in the susceptible variety Ruso achieved by mildew control agree with the assumption that mildew must even in Finland be considered one of the minimum factors influencing specific yielding capacity. According to Large and Doling (1962, 1963), yield losses in barley in British circumstances could be expressed as $2.5 \sqrt{M\,\%}$, where M means per cent green leaf area covered by mildew on the upper four leaves at heading stage. The corresponding scheme for winter wheat is $2 \sqrt{M\,\%}$. Although too much stress should not be laid upon these figures, they have been found to agree to a fairly large extent with the estimate of total yield loss in spring wheat formed on the basis of official varietal trials e.g. under Swedish conditions (Leijerstam 1962, 1972 b). Thus, if the mildew percentage is 1 to 10, the theoretical yield losses are 2 to 8 % of the total yield. In Finnish conditions the figures must be lower owing to the late occurrence of the mildew infection and the fast development of crops. It is also worth noticing that mildew control evens out the yield differences between varieties with various mildew infections. There are, however, some difficulties in studying the real effects of mildew on the total yield in field conditions. Mildew mainly affects grain development decreasing the 1000-grain weight. This is likely to be a good basis for estimating losses caused by mildew in different years. In Table 1 the figures of 1000-grain weight conform quite credibly to those of grain yields.

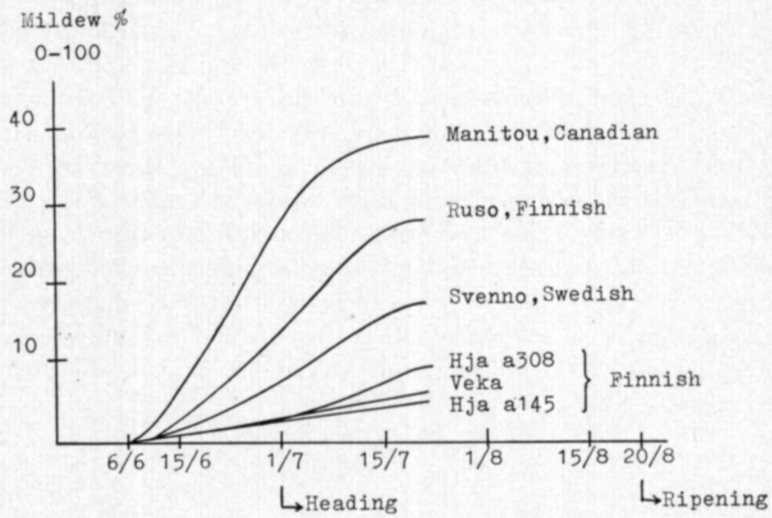

Fig. 1. Development of mildew infection in some spring wheats at Tammisto Experimental Farm in 1968 (Nissinen 1971).
Veka, Kärn II × Tammi
Hja a145, Veka × (Kärn II × Kimmo)
Hja a308, Ruso × (Kimmo × Aurore)

Fig. 1. shows the differences in the development of mildew infection on varieties due to various levels of field resistance. The results stress the importance of this kind of resistance. It is likely that in Finnish conditions the specific field resistance of different varieties is brought about quite clearly by the short growing season and the fast development of crops. From the plant breeder's point of view, choosing field resistant lines is, however, no solution to breeding mildew resistant varieties. According to Fajersson and Lundin (1969), combining a gene for mildew resistance into the field resistance variety Ring increases the grain yield in the new variety Rang in many cases by 10—15 %. One reason for mildew control not having any distinct effect on the more field resistant varieties Veka and Hja a 145 in trials in 1970—72 could have been the fact that mildew in those years was quite late and

infection was relatively low. It must also be noticed that Karathane is not effective enough to control mildew (SVENSSON 1971).

Table 2. Reaction of test varieties to powdery mildew (Erysiphe graminis f.sp.tritici) in 1971–1972 in Finland.

Variety	Trial field			
	Tammisto 60°N	Anttila 60°N	Nikkilä 61°N	Lieto 60°N
Ulka	2–3	2–3	1	2
Hope	3–4	3–4	3	4
Chul	3–4	3	3	4
Axminster	3	3–4	3	3–4
Normandie	0–1	0–1	1	0–1
Salzmünde 14/44	1	0–1	0	0
Halle 13471	0–1	0–1	0–1	0
Weihenstephan M_1	0–1	0–1	0–1	0–1
C.I. 12633	0–1	0	0	0
Idaed 59B	0–2	1	1	1
FAO 163b	0–2	0–2	2	1–2
Kenya × Lemphi 50–13596	0	0	0	0
Amphidiploid 15 AD 4/14–2/6	0	0	0–1	0–1
Norin 29	0–2	2	–	–

0, immune, no sign of infection
1, very resistant, minute lesions
2, moderately resistant, small lesions with slight necrosis
3, moderately susceptible, lesions medium in size, no necrosis
4, very susceptible, great pustules without necrosis

Test varieties with different combinations of genes for resistance are also used in order to follow the variation of aggressiveness of mildew (Table 2). The racial population in Finland has not been examined very extensively and probably it is not worth while here to study different races individually. It is more important for the breeder to note which of the test varieties are attacked by fungus in order that he can select proper resistant genes in preparing breeding programs. According to LEIJERSTAM (1962, 1965, 1972 a, 1972 b) the racial population does not deviate greatly in the different Scandinavian countries.

Up to now, breeding for the race-specific resistance has been generally preferred. Risk of a rapid break down of resistance by new races of fungus is a great disadvantage connected to that kind of resistance. New efforts have also been made to improve the level of field resistance and to utilize it with race-specific resistance, because a certain level of field resistance is the best guarantee in various growing conditions. As Fig. 1 shows, breeders in Finland also have an opportunity to select more field resistant lines from their material. Table 1 also indicates that field resistance can be a relatively important characteristic in Finnish conditions and shows a valuable basis for breeding mildew resistant spring wheat varieties.

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SELOSTUS

Viljahärmän merkitys kevätvehnällä Suomessa vuosina 1970—1972.

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Kemiallisen torjunnan avulla pyrittiin selvittämään viljahärmän vaikutusta kevätvehnän satoon. Kokeet järjestettiin Hankkijan kasvinjalostuslaitoksen koekentillä vuosina 1970—1972. Härmäntorjuntaan käytettiin 1 kg/ha Karathane WD-valmistetta, jossa vaikuttavana aineena on dinokappi (22.5 %).

Karathane-ruiskutus lisäsi härmänalttiiden jalosteiden, Ruso, Touko, Hja a376 ja Hja a1416 satoa, sadonlisäyksen vaihdellessa 2.4—6.6 %. Vastaavasti lisäykset 1 000-jyvän painoissa vaihtelivat 2.2—5.3 %. Keskimääräinen sadon ja 1 000-jyvän painon lisäys Rusokevätvehnällä oli 4.2 ja 3.6 %. Kenttäkestävillä jalosteilla, Vekalla ja Hja a145:llä härmäntorjunnalla ei saatu mainittavia sadonlisäyksiä.

Härmänalttiilla lajikkeilla suhteelliset satoerot olivat samansuuruiset sekä ruiskuttamattomilla että ruiskutetuilla koejäsenillä. Ilman härmäntorjuntaa Hja a145 oli 4—9 % Rusoa satoisampi. Karathaneruiskutus kohotti kuitenkin Ruson jyväsatoja niin, että satoero Hja Hja a145:n hyväksi oli parhaimmillaan enää 3 %.

Tulokset antavat aihetta olettaa, että myös meillä härmänkestävyys voi muodostua yhdeksi minimitekijäksi lajikkeen sadontuottokyvyn kannalta. Näin ollen härmänkestäyys on katsottava yhdeksi lajikeominaisuudeksi, johon tulevaisuuden vehnänjalostuksen tulee kiinnittää huomiota.