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Damping-off of sugar beet in Finland.
III Effect of temperature and disease forecasting

MAURITZ VESTBERG
Department of Plant Pathology, University of Helsinki,
SF-00710 HELSINKI 71, Finland

Abstract. The effect of temperature on the severity of damping-off of sugar beet was studied under controlled conditions. The disease incidence increased with increasing temperature. When the time up to emergence in a finesand soil was characterized by low temperatures (8°C night, 15°C day), a period of 14—21 days immediately after emergence caused a strong increase in disease incidence. In peat soil, even 7 days was enough to initiate such an increase. In neither of the soils used did three days of high post-emergence temperature cause any marked disease increase. When the pre-emergence period was characterized by high temperatures (15°C night, 25°C day) the disease was at a high level and in the very fine sand soil could not be lowered by lower temperatures. In the peat soil, however, a constant, low post-emergence temperature significantly inhibited the development of the disease. The possibilities of damping-off forecasting by comparing the disease incidence in pot experiments to damping-off in the field seemed rather limited. When the temperature is taken into account, a negative prognosis may be possible. The basis of such a prognosis is the determination of the inoculum potential of the soil.

Introduction

In Finland damping-off of sugar beet is mainly caused by the fungus *Pythium debaryanum* auct. non Hesse (VESTBERG et al. 1982). Of the factors affecting disease severity and aggressiveness of *Pythium* spp. temperature is one of the most important. *In vitro* mycelial growth of *Pythium debaryanum* is optimal at about 25—28°C (MIDDLETON 1943, HALPIN et al. 1951). However, the fungus also grows well at very low temperatures, even down to +1°C (MIDDLETON 1943). Under natural conditions, optimum soil temperatures for *Pythium* spp. are lower than those measured *in vitro* (SVERRISON 1979, LIFSHITZ and HANCOCK 1983).

The aim of this work is to study the effect of periods of high or low temperatures at and after emergence on the severity of damping-off of sugar beet. Moreover, the possibilities are considered of forecasting disease severity by comparing disease percentages in pot trials with those in the field with the allowance made for the temperature factor.

Index words: sugar beet, damping-off, temperature, disease forecasting

Materials and methods

Temperature

The effect of temperature on damping-off in sugar beet was studied using a naturally infested peat soil from Janakkala and a very fine sandy soil from Laitila. Two growth chambers were used, one with low (8°C night and 15°C day) and the other with high diurnal temperatures (15°C night and 25°C day). During the experiment, pots were transferred from low to high temperatures and vice versa. The light intensity in the growth chambers was about 5500 lux and soil moisture was kept at about 70—90 % of water holding capacity.

Disease forecasting

In spring 1980, 36 sugar beet fields were chosen with varying degrees of damping-off according to earlier observations made by sugar beet advisors. Within each field, four areas of 3 × 5 m, i.e. 6 rows with a length of 5 m each, were chosen at random and marked so that exactly the same areas could be recovered the following year. In spring and autumn 1980 soil samples of about 10 l each were collected from the four areas within each field. For practical reasons, the number of fields on which damping-off could be reliably observed fell to 22 in 1981.

Assaying for damping-off

In the growth chamber experiment 0.5 l plastic pots were sown each with 30 untreated sugar beet seeds of the variety Monohill. After emergence readings were made on damping-off frequency at regular intervals until the end of the experiment. Seedlings with visible symptoms of damping-off were removed from the pots. Soil samples from fields chosen for disease forecasting were

Table 1. The effect of pre- and post-emergence temperature on post-emergence damping-off of sugar beet. Growth chamber experiment. Low temperatures = +8°C night and +15°C day. High temperatures = +15°C night and +25°C day. Light intensity about 5500 Lux. Duration of experiment 35 days.

Temperature		Post-emergence damping-off %		
Up to emergence	After emergence	Very fine-sandy soil	Peat soil	Mean
Low	low	41	49	45.0
»	high	94	96	95.0
»	3 days high → back to low	56	38	47.0
»	7 days high → back to low	79	41	60.0
»	14 days high → back to low	93	69	81.0
»	21 days high → back to low	100	82	91.0
High	high	100	94	97.0
»	low	85	39	62.0
»	3 days low → back to high	96	95	95.5
»	7 days low → back to high	95	93	94.0
»	14 days low → back to high	95	94	94.5
»	21 days low → back to high	90	71	80.5

brought into the greenhouse for examination of their damping-off potential. After thorough mixing, 1½ l of each subsample from the field was put into two plastic pots and 35 untreated seeds of Monohill were sown in each. One of the pots was subsected to a low (8°C) temperature and the other to a high (18°C) temperature. After emergence, readings were made at about weekly intervals and diseased seedlings were removed from the pots.

In the field, sugar beet advisors made damping-off observations about one week after emergence and again two weeks later.

In the present experiments post-emergence damping-off was determined from the number of diseased plants as a percentage of those emerged. No distinction was made between degrees of disease severity. Pre-emergence damping-off was determined as the difference in emergence between healthy control soil and diseased soil.

Results and discussion

Temperature

The effect of temperature on post-emergence damping-off of sugar beet is presented in Table 1. Seedlings grown continuously at low temperatures showed an infection frequency averaging 45 %, while of those grown at consistently high temperatures, 97 % succumbed to post-emergence damping-off. When the temperatures up to emergence were low, a warm period of 14—21 days duration starting immediately after emergence increased the disease incidence to about the same level as at constant high temperatures. A warm period of three days had no, or only a slight disease increasing effect. Seven days of high temperatures did not enhance disease symptoms in the Janakkala soil, while in the very fine sand soil from Laitila this period of 7 days increased disease incidence significantly.

With high temperatures from sowing to emergence followed by low temperatures till the end of the experiment, the percentage of damping-off dropped from 100 to 85 and from 94 to 39 in the Laitila and Janakkala soils respectively, as compared to cultivation at continuously high temperatures. Periods of 3—14 days at low temperatures had no disease decreasing effect whatsoever. In the Janakkala soil a cold period of 21 days had a slight disease decreasing effect (Table 1).

The disease increasing effect of warm periods is illustrated in Figure 1A, where the

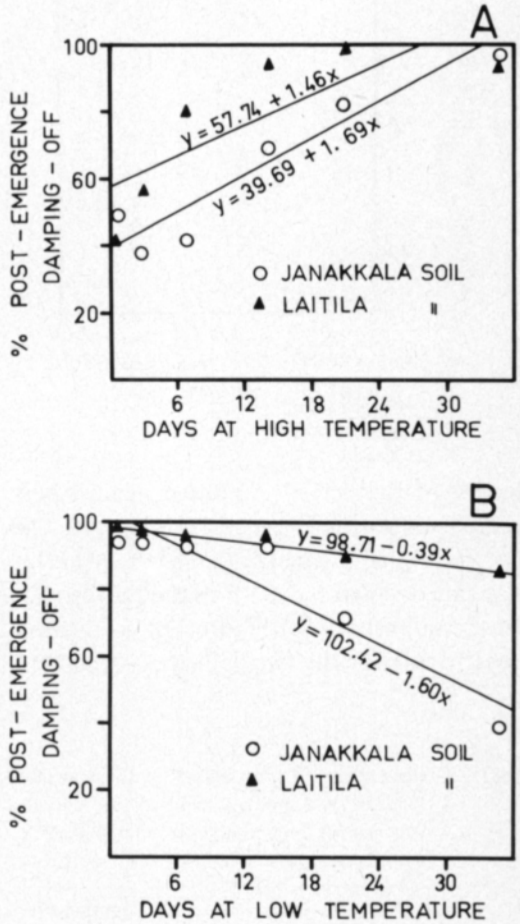
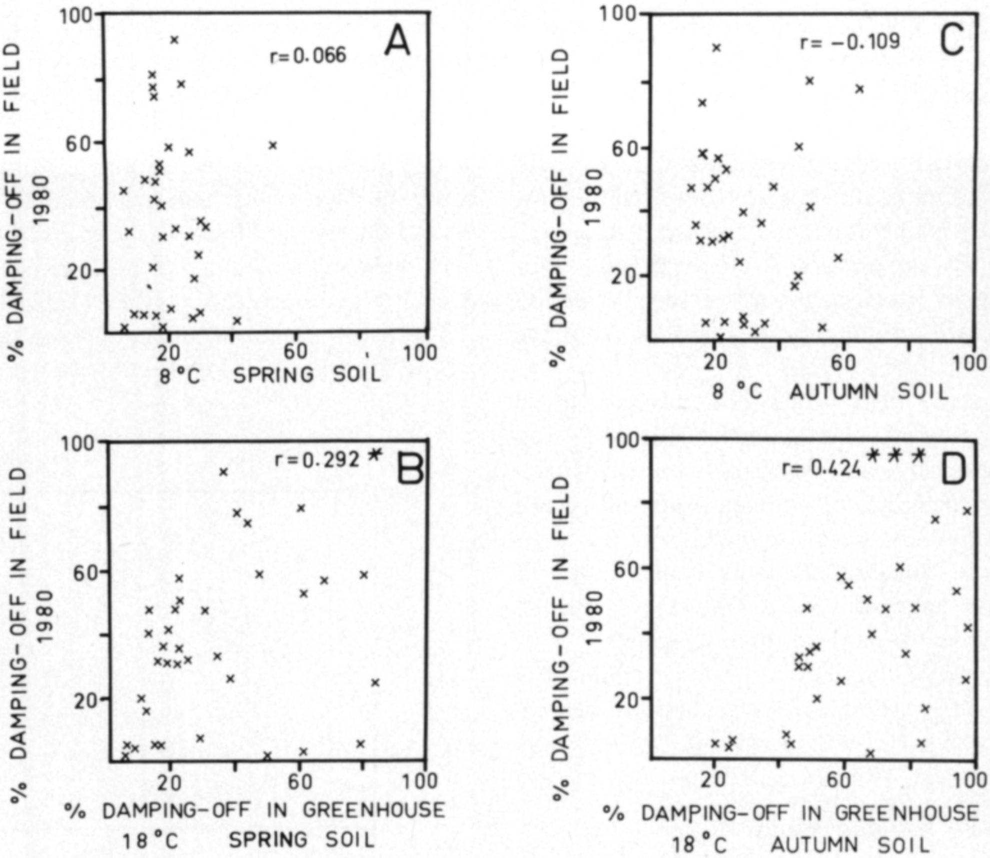


Fig. 1. Effect of low (A) and high (B) temperature periods of varying lengths on the level of damping-off in a growth chamber experiment.
Low temperature
= + 8°C night and + 18°C day
High temperature
= + 15°C night and + 25°C day
Light intensity about 5500 Lux
The Janakkala soil is a peat soil and the Laitila soil a very finesandy soil.



length of the period is plotted against percentage of post-emergence damping-off. The correlation coefficient is 0,938*** in the Janakkala soil and 0,800*** in the Laitila soil. In the opposite case (Figure 1B) correlation coefficients for the two soils are —0,931***

Table 2. Percentages of damping-off in 36 sugar beet fields in 1980 and in 22 fields in 1981 and occurrence of post-emergence damping-off in the greenhouse in soil from the same fields.

	% damping-off	
In field 1980	36.8	(0.0—91.2)
» » 1981	29.8	(2.7—80.4)
In greenhouse at 8°C		
Soil collected in spring	21.8	(3.4—52.5)
» » » autumn	31.3	(10.0—64.8)
In greenhouse at 18°C		
Soil collected in spring	32.5	(6.7—84.1)
» » » autumn	61.6	(9.8—98.3)

and —0.964*** respectively when the length of the cold period is 0—36 days.

The results indicate that temperature is a factor of considerable importance in determining severity of damping-off under field conditions. The pathogenicity of *P. debaryanum* in vitro is maximal at 25—28°C (MIDDLETON 1943). Under natural conditions in the soil the optimum occurs at somewhat lower temperatures due to competition from antagonists at the higher temperatures (SVERRISSON 1979). The results of this study are in accordance with the works by BUCHHOLTZ (1938) and NÖLLE (1960). According to these workers, at soil temperatures above 15°C *Pythium* damping-off rapidly increases in aggressiveness. In Denmark, MIKKELSEN (1982) made a survey of damping-off in sugar beet during 1954—1982. He found that in years with high temperatures at plant emergence and establishment the disease was

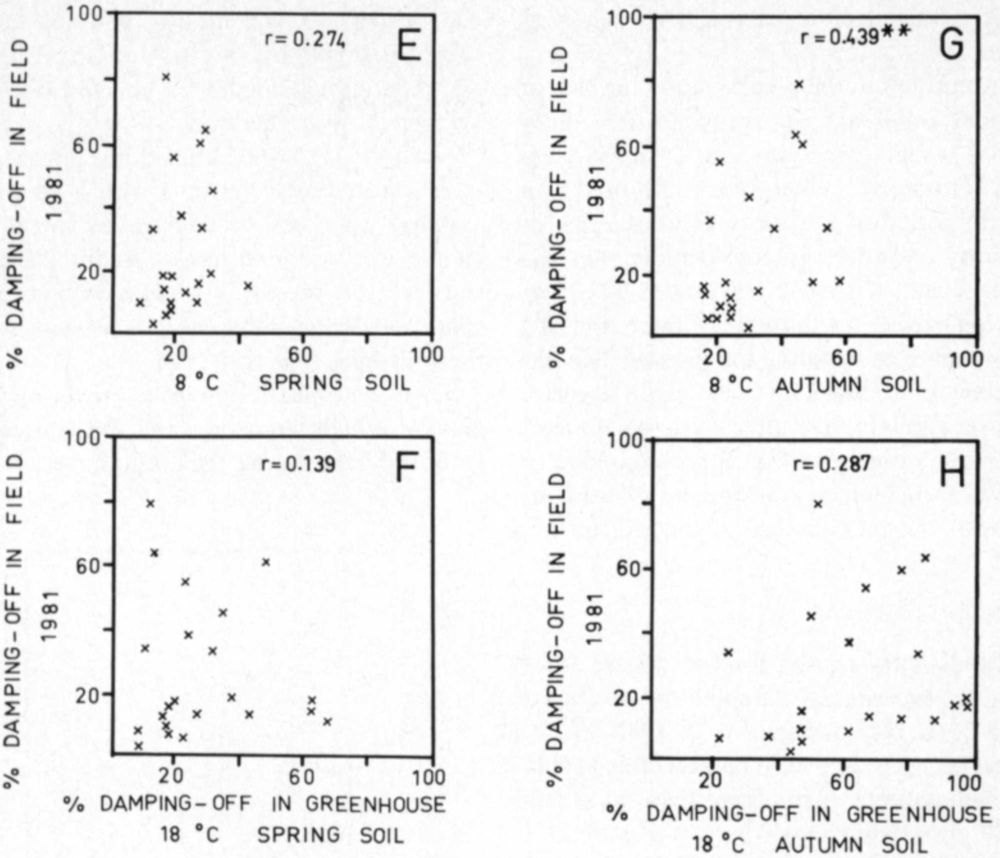


Fig. 2. Correlations between damping-off in the field and in the greenhouse using soil collected from the same fields in spring and autumn 1980. Temperature in the greenhouse alternately +8°C and +18°C.

Table 3. Correlation coefficients between damping-off in the greenhouse of sugar beet cultivated in soil collected from 36 localities in 1980 and damping-off in the same fields in 1980 and 22 fields in 1981.

Greenhouse	Correlation coefficient	
	field 1980	field 1981
Soil samples collected in spring		
Cultivation at 8°C		
Post-emergence damping-off	0.066	0.274
Pre- + post-emergence damping-off	0.165	0.140
Cultivation at 18°C		
Post-emergence damping-off	0.292*	0.139
Pre- + post-emergence damping-off	0.182	—0.145
Soil samples collected in autumn		
Cultivation at 8°C		
Post-emergence damping-off	—0.109	0.439**
Pre- + post-emergence damping-off	—0.068	0.226
Cultivation at 18°C		
Post-emergence damping-off	0.424***	0.287
Pre- + post-emergence damping-off	0.359**	0.357

more severe than in years with low temperatures.

According to the present study the risk of serious outbreaks of damping-off is fairly small when temperatures after sowing are low. However, if emergence is followed by a warm period of 1 week or more the risk of serious outbreaks is considerable. On the other hand, if sowing is followed by a long period of very warm weather, there is hardly any chance of avoiding the disease. This experiment indicates that there are differencies between soils in their disease reaction to temperature variations. This is probably due to physical or biological properties of the soil, factors which need to be investigated further.

Disease forecasting

At the sites chosen for the disease forecasting experiment damping-off averaged 36.8 % in 1980 and 29.8 % in 1981. Variations between sites were considerable (Table 2). Soil collected from these fields in spring 1980 gave damping-off percentages of 21.8 and 32.5 in the greenhouse at 8°C and 18°C respectively. Soil collected in autumn 1980 gave 31.3 and 61.6 % damping-off.

Table 3 shows that in most cases the correlation for field soils between damping-off in the field and in the greenhouse is not significant, especially when the temperature in the greenhouse was held at 8°C. On average there is a somewhat better correlation for field soil sampled in autumn than in spring. In 1980 there was a rather good correlation between damping-off percentages in the field and in the greenhouse at 18°C. In 1981, however, the best correlation was found for the low greenhouse temperature. The correlations were slightly higher when the disease incidence in the greenhouse was rated as post-emergence damping-off than as pre- + post-emergence damping-off (Table 3).

In Figure 2 the percentage of field post-emergence damping-off in 1980 and 1981 is plotted against damping-off percentages in the greenhouse. As a rule, the points show a wide dispersion, and the feasibility of forecasting damping-off in sugar beet thus appears to be quite limited. This conclusion is in agreement with the work of BARTELS and WINNER (1971), who studied the *Pythium* infection of beet side roots with a view to making prognoses of damage by methods similar to those used in this study. The results of the present investigation indicate some possibilities for a negative prognosis of the following type (Fig. 2D):

Sugar beet plants should be grown under glass at a high temperature in soil collected from the field during the autumn.

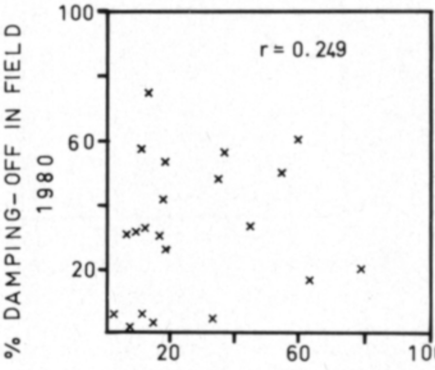


Fig. 3. Correlation between the 1980 and 1981 seasons for the percentages of damping-off in 22 sugar beet fields.

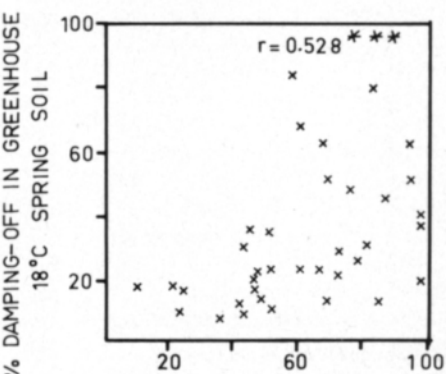


Fig. 4. Correlation between damping-off frequencies in soil samples collected in spring and autumn from sugar beet fields in 1980. Greenhouse temperature + 18°C.

1) If no disease occurs in the greenhouse, the risk of outbreaks occurring in the field is very small.
2) If heavy outbreaks occur in the greenhouse, the soil has a high inoculum potential and there is a risk of severe attacks in the field. However, the disease may remain at a low level if conditions unfavourable for development of the disease prevail.

Apart from the infection potential of the soil, the severity of damping-off of sugar beet under field conditions depends on several other factors. The lack of correlation between 1980 and 1981 seasons for the level of damping-off in 22 beet fields shows that these other factors, in particular temperature, are of great importance (Fig. 3). On the other hand, if conditions are standardized, infection potentials of soil samples can be compared to each other with fair reliability (Fig. 4).

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SELOSTUS

Sokerijuurikkaan taimipolte Suomessa. III Lämpötilan vaikutus tautiin ja sen ennustamismahdollisuudet.

Mauritz Vestberg

Helsingin yliopiston kasvipatologian laitos, 00710 Helsinki 71

Vuodesta 1978 alkaen on Helsingin yliopiston kasvipatologian laitoksen ja Sokerijuurikkaan Tutkimuskeskuksen välisenä yhteistyönä tutkittu sokerijuurikkaan taimipoltetta. Tämä kirjoitus käsittelee lämpötilan vaikutusta tautiin ja sen ennustamisen mahdollisuutta.

Lämpötilan vaikutusta tutkittiin kasvatuskaapissa käyttäen luonnollisesti saastunutta turvemaata (Janakkalasta) ja hienoa hietamaata (Laitilasta). Tutkimuksessa selvitettiin taimelletuloa seuranneiden viileiden tai lämpimien ajanjaksojen merkitystä taimipoltteeseen, ottaen huomioon myös taimelletuloa edeltävä lämpötila. Matalassa lämpötilassa (+8°C öisin, +15°C päivisin) oli taimipoltetta 45 % ja korkeassa (+15°C öisin, +25°C päivisin) 97 %. Taimipolte lisääntyi voimakkaasti kun taimelletuloa edeltävän viileän ajanjakson jälkeen seurasi 14—21 päivän korkea lämpötila. Turvemaassa 7 päivän lämmin jakso taimettumisen jälkeen ei lisännyt tautia, mutta hietamaassa tauti lisääntyi voimakkaasti tämän lämpimän jakson aikana. Sensijaan taimelletulon jälkeinen matala lämpötila alensi taimipoltetta enemmän turvemaassa kuin hietamaassa.

Vuonna 1980 valittiin ennustamiskoetta varten 36 sokerijuurikaspeltoa eri puolilta Etelä- ja Lounais-Suomea. Näihin merkittiin jokaiseen 4 aluetta (3 × 5 m) siten, että alueet voitiin löytää myös seuraavina vuosina. Alueilta otettiin maanäytteet sekä keväällä että syksyllä 1980. Maanäytteissä kasvatettiin sokerijuurikkaan taimia sekä alhaisessa (+8°C) että korkeassa (+18°C) kasvihuonelämpötilassa. Tutkimus osoitti, että sokerijuurikaspeltojen taimipoltteisuuden ja kasvihuoneessa kasvatettujen sokerijuurikkaiden taimipoltteisuuden välillä oli heikko korrelaatio. Taimipoltteen ennustaminen on kuitenkin mahdollista seuraavalla tavalla: Jos multanäytteissä kasvatettujen sokerijuurikkaissa ei esiinny taimipoltetta, on taudin ilmeneminen myös pellolla hyvin pieni. Jos sensijaan multanäytteissä kasvatetuissa sokerijuurikkaissa on runsaasti taimipoltetta (korkea tautipotentiaali), on todennäköistä, että tautia esiintyy pellollakin runsaasti. Jos olosuhteet eivät ole kuitenkaan suotuisat taudin kehittymiselle, vaikka maassa on runsaasti taimipoltetta, voi tautia olla vähän sokerijuurikkaissa.