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OCCURRENCE AND HARMFULNESS OF FUNGAL DISEASES ON ROSE BUSHES CULTIVATED IN THE AREA OF KRAKOW PART 1. POWDERY MILDEW (*Sphaerotheca pannosa*)

WYSTĘPOWANIE I SZKODLIWOŚĆ CHORÓB GRZYBOWYCH NA KRZEWACH RÓŻ UPRAWIANYCH NA TERENIE KRAKOWA CZ. 1. PORAŻENIE PRZEZ MĄCZNIAKA PRAWDZIWEGO (*Sphaerotheca pannosa*)

Abstract: The aim of the present paper objective was determination of the occurrence of powdery mildew on rose beds situated in convent gardens and a park in Krakow. The studies were conducted in 2002–2004. The obtained results demonstrated that powdery mildew is a serious disease on multiflower rose beds. The pathogen attacks the plants every year and in subsequent years the highest infection indices may reach between 37.9 and 100 %. The disease proved the gravest hazard in Carmelite Sisters' convent garden and in St. Bernard's monastery garden, except the year 2002. Rose from the Cistercians' monastery garden were the least affected.

Keywords: roses, *Sphaerotheca pannosa*, atmospheric conditions, urban green

Due to their decorative qualities and resistance to some harmful compounds, roses are bushes most useful for plantings, particularly in urban areas. Rose beds are an element of city landscape and an essential element of the urban green. The bushes grow and blossom even in places with high traffic density. However, only healthy and properly tended plants have decorative values [1].

Powdery mildew caused by *Sphaerotheca pannosa* (Wallr. ex Fr) Lev. var. rosae Wor. is one of the most dangerous and commonly occurring diseases in roses [2, 3]. Disease symptoms are visible mainly on the youngest shoots and leaves. Usually at the beginning of June white powdery coating appears on diseased organs, graying on shoots and pedicles. Leaves stop their development, crease, yellow or acquire pinkish colour and their edges curl down. The shoot ends become thickened and twisted. The fungus

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may also infect the flowers and disease symptoms are visible on sepal calyx and petals. Considerable intensification of disease symptoms may lead to inhibition of flowering. Diseased plants grow poorly, their photosynthesis and transpiration are disturbed. Very strong infection may lead to premature defoliation and inhibition of plant development. Blossoms and whole bushes lose their decorative value. Intensification of the disease symptoms depends among others on the atmospheric conditions [3–6].

The objective of the work was determination of the occurrence of powdery mildew on rose beds situated in convent gardens in Krakow.

Material and methods

The research was carried out in Krakow in 2002–2004 on rose beds situated in four convent gardens: Carmelite Sisters (40, Lobzowska str.), Felician Sisters (6, Smolensk str.), St. Bernard's order (2, Bernardynska str.), Cistercians' order (11, Klasztorna str.) and in Polish Aviators' Park (John Paul II Av.). Only the first three gardens are located in the very centre of Krakow, whereas Cistercians' garden and Polish Aviators' Park are located in the eastern part of the city in a sparsely build-up area. The plant husbandry in individual analysed places comprised agrotechnical measures, ie digging over the rose beds and NPK fertilization of flowers. No chemicals were used for pest or disease control during the vegetation season. Shoots were cut in autumn and the bushes were covered with earth to protect them against frost during the wintertime.

In the subsequent years observations were conducted from May until October. On each date 20 multiflower rose bushes were analyzed in three replication. Assessed was powdery mildew infection in shoots, leaves, flower buds and blossoms on a four degree scale [1]. The infection index was computed from the obtained data [7].

The results were verified statistically using analysis of variance for two-factor experiments (factor A – observation date, factor B – research point). The significance was verified using the Duncan test at significance level $p = 0.05$.

Meteorological data was obtained from State Meteorological Service Bulletins [8–10]. The hydrothermic coefficient was also computed and on its basis humidity was determined [11].

The data on air pollution were provided by the Department of Environment Monitoring and Automatic Air Analyses Laboratory in Krakow and presented in the paper by Dluzniewska and Nadolnik [12].

Results

The weather conditions during the research period were presented in Fig. 1 and Table 1. The lowest average temperature for the May to August period was registered in 2004. Considerable differences were noted also in the precipitation amount in the subsequent years of the research. In 2002 the greatest amount of precipitation was observed in July, when also excessive humidity was noted (Table 1). Too high a precipitation amount was also registered in October of the same year. However, average relative air humidity was the lowest in this season. The year 2003 was

Table 1

Meteorological data for the period of research in 2002–2004 [8–10]

Month	Hydrothermic coefficient			Content of humidity			Number of days with precipitation			Average relative air humidity [%]			Insolation [hours total]		
	2002	2003	2004	2002	2003	2004	2002	2003	2004	2002	2003	2004	2002	2003	2004
April	1.5	1.5	0.9	optimal	optimal	deficient	11	16	12	53	—	67	153	171	188
May	1.3	2.5	1.1	optimal	excessive	optimal	11	11	17	49	70	70	224	242	194
June	1.8	0.6	1.1	optimal	deficient	optimal	12	11	16	59	66	69	206	281	180
July	2.2	2.1	1.8	excessive	excessive	optimal	10	16	22	57	76	74	226	186	201
August	1.5	0.4	1.4	optimal	deficient	optimal	8	8	16	58	66	76	212	281	229
Sept.	1.9	0.7	0.9	optimal	deficient	deficient	9	8	8	62	72	76	128	184	188
Oct.	3.5	2.6	1.3	excessive	excessive	optimal	21	23	10	71	84	82	70	85	117
Total							82	93	101	—	—	—	1219	1430	1297

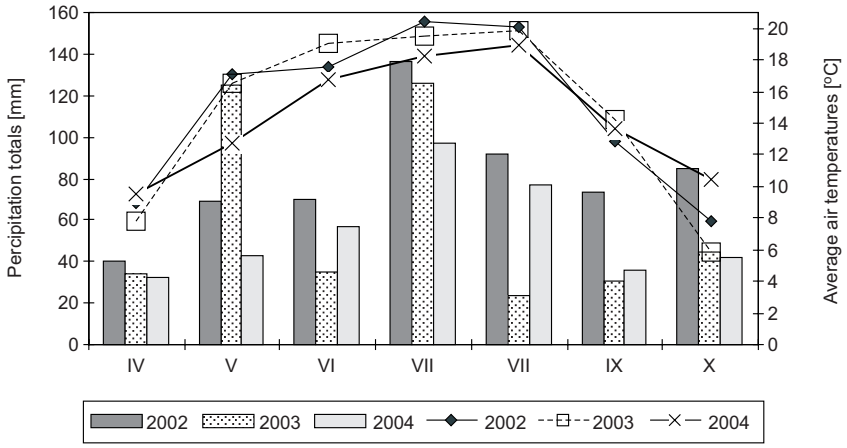

Fig. 1. Precipitation totals [mm] and average air temperatures [°C] in Krakow during the period of reserch [8–10]

characterized by the most unfavourable distribution of precipitation. Excessive humidity occurred in May and July. On the other hand, in April, June, August and September there was too little humidity and the number of sunshine hours was the highest in this season. In the third year of the research the relationships between the precipitation amount and the temperature were positive and the humidity amount was optimal during the whole vegetation season, except April and September. The greatest number of rainy days were noted in the same year.

In 2002 powdery mildew appeared by the end of May on rose bushes in the Carmelite Sisters' garden and in Polish Aviators' Park (Table 2).

Table 2

Dynamics of rose infection by *Sphaerotheca pannosa* in 2002

Date of observation 2002	Infection index [%] in respective observation points				
	Carmelite Sisters	Felicjan Sisters	St. Bernard's monastery	Cistercian monastery	Polish Aviators' Park
31.05	20.0 b-j	0.0 a	0.0 a	0.0 a	8.7 ad
14.06	25.3 d-m	0.0 a	0.0 a	3.3 ab	13.7 a-f
30.06	32.0 g-o	3.3 ab	0.0 a	4.3 ab	16.7 a-h
15.07	35.7 i-p	11.7 a-e	10.7 a-d	4.3 ab	23.0 c-l
30.07	41.3 m-p	17.3 a-h	10.7 a-d	6.3 a-c	29.0 e-n
14.08	48.0 o-q	24.7 d-m	15.0 a-g	12.0 a-e	32.7 g-p
28.08	61.0 q-r	30.3 f-o	18.7 b-i	19.3 b-j	41.0 l-p
12.09	71.0 r	40.0 k-p	22.7 c-k	24.0 c-m	45.7 n-k
27.09	76.7 r	45.3 n-q	25.0 d-m	34.7 f-o	46.7 n-q
11.10	100.0 s	50.3 p-q	33.3 n-p	37.3 j-p	46.7 n-q
26.10	100.0 s	67.7 r	50.0 p-q	43.3 n-p	50.0 p-q

Latest of all the pathogen attacked the plants in St. Bernard's monastery garden. The disease symptoms were spotted there in mid-July. On all invetsigated sites the disease was exacerbating significantly on the subsequent dates of observation and reached the highest level by the end of October. Roses in the Carmelite Sisters' garden were significantly the most diseased and there the infection index reached 100 %. On the other hand the notably lowest infection was observed in the gardens of St. Bernard's and Cistercian monastery.

In 2003 the disease appeared on rose bushes very late (Table 3). Only in mid-September were the diseased plants spotted in the gardens of the Carmelite and Felician Sisters' convets and in St. Bernard's monastery garden. The rose infection index was significantly lower than in 2002 and did not exceed 38 %. The disease most significantly affected the plants in St. Bernard's monastery garden, whereas the smallest disease symptoms were observed on roses growing in Cistercians' monastery garden.

Table 3

Dynamics of rose infection by *Sphaerotheca pannosa* in 2003

Date of observation 2003	Infection index [%] in respective observation points				
	Carmelite Sisters	Felicjan Sisters	St. Bernard's monastery	Cistercian monastery	Polish Aviators' Park
15.09	17.5 d	25.8 f	35.4 h	0.0 a	0.0 a
30.09	21.6 e	30.4 g	37.9 i	7.2 b	10.0 c

In 2004 vegetation period small numbers of bushes invaded by powdery mildew were noticed in mid-June (Table 4). In the next months the infection index was increasing slightly. Only in the middle of September did the pathogen invad more strongly the plants in the convent gardens of Carmelite and Felician Sisters' convents. In all convent gardens the most serious infection was registered on bushes in the middle of October. Roses from the Cistercian monastery garden and Polish Aviators Park revealed significantly the worst healthiness.

Table 4

Dynamics of rose infection by *Sphaerotheca pannosa* in 2004

Date of observation 2004	Infection index [%] in respective observation points				
	Carmelite Sisters	Felicjan Sisters	St. Bernard's monastery	Cistercian monastery	Polish Aviators' Park
11.06	1.6 a-c	0.0 a	3.3 a-c	0.0 a	0.0 a
27.06	0.9 ab	0.0 a	9.2 a-d	1.6 a-c	1.6 a-c
14.07	0.0 a	1.5 a-c	10.1 a-d	0.0 a	0.9 ab
4.08	0.0 a	5.9 a-c	13.3 b-d	0.0 a	0.9 ab
28.08	1.5 a-c	4.6 a-c	14.5 b-d	0.0 a	1.2 ab
18.09	20.9 de	5.9 a-c	19.2 de	0.0 a	5.9 a-c
1.10	28.8 ef	10.2 a-d	36.8 f	1.2 ab	1.2 ab
15.10	37.5 f	14.2 cd	58.3 g	1.6 a-c	0.9 ab
28.10	29.2 ef	10.9 a-d	50.0 g	0.0 a	0.0 a

Discussion

The reserch conducted demonstrated that powdery mildew is a serious disease of multiflower rose bed field plantations. The pathogen attacks plants every year and the highest infection indices in subsequent years may reach even between 37.9 and 100 %. The disease posed the gravest hazard in convent gardens of the Carmelite Sisters and except the year 2002 also in St. Bernard's monastery garden. Roses which were the least infected by this fungus were growing in the Cistercians monastery garden.

Depending on the weather course the first symptoms of powdery mildew in field conditions appear usually in mid-May and intensify during the vegetation season [3, 4]. In field cultivation the greatest intensification of the disease symptoms is observed in two periods: by the end of May and at the beginning of June at intensive bush growth, and in the second decade of August. In the second period roses, from which the blooms were not cut, start new shoots [13]. Particularly high level of bush infection by the end of summer and at the beginning of autumn is due to the susceptibility of young shoots and leaves to infection. Developing leaves up till the fifth day very easily give in to infection. 5-day-old and older leaves are less susceptible. It is considered that this fact is connected with the thickness of the cuticules of cell walls which is increasing with leaf age [14]. Moreover, young leaves of sensitive species contain β-alanine, necessary for fungi spore germination [3].

Also the weather conditions, dew at night and sunny weather during the day, favour the infection. A factor favouring *S. pannosa* development are great fluctuations of temperature. In field cultivation the conditions particularly favourable for the fungus development are at night, when the temperature is 15 ^{o}C and air humidity reaches 90–99 %. Fungus growth is favoured on strongly insolated walls of buildings with the southern aspect, where differences between day and night temperatures are very big [4]. The urban climate is characterized by a raised temperature and lowered humidity. A decrease in humidity results from a lack of a retention surface, drainage of the ground by excavations and channels. Excessive transpiration and evaporation are caused by the high temperature of heating buildings, and surfaces of pavements, streets or squares [15].

Powdery mildew mycelium develops best in quite dry air at high temperatures and in strong light [4]. Rose powdery mildew spreads during the vegetation season by means of conidial spores. The spore formation is enhanced by a decrease in air humidity and increase in temperature. At very high air humidity the temperature of 21 ^{o}C is optimal for spore germination and between 18 and 25^{o}C for mycelium growth. Spores germinate best at air humidity 97–99 %, whereas water on the leaf surface inhibits this process [3, 16, 17].

A great diversification among rose varieties considering their resistance to powdery mildew has also been pointed out [2, 5]. About 30 % of varieties with red and pink flowers were resistant to the disease whereas the others were medium resistant or highly susceptible. On the other hand among varieties with white or yellow blossoms between 60 and 75 % were prone or very prone to the disease. The variety susceptibility was connected with the size of the stomatal apparatus and the thickness of skin [18].

Pollutants from the atmosphere may also affect plant infection by pathogens [19]. Krakow belongs to the group of European cities with the worst air quality [20]. SO_2 concentrations were similar in all measuring points over the entire period of observations, whereas the suspended particulate matter, NO and NO_2 concentrations were higher in the Cistercians' monastery garden and in Polish Aviators' Park. The admissible level of airborne matter was exceeded only for the suspended particulate matter [12].

In the paper by Nadolnik [1] it was observed that the occurrence of rose powdery mildew was the most intensified on a lawn situated in a place with less heavy traffic. It shows that fungi causing powdery mildew may completely vanish at high concentrations of individual components of pollution [21].

The occurrence and development of fungi and symptoms of plant infection by parasitic fungi may increase or be inhibited under the influence of SO_2 fumigation. The species which benefit from SO_2 fumigation comprise *Sphaerotheca fuliginea* causing powdery mildew in cucumbers. This fungus revealed a greater capability of infecting the host plant and conidia spore germination at cucumber exposure to the activity of 143 $\mu g\ SO_2\ m^{-3}$. Higher concentrations of SO_2 inhibited the fungus growth [19, 22].

Air pollution may also modify the plant-pathogen-endophyte relationship. *Hyalodendron album* endophyte present on lilac leaves act antagonistically on *Microspharea alni*. It was observed that the endophyte is most probably more sensitive to O_3 and SO_2 than the pathogen [19, 23].

The analysed dynamics of powdery mildew development makes possible the application of protection measures in rose gardens, which will reveal long-term activity and low toxicity. Cultivation measures which have just been completed make it possible to maintain the plants in good condition, which improves the flowers' decorative qualities.

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WYSTĘPOWANIE I SZKODLIWOŚĆ CHORÓB GRZYBOWYCH NA KRZEWACH RÓŻ UPRAWIANYCH NA TERENIE KRAKOWA CZ. 1. PORAŻENIE PRZEZ MĄCZNIAKA PRAWDZIWEGO (*Sphaerotheca pannosa*)

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Abstrakt: Celem pracy było określenie występowania mączniaka prawdziwego na skwerach różanych położonych w ogrodach przyklasztornych i parku Krakowa. Badania prowadzono w latach 2002–2004. Uzyskane wyniki potwierdziły, że mączniak prawdziwy jest groźną chorobą w uprawie polowej wielokwiatowych róż rabatowych. Patogen atakuje rośliny corocznie, a najwyższe indeksy porażenia w kolejnych latach mogą sięgać wartości 37,9–100 %. Choroba największe zagrożenie wywoływała w ogrodach karmelitanek i z wyjątkiem roku 2002 u bernardynów. Natomiast najmniej porażane przez grzyba były róże z ogrodu cystersów.

Słowa kluczowe: róże, *Sphaerotheca pannosa,* warunki atmosferyczne, zieleń miejska