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**OCCURRENCE AND HARMFULNESS OF FUNGAL DISEASES  
ON ROSE BUSHES CULTIVATED IN KRAKOW  
PART II. BLACK SPOT (*Diplocarpon rosae*) INFECTION**

**WYSTĘPOWANIE I SZKODLIWOŚĆ CHORÓB GRZYBOWYCH  
NA KRZEWACH RÓŻ UPRAWIANYCH NA TERENIE KRAKOWA  
CZ. II PORAZENIE PRZEZ CZARNĄ PLAMISTOŚĆ (*Diplocarpon rosae*)**

**Abstract:** The aim of the paper was to determine the occurrence of black spot on rose bushes growing in convent gardens and in a Krakow park. The research was conducted in 2002–2004. In the selected points black spot posed the gravest hazard in 2002. In all years of the research rose in the Carmelite convent garden and in Polish Aviators' Park were most strongly infected by *Diplocarpon rosae*. The diseases were the least intensified in the St. Bernard monastery garden and in Cistercians' garden, except the year 2002.

**Keywords:** roses, rose black spot, city green areas, air pollution

Krakow is one of large European cities with the worst air quality [1]. The main element of the urban landscape, which also alleviates the effects of pollution are urban green areas. Green areas are capable of capturing a considerable part of gaseous and dust pollutants from the air [2]. Plants respond to air pollution by their shoot injuries and growth inhibition and even by die-back [3]. Pollutants may also affect the interactions between host plants and pathogens. These substances may directly influence the growth and development of mycelium, and spore germination, but also fungal pathogenicity. Pollutant compounds originating from the atmosphere may affect pathogens directly or indirectly through a change of host plant susceptibility [4].

In compliance with the act of 16th April 2004 [5] the aim of environmental protection is among others protection of city green areas involving maintenance, sustainable use and restoration of green resources and elements. Green areas in cities fulfil aesthetic, recreational, health and protective functions. Green areas on the estates included in the historic monument register are particularly important. In Krakow such places include *eg* convent gardens.

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Rose black spot caused by *Diplocarpon rosae* Wolf fungus is a common and dangerous rose disease, which generally causes considerable losses on plantations. Recommendations on its control prove little efficacious in practice. As a result numerous rose bushes lose leaves already in midsummer. Infection by *D. rosae* greatly diminishes decorative qualities of the plants [6–9].

The present study aimed to determine the occurrence of black spot on rose beds situated in convent gardens and a park in Krakow.

## Material and methods

The research was conducted in 2002-2004 on rose beds in four convent gardens of the following orders: Carmelite Sisters (40, Łobzowska str.), Felician Sisters (6, Smoleńsk str.), St. Bernard's order (2, Bernardyńska 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 research methods were presented in the paper by Dłużniewska and Nadolnik [9].

## Results

The weather conditions during the period when the research was conducted were presented in the paper by Dłużniewska and Nadolnik [9]. The lowest average temperature in the period from May to August was registered in 2004. Also considerable differences in precipitation amounts were observed in the respective years of the research. In 2002 the highest rainfall was noted in July when also excessive humidity occurred. Superfluous rainfall was also noticed in October of the same year. The year 2003 was characterized by the most unfavourable precipitation distribution. Excessive humidity was noted in May and July, whereas in June, August and September too little humidity was registered. In the third year of the research the dependencies between the precipitation amount and the temperature were favourable and the humidity was optimal for the entire vegetation season, except September.

Data on air pollution were provided by the Department of Environment Monitoring and Automatic Air Analyses Laboratory in Krakow (Table 1) [10]. The results from the Main Square station referred to the convent gardens of Carmelite Sisters, Felician Sisters and St. Bernard's order. Polish Aviators' Park and Cistercians' garden are located within the Nowa Huta station range. The measuring stations did not register all selected pollutants over the investigated period. No data were available from August to October 2004 because of modernization of monitoring network, communication and data processing systems. SO<sub>2</sub> concentration was similar at both measuring points. In the years 2002 and 2003 the suspended particulate matter, NO and NO<sub>2</sub> concentrations were higher in Nowa Huta. The admissible level for airborne substance – 40 µg · m<sup>-3</sup> was exceeded. In 2002 the norm was exceeded four times, in 2003 three times and once in 2004. At the Main Square the exceeded values for suspended particulate matter were observed in April 2002 and 2003.

Table 1.

Air pollution during the research period in 2002–2004 annual average [11]

Month	SO <sub>2</sub> [µg/m <sup>3</sup> ]			PM [µg/m <sup>3</sup> ]			NO [µg/m <sup>3</sup> ]			NO <sub>2</sub> [µg/m <sup>3</sup> ]		
	2002	2003	2004	2002	2003	2004	2002	2003	2004	2002	2003	2004
Main Square measuring station												
April	13	<b>14</b>	11	<b>48</b>	<b>45</b>	–	–	<b>4</b>	–	–	28	–
May	9	10	6	37	36	–	–	<b>4</b>	–	–	23	–
June	8	8	6	32	32	–	–	<b>4</b>	–	–	<b>24</b>	–
July	9	7	6	32	28	–	–	<b>4</b>	–	–	22	–
August	7	7	–	39	32	–	–	5	–	–	26	–
Sept.	7	9	–	36	39	–	8	<b>14</b>	–	22	32	–
Oct.	11	<b>14</b>	–	38	38	–	22	17	–	30	32	–
Nowa Huta measuring station												
April	11	<b>14</b>	–	55	51	55	10	8	11	32	30	30
May	8	7	–	37	<b>40</b>	28	8	8	8	25	28	<b>24</b>
June	7	9	–	28	<b>34</b>	32	9	9	9	<b>24</b>	30	29
July	10	7	–	39	30	33	7	11	12	<b>24</b>	27	28
August	9	9	–	59	39	–	10	11	–	25	31	–
Sept.	7	9	–	63	<b>54</b>	–	12	25	–	26	<b>34</b>	–
Oct.	10	11	–	55	<b>42</b>	–	<b>34</b>	<b>24</b>	–	29	29	–

In 2002 black spot symptoms were noticed by the end of May on all investigated sites except the Carmelite Sisters' garden (Table 2). The disease was exacerbating significantly at subsequent dates. In mid-August the infection index by *D. rosae* increased rapidly. In Polish Aviators' Park this index reached 100 %. By the end of August 100 % of infected plants were observed in Carmelite Sisters' and Cistercians' gardens and in Polish Aviators' Park. The plants were rapidly losing leaves. Such fast development of the disease might have been caused by too much precipitation in July and resulting excessive humidity. Significantly smallest infection was observed in St. Bernard's monastery garden.

Table 2

Dynamics of rose infection by *Diplocarpon rosae* in 2002

Date of observation	Infection index [%] in respective observation points				
	Carmelite Sisters	Felicjan Sisters	St. Bernard's monastery	Cistercian monastery	Polish Aviators' Park
31.05	0.0 a	11.7 a–e	7.7 a–c	13.3 a–f	8.3 a–d
<b>14.06</b>	5.7 b	20.0 b–g	21.0 c–g	<b>24.3</b> e–i	15.0 b–f
30.06	10.0 a–e	35.7 h–k	21.0 c–g	39.7 j–m	35.7 n–k
15.07	<b>24.3</b> e–i	<b>43.0</b> k–o	22.7 d–h	55.7 n–g	50.0 l–p
30.07	37.7 i–l	52.0 m–p	27.7 f–j	55.7 n–g	56.7 o–q
<b>14.08</b>	71.3 r	66.3 q–t	32.7 g–k	63.3 p–r	100.0 s
28.08	100.0 s	72.3 r	<b>42.3</b> k–h	100.0 s	100.0 s

In 2003 the disease symptoms occurred later than in the first year of the research (Table 3). In Carmelite Sisters' garden and in Polish Aviators' Park rose leaves with black spots were noticed at the beginning of June. On the other hand in the gardens of St. Bernard's and Cistercians' monastery the disease symptoms appeared only in the first decade of July. Later in the vegetation season black spot infection of roses was increasing significantly. By the end of September bushes growing in the Carmelite Sisters' garden were apparently the most heavily infected by the pathogen. The plant infection index exceeded 83 %. Very strong infection was also noted in Polish Aviators' Park, where the index reached the level of about 77 %. Notably healthiest roses were cultivated in St. Bernard's and Cistercians' monastery gardens.

Table 3

Dynamics of rose infection by *Diplocarpon rosae* 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
6.06	21.7 ef	3.3 ab	0.0 a	0.0 a	11.7 c
20.06	29.2 gh	20.0 de	0.0 a	0.0a	36.7 ik
9.07	<b>43.3 l</b>	25.4 fg	5.8 b	2.8 ab	<b>42.2 l</b>
20.07	<b>54.2 m</b>	30.0 h	<b>24.6 f</b>	16.9 d	51.7 m
15.08	<b>60.4 n</b>	36.2 ij	<b>32.4 hi</b>	30.0 h	55.3 m
30.08	68.3 op	<b>43.3 l</b>	31.2 h	33.9 hj	66.9 o
15.09	79.6 q	50.9 m	36.2 ij	37.5 jk	71.7 p
30.09	83.3 r	<b>55.4 m</b>	<b>40.8 kl</b>	<b>42.0 l</b>	77.3 q

In 2004 black spot symptoms were visible at the beginning of June (Table 4). The disease was developing gradually in subsequent months. At the beginning of October significantly most serious infection by black spots was observed in the Carmelite Sisters' garden and in Polish Aviator's Park.

Table 4

Dynamics of rose infection by *Diplocarpon rosae* 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	22.5 c-g	13.3 a-d	<b>4.2 ab</b>	0.9 a	<b>4.2 ab</b>
27.06	17.5 b-e	22.5 c-g	23.3 c-f	10.9 a-c	28.3 c-g
<b>14.07</b>	29.2 d-j	30.9 e-j	25.9 c-f	22.5 c-g	30.0 c-h
<b>4.08</b>	35.0 f-j	<b>42.5 i-k</b>	29.2 d-h	27.5 c-f	30.5 d-j
28.08	35.5 f-j	<b>43.0 i-k</b>	30.5 d-j	27.0 c-f	35.6 f-j
18.09	37.5 g-k	<b>45.0 jk</b>	37.5 f-i	27.5 d-i	<b>40.5 g-k</b>
1.10	62.5 l	52.5 k-l	<b>42.5 i-k</b>	30.0 e-j	<b>64.5 l</b>

## Discussion

The research confirmed that black spots belong to the most serious rose diseases. The pathogen considerably diminishes the plant decorative qualities and causes premature defoliation of bushes [7, 12]. On the analyzed sites, black spots posed the gravest hazard in 2002. In all investigated years roses were the most seriously infected by *D. rosae* in Carmelite Sisters' convent garden and in Polish Aviators' Park. On the contrary, the disease was the least exacerbated in St. Bernard's monastery garden and in Cistercians' garden, except the year 2002.

*D. rosae* infestation is visible as black round or irregular spots with frayed edges. The tissue around the spots is yellowing and the leaves fall prematurely. The leaves from the lower part of bushes fall first, then those from the upper part. Bushes are less frost resistant, have less vitality and die faster. Weakened plants are easily infested by other fungi pathogens and pests [7, 8, 11].

Development of the disease is connected with atmospheric conditions. Wet weather during summer favours infection. Germination of *D. rosae* spores, therefore rose infection by black spots occurs when the leaves are moistened for 9–18 hours [3, 13–14].

Infection may be also affected by pollutants originating from the atmosphere, which in host plants lead to changes, such as a change of wettability and chemical composition of the surface and a change of leaf secretion products [4].

Air pollution may also influence plant-pathogen-endophyte interactions through a change of the species composition of endophyte communities, which may be antagonistic to pathogenic fungi [15]. Yeast, which is an antagonist of leaf pathogens is particularly sensitive to SO<sub>2</sub>. It was noticed that at low concentrations of SO<sub>2</sub> (< 50 ppb) yeast *Sporobolomyces roseus* and *Cryptococcus laurentii* reduced *Alternaria brassicae* infection in the cruciferous. On the other hand at SO<sub>2</sub> concentration over 100 ppb an apparently increased plant infection was registered. The results of the experiment show that high concentrations of SO<sub>2</sub> reduce the activity of saprophytic yeast, which favours plant pathogen infections [4].

Nadolnik [2] observed that lesions on rose leaves caused by black spot were less intensified on bushes growing on the site with high traffic density. *D. rosae* fungus is counted among species sensitive to high pollutant concentrations [16].

The effect of air pollution on plant pathogenic fungi depends on many factors, such as: concentration, amplitude of daily seasonal concentrations, time of activity composition of vegetation cover and degree of its injury by phytotoxic components of pollution, land topography, climatic conditions, soil and habitat quality and sensitivity of the pathogens themselves [16].

Monitoring of the healthiness of plants cultivated in urban green areas is useful for making decisions concerning cultivation measures to maintain plants in good condition. Damage due to improper care of green areas may result in a penalty imposed by the president of the city [17].

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**WYSTĘPOWANIE I SZKODLIWOŚĆ CHOROBY GRZYBOWYCH NA KRZEWACH RÓŻ  
UPRAWIANYCH NA TERENIE KRAKOWA  
CZ. II PORAZENIE PRZEZ CZARNĄ PLAMISTOŚĆ (*Diplocarpon rosae*)**

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**Abstrakt:** Celem pracy było określenie występowania czarnej plamistości na skwerach różanych położonych w trzech ogrodach przyklasztornych i jednym parku Krakowa. Badania prowadzono w latach 2002–2004. W wybranych punktach największe zagrożenie czarna plamistość stanowiła w 2002 r. We wszystkich latach badań najbardziej opanowane przez *D. rosae* były róże w ogrodzie Karmelitanek i Parku Lotników Polskich. Natomiast w najmniejszym nasileniu choroby obserwowano w ogrodach Bernardynów i z wyjątkiem 2002 r. u Cystersów.

**Słowa kluczowe:** róże, czarna plamistość, zieleń miejska, zanieczyszczenie powietrza