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Health evaluation of cactus collection in botanical garden at Cluj-Napoca, Romania

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Abstract

In terms of artificial collections, cacti receive a specific microclimate, which ensures constant physical parameters leading to a low resistance and high susceptibility to attack by pests and diseases. The *Cactaceae* collection of the botanical garden "Alexandru Borza", Cluj-Napoca, Romania counts more than 4100 plants belonging to 115 genera. Following inventory collection, 4069 plants were studied. Preliminary assessment results that the radicular system of the best represented *Cactaceae* species is much worse than those stems. Genus: *Astrophytum, Aylostera, Echinocerus, Notocactus*, *Weingartia* had disease insidence of grade 2 (the area affected by 26-50%). The highest intensity of the attack was reported in the genus *Echinocereus* (47.24). In calculating the attack degree there was a greater uniformity in genus *Aylostera* (36.34), *Echinocereus* (37.46), *Rebutia* (37.83); *Weingartia* (33.37). In considerable stem attack by pahthogens, the highest attack frequencies were recorded in *Astrophytum* (51.75); *Ferocactus* (65.76) and *Notocactus* (58.18). The attack intensity, expressed in intensity degrees, reached value 2 (30.79) in the case of *Cleistocactus* genus, whereas the other genera remained under grade 1.

Key words: Cacti, *Cactaceae,* diseases, attack degree, attack intensity

Introduction

In Romania, in the patrimony of the 11 botanical gardens and in over 100 private collections, cacti represent a very important balance both numerically and qualitatively. The study of *Cactaceae* diseases in the botanical collections is very important because the specific growing conditions are totally different from natural habitats of these species. In greenhouse conditions, taxa agglomeration in small areas is a very important factor in triggering pest holes. Special conditions of temperature, humidity, light, growth substrate, often limited, are a part of these factors which differ from the optimal environment demand of *Cactaceae*.

Many authors (Miller, 1980; Rosciglione, 1980; Anson, 1982l; Chase 1982; Arnold, 1986; Nakhutsrishvili, 1986; Simay, 1987; Turner, 1992; Glang, 1993; Chavez, 1998; Anderson, 1999; Kobayashi, 2000; Swart and Kriel, 2002) have described multitude of cacti diseases. Feszt *et al*. (2006) has published diamensions of the viruses extracted from *Cactaceae* vegetative parts multiplied from Cluj-Napoca Botanical Garden collection.

Materials and methods

The *Cactaceae* collection used for the study is located in one of the side greenhouses of the greenhouse complex. In compiling the cactus collection, it was considered that the family should be represented by a range as high as found in nature. The *Cactaceae* collection from Cluj-Napoca botanical garden counts more than 4100 plants belonging to 115 genera, from the 241 total known, after the Backeberg system (Backeberg, 1962, 1966, 1968). From inventory collection, 4069 plants were checked of which 116 were dry. The remaining number of 3953 belong to 94 genera. The plants which at the moment of the inventory (2004) were younger than 3 years as well as some epiphyte genera as *Lepismium, Rhipsalis, Rhipsalidopsis, Zygocactus, Wittia*, which require subtropical climate conditions, being in other greenhouses than the ones reserved for xerophytes plants were not taken into consideration.

The inventory was made while transplanting the cacti. Transplantation was performed over a period of four months, from 04.11.2004 to 04.03.2005. Each plant has been reviewed separately, and data were recorded which include: Nr. - Current number; Gender, Species - gender, species, Prov. - provenience (from the individual seed or cuttings domestic or international exchange); Place - place of origin of plant material (+ or sowing or seedling year) Vig. - Vigor; Ch. - Changes in color; Ro. - Root (root integrity expressed in percentages); Stem. - Stem (stem integrity expressed in percentages) Sub. - Suber (grade suberizing percentage); Con. - Concave (morphological changes resulting from attack); Vex. - Convex (morphological changes resulting from attack); Cir. - Circular (morphological changes resulting from attack), Irr. - Irregular (morphological changes resulting from attack), Col. - Color (morphological changes resulting from attack), Vir. -Virosis; Myco. - Mycoplasma; Bac. - Bacterise ; Myc. - Mycosis; Mit. - Mites; Pad. – Lice; Het. - Heterodera; Com. - Comments.

Follow up observations were made to identify the suspected plants through further studies in laboratory. This way there were selected plants which: presented inlay symptoms; import plants of unknown origin; cacti which deviate by shape, color or appearance from normal: nonspecific discoloration, witches broom forms, fascia, crystal shapes, monstrous forms, spiral increases, flower deformations, *etc*.

The process of occurrence of diseases in plants included two main

points: the attack and the attack effect. Attack value is represented by frequency, intensity and degree of attack. Frequency attack (F) is the relative value of the number of plants (n) or members of plant attacked by a phytopathogen agent (virus, bacteria, fungus) reported to the number of plants or members. Data is calculated by the relationship: F= n x 100 / N.

Attack intensity (I) is the degree of coverage or attack expansion, reporting the attacked area with regard to the total area. To indicate the intensity attack scale ranks are used that can have a different number of ranking frames. In most cases, attack intensity is scale as 4, 5 or 6 frames. These frames correspond to certain percentage intervals of the intensity of the attack. The relative expression of attack intensity (I) is the relationship:

$$I = \sum (i \times F)/N,$$

where, i = grade or attacked area (%), F = number of cases with attack for every grade, N = total number of cases with attack.

Attack degree (AD) is expression of the attack's extension over the total number of plants observed. The value expression for this is given by the relationship: AD = F x I/100.

In order to compare the *Cactaceaes* health from the Botanical Garden with the situation from nature, respectively from the *Cactaceaes* place of origin, the notation scale of intensity attack indicated by James (1971) quoted by De la Torre (1987 (a), 1987 (b), 1988 , 2001) was used (Table 1).

Table 1. Attack intensity notation scale for *Cactaceae* diseases (De la Torre, 1988)

Affected surface (%)	Attack intensity degree
Healthy plant	0
1-25	1
26-50	2
51-75	3
76-100	4

The health of Mexican indigenous cacti plants, is affected with attack intensity degree like 2, 3 even 4 (de la Torre, 1988). In the collection of Botanical Garden Cluj-Napoca, Romania, the degree of attack intensity is not higher than 2. In the data processing the integrity of the radicular system and, separately, the integrity of the plant stem for a certain genus was pursued.

Results and discussion

Radicular system health: Regarding the radicular system, the smallest values of the attack degree were observed in *Cereus* (0.03); *Mammillaria* (4.9); *Cleistocactus* (4.8); *Eriocactus* (2.27); *Lobivia* (7.04); *Pilosocereus* (0.02). The minimal values of the attack degree for *Cereus* and *Pilosocereus* were due to a peculiar resistance to attacks provoked by pathogens agents of the radicular system. The species of the *Cereus* are probably preferred as stocks for genera with less sensitive radicular system (Table 2).

After the selection of plants through the inventory method and examination of health of every genus, sick plants were isolated and kept in an humid environment. After the mycelium burst, advent, emergence and eventual fructifications the material was prepared through standard procedures in order to be subjected for verification through light or electronic microscopy. Through these methods the following diseases were identified of the radicular system: dry rot or fusarium fading caused by many traits of *F. oxysporum* with a different pathology; root blight *P. parasitica*, or *Cactacee* stem's base caused by *P. cactorum*; another disease caused by *Rhizoctonia solani*; *Verticilium albo-atrum*.

In *Cactaceae* collection of the botanical garden, at the radicular system level, diseases caused by bacteriosys or mycoses as *Armillaria mellea, Sclerotinia sclerotiorum, Thielaviopsis basicola* were not prevalant as these diseases are generally encountered in apartment plants.

In the Botanical Garden collection, sick plants were infected by many species of *Fusarium*. Some were very aggressive, causing the plants' death manifested by a red-brown colour, sometimes aqueous discolouration. Other *Fusarium* strains had effects on integral cultivars, or on some portions from a culture, generally managing to cause mother plant's rot with remaining young portion alive. The most devastating effect was represented by *F. oxysporum* which caused root loss and rot progression on the central cylinder, to the top growth. If noticed in time, the rotten portion can be eliminated together with a part of healthy tissue. The resulted plant part can be rooted.

A non aggressive form of *Fusarium* causes slow tracheomicoza, where the plant can survive a couple of years, without normal growth. Normally, these plants can be saved if the sick portion is removed and the plants manage to root. Many times secondary compounds of fusarioze inhibit the synthesis of the hormones that results into inhibition of rooting. This way hormonal balance of the attacked plant is modified, which leads to inhibition of further rooting. These cases were observed in cacti that lived in latent period many years without having root. At globular cacti, normally when the rot of the radicular system is noticed, and the infection is generalized over parcel and the plant survives.

Fusarium can be present alone or through over infection by other pathogen agents, as *Pythium, Verticillium, Sclerotinia* can appear. Dependent on the association of pathogen organisms, which determine the destruction of the host plant tissues, this can colour differently, having as well a consistent difference from the normal. *Fusariozes* symptoms are described in literature. Attacked tissues rot from root to parcel towards the stem. The typical color of brown rot caused by *Fusarium* may acquire red, purple nuances, blackish with a characteristic mycelium smell.

Table 2. Evaluation of the attack caused by phytopathogen agents on the *Cactaceae* radicular system, Cluj-Napoca Botanical Garden

Genus	Number of studied taxa	Frequency of attack (F)	Intensity of attack (I)	Attack intensity degree	Attack degree
Astrophytum	114	81.57	32.80	2	26.75
Aylostera	119	92.43	39.32	2	36.34
Cereus	156	2.56	1.41	1	0.03
Echinocereus	116	79.31	47.24	2	37.46
Ferocactus	111	61.26	22.97	1	14.07
Gymnocalycium	310	59.03	22.90	1	13.51
Mammillaria	894	37.91	12.95	1	4.90
Notocactus	232	81.89	36.03	2	29.50
Parodia	213	57.74	23.61	1	13.63
Rebutia	252	98.80	38.29	2	37.83
Weingartia	100	94.00	35.50	2	33.37
Cleistocactus	63	28.57	16.82	1	4.80
Eriocactus	75	21.33	10.66	1	2.27
Lobivia	80	40.00	17.62	1	7.04
Pilosocereus	49	2.04	1.42	1	0.02

Table 3. Evaluation of the attack caused by phytopathogen agents on *Cactaceae* stem, Cluj-Napoca Botanical Garden

Genus	Number of studied taxa	Frequency of attack (F)	Intensity of attack (I)	Attack intensity degree	Attack degree
Astrophytum	114	51.75	10.87	1	5.62
Aylostera	119	16.80	4.36	1	0.73
Cereus	156	24.35	3.97	1	0.96
Echinocereus	117	19.82	5.51	1	1.09
Ferocactus	111	65.76	13.24	1	8.70
Gymnocalycium	310	18.70	5.16	1	0.96
Mammillaria	894	18.79	5.22	1	0.98
Notocactus	232	58.18	15.17	1	8.82
Parodia	213	24.41	6.57	1	1.60
Rebutia	252	1.58	0.23	1	0.0036
Weingartia	100	30.00	6.50	1	1.95
Cleistocactus	63	61.90	30.79	2	19.05
Eriocactus	75	42.66	8.26	1	3.52
Lobivia	80	55.00	9.75	1	5.36
Pilosocereus	49	2.85	20.00	1	0.57

This smell is perceived in heavily infected collections, usually when spraying. Unpleasant odour and an aqueous consistence is usually a sign of infection with bacteria and torulae.

An over infected fusarioza by *Verticilium alboatrum* gives a typical yellow tint. *Fusarium* in association with *Pythium* causes humid rot, which manifests through interior tissues liquefaction of the cactus and content drain in the soil. The epidermis of the cactus remains with a prick skeleton which normally falls laterally.

Stem health: In evaluation of the attack produced by phytopathogens on stem the highest attack frequencies were recorded in *Astrophytum* (51.75); *Ferocactus* (65.76); *Notocactus* (58.18).

Intensity attack expressed in intensity degrees reached to 2 value (30.79) in the case of *Cleistocactus*, the other genera remaining below the intensity of 1 degree. The highest values of *Astrophytum* and *Ferocactus* are owned to natural phenomena of suberizing of parcel as well as to anthracnose which trig and worsens suberizing. Some species of *Notocactus* have a greater suberizing capacity stem which has protection role and is of non pathogen origin. With regard to attack on stem, the frequencies were higher in *Astrophytum* (51.75); *Ferocactus* (65.76) *Notocactus* (58.18); *Cleistocactus* (61.9); *Eriocactus* (42.66); *Lobivia* (55). These high values are not exponential followed by high values of intensity and attack degree (Table 3).

The only exception was *Cleistocactus* genus, because of the multiple dry portions of branches which makes the stem to show high intensity and attack degree values. The grading scale undertaken after James (1971) quoted in De la Torre (1988) reached 2 value, while in the case of the other 14 genera it remained at the 1 value. In case of *Cleistocactus,* the causes of peak growth and branches which form the stem are of unknown origin. Causes can be of pathogen or non-pathogen origin. The non-pathogen origin is known as the physiological phenomenon, through which a plant guides reserve substances from the stems extremities to some favoured areas. Such phenomena are frequent, especially at the plants winter reponses when plants being in latent state temperature conditions are very high.

In such conditions, in case of long drought, plants have the capacity to auto eliminate certain portions through guiding reserve substances. In case of soil moisture increase, the shoot stem forms new sprouts near the mortified tissue. The pathogen origin of dried peak growth is normally owned to *Helminthosporium cactivorum.* This mycosis was not signaled in Cluj-Napoca Botanical Garden in the *Cactacae* collection.

In the assessment study of the attack with pathogen agents on stem, the lowest values regarding frequency were recorded in *Rebutia* (1.58) and *Pilosocereus* (2.85) . In *Pilosocereus* intensity was higher (20) (compared with low values of frequency and attack degree). *Rebutia* proved to be the most resistant to pathogen agents attack with 1.58 frequency, 0.23 intensity and 0.0036 attack degree. Attack degree having values below zero were scored in *Aylostera* (0.73); *Cereus* (0.96); *Gymnocalycium* (0.96); *Mammillaria* (0.98); *Rebutia* (0.0036); *Pilosocereus* (0.57). Higher values in evaluating attack intensity are owned to singular cases of antracnoze of *Astrophytum* and *Ferocactus*. In *Notocactus,* stem suberizing was of non pathogen nature. In *Pilosocereus*, high intensity was due to problems caused by

Table 4. Evaluation of the attack caused by phytopathogen agents on *Cactaceae*, Cluj-Napoca Botanical Garden

Genus	Number of studied taxa	Frequency of attack (F)		Intensity of attack (I)				Attack degree	
		Root	Stem	Root	Intensity grade	Stem	Intensity grade	Root	Stem
Astrophytum	114	81.57	51.75	32.80	2	10.87	1	26.75	5.62
Aylostera	119	92.43	16.80	39.32	2	4.36	1	36.34	0.73
Cereus	156	2.56	24.35	1.41	1	3.97	1	0.03	0.96
Echinocereus	116	79.31	19.82	47.24	2	5.51	1	37.46	1.09
Ferocactus	111	61.26	65.76	22.97	1	13.24	1	14.07	8.70
Gymnocalycium	310	59.03	18.70	22.90	1	5.16	1	13.51	0.96
Mammillaria	894	37.91	18.79	12.95	1	5.22	1	4.90	0.98
Notocactus	232	81.89	58.18	36.03	2	15.17	1	29.50	8.82
Parodia	213	57.74	24.41	23.61	1	6.57	1	13.63	1.60
Rebutia	252	98.80	1.58	38.29	2	0.23	1	37.83	0.0036
Weingartia	100	94.00	30.00	35.50	2	6.50	1	33.37	1.95
Cleistocactus	63	28.57	61.90	16.82	1	30.79	2	4.80	19.05
Eriocactus	75	21.33	42.66	10.66	1	8.26	1	2.27	3.52
Lobivia	80	40.00	55.00	17.62	1	9.75	1	7.04	5.36
Pilosocereus	49	2.04	2.85	1.42	1	20.00	1	0.02	0.57

singular cases of parcel infection and inferior stem portions with *Phomopsis sp.*

Preliminary assessment of the *Cactaceae* collection health results indicate that the radicular system of the best represented *Cactaceae* species is much infected than the stems. Six genera: *Astrophytum, Aylostera, Echinocerus, Notocactus, Rebutia, Weingartia,* assessed through grade scale reached 2 note (affected area 26-50%). The highest attack intensity was observed in *Echinocereus* (47.24). In calculating the attack degree, a bigger uniformity was noticed in *Aylostera* (36.34), *Echinocereus* (37.46), *Rebutia* (37.83) and *Weingartia* (33.37) (Table 4).

In the case of *Astrophytum,* although the attack frequency at the radicular system was higher (81%), intensity and attack degree were low. The analysis of different genus revealed differences in the values of the three parameters studied, which suggests specificity of receptivity and different resistance to the pathogen attack. Regarding the stem's health state, from the 15 genera that were best represented in the collection, only in the case of *Cleistocactus* genus, attack intensity of 2 degree was observed.

This study is the first of its kind aiming on the evaluation of the health of a *Cactaceae* collection in a Botanical Garden in the *Cactaceae* collection. In Cluj Napoca Botanical Garden, the health of the radicular system proved to be very weak in comparison with the health of the stem. The terminology borrowed in order to quantify radicular system integrity does not refer entirely to health or, better said, to the disease state of the roots, but reports to an ideal value of 100% healthy and implicitly 0% sick at the same time.

It can be concluded that in evaluating the roots health, a high value of intensity and attack degree does not necessarily represent a sick root but a weak rooting (below 50%). Within a genus there are very big differences between species, when it comes to the values of intensity and attack degree of the roots. These can be owned to genetic characterstics as well as to species features (revolving, superficial rootting) disturbing biological factors (fungus, heterodera, lice, *etc*) and their virulence or cultural mistakes which cause the loss of radicular body. Plants, with weak rooting or with pronounced sensibility, when grafted on an appropriate stock eliminate these inconveniences.

In case of the stem disease, intensity and attack degree are influenced by natural suberizing or anterior wound cicatrices (for example hail, lice stings, acarine, *etc*.). As in the case of the roots there were deformations from the ideal form of 100% healthy plant. While with advancement in age, many species natural suberization appears to play role in protection and development of mechanical resistance in old tissues. This phenomenon appears almost symmetrically on longitudinal plan and developes to the top of the plant. In addition to this phenomenon, in some cases fungus attack occurs, that usually evolves forward asymmetrically and radially from different points of the plant. The method is applicable and practical in assessing the health of other specialized collections in the botanical garden (orchid, bromeliads, carnivore and juicy plants).

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