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SPECIES COMPOSITION AND STRUCTURE OF THE COMMUNITIES OF PLANT-PARASITIC AND FREE-LIVING SOIL NEMATODES IN THE GREENHOUSES OF BOTANICAL GARDENS OF UKRAINE

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Species Composition and Structure of the Communities of Plant-Parasitic and Free-Living Soil Nematodes in the Greenhouses of Botanical Gardens of Ukraine. Gubin, A. I., Sigareva, D. D. — In greenhouses of botanical gardens of Ukraine 81 species of nematodes were found. The richest by the number of species was Tylenchida order that was presented by 25 species (31 % of species composition). The dominant group of nematodes was plant-parasitic (most frequent was *Rotylenchus robustus* (de Man, 1876) Filipjev, 1936 and *Meloidogyne incognita* (Kofoid et White, 1919) Chitwood, 1949). The group of saprobiotic nematodes, which was presented by 52 species (64 %), appeared to be the richest by the number of species. It is shown, that formation of nematode communities in greenhouses of botanical gardens was caused by the interaction of many related factors, crucial of which is the composition of plant collections. The structure of communities is quite constant and almost independent of the quantity of nematodes species. Plant-parasitic species dominate by the number and frequency of detection, and represent a kind of a core of nematode communities.

Key words: soil nematodes, species community, botanical gardens, greenhouses, Ukraine.

Видовой состав и структура сообществ фитопаразитических и свободноживущих почвенных нематод в оранжереях ботанических садов Украины. Губин А. И., Сигарёва Д. Д. — В оранжереях ботанических садов Украины обнаружен 81 вид нематод. Наиболее богатым по количеству видов оказался отряд Tylenchida, представленный 25 видами (31 % видового состава). Доминирующей группой являлись фитопаразиты, из которых наиболее распространёнными были *Rotylenchus robustus* (de Man, 1876) Filipjev, 1936 и *Meloidogyne incognita* (Kofoid et White, 1919) Chitwood, 1949). Самой богатой по видовому составу оказалась группа сапробиотических нематод, которая была представлена 52 видами (64 %). Показано, что формирование нематодных комплексов в оранжереях ботанических садов обусловлено взаимодействием множества факторов, ключевым из которых является состав растительных коллекций. Структура комплексов довольно устойчива и практически не зависит от количества видов нематод. Фитопаразитические виды доминируют как по численности, так и по частоте встречаемости и являются своеобразным ядром нематодных сообществ.

Ключевые слова: почвенные нематоды, сообщество видов, ботанические сады, оранжереи, Украина.

Introduction

Nematode communities are an integral part of the soil ecosystems and play an essential role in many biological processes. Traditionally, the vast majority of nematological research is devoted to plant-parasitic species, which cause significant damage to crop production all over the world. However, in light of the increasing anthropogenic impact in natural ecosystems, a comprehensive study of roundworms currently is no less urgent. The study of nematode communities plays an important role in understanding of natural biological processes and allows finding out patterns of formation, functioning and anthropogenic changes in biocenoses (Kozlovskyi, 2009).

Greenhouses of botanical gardens are the perfect model objects for the study of nematode communities. The main features that distinguish greenhouses of botanical gardens from agricultural (industrial) greenhouses are: 1) absence of crop rotation; 2) wide range of plants simultaneously growing on a relatively limited area; 3) long-term (frequently perennial) growing of plants in containers or directly in the ground greenhouses (Sigareva et al., 2010).

Greenhouses are the artificially created specific ecosystems each of which is unique, in spite of the general principles. The differences caused by a variety of physical factors (temperature, water and light modes, the composition of soil mixes etc.), biological (species composition of plants, animals, fungi and other organisms), qualification of the personnel, type of financing, etc. Due to the influence of these factors the structure of nematode communities in each of the botanical gardens are different.

All the currently available information on the integrated study of nematode communities in the greenhouses of the botanical gardens of Ukraine mainly relates to plant-parasitic helminthes, and it is rather fragmentary (Kirjanova, Krall, 1971; Timchenko, 1991).

Material and methods

The material was collected during 2008–2011 in greenhouses of Donetsk botanical garden of NAS of Ukraine (DBG), botanical garden of Kharkiv national university named after V. Karazin (BGKNU), M. M. Gryshko National botanical garden of NAS of Ukraine (NBG), botanical garden of Lviv national university named after I. Franko (BGLNU), Kryvyi Rih botanical garden of NAS of Ukraine (KRBG) and Nikita botanical garden — National scientific centre of NAAS of Ukraine (NBG–NSC). As far as the research included not only free-living soil nematodes, but also plant-parasites, the extracts of the worms were carried out not only from the soil, but also from above and below ground organs of the plants. Altogether 153 species of plants belonging to 62 genera and 44 families were examined.

For the extraction of nematodes from soil and tissues of plants, Baermann's funnel technique was used (Baermann, 1917; Decker, 1972; Kirjanova, Krall, 1969). Exposition term was 5 days. TAF (triethanolamine 2 ml (40 %) formalin 7 ml and distilled water 91 ml) was used for fixation of the nematodes (Courtney et al., 1955). Temporary microscope slides preparation and nematodes staining were done by standard techniques (Decker, 1972; Matveeva, 1989).

Species identification was carried out with using the microscopes MBS–9, MBI–3 (LOMO), and Zeiss Primo Star with Canon Power Shot A 640 camera. We used the monographs by Eliava (1988), Goodey (1963), Kirjanova and Krall (1969, 1971), Krall (1978), Mai and Mullin (1996), Ryss (1988), Siddiqi (2000), Stirling et al. (2002). Frequency of detection and the average quantity of nematodes were counted for the 100 cm^3 of soil and 1 g of plant tissues.

The similarity between nematode communities in different botanical gardens was estimated using Jaccard index, cluster analysis using complete linkage method. The type of the distance was the Euclidean distance (2-norm distance) (Sneath, Sokal, 1973) determined using Statistica 6.1 for Windows.

Results and discussion

Totally 81 species of nematodes belonging to 64 genera, 29 families and 8 orders were found. The largest variety of nematodes species was observed in the M. M. Gryshko National botanical garden (59 species), the smallest was in the botanical garden of Lviv National University (21 species).

The order Tylenchida was the richest by the number of species; it was represented by 25 species (31 %) belonging to 18 genera and 8 families (table 1). It is this order that includes most of the known plant-parasitic nematodes. In addition, many species belonging to the orders Rhabditida and Dorylaimida were found. The former order was represented

Table 1. Taxonomic distribution of nematodes in the greenhouses of botanical gardens of Ukraine

Таблица 1. Таксономическое распределение нематод в оранжереях ботанических садов Украины

Order	Number of species	Number of species, %
Tylenchida	25	31
Rhabditida	21	26
Dorylaimida	18	22
Araeolaimida	9	11
Enoplida	4	5
Chromadorida	2	3
Monhysterida	1	1
Teratocephalida	1	1

by 21 species (26 %) belonging to 17 genera and 4 families, the latter order — by 18 species (22 %) belonging to 14 genera and 8 families. The orders Chromadorida, Monhysterida and Teratocephalida were the smallest by the number of species (table 1).

All found nematodes can be divided into four groups according to their feeding habits: plant-parasitic, fungivorous, saprobiotic and predatory. Information on the details of species allocation and distribution in different botanical gardens is given in the table 2.

Table 2. Trophic distribution and dissemination of nematodes in the greenhouses of botanical gardens of Ukraine

Таблица 2. Трофическое распределение и распространение нематод в оранжереях ботанических садов Украины

Species of nematodes	DBG	BGKNU	BGLNU	NBG	KRBG	NBG–NSC
Plant-parasitic						
Aphelenchoides fragariae (Ritzema Bos, 1890) Christie, 1932	–	–	–	+	–	–
Belondira paraclava Jairajpuri, 1964	–	+	–	–	–	+
Ditylenchus destructor Thorne, 1945	–	–	–	+	–	–
D. dipsaci (Kuhn, 1857) Filipjev, 1936	+	+	+	+	+	+
Helicotylenchus dihystera (Cobb, 1893) Sher, 1961	+	+	+	+	+	+
Hemicycliophora parvana Tarjan, 1952	+	+	–	–	+	+
Heterodera fici Kirjanova, 1954	–	+	–	–	–	–
Longidorus elongatus (de Man, 1976) Thorne et Swanger, 1936	+	–	+	–	–	+
Macroposthonia annulata de Man, 1880	–	+	–	+	–	–
Meloidogyne incognita (Kofoid et White, 1919) Chitwood, 1949	+	+	+	+	+	+
Paratrichodorus acutus Bird, 1967	+	–	–	–	–	–
Paratylenchus nanus Cobb, 1923	+	+	–	+	+	+
Pratylenchus crenatus Loof, 1960	+	+	+	+	–	+
P. penetrans (Cobb, 1917) Filipjev et Sch. Stekhoven, 1941	–	–	–	–	+	+
Rotylenchus robustus (de Man, 1876) Filipjev, 1936	+	+	+	+	+	+
Tylenchorhynchus claytoni Steiner, 1937	+	+	+	+	+	+
T. dubius (Buerschli, 1873) Filipjev, 1936	–	–	–	+	–	+
Xiphinema americanum Cobb, 1913	–	+	–	+	+	+
Fungivorous						
Aglenchus agricola (de Man, 1884) Andrassy, 1954	+	+	–	+	+	+
A. costatus (de Man, 1921) Andrassy, 1954	+	+	–	+	+	+
Aphelenchoides asterocaudatus Eroshenko, 1967	–	+	–	+	+	+
A. bicaudatus (Imamura, 1931) Filipjev et Sch. Stekhoven, 1941	–	–	–	+	–	+
A. limberi Steiner, 1936	–	–	–	+	+	+
Aphelenchus avenae Bastian, 1865	+	+	+	+	+	+
Tylenchus davainei Bastian, 1865 (Filipjev, 1934)	+	+	–	+	+	+
Saprobiotic						
Acrobeles ciliatus Linstow, 1877	+	+	+	+	+	+
Acrobeloides buetschlii (de Man, 1884) Steiner et Buhrer, 1933	+	+	+	+	+	+
Alaimus primitivus de Man, 1880	+	+	+	+	+	+
Amphidelus dolichurus de Man, 1876	–	–	–	+	+	–
Anaplectus granulosus Bastian, 1865	–	–	–	–	+	–
Aphanolaimus attentus de Man, 1880	+	+	–	+	+	+
Aulolaimoides elegans Micoletzky, 1915	–	–	–	+	–	–
Bastiania gracilis de Man, 1880	–	–	–	+	+	–
Boleodorus thylactus Thorne, 1941	–	–	–	–	+	–
Butlerius butleri T. Goodey, 1929	+	–	–	+	+	–
Caenorhabditis dolichura (Schneider, 1866) Dougherty, 1955	+	–	–	–	–	–
C. elegans (Maupas, 1900) Dougherty, 1953	+	+	+	+	+	+
Cephalobus parvus Thorne, 1937	–	+	–	+	–	+
C. persegnis Bastian, 1865	–	–	–	–	–	+
Cervidellus insubricus (Steiner, 1914) Thorne, 1937	+	+	+	+	+	+
Chiloplacus symmetricus (Thorne, 1925) Thorne, 1937	+	+	–	+	+	+

Species of nematodes	DBG	BGKNU	BGLNU	NBG	KRBG	NBG–NSC
Chronogaster andrassyi Loof et Jairajpuri, 1965	–	–	–	+	–	–
Cylindrolaimus communis de Man, 1880	–	–	–	+	–	–
Demaniella cibourgensis Steiner, 1914	–	–	–	–	+	–
Diploscapter coronata (Cobb, 1893) Cobb, 1913	–	+	–	–	–	–
D. rhizophilus Rahm, 1928/29	+	+	–	+	+	–
Eucephalobus mucronatus (Kozlowska et Rogusa-Wasilewska, 1963) Andrassy, 1967	+	+	–	+	+	+
E. oxyuroides Steiner, 1936	+	+	+	+	+	+
Eudorylaimus carteri (Bastian, 1865) Andrassy, 1959	+	+	+	+	+	+
E. monhystera de Man, 1880	+	+	–	+	–	–
E. obtusicaudatus (Bastian, 1865) Andrassy, 1959	+	+	+	+	+	+
E. paesleri Andrassy, 1959	–	+	–	–	–	+
E. projectus (Thorne, 1939) Andrassy, 1959	–	–	–	+	+	–
Malekus acridens Thorne, 1974	–	–	–	+	–	–
Mesodorylaimus bastiani (Butschl i, 1873) Andrassy, 1959	+	–	–	–	+	–
Mesorhabditis monhystera (Butschli, 1873) Dougherty, 1955	+	+	+	+	+	+
Monhystera filiformis Bastian, 1865	–	–	–	+	–	–
Odontolaimus chlorurus de Man, 1880	–	+	–	–	–	–
Onchulus longicauda (Daday, 1899) Andrassy, 1964	–	+	–	–	–	–
Panagrolaimus rigidus (Schneider, 1866) Thorne, 1937	+	+	–	+	+	+
Paracyatholaimus intermedius (de Man, 1880) Micoletzky, 1924	–	–	–	–	–	+
Paraplectonema pedunculata (Hofmanner, 1913) Strand, 1934	+	–	+	+	–	–
Paraseinura musicola Timm, 1961	+	–	–	+	–	+
Pelodera teres Schneider, 1866 (Dougherty, 1955)	+	+	+	+	+	+
Peplorhabditis vestibularis Ivanova, 1960	+	–	–	+	–	–
Plectus rhizophilus de Man, 1880	+	+	–	+	+	–
Prismatolaimus intermedius (Butschli, 1873) de Man, 1880	+	+	+	+	–	+
Psilenchus hilarulus de Man, 1921	–	+	–	–	+	–
Rhabditis musicola Rahm, 1928	–	+	–	–	–	–
Swangeria fragilis Thorne, 1939	–	–	–	–	–	+
Teratocephalus terrestris Butschli, 1873	–	–	–	+	–	–
Tobrilus gracilis (Bastian, 1865) Andrassy, 1959	+	–	–	–	+	–
Tridontus longicaudatus Khera, 1965	–	+	–	–	–	–
Tripyla cornuta Skwarra, 1921	–	–	–	+	+	+
Wilsonema auriculatum (Butschli, 1873) Cobb, 1913	+	+	–	+	+	+
W. cephalatum (Cobb, 1893) Cobb, 1913	–	–	–	+	–	–
Zeldia serrata Heyns, 1962	+	+	–	+	–	+
Predatory						
Anatonchus tridentatus (de Man, 1876) de Coninck, 1939	–	–	–	+	–	–
Mononchus papillatus Bastian, 1865	+	+	+	+	+	+
Seinura oxura (Paesler, 1957) Goodey, 1960	–	–	–	+	–	–
Tigronchus tauricus Kirjanova, 1971	–	–	–	+	–	–

Note. DBG — Donetsk botanical gardens of NAS of Ukraine; BGKNU — botanical gardens of Kharkiv national university named after V. Karazin; BGLNU — botanical gardens of Lviv national university named after I. Franko; NBG — M. M. Gryshko National botanical gardens of NAS of Ukraine; KRBG — Kryvyi Rih botanical gardens of NAS of Ukraine; NBG-NSC — Nikita botanical gardens — National scientific centre of NAAS of Ukraine; «+» — species presented; «–» — species absent.

The group of saprobiotic nematodes represented by 52 species (64 % of species composition) appeared to be the richest by the number of species. The most widespread among them were *Acrobeles ciliatus* Linstow, 1877; *Acrobeloides buetschlii* (de Man, 1884) Steiner et Buhrer, 1933; *Alaimus primitivus* de Man, 1880; *Caenorhabditis elegans* (Maupas, 1900) Dougherty, 1953; *Cervidellus insubricus* (Steiner, 1914) Thorne, 1937; *Eucephalobus oxyuroides* Steiner, 1936; *Eudorylaimus carteri* (Bastian, 1865) Andrassy, 1959; *E. obtusicaudatus* (Bastian, 1865) Andrassy, 1959; *Mesorhabditis monhystera* (Butschli, 1873) Dougherty, 1955; *Pelodera teres* Schneider, 1866 (Dougherty, 1955).

Table 3. Trophical structure of the nematode communities in the greenhouses of botanical gardens of Ukraine

Таблица 3. Трофическая структура сообществ нематод в оранжереях ботанических садов Украины

Botanical garden	Species number					Species number, %			
	Saprobiotic	Plant-parasitic	Fungivorous	Predatory	Total	Saprobiotic	Plant-parasitic	Fungivorous	Predatory
DBG	27	10	4	1	42	62	24	12	2
BGKNU	28	12	5	1	46	61	26	11	2
BGLNU	12	7	1	1	21	57	33	5	5
NBG	36	12	7	4	59	61	20	12	7
KRBG	28	9	6	1	44	62	23	13	2
NBG–NSC	24	13	7	1	45	53	29	16	2
Total	52	18	7	4	81	64	23	8	5

Note. Explanation of the abbreviations is given in table 2.

Plant-parasitic nematodes were represented by 18 species (23 % of species composition). The most common species were *Ditylenchus dipsaci* (Kuhn, 1857) Filipjev, 1936; *Helicotylenchus dihystera* (Cobb, 1893) Sher, 1961; *Meloidogyne incognita* (Kofoid et White, 1919) Chitwood, 1949; *Rotylenchus robustus* (de Man, 1876) Filipjev, 1936; *Tylenchorhynchus claytoni* Steiner, 1937.

Fungivorous nematodes accounted for 8 % of species composition (7 species). The most common among them was *Aphelenchus avenae* Bastian, 1865.

Predatory nematodes were represented by 4 species (5 % of species composition). *Mononchus papillatus* Bastian, 1865 was the most common among them.

In most cases, the dominant group of nematodes was plant-parasitic. In all six gardens, two species of plant-parasitic helminthes dominated: *R. robustus* and *M. incognita*. The average quantity and frequency of detection of these nematodes were much higher than similar values for other species. In addition to that, quite often *D. dipsaci, H. dihystera* and *T. claytoni* dominated as well. The number of saprobiotic nematodes was the greater the more intense were the putrefactive processes in the root system caused by plant-parasitic nematodes. In turn, the greater was the level of destruction of the root system the lower was the number of plant-parasitic nematodes that migrated depending on the rots spreading in healthy tissues and rhizosphere. In addition, the reduction of the number of plant-parasitic, saprobiotic and fungivorous nematodes in many cases was accompanied by an increase of predatory nematodes number.

At the same time, the percentage of different trophic groups of nematodes in different gardens is quite homogeneous, regardless of the total number of nematodes species. The maximum discrepancy between the minimum and maximum values of species quantity within a single trophic group was just 13 % (table 3).

For this reason we characterize the detected nematode communities as quite a stable and ecologically similar structural formation, and consider the fauna of nematodes in the greenhouses of botanical gardens as a unified whole. Also, this confirms that despite a considerable geographical remoteness of botanical gardens, the conditions in the greenhouses actually differ to a little extent, and cause the formation of quite a stable specific fauna of nematodes.

The quantitative composition of nematode communities does not give comprehensive information about their similarity. For a more detailed analysis of the similarity of nematode communities in different botanical gardens, a symmetric matrix of values of the coefficient of Jaccard index was compiled (table 4).

Table 4. The matrix of similarity of species composition of the nematode communities in the greenhouses of botanical gardens of Ukraine

Таблица 4. Матрица сходства видового состава сообществ нематод в оранжереях ботанических садов Украины

	DBG	BGKNU	BGLNU	NBG	KRBG	NBG–NSC
DBG	–	0.6	0.5	0.55	0.59	0.58
BGKNU	60	–	0.39	0.52	0.55	0.63
BGLNU	50	39	–	0.33	0.35	0.43
NBG	55	52	33	–	0.54	0.57
KRBG	59	55	35	54	–	0.56
NBG–NSC	58	63	43	57	56	–

Note. Explanation of the abbreviations is given in table 2.

Based on the indexes of similarity, a cluster analysis was conducted and the dendrogram was constructed (fig. 1).

As the dendrogram shows, nematode communities in NBG–NSC and DBG form a separate group (cluster), which is very different from the nematode communities from other botanical gardens. This fact can be explained by several factors like: geographical location of the gardens, similar species composition and similar sources of formation of plant collections. However, finding out the true cause of the similarity of the nematode communities it is not only extremely difficult, but in practice, it is unlikely to be possible at all. This particularly concerns the question of the ways of plant collections formation, which, in our opinion, is one of the most likely explanations.

The origin of most plants found in the collections of botanical gardens is unknown or limited by general information that is not suitable for our purposes. The fact that these gardens contain some of the largest collections of succulents among all the botanical gardens of Ukraine, which certainly shows a mass exchange of these plants between the two organizations, can be taken as the most likely explanation for such a distribution of nematode communities.

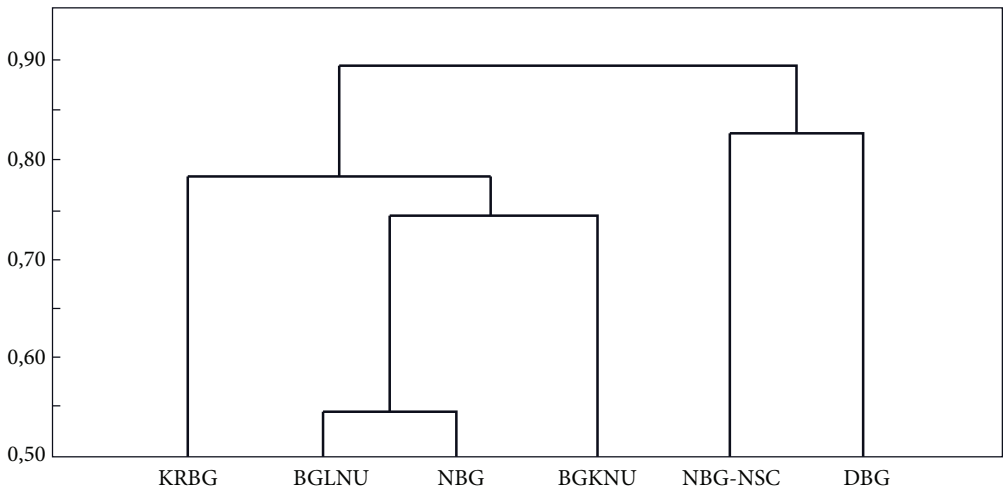

Fig. 1. Dendrogram of similarity of the nematode communities in the greenhouses of botanical gardens of Ukraine (amalgamation by the method of complete linkage). Explanation of the abbreviations is given in table 2.

Рис. 1. Дендрограмма сходства нематодных сообществ в оранжереях ботанических садов Украины (объединение по методу полной связи). Расшифровка сокращений дана в таблице 2.

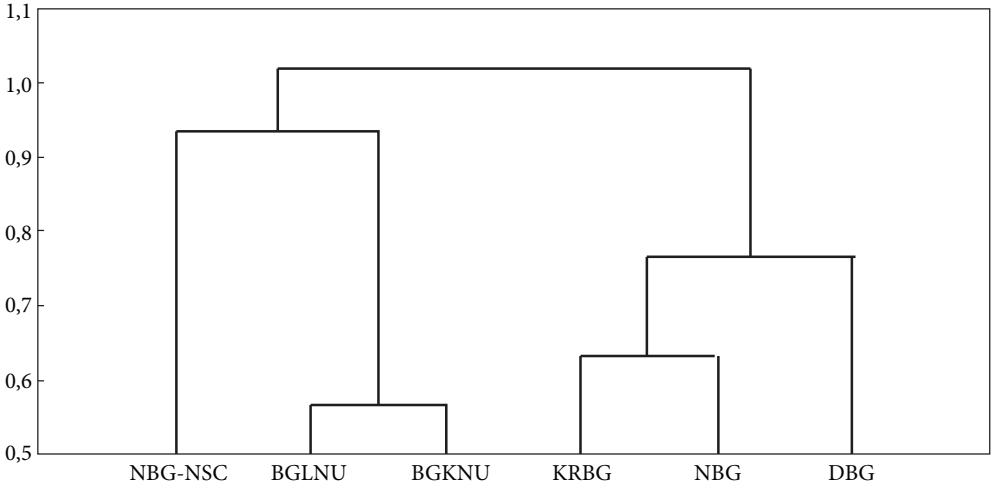

Fig. 2. Dendrogram of similarity of plant-parasitic nematodes' communities in the greenhouses of botanical gardens of Ukraine (amalgamation by the method of complete linkage). Explanation of the abbreviations is given in table 2.

Рис. 2. Дендрограмма сходства сообществ фитопаразитических нематод в оранжереях ботанических садов Украины (объединение по методу полной связи). Расшифровка сокращений дана в таблице 2.

Since plant-parasitic nematodes dominated in most cases of nematode communities, a cluster analysis was performed, and a dendrogram of plant-parasitic nematode communities' similarity was composed in order to find out whether they determine a distribution like this (fig. 2).

As shown in this dendrogram, communities of plant-parasitic nematodes form two completely different groups ("NBG–NSC, BGKNU, BGLNU" and "KRBG, NBG, DBG"). The first group includes the oldest gardens of Ukraine founded in the XIX century (NBG–NSC and BGKNU) or based on plants collections, gathered at that time (BGLNU). The most similarity of parasite communities was noted in BGLNU and BGKNU. Both these gardens belonging to the universities have a small area of greenhouses, small collection of plants and usually little funding. These factors also make a difference in the character of farming. All this speaks for the dependency of plant-parasitic nematode community structure from these factors.

Complex "KRBG, NBG, DBG" consists of academic gardens, with a large area of greenhouses, between which there is a constant exchange of plant material. Although NBG–NSC belongs to the academic ones, the area of greenhouses therein is very small, and the exchange with this garden is carried out practically at the level of succulents only, because they constitute a single fund collection in the greenhouses of this institution.

Thus, it was found that formation of nematode communities in greenhouses of botanical gardens is caused by the interaction of many related factors such as: age of gardens, area of covered ground, composition of plant collections, farming mode, intensity of exchange plant material, etc. Crucial here is exactly the composition of plant collections. The structure of nematode communities is quite resistant and almost independent from the number of nematodes species. Plant-parasitic species dominate by the number and frequency of detection, and represent a kind of a core of nematode communities.

References

Baermann, G. Eine einfache Methode zur Affindung von Ankylostomum (Nematoden) larven in Erdprobem // Geneesk. Tijdschr. Ned. — 1917. — Ind. 57. — S. 131–137.

Courtney, W. D., Polley, D., Miller, V. L. TAF, an improved fixative in nematode technique // Plant Disease Reporter. — 1955. — **39**. — P. 570–571.

Decker, H. Plant nematodes and their control. (Phytonematology). — Moscow : Kolos, 1972. — 444 p. — Russian : *Деккер Х.* Нематоды растений и борьба с ними (Фитонематология).

Eliava, I. J. Free-living nematodes of the family Dorylaimidae. — Leningrad : Nauka, 1988. — 264 p. — Russian : *Элиава И. Я.* Свободноживущие нематоды семейства Dorylaimidae.

Goodey, T. Soil freshwater nematodes. — London : Methuen, 1963. — 544 p.

Kirjanova, E. S., Krall, E. L. Plant-parasitic nematodes and measures of their control. — Moscow : Nauka, 1969. — Vol. 1. — 477 p. — Russian : *Кирьянова Е. С., Кралль Э. Л.* Паразитические нематоды растений и меры борьбы с ними.

Kirjanova, E. S., Krall, E. L. Plant-parasitic nematodes and measures of their control. — Moscow : Nauka, 1971. — Vol. 2. — 522 p. — Russian : *Кирьянова Е. С., Кралль Э. Л.* Паразитические нематоды растений и меры борьбы с ними.

Kozlovskyi, M. P. Phytonematods of terrestrial ecosystems of the Carpathian region. — Lviv, 2009. — 316 p. — Ukrainian : *Козловський М. П.* Фітонематоди наземних екосистем Карпатського регіону.

Krall, E. L. Parasitic root nematodes. Family Hoplolaimidae. — Leningrad : Nauka, 1978. — 420 p. — Russian : *Кралль Э. Л.* Паразитические корневые нематоды. Семейство Hoplolaimidae.

Mai, W. F., Mullin, P. G. Plant-parasitic nematodes. A pictorial key to genera. — New-York : Cornell University Press, 1996. — 278 p.

Matveeva, M. A. Protecting plants from nematodes. — Moscow : Nauka, 1989. — 150 p. — Russian : *Матвеева М. А.* Защита растений от нематод.

Ryss, A. Yu. Parasitic root nematodes of the family Pratylenchidae (Tylenchida) of the world fauna. — Leningrad : Nauka, 1988. — 368 p. — Russian : *Рысс А. Ю.* Корневые паразитические нематоды семейства Pratylenchidae (Tylenchida) мировой фауны.

Siddiqi, M. R. Tylenchida: parasites of plants and insects. — Norfolk : CABI, 2000. — 834 p.

Sigareva, D. D., Bondarenko-Borisova, I. V., Boltovskaya, E. V., Gubin, A. I. Methodic recommendations for the protection of ornamental plants in greenhouses from nematodoses in botanical gardens of Ukraine. — Donetsk, 2010. — 44 p. — Russian : *Сигарева Д. Д., Бондаренко-Борисова И. В., Болтовская Е. В., Губин А. И.* Методические рекомендации по защите декоративных растений закрытого грунта от нематодозов в условиях ботанических садов Украины.

Sneath, P. Clustering methods in the statistical analyses // Proc. Nat. Acad. Sci. USA. — 1973. — **70**. — P. 3762–3776.

Stirling, G., Nicol, J., Reay, F. Services for Nematode Pests : Operational Guidelines // Rural Industries Research and Development Corporation. — Canberra, 2002. — 120 p.

Timchenko, L. S. Peculiarities of pathogenic process in root knot of ornamental plants // Introduction and acclimatization of plants. — 1991. — N 15. — P. 100–102. — Russian : *Тимченко Л. С.* Особенности патогенного процесса при мелоидогинозе декоративных растений.

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