

## **ECOLOGICAL GROUPING OF PLANT NEMATODES**

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**Abstract:** Phytonematodes typically infect plants of various ages, but they are especially dangerous to woody plants in the first years of life. Plant infestations with phytohelminths are characterized by stunted growth, deformation of stems and shoots, shoot wilting, and chlorosis. Studying phytonematodes, their species, development conditions, and adaptation processes is important.

The ability of phytonematodes to adapt to specific moisture levels allows them to be divided into the following major ecological groups: xerophylls, mesophylls, hygrophiles, and eurybionts. Xerophylls comprise an ecological complex of nematode species confined to strictly arid environments. The mesophilic ecological complex includes nematode species confined to biotopes with moderate moisture levels. Hygrophiles comprise a complex of species confined to areas with excessive moisture due to the close proximity of groundwater. Hygrophila are divided into two subgroups: megathermic and mesothermic. Mesothermic hygrophila are confined to floodplain forests (tugai) of river valleys. Under irrigated agriculture, megathermic hygrophila can migrate to cultivated areas and cause significant damage to agriculture. Mesothermic hygrophila include nematode species confined to biotopes with excessive moisture and moderate or cold temperatures. Some species of mesothermic hygrophila are potentially dangerous parasites of agricultural plants grown under irrigated conditions, but cannot survive in dryland plantings. It should be noted that this unique habitat has a unique set of environmental factors, as well as a unique composition of plant nematodes.

Root gall-forming plant nematodes cause the disease meloidogyna. They are dangerous pests, damaging up to 5% of the world's cultivated plant crops. Plant nematodes, or plant helminths, are microscopic worms belonging to the class Nematoda of the phylum Roundworm. Their bodies are typically filiform or spindle-shaped, typically 0.5–35 mm long, and covered with a dense shell (cuticle). The oral cavity of plant nematodes contains a stele—a piercing, sucking mouthpart with which the nematode pierces plant tissue. The bulbus—a muscular expansion of the middle part of the esophagus—is responsible for nutrient absorption in nematodes. Many species of plant nematodes overwinter in the soil, particularly in the wintering parts of plants (roots, tubers, bulbs, galls). Plant nematode eggs are the overwintering stage, so when the larvae hatch, they infect plants by burrowing into small roots, and some migrate to above-ground parts. Plant nematodes are extremely fecund, laying up to 3,000 eggs per season. Furthermore, many nematodes produce several generations per year, resulting in a single female producing up to several billion offspring.

**Keywords:** plant nematodes, plant helminths, organism, growth, biotope, mesophiles, hygrophiles, xerophiles, eurybionts.

**Study Objective:** Nematodes are a vital component of the soil community and the most numerous animals on Earth. They play a key role in recycling organic matter and controlling soil microbial populations, regulating carbon and nutrient dynamics, and promoting soil fertility. More than 4,000 plant-parasitic nematodes have been identified. They annually destroy approximately 14% of plant yields. Plant nematodes transmit viruses and aggravate fungal and bacterial diseases. They disrupt root uptake of water and nutrients, reducing productivity. They lead to massive plant mortality during drought. Plant nematodes depend on air and soil humidity, temperature, acidity, and soil texture. They are typically spread by plant material, irrigation water, and rainwater. They infect plants of all ages, but are especially dangerous to woody plants during the first years of life. Plant-borne helminth infections are common in many deciduous and coniferous trees, fruit trees and ornamental shrubs, flowers, and agricultural crops. Plant infestations typically result in stunted growth, trunk and shoot deformation, shoot wilting, chlorosis, and browning of needles and leaves. Underdevelopment and deformation of the root system are particularly noticeable. Root-borne nematodes of the *Meloidogone*, *Xiphinema*, and *Dongidorus* genera form spherical galls on the roots of deciduous trees and thicken the roots of conifers. Nematodes of the *Neroderia* genus cause the mass formation of secondary lateral roots.

**Research materials and methods:** Among environmental factors influencing reproductive energy and development rate, soil moisture and temperature play a key role in the distribution and population dynamics of plant nematodes, as nematodes are active in water films and are highly sensitive to cooling or overheating. A number of specialized indices have been developed to effectively assess the degree of habitat disturbance and provide insight into the state of the soil ecosystem based on nematode community analysis. Numerous methods have been developed for isolating nematodes from the soil, fixing them, and preparing temporary and permanent specimens to obtain information on the composition, structure, and abundance of nematodes in the soil. **Sampling.** The simplest sampler is a piece of metal pipe of the required diameter, sharpened on one end. For most nematodes, samplers with a diameter of at least 3 cm are recommended for their counting. Sampling in natural biotopes is typically carried out at a depth of 10-15 cm. However, the sampling depth can vary significantly depending on the study area. In forests, 90-98% of nematodes are concentrated in the upper 3-5 cm organogenic horizon, so in such ecosystems, it is reasonable to conduct sampling at the depth of the organogenic horizon. In meadows and agrosystems, only 30% of nematodes are concentrated in the upper 10 cm layer, and approximately 80% are in the upper 30 cm. In such ecosystems, sampling is usually carried out to a depth of 30 cm. When studying the vertical distribution of nematodes, the sampling depth can reach 150 cm. Nematode abundance may vary depending on weather conditions. Nematodes are unevenly distributed in the soil, forming patches of high and low density. In our studies, samples were collected from 5 to 30 soil samples to determine the abundance and diversity of the nematode complex in the studied biotope. The number of samples collected and the samples analyzed varied. During the study, several plots of the same type located at a distance from each other were selected. Samples were collected in 10 samples from three separate plots. The Berman method was used to isolate nematodes from the soil, i.e., for extraction. This method depends on the soil layer thickness (the thinner the soil layer, the better the nematodes emerge from the substrate). Nematodes were extracted from 25-100 g of fresh soil. Soil acidity and texture, seasonal physiological changes in the host plants, and other factors are also important. For example, high numbers of plant nematodes, which cause diseases in conifer seedlings, are observed in nurseries located on sandy soils, at soil temperatures of 18-20°C and humidity of 18-28%.

Plant nematodes overwinter in the soil, with some species in roots, tubers, bulbs, and galls. They can spread through contaminated plant material, soil, irrigation water, or rainwater. The ability of plant nematodes to adapt to specific humidity levels allows them to be divided into the following major ecological groups: xerophiles, mesophiles, hygrophiles, and eurybionts. The xerophiles include a complex of nematodes confined to strictly arid environments. Nematode species belonging to this group have not been found in riparian plants. The mesophiles include plant nematode species confined to biotopes with moderate humidity. These species have not been found in riparian plants.

Results and discussion: Hygrophila constitute a complex of nematode species confined to biotopes with excessive moisture due to close groundwater tables. The Zerafshan tugai biotopes belong to this type of biotope, which is perhaps why 127 (836 specimens) of the 152 nematode species found belong to this ecological group. Hygrophila are divided into two subgroups: megathermal and mesothermal.

Megathermal hygrophila are confined to floodplain forests (tugai) of river valleys in Central Asia. Cold-resistant species are not found among the nematodes of this ecological complex. The hydrothermal regime of floodplain forests inhabited by megathermal hygrophila is virtually identical to that of agricultural crop cultivation in the valleys. Under irrigated agriculture, megathermal hygrophila can migrate to cultivated areas and cause significant damage to agriculture. Our research recorded 86 nematode species belonging to megethermic hygrophiles. These species are found primarily in spring, summer, and autumn. High populations were found in spring and summer for the following nematode species: *Meloidogone hapla*, *Mincognita*, *Neterodira uzbiirestonica*, *H. turangae*, *N. glycyrrhira*, *Pratulenchus pratensis*, *P. vulnus*, *P. tulaganovi*, *Ditylenchus dipsagi*, *Nathorylenchus aliii*, *N. loksul*, *N. thorneki*, *Ektapne – Renoviya macrostylus*, *Apnelenchoides besseyi*, *Aph. bicaudatus*, *Aph. compsticola*, and *Aph. spinosus*. Mesothermic hygrophiles include nematode species confined to biotopes with excessive moisture and moderate to cold temperatures. These biotopes are also typical of the river floodplains of Central Asia, where formations of small-leaved microdark forests are concentrated. Some species of mesothermic hygrophiles are potentially dangerous parasites of agricultural plants grown under irrigated agriculture, but cannot survive in dryland plantings. Due to the close proximity of tugai biotopes to mountainous terrain, nematode species included in this group were very common and comprised 41 species. The population of these species can also increase in winter. It was found that nematode species such as *Merlinius dubius*, *M. soclatus*, *Rotylenochus goocleyi*, *Filenohus polyhipnus*, *F. delenus*, *F. discrepans*, *Aphelenhoides kuchnii*, and *Aph. sacchari*, *Aph. saprophilus*, *Aph. scalacaudanus*, *Mesorhabditus inarimensis*, *M. signifera*, *Rhabditus brevispina*, *Acrobeloides emarginatus*, *Prismatolaimus clolichurus*, *Mylonchulus lausitrita*, *Gylencholaimus proximus*, and *Eudoruclaimus pratensis*.

Nematode species such as *Aph. kuchnii* and *Aph. sacchari* are much more common in winter than in spring, summer, and fall. This indicates that the nematodes are significantly better adapted to the winter period.

The morphological characteristics and life cycle of the bitterling nematode were also studied on the weed *Acroptilon repens* in foothill conditions. The second-instar larvae overwinter in the upper soil layers. Infection of the weed occurs during the germination period in March. The larvae penetrate the axils of seed leaves and the growing points of young shoots. As the plants develop, grayish-white galls form on the leaves, stems, and root collar. Mature galls darken.

During the weed's growing season, two generations of nematodes can develop. The first generation develops in early June, the second in late August. At the end of the weed's growing season, numerous second-instar larvae can be found on the galls. In severe infestations, galls form in clusters around the main and lateral stems, causing the plants to take on a deformed appearance: reproductive organs develop poorly or not at all.

During the study period, 45 species of plant nematodes were identified in the root system and root soil of cultivated pecans in Uzbekistan. These belong to 7 orders, 26 families, and 29 genera. Of the registered plant nematodes, 17 species from the orders Dorulaimida and Gylenchida are parasitic. The remaining species are classified as pararhizobionts (18 species), eusaprobites (3 species), and deisaprobites (17 species).

The study results showed that the order Phabditida predominates on pecans, representing a large number of species, accounting for 37.7% of the total plant nematode population.

Phytonematodes from the order Gylenchida rank second, accounting for 22.2% of the total plant nematode population. The remaining orders (Chromadorida, Plectida, Alamida, and Mononchida) are represented by more than one or two species. The order Rhabditida had the highest nematode population density on pecan, accounting for 71.6% of all nematode individuals. Aphelenchida represented 16.5% of all nematode individuals. Dorilaimida represented 10.5%, while Alaimids, Mononchidae, Aphelenchidae, Ecclida, and Chromodoridae accounted for less than 1.4% of the total nematode population.

Plant nematode species were dominated by plant helminths and devisaprobionts, which accounted for 37.7% of all plant nematode species. Devisaprobionts were particularly numerous, accounting for 53.7% of the total nematode population in the samples. Eusaprobites constituted a smaller proportion of nematode species. The nematode fauna of vegetable crops primarily belongs to two subclasses (Adenophorea, Secernentea), 6 orders (Araeolaimida, Monhasterida, Enoplida, Dorylaimida, Rabditida, Gylenchida), 15 families, and 31 genera. These taxa are unevenly represented in terms of species numbers, with the order Gylenchida (24 species) being the most diverse, followed by the order Rhabditida (16 species). It should be noted that a unique habitat, with its unique set of environmental factors, also determines the composition of plant nematodes.

Based on the nematode's interactions with plants and their feeding habits, all species are divided into four ecological groups: pararhizobionts, eusaprobites, deusaprobites, and phytohelminths. Pararhizobionts—common free-living soil nematodes, mostly confined to the rhizosphere—are represented by 15 species. The vast majority of species in this ecogroup are concentrated in two layers (0-10 cm and 10-20 cm) of the root soil. However, three species—Eudorylaimus monhystera, Eud. sulphasae, and Gylenchida laimus minimus—were also found in small numbers in the root system of cucumbers. Among the parasitic pararhizobionts, Nygolaimus brahyuris and Mezodorylaimus bastiani were found in the root soil of greenhouse tomato plants.

Eusaprobites are represented by two species. The first species is found in small numbers in the root system and root soil of greenhouse tomato plants, while the second is found only in soil. Therefore, it can be said that the aforementioned eusaprobites are of no practical value for greenhouses.

Desisaprobates—atypical saprobates—are represented by 14 species. In our opinion, three species of this ecogroup are of greatest interest: Pangrolaimus rigidus, Heterocephalobus elongates, and Chiloplacus propinguus, which have been recorded in the root systems of cucumbers and tomatoes.

Phytohelminths are true phytophages. Twenty-four species have been identified in this ecogroup. Phytohelminths are divided based on their feeding habits and feeding method into ectoparasitic mycohelminths (16 species), ectoparasitic perforating phytophages (5 species), and true endoparasitic phytohelminths (3 species). The mycophasic subgroup includes species belonging to the genera Aphelenchus, Paraphelenchus, Seinura, Aphelenchoides, and Glylenchus.

The ectoparasitic perforating phytophages subgroup is represented by five species. However, two of these (Merlinius dubius and Helicotilenchus multicinclus) are found in the root systems of cucumbers and tomatoes. Apparently, nematodes of this subgroup sometimes behave like true endoparasitic phytohelminths. Among the phytohelminths of tomatoes and cucumbers, a special place is occupied by true endoparasitic phytonematodes, represented by three species: Meloidogyne hapla, Ditylenchus dipsagi, and Pratylenchus pratensis. These species have been recorded in the root systems of both crops, and the latter two also in the above-ground parts.

Conclusions. Thus, of the 55 nematode species, 33 species are associated with plants to varying degrees, and in all cases, the majority of species found in the vegetative organs of plants are dominated by representatives of the ecological group of phytohelminths.

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