Hungarian University of
Agriculture and Life Sciences
Department of Foreign Languages

Specialist Training Programme in
Professional Communication in a
Foreign Language

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Undersigned Eszter Erdős, disagree that my dissertation can be used for research purposes.

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THE EFFECT OF PEAT-BASED GROWING MEDIA AND PEAT-FREE GROWING MEDIA ON NEMATODES

ESZTER ERDŐS

Abstract

The success of crop production depends on many factors. One of the most important factors is physical and chemical properties of the growing medium. These growing media can be peat-based or peat-free. Each type of growing medium has its advantages and disadvantages, which must be selected according to the purpose of cultivation. These can be peat, coir, bark, compost, perlite, etc. Due to their unique chemical and phisycal properties, they have different microbiome activity. Their microbial activity has a great influence on the nematodes inside. Thus, the choice of nutrient medium can even be an environmentally friendly method of protection against plant parasitic nematodes.

Keywords: nematodes, peat-based, peat-free, growing media

1. Introduction

In agriculture, farmers have to deal with many problems such as abiotic and biotic factors. If pests are damaged, they are classified as biotic factors. With their damage, they can reduce the quantity and quality of the crop. For example, such damage is when various nematodes appear in the soil. Environmental protection against nematodes is still an unsolved problem in soil cultivation all over the world. Farmers try several methods to protect their crops. The basis of protection against nematodes is the introduction a suitable crop rotation. Plants prone to infection should be replanted in the same area after at least 3-4 years. Adequate pre-seeding is also very important for defence. Physical and chemical properties of the soil greatly influence the life, reproduction and damaging effects of nematodes. That is why it is also important to carry out regular soil tests get an idea of how many and what kinds of nematodes are in our soil. Based on this information, we can prepare and prevent nematode infection. Before planting and sowing, protection against pathogens living in the soil is also of decisive importance. Well-developed biological control methods/products are available against seedling diseases. By choosing the planting medium, we can influence the life cycle of pathogens and nematodes living in the soil, their reproduction and the extent of the damage they cause. In many studies around the world, the properties of different planting media are being investigated, which can have nematode-reducing effect, thus providing a potential opportunity for chemical-free control. In my thesis, I would like to compare the peat-

free and the peat-based planting medium to see what effect they can have on nematode populations and thus on the cultivated plant.
I consider this topic very important and I would like my results to reach more people, so that I can help agricultural workers to achieve more economical production to protect the environment.

2. Literature Review

2.1 What is growing media?

Growing media are materials in which plants are grown in situ (CEN, 1999). Growing medium can be defined as a substance in which plant roots grow and thanks for this they extract water and nutrients. The key of a healthy root system is selecting a good growing medium to good crop production management (Landis et al 1990).

The term substrate is frequently used as a synonym for growing medium but its definition is not so precise. These include all such materials that are used in the hobby and professional markets, whether produced by the growing media industry or by growers as own-mixes (Schmilewski, 2008). A favorable growing media are a composite of two or three constituent selected to provide certain biological, physical or chemical, properties. Mixtures of inorganic and organic ingredients are popular because these materials have opposite, yet complementary, properties (Landis et al, 1990). These ingredients are the basic components of mixes, which are usually formulated on a percentage volume basis (Schmilewski, 2008). Such common organic materials include peat, composted biodegradable waste, coconut coir, composted bark, wood fibre, rice hulls, sawdust, vermiculite, perlite or any other locally available appropriate material. These materials are lightweight, have high CEC and water-holding capacity, and some contain small amounts of mineral nutrients. Some of these organic ingredients require screening or composting of local raw materials before use. Usually composted green waste and kitchen waste are

most likely to be used as constituents of growing media (Landis et al 1990; Schmilewski, 2008).
It is absolutely the key element for the grower that the growing medium functions well under his growing conditions and the price plays the second relevant factor in his decision to purchase (Schmilewski, 2008). Growers must be familiar with the advanteges and disadvantages of the various ingredients and how they can affect plant growth when creating a suitable growing medium for them, or even when buying a commercial one (Landis et al 1990). Composts, coir materials, bark and composted bark as well as wood fibre products are the constituents which have become most successfully established as replacements for peat (Schmilewski, 2008).

2.2 Quality of growing media

Horticultural crops have a lot of requirements which the grower needs to accomplish with the help of individually tailored growing techniques and cultivation measures (Schmilewski, 2008).
In climate-controlled greenhouses the modern horticulture with fertilisation programmes, computer-controlled irrigation, potting machines, pricking robots and just-intime production requires quality assured and dependable growing media (Carlile et al, 2015). Several specialist companies produce a ready-made growing media or special mixtures at the grower's request. For the development of formulations and the manufacture of growing media suitable for this market a large number of phisycal, chemical, biological and economic characteristics of the components must be taken into account (**Table 1**) (Schmilewski, 2008).

PHYSICAL	CHEMICAL	BIOLOGICAL	ECONOMIC
structure and structural stability	pH	weeds, seeds and viable plant propagules	availability
water capacity	nutrient content	pathogens	consistency of quality
air capacity	organic matter	pests	cultivation technique
bulk density	noxious substances	microbial activity	plant requirements
wettability	buffering capacity	storage life	price

Table 1.: Criteria for determining the quality of growing media and their components (Schmilewski, 2008).

The quality of growing media depends on several physicochemical properties, which are unique to each type of growing media components, and can be steered to assure optimal plant growth, for example pH and nutritional elements (N, P, K, Ca, Mg and P) and electrical conductivity (EC) are important chemical characteristics (Carlile et al., 2015). In the case that a particular growing medium or its ingredients have sub-optimal characteristics, it is essential to know also which additives and alternatives would be good for optimization of the formulation (Schmilewski, 2008).

2.3 Functions of growing media

A growing medium serves four basic functions. The first of all is physical support. The growing medium must be porous and provide physical support at the same time. Young crops are fragile and must remain upright so that they can photosynthesize and grow (Landis et al 1990). The second function is aeration. The roots of plants need oxygen for photosynthesis, which is used to produce energy so that the roots can grow and absorb the essential water and mineral nutrients they need. The byproduct of photosynthesis and respiration is carbon-dioxide that must be released into the atmosphere to prevent the toxic concentrations in the root zone (Landis et al 1990). The third function is water supply. Plants use water for growth and development, and the good water supply must be provided by the growing medium. These are formulated so that they can hold water in the micropores between their particles. A lot of growing media contain a high percentage of organic matters such as compost or peat because these materials can hold water like a sponge. Consequently, growing media must have adequate porosity to absorb and store large amounts of water (Landis et al, 1990). Moreover soil moisture strongly affects microbial activity in growing media. Water-filled porosity which also know as soil water saturation can be an expression for soil moisture content. This feature allows for accurate prediction of microbial activity in different soil types (Linn és Doran, 1984; Moyano et al., 2012). The fourth function is the supply of mineral nutrients. The growing medium provides most of the necessary mineral nutrients that plants need for rapid growth. These mineral nutrients are electrically charged ions. Positively charged ions are cations which include potassium (K+), ammonium nitrogen (NH4 +), magnesium (Mg+2) and calcium (Ca+2). The capacity of a growing medium to adsorb these cations is named to as cation exchange capacity (CEC). Different growing media components vary considerably in their CEC, but compost, peat and vermiculite have a high CEC value, which explains their popularity in growing media (Landis et al, 1990).

2.4 Different types of growing media

The total amount of materials used in growing media is difficult to estimate globally, because up-to-date informations are not available for many areas of the world including North and South America, Australia, and Southeast Asia, where soilless growing has expanded in recent years but mainly into hydroponic systems in Thailand, Japan, China and Malaysia (Nukaya, 2006; Zhu and Wang, 2013; Montri and Wattanapreechanon, 2007). In Europe more than 34 Mm^3 of growing media were manufactured per year. Their components 92% was organic materials and 77% was peat (Schmilewski 2009). Principal users of these media were reported as Germany (9 Mm^3), Italy (5 Mm^3), the Netherlands (4 Mm^3), the United Kingdom (3.3 Mm^3) and France (3 Mm^3). In several countries growing media are primarily used by commercial growers, but in some the hobby market or retail consumes the bulk of growing media. In the United Kingdom and France production for the hobby market has been reported as 64% (Schmilewski, 2009) and 70% (UK Department of Environment, Food and Rural Affairs, 2014), respectively, of the total for these countries.

One of the big peat producing companies called The Canadian Sphagnum Peat Moss Association, whose members supply most of the peat used in the United States, estimated in 2002 to 2003 that they supplied more than 8.7 Mm3 to the United States and 70% going to professional growers (Carlile et al 2015).

2.4.1 Peat

Peat is partially degraded organic material what accumulates over thousands of years within mires, the latter defined as living peatlands (Rydin and Jeglum, 2013). *Sphangum* peat has been the most reliable growing medium in horticulture for several decades because it has beneficial unique physico-chemical characteristics, and low economic cost (Schmilewski, 2009; Barrett et al., 2016; Caron and Rochefort, 2011). Furthermore it has excellent air and water retention, low pH level and salinity and because of the high cation exchange capacity (CEC) of peat favors plant nutrient uptake too (Carlile et al., 2015). Thanks to its mode of formation, peat is free of pathogens and pests, and under controlled conditions it is also free of weed seeds. In addition to this processing, handling, fractionating and mixing are simple and do not have health risks (Schmilewski, 2009). In Europe peat is the predominant growing media. This is confirmed by the fact that 86% of the total growing media required for horticulture within the European Union, is composed of peat, and this means 29.3 million m3 of peat usage annually (Altmann, 2008). Specific equipment has been developed for peat extraction, for example nowdays milling machinery is widely used nowdays to remove the surface layer of peat from drained peatlands. This 1 or 2 cm layer may be allowed to dry further before aggregation into large piles (**Figure 1**), the latter then often covered with sheeting to prevent rewetting, and left in the field until required. Peats vary in age and are commonly classified by the simple but very practical von Post scale developed in the 1920s (von Post, 1922), in which three categories of peat, younger, undecomposed of low humification. Partly decomposed, and older, highly decomposed peats are identified (Carlile et al. 2015). Wet peatlands are fragile ecosystems with important ecosystem functions such as water purification, climate regulation and biodiversity conservation. Moreoverthey sequester 30% of the global soil carbon despite constituting only 3% of the global terrestrial area (Joosten et al., 2016). However, unsustainable peat extraction damages the unique habitat of many species including plants and animals (Kern et al.,2017). Peat excavation is thus associated with a large ecological footprint (Owen, 2007; Altmann, 2008). In the near future severe peat supply bottlenecks are expected due to rapidly declining global deposits and thanks to peatland conservation policies (Bos et al., 2011). In a recent years, substantially more effort and funding have been invested in the testing of alternatives to peat than in peat itself (Schmilewski, 2009). Principal plant growing media alternatives for peat with unique physicochemical properties, like coir pith, wood fiber, compost, and inorganic materials are currently used (Carlile et al., 2015; van Gerrewey, 2020).

Figure 1.: Peat mining (http1)

2.4.2 Coir

Coir is the material that forms the middle layers or mesocarp of coconut fruits (*Cocos nucifera L.*) (Schmilewski 2009). Coir is one of the most abundant plant-derived organic waste materials in many tropical and subtropical countries. Long fibers are extracted from the mesocarp after soaking and used in different ways for example the production of brushes, matting and insulating materials (Carlile et al. 2015). The remaining material constitutes coir pith is frequently used either as a pure substratum or as a component in horticulture growing media mixtures as a peat alternative (Verhagen and Zevenhoven, 2017). Coir pith may contain high salt levels (Na, Cl, K) and before preparation for horticultural use, it is washed with water or leached with several solutions such as $Ca(NO_3)^2$, which is called buffered coir. After washing or leaching, the dried coir pith is compressed into blocks or briquettes for ease of transport. These are then reconstituted with the addition of water, in an expansion ratio of 1:12 (w/v) or in higher expansion ratio, as is requested by manufacturers (Maher et al., 2008). In addition to coir pith, coir fibers (1–3 cm) are used to improve aeration in growing media. Coir chips prepared from the hard outer husk of the coconut, are also used to enhance aeration, particularly with media for long-term nursery crops (Carlile et al. 2015). The chemical and physical characteristics of coir materials vary greatly with their origin, time in storage and the duration of the treatment process (Schmilewski 2009). Coir is widely regarded as a rapidly renewable resource. Developement in processing and quality control in situ have led to a huge upsurge in the export and use of coir in growing media, especially in Europe but also in the western parts of the United States (Carlile et al, 2015).

Figure 2.: Coir growing-media (http2)

2.4.3 Composted bark

Bark from both hardwood and softwood species is a major component of growing media, particularly in areas where peat is scarce or expensive. Mostly spruce and other softwood barks are used for bark composting. Crushed and screened raw bark is subjected to a rotting process in which the bark ferments outdoors. The main aim of the fermentation is to reduce N amount in bark which would otherwise lead to plant growth problems. In Europe, the principal users of bark are France, with >1.2 million m^3 in 2005, mainly from the maritime pine (*Pinus pinaster Aiton*), and the second is Spain with 0.5 million m^3 (Schmilewski, 2009). In New Zealand bark from the Monterey pine (*Pinus radiata D. Don*) is the principal organic component of growing media and, along with maritime pine and slash pine (*Pinus elliottii Engelm*.). These are used in Australia, along with hardwood bark from *Eucalyptus diversicolor F. Muell. and E. calophylla Lindl*. (Handreck and Black, 2010). In the in eastern states of the United States, the loblolly pine trees (*Pinus taeda L*.) are the principal sources of bark for use in growing media (Bilderback et al., 2013), whereas in the Pacific Northwest it is the Douglas-fir (*Pseudotsuga menzesii (Mirb.) Franco*) which is widespread for this function. Freshly harvested bark may contain phytotoxic materials for example phenols and tannins, and some conifer species in northern Europe contain Mn (Solbraa, 1979), at the same time, maritime pine such as *Pinus abies L,* has a lower Mn content than barks of pine trees. Although some barks may be used in growing media shortly after removal from the tree, after shredding, and screening. Bark may be cured or aged, usually for 6 to 12 months, or more commonly, composted to eliminate potential problems of phytotoxicity arising from organic compounds (Solbraa, 1979). By adding composted bark to the growing medium their has the following advantages, the air capacity can be increased, the drainability can be improved, the cation exchange capacity can be raised and a pH-buffering effect can be achieved. However, the pH and salt content of composted bark can be too high (Schmilewski 2009).

Figure 3.: Bark growing-media (http3)

2.4.4 Compost

Locally available organic materials such as composted materials including green wastes, municipal solid wastes, and even sewage sludge or bark are also used in growing media (Carlile et al, 2015). Because of its variability in physicochemical and microbial properties, composts are mainly used as mixture components (Schmilewski, 2008). They have advantages such as the high air content of bark and nutrient supply of many composted materials, these media components may have disadvantages such as microbial, physical, and chemical contaminants in composts. Innovative approaches involve the increasing use of wood fiber in Europe and realizing the use of composted wastes as next-generation components of growing media (Carlile et al, 2015). Composted materials are available in large quantities in several countries, but of all candidate materials for growing media, composts are diverse physically with respect to air space, water retention and bulk density, and thez are diverse chemically in terms of pH and nutrition; and diverse microbiologically too (Raviv, 2011, 2013). For these reasons, composted materials are always used in combination with other materials (Carlile et al. 2015). Composts are not uniform or homogeneous there is a lack uniformity, even at batch level, resulting in high variability in biological and phisicocemical properties (Raviv, 2013). This variability between batches is caused by the type of starting materials, and composting parameters for example temperature and moisture (Carlile et al., 2015). Because of this, the composts microbial community may vary.

Figure 4.: Compost growing-media (http4)

2.4.5 Inorganic Materials

In addition to organic materials, inorganic substances are also added to the growing medium. These inorganic materials derived from the thermal expansion of molten basalt and silicaceous clays are used extensively in the production of growing media. Notable is mineral wool produced by "spinning" molten basalt into threads and thanks to the compression and aggregation of these to form blocks or mats. Production of tomato (*Solanum lycopersicum L.*), pepper (*Capsicum annuum L. var. annuum*) and cucumber (*Cucumis sativus L.*), is mainly undertaken with mineral wool mats (Carlile et al, 2015). In addition to this sand and perlite are inorganic materials and commonly used in growing media mixtures. The use of sand can help improve peat stability (Verhagen and Zevenhoven, 2017). Application of perlite in peat growing media improves air content and water uptake (Carlile et al., 2015).

2.6 **Nematodes**

The class Nematoda belongs to the phylum *Nemathelminthes*, and we distinguish three subclasses: *Penetrantia, Secernentia and Torquentia*. They belong to the third largest group of animals in terms of the number of species (Andrássy and Farkas, 1988; Budai et al. 2005). They can be divided into two large groups, parasitic (*Nematoda parasitica*) and free-living (*Nematoda libera or errantia*) (Andrássy and Farkas, 1988). Its free-living species populate the seas and other stagnant waters, rivers and all possible habitats on land (Andrássy, 1988). Nematodes are rich in species and they have a varied lifestyle (Andrássy, 1988). Their role in soil life is invaluable, even 1 cm3 of arable land generally contains approximately 100 nematodes (Andrássy and Farkas, 1988). The Hungarian nematode fauna was described by István Andrássy in 1972. This classification contains 448 species, but it has since been found that their number is many times that number (Budai et al., 2005). In Hungary, we know about 70 species of nematodes that live on cultivated crops and can cause economic damage (Andrássy and Farkas 1988).

The majority of nematodes are small and they have slender bodies what are almost transparent like glass. Due to their size (1 mm on average), we almost never see them (Andrássy and Farkas 1988).

The sensory systems of nematodes are very diverse and they are partly concentrated towards the end of the head, and partly on other parts of the body. The most important sensory organs of the head are the labial warts) also known as papillae, which sit on the top and sides of the lips. These papillae are small protrusions and a channels that is nerve towards the inside of the body. Lip warts are probably chemical sensors. In addition, the most characteristic sensory organs of nematodes are lateral organs, also known as amphidia. According to the latest assumption, this organ was formed from a modified labial wart and a papilla of the lateral lips during evolution. This chemical sense organ plays a role in finding food, recognizing it and helping the sexes find each other (Andrássy and Farkas, 1988).

Figure 5.: *Meloidogyne incognita* nematode (http5)

Nematodes can cause a serious problem on most agricultural plants and causing serious crop losses worldwide (Pérez and Lewis, 2004, Barker 1985). The damage they cause to crop production can be estimated at 5-15% of the value of plant products that can be produced in the world. For example, the root knot nematode *Meloidogyne hapla*, the stem nematode *Ditylenchus dipsaci*, the beet nematode *Heterodera schachtii* and the wheat nematode *Anguina tritici* cause significant economic damage to field crops. In addition, the virus-inoculating nematode *Longidorus elongatus* and the grape-sucking nematode *Xiphinema index* cause the most serious damage in orchards and vineyards, or in larger gardens and greenhouses, because they can also infect the plants with viruses. *Meloidogyne* species are the most dangerous for ornamental plants, heat-demanding and sprouting vegetables in greenhouses (Andrássy and Farkas 1988). The horticultural root knot nematode *M. incognita* forms bead-like thickened knots on pepper roots and tomatoes, melons, and cucumbers also show clumping on the root system. This process results in stunted growth, poor binding, a decrease in yield and finally the death of plants (Andrássy and Farkas 1988). They can also act as secondary parasites when weakened plants attacked by other pathogens are destroyed (Andrássy 1988, Sasser 1990). The indirect damage caused by nematodes is often even more significant than their direct damage, because they can spread bacterial, fungal or viral diseases. The plant attacked by them is completely destroyed or greatly retarded in its development (Jermy and Balázs, 1990). Plant-damaging nematodes are a big problem mainly in areas with a rainy climate. Due to this fact that our country is fortunate because of its geographical position, but there are areas of our crop production where the losses caused by nematodes are significant (Budai et al. 2005).

Figure 6.: Plant parasitic nematodes damage on carrot (http6)

2.7 Peat-based growing media effect on nematodes

In this research Jan Lagerlöf and his co-authors had a hipothesis that the fungivorous nematodes can reduce some plant disease and improve plant health. These fungivorous nematodes have a special mouth stylet by which they can penetrate fungal cells and eat the cell contents, thereby damaging the mycelium. Population densities of fungivorous nematodes are lower than those of bacterivorous or phytoparasitic nematodes in soil (Freckman and Caswell, 1985) but if there is a good fungal hosts, their populations may increase within a short time period (Hoffman and S'-Jacob, 1989; Arancon et al., 2003).
In recent years the disease-suppressive effect of compost added to growing media has gained much interest (Hoitink & Boehm, 1999; Noble & Coventry, 2005). Research proved some of the disease-

suppressive composts contained high densities of fungivorous nematodes. Although they have different favorable properties for suppressing the disease in the soil, the combined effect of fungivorous nematodes and disease-suppressive compost have been studied earlier only in a few cases (Bae & Knudsen, 2001; Hasna et al., 2008).

Their hipothesis had been demonstrated in studies and the first systematic study was performed by Rhoades and Linford (1959) and they tested that *Aphelenchoides spp.* and *Aphelenchus avenae* can suppress the damage of Rhizoctonia solani in cauliflower seedling and moreover they can be enchance the disease-suppresive effect of compost. They wanted to prove this hypothesis in the following experiment. They used different types of growing media. The first growing media was a mixture including 20% of peat and 80% of compost and the second one was pure peat as a substrate in growing pots in greenhouse. In each substrate, these were the threatments: (A) with *R. solani* and nematodes, (B) with only R. *solani*, (C) with only nematodes, (D) control without *R. solani* or nematodes. The effectiveness of treatments were measured as percentage of healthy plants 7, 10, 14 days after start of the experiment. They contucted two different experiment with this parameters, but one with *Aphelenchoides spp*. and one with *Aphelenchus avenae* (Lagerlöf, 2011).

2.8 Peat-free growing media effect on nemartodes

Composting is an effective tool to recycle green waste and thus the raw materials are stabilized and provide valuable nutrients for plants (Lasardi and Stentiford, 1996). Additionally compost can impove soil quality and provide organic matter for soil microbial populations (Chang et al., 2007). Compost also has suppressive effect on plant soil-borne pathogens and pests and has nematicide effect on plant-parasitic nematodes too (Bailey & Lazarovits, 2003).

In this experiment, Renco and his co-authors present an experiment where the effect of five types of compost material on the nematode populations living in the soil was examined.

These are the five composts:

- C1: fresh olive pomace, straw, chicken manure, urea;
- C2: fresh olive pomace, lettuce residues, cow manure, straw, sawdust;
- C3: sewage sludge, municipal green residues;
- C4: grass, leaves, tree branches, soil;
- C5: by-product from penicillin production (mycelium), straw and sawdust) (Renco, 2009).

They were tested in a pot experiment to investigate their short-term effect on the nematode community which lives in grassland soil.

They mixed the compost with soil at the rates of 10, 25, 50 and 100 g (kg soil)$^{-1}$ and after two month decomposition period barley was planted in pots. Five months after barley showing the nematodes were extracted from each pot, after that the nematodes were identified according to the following aspects: fungal, bacterial feeders, predators, omnivores and plant parasites. All of the compost treatments had negative effect on fungal feeders and suppressed them. Moreover composts significally reducing the density of plant-parasitic nematodes compared with non-amanded soil.

Composts from urban green residues, olive pomace plus cow manure and penicillin substrate had the highest suppressiveness on plant parasitic nematodes (Renco, 2009).

3. Methods

Peat-based growing media effect on nematodes

The composts used in the experiment were obtained from the Netherlands. By volume, one of the composts consisted of wood chips (88%), clay (10%) and manure (2.5%), while the other compost consisted of garden waste. Other characteristics of the composts are described in Termorshuizen et al. (2006). Both composts contained large amount of the fungivorous nematodes *Ditylenchus sp.* and *Aphelenchoides spp*. In this experiments they used *Aphelenchus avenae*, which was isolated from a Swedish potato field and the nematode extractions were made by Baermann funnel for 24 hours (Sohlenius, 1979). They made growing media, which includes compost, peat, fertilizer and lime to ensure a similar nutritional level for all mixtures. Before the bioassays were performed these mixtrures were incubated under 70% RH for a week at 20 Celsius. All of the mixtures consist of 20% compost with 80% peat The two composts contained fungivorous nematodes. Around 10% of these were *Aphelenchoides spp*. and the others belonged to the genus *Ditylenchus* and the bacterivorous nematodes belonged to *Rhabditida* genus. Composts were kept at 4 Celsius and periodically examined the nematodes. During the storage period no significant difference was found between the number of fungivorous or bacterivorous nematodes. This experiment combined three substrates as 100% peat and the mixtures of 80% peat and 20% composts and four treatments with eight replicates of each (Lagerlöf, 2011).

These treatments were tested in each substrate:

A. With R. solani and nematodes (*Aphelenchoides spp.* or *Aphelenchus avenae*).

B. With *R. solani*.

C. With nematodes (*Aphelenchoides spp.* or *A. avenae*).

D. Without *R. solani* or nematodes (control).

The Wageningen University and Research Center provided them the *Rhizoctonia solani* inoculum and it was growing on Potato dextrose agar. They inoculated two mixtures from *R. solani* and it was incubated in the dark on 248 Celsius for two weeks. They put 200 ml substrate with 50ml water to the pots, which were treated with the treatments described above. The pots treated with 20 000 nematodes also according to the treatments described above. All treatments were sown with nine seeds of cauliflower in each pot and placed in the greenhouse. Then cauliflower seedlings were counted after 7, 10 and 14 days (Lagerlöf, 2011).

Peat-free growing media effect on nematodes

The composts used in the experiment are all different industrial raw wastes, which are presented in **Table 1.**

Table 1: Percentage composition of used composts (Renco, 2009).

Raw material	% of compost mixture				
	C_1	C_2	C_3	C_4	C_5
Fresh olive pomace	87.4	48	–	–	–
Chicken manure	8	–	–	–	–
Cow manure	–	14	–	–	–
Lettuce residues	–	28	–	–	–
Urea	0.6	–	–	–	–
Straw	4	5	–	–	5
Sawdust	–	5	–	–	5
Sewage sludge	–	–	30	–	–
Urban green residues	–	–	70	90	–
Soil	–	–	–	10	–
Penicillin production wastes	–	–	–	–	90

C1 and C2 composts were based on fresh olive pomace combined with a low percentage of chicken manure or cow manure and lettuce crop residues. Composts C3 and C4 were derived from municipal green wastes which combined with sewage sludge or soil. Compost Compost C5 made by mycelium waste from penicillin production. Compost formulations of C3, C4 and C5 were commercially available, but C1 and C2 were at an experimental phase.

They collected natural grassland soil and added amounts of 10, 25, 50 and 100 g (kg soil)$^{-1}$ of each compost and these mixtures were poured into 350 ml pots, which has eight replicates for each compost × rate treatment. Control was the non-amended soil. Pots were arranged in randomised blocks under outdoor conditions, and if needed they get watering to maintain humidity. They put two spring barley *Hordeum vulgare L.* seeds in each pot and the experiment was continued for a further 5 months.

They took a 100 g soil sample from each pot 2 months after sowing barley and at the end of the experiment and they examined the nematodes population in it

4. Results

Peat-based growing media effect on nematodes

The results showed the ability of fungivorous nematodes to suppress plant diseases. One compost mixture had suppressive effect, while plant health in the other compost mixture was not better than in 100% peat as substrate. The nematodes and the growing media did not have a suppressive effect on each other. The effects of fungivorous nematodes in combination with compost and other control measures on disease suppression requires further attention. In addition to this the results confirm the usefulness of fungivorous nematodes in agriculture and horticulture. Figure 7. show the results of the two experiment. The first is with Aphelenchoides spp. Nematodes and the second is with *Aphelenchus avenae* nematodes. It shows the effect of substrate treatment on the proportion of healthy cauliflower *(Brassica oleracea)* seedlings in pot experiments with three substrates inoculated with *Rhizoctonia solani* (Lagerlöf, 2011).

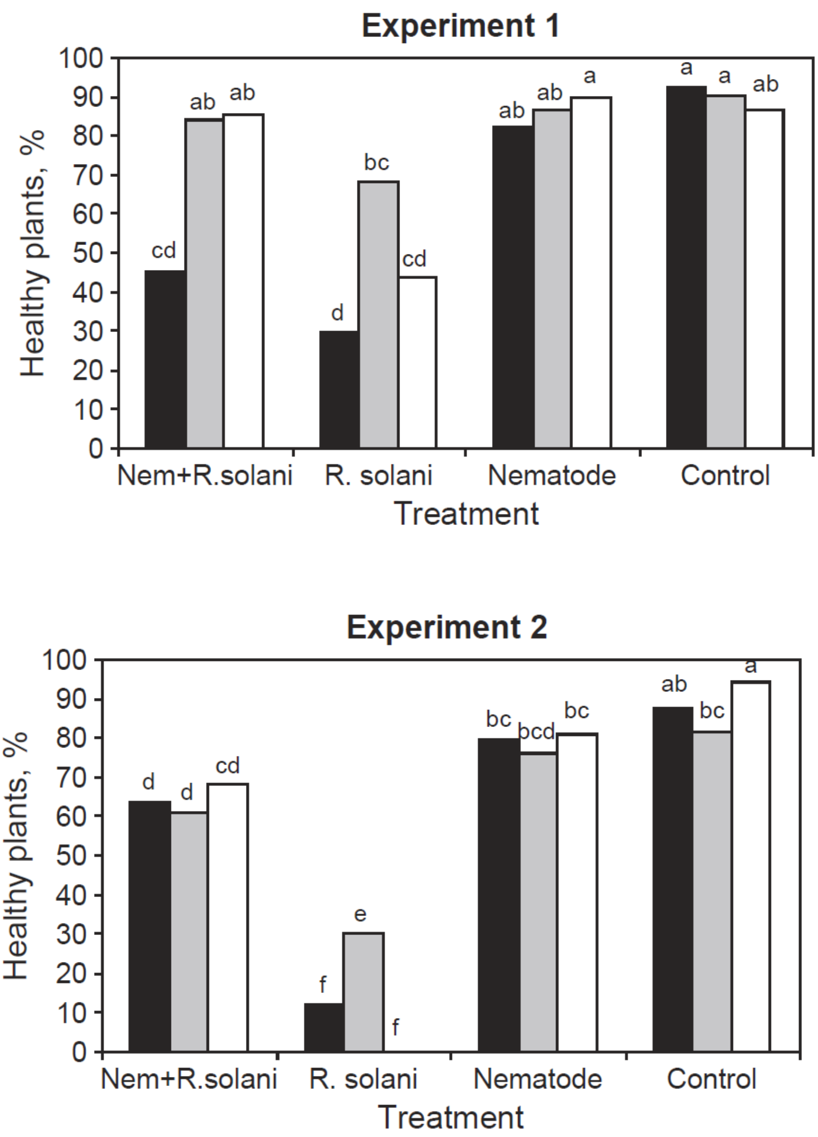

Figure 7. Effect of substrate_treatment on the proportion of healthy cauliflower (Brassica oleracea) seedlings in pot experiments with three substrates inoculated with Rhizoctonia solani and nematodes Aphelenchoides spp. (Experiment 1) or Aphelenchus avenae (Experiment 2), n_ 8. Substrates: black bars_q-compost 20%_peat, grey bars_m-compost 20%_peat, white bars_peat 100%. Bars marked with different letters are significantly different (pB0.05) (Lagerlöf, 2011).

Peat-free growing media effect on nemartodes

Table 2 shows the results of the experiment, which I also detail for the 3 most important nutritional groups.

Table 2: Effect of different rates of five composts on soil nematode trophic groups (Renco, 2009).

Compost	Rate (g (kg soil)$^{-1}$)	Number of individuals											
		BF		FF		PP		RFF		P		O	
C_1	0	77	a	81	a	209	a	40	a	14	a	32	a
	10	63	a	22	b	194	ab	14	b	22	c	30	a
	25	59	a	13	c	172	b	15	b	20	b	35	a
	50	52	b	13	c	134	c	19	b	23	bc	23	b
	100	46	b	15	bc	98	c	18	b	24	bc	24	b
C_2	0	77	a	81	a	209	a	40	a	14	a	32	a
	10	73	a	16	b	98	b	20	b	38	b	48	b
	25	93	ab	23	b	108	b	11	c	43	b	44	b
	50	115	ab	12	b	65	c	4	d	42	b	53	b
	100	131	b	16	b	25	d	4	d	45	b	46	b
C_3	0	77	a	81	a	209	a	40	a	14	a	32	a
	10	37	b	30	b	162	b	12	b	16	a	12	b
	25	32	b	25	c	160	b	13	b	15	a	17	b
	50	32	b	24	c	154	bc	22	b	29	b	13	b
	100	42	b	31	b	78	c	24	b	31	b	14	b
C_4	0	77	a	81	a	209	a	40	a	14	a	32	a
	10	21	b	3	c	29	cd	4	b	15	a	14	b
	25	34	b	3	c	20	d	5	b	18	a	15	b
	50	32	b	12	b	53	bc	7	b	17	a	17	b
	100	35	b	10	b	69	b	5	b	18	a	16	b
C_5	0	77	a	81	a	209	a	40	a	14	a	32	a
	10	121	b	15	c	76	cd	20	b	36	bc	66	cd
	25	141	b	15	c	90	bc	20	b	46	c	63	c
	50	129	b	29	b	84	cd	10	c	32	b	55	b
	100	135	b	31	b	48	d	6	c	37	bc	70	d
General comparison among composts													
C_1	–	58	b	29	ab	161	b	21	b	21	a	29	a
C_2	–	97	c	38	b	101	a	16	ab	36	b	45	b
C_3	–	43	a	30	ab	152	b	22	b	21	a	18	a
C_4	–	40	a	22	a	76	a	12	a	16	a	21	a
C_5	–	120	d	34	b	101	a	19	b	32	b	57	c
General comparison among rates													
0	–	77	a	81	a	209	a	40	a	14	a	32	a
1.0%	–	63	a	16	b	112	b	14	b	25	b	34	a
2.5%	–	71	a	16	b	110	b	13	b	28	b	35	a
5.0%	–	72	a	18	b	98	b	14	b	28	b	32	a
10%	–	77	a	21	b	64	c	11	b	31	b	34	a

Each value is a mean of eight replications. Data marked by the same letters in each column are not statistically different according to Duncan's Multiple Range Test ($P = 0.05$). BF = bacterial feeders, FF = fungal feeders, PP = plant parasites, RFF = root-fungal feeders, P = predators, O = omnivores.

Bacterial feeders population was significantly suppressed by all rates of C3 and C4 compared with the non-amended soil and by the two highest rates of C1 by contrast, all rates of C5 and the highest amount of C2 resulted in a significant increase of bacterial feeders. In a general comparison among composts, the highest bacterial feeders population was in C5 with soil amendent.

The number of fungal feeders was significantly lower in all the amended pots than in non-treated soil without amendments, but suppressiveness was not related to compost rates.

Significant differences among composts were found only between C2 C4 and C5. The most prevalent nematoda was *Aphelenchus* genus within this trophic group, comprising about 90% of fungal feeders nematodes in soil amended with all rates of C1, C3 and C5.

The soil density of the plant parasitic nematodes group was always significantly reduced, compared with the non-treated soil, except the lowest rate of C1 by all compost treatments. In general, C4 has the highest suppressiveness on plant parasitic nematodes, after that C2 and C5 and C1 and C3, which resulted in a significantly lower reduction of soil phytoparasites. All rates significantly suppressed soil density of plant parasitic nematodes in contrasted with the untreated control. A the results show there is a negative linear relationship between compost rates and plant parasitic nematodes number.

5. Discussion and conclusion

Farmers have to deal with many problems in agriculture, both abiotic and biotic factors affect cultivation. There are several solutions for pest control, such as the choice of growing medium. Many substrates are available to growers either in soil or soilless cultivation. Examples of such substrates are peat, coir, bark and compost. Based on their unique physical and chemical properties, they affect microbial activity and the organisms living in them. In this thesis, I presented the peat-based and peat-free growing medium and gave examples of this from the research on this topic. Peat is a very common substrate because it is cheap and easy to use in cultivation, however, its extraction has a negative impact on the environment. Therefore, the goal of more and more research is to find some alternative solution to replace peat. A good example of this is compost, which has a very favorable effect on microbial activity and also has suppressive properties to control pests living in the soil and it has nematicide effect too. I think that it is very important to choose the right breeding medium, because producers can save money. In addition, it can prevent the growth of various harmful substances, so it is not necessary to apply harmful chemicals to our environment.

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KONZULTÁCIÓS
NYILATKOZAT

A Erdős Eszter (hallgató Neptun azonosítója: BEN4B6) konzulenseként nyilatkozom arról, hogy a szakdolgozatot áttekintettem, a hallgatót az irodalmi források korrekt kezelésének követelményeiről, jogi és etikai szabályairól tájékoztattam.

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Kelt: Gödöllő év 2023.04.24.

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