



URBAN HORTICULTURE

Cultivation and care:

Essentials of urban garden management

Volume 5



UNIVERSITY
OF AGRONOMIC SCIENCES
AND VETERINARY MEDICINE
OF BUCHAREST



ЛЕСОТЕХНИЧЕСКИ
УНИВЕРСИТЕТ

MATE



CONTRIBUTORS

USAMV

Roxana CICEOI
Oana VENAT
Viorica LAGUNOVSKI-LUCHIAN
Marian MUŞAT



UNIVERSITY
OF AGRONOMIC SCIENCES
AND VETERINARY MEDICINE
OF BUCHAREST

Editing
Oana VENAT

University of Forestry

Mariela MARINOVA
Milena YORDANOVA
Vera PETROVA
Zhelyu AVRAMOV



Technical
Gergana MLADENOVA

ZMMAE

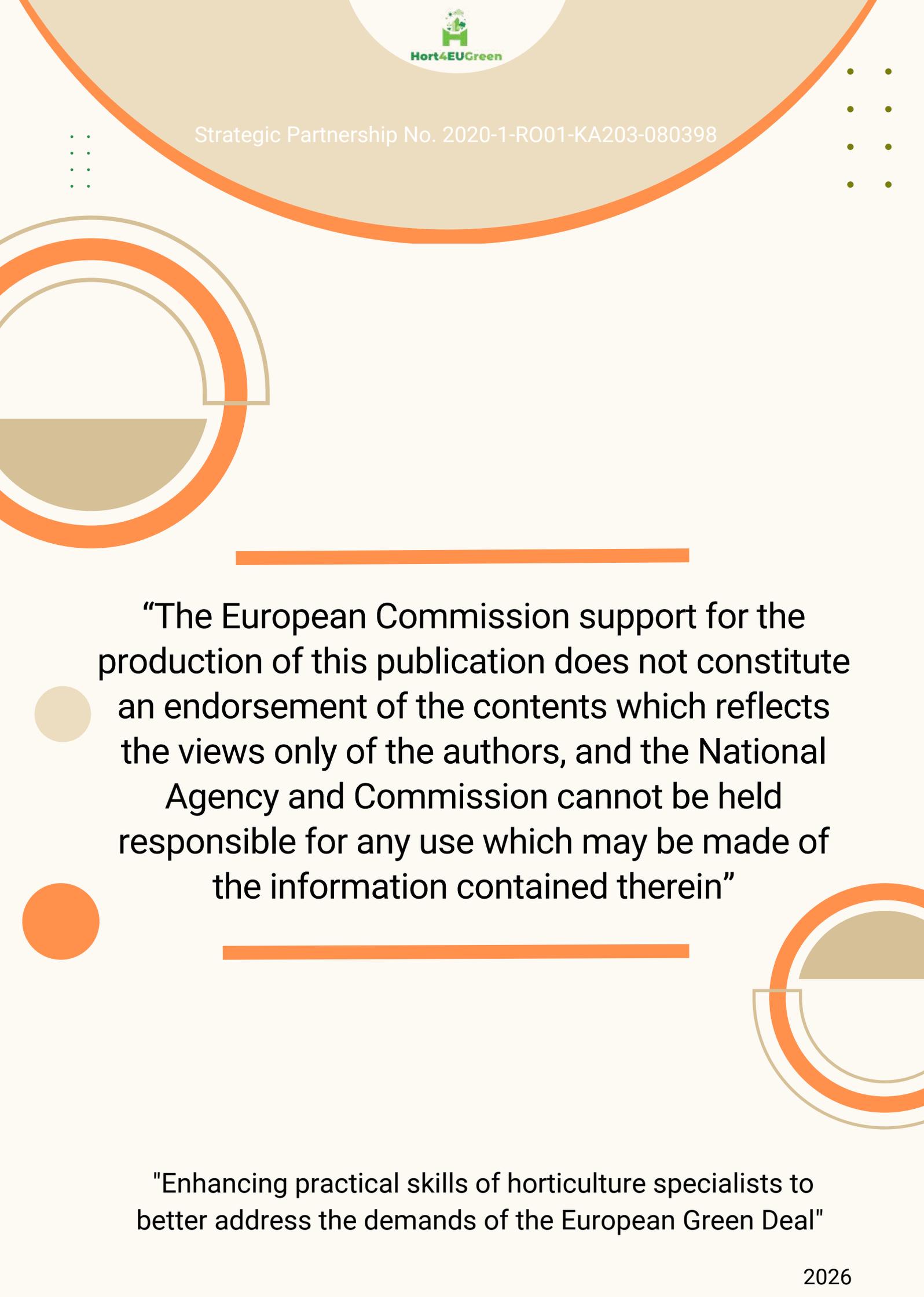
Okray OREL
Yeasemin SABAHOGLU



UNI-MATE

Gergő GYURCSO





“The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the National Agency and Commission cannot be held responsible for any use which may be made of the information contained therein”

“Enhancing practical skills of horticulture specialists to better address the demands of the European Green Deal”

Table of Content



Volume 5

Essentials of urban garden management

Introduction	5
Learning outcome descriptors.....	8
General and transferable skills	8
Knowledge, understanding and professional skills	8
Summary	9

Unit 5.1 Soil and substrates

Introduction	11
5.1.1 Soil tests and soil preparation	16
5.1.2 Working with the soil and for the soil	21
5.1.3 Types of substrates	30

Unit 5.2 Irrigation of plants

Introduction	48
5.2.1 Frequency of watering (depending on growing conditions and using methods)	60
5.2.2 Possibilities to reduce watering.....	64

Unit 5.3 Ecological and biodynamic preparations and infusions

Introduction	80
5.3.1 New trends in phytopharmacy: plant decoctions and pests control.....	82
5.3.2 Rules for preparing decoctions and select ecological plant protection measures.....	92
5.3.3 Rules for spraying and routes of application	102

Reference	106
-----------------	-----

Volume 5 Cultivation and care: essentials of urban garden management

Milena Yordanova

Introduction

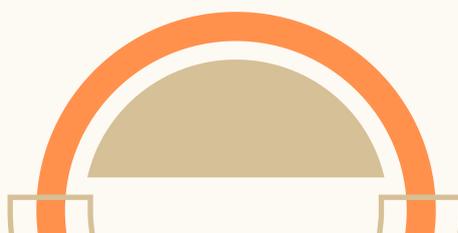


When urban soil is not suitable for gardening

-
-
-
-
-

An urban garden can be a heavenly place for socializing, learning new skills, education and interesting workshops, outdoor recreation, mental relaxation from busy everyday life and many other activities, but above all it must be safe and usable for the aim of growing edible, medicinal and ornamental plants. And quite often the soil in the spaces between the blocks does not meet this requirement. The reasons can be many - salting as a result of winter treatments against freezing of roads, sidewalks and alleys, too high or too low pH, pollution with waste products from industrialization, the neighborhood bathroom of pets, poor quality structure, too many inert materials with large fraction, to have no soil at all, etc.

https://www.epa.gov/sites/default/files/2014-03/documents/urban_gardening_fina_fact_sheet.pdf



First of all, there is the need to understand what soil is and how it works. The answer to this and other questions are given by FAO:

“Soil is the thin layer of material on the Earth's surface. It is a natural resource consisting of weathered and organic materials, air and water. As it is the medium in which plants establish themselves and grow, the most widely recognized function of soil is its support for food production. Soil provides nutrients and water that are absorbed through plant roots and contribute to the regulation of water and atmospheric gases and therefore play climate regulation”.

<https://www.fao.org/soils-2015/faq/en/>

According to USDA healthy soil have five essential functions:

Water Regulation - Soil helps control and absorb rainfall, snowmelt, and irrigation water. Water and dissolved substances pass through the soil.

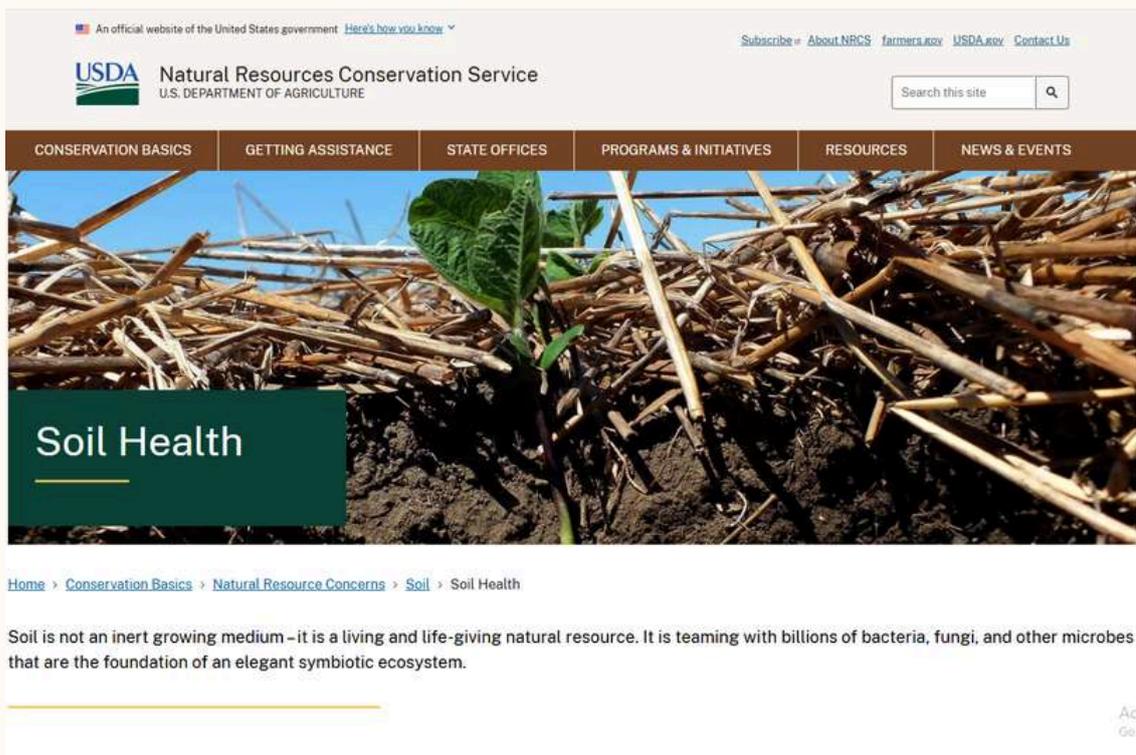
Support for Ecosystems - The diversity and productivity of living plants depend on the soil.

Filtration and Buffering of Potential Pollutants - Minerals and microbes in the soil are responsible for filtering, buffering, breaking down, immobilizing, and detoxifying organic and inorganic materials, including byproducts and atmospheric deposits.

Nutrient Capture and Decomposition - Carbon, nitrogen, phosphorus, and many other nutrients are stored, transformed, and cycled in the soil.

Physical Stability and Support - The soil structure provides a medium for plant roots. Soils also provide support for human structures and protection for archaeological activities.

<https://www.nrcs.usda.gov/conservation-basics/natural-resource-concerns/soils/soil-health>



The screenshot shows the top portion of the USDA Natural Resources Conservation Service website. At the top left, it says "An official website of the United States government" and "Here's how you know". To the right are links for "Subscribe", "About NRCS", "farmers.gov", "USDA.gov", and "Contact Us". The main header features the USDA logo and "Natural Resources Conservation Service U.S. DEPARTMENT OF AGRICULTURE". A search bar is on the right. Below the header is a navigation menu with tabs: "CONSERVATION BASICS", "GETTING ASSISTANCE", "STATE OFFICES", "PROGRAMS & INITIATIVES", "RESOURCES", and "NEWS & EVENTS". The main content area has a large image of a plant growing in soil with straw mulch. A dark green box with the text "Soil Health" is overlaid on the image. Below the image is a breadcrumb trail: "Home > Conservation Basics > Natural Resource Concerns > Soil > Soil Health". A paragraph of text follows: "Soil is not an inert growing medium – it is a living and life-giving natural resource. It is teeming with billions of bacteria, fungi, and other microbes that are the foundation of an elegant symbiotic ecosystem."



Learning outcome descriptors

By the end of the module, the trainees should be able to demonstrate proficiency in urban horticulture practices, acquire a comprehensive understanding of key urban horticulture practices, including soil management, irrigation techniques, and plant selection in urban environments.



General and transferable skills

1	Develop the ability to assess and analyze soil composition in urban environments. This skill involves understanding soil types, nutrient levels, and pH balance.
2	Make informed decisions regarding soil amendments and fertilization strategies, ensuring optimal conditions for plant growth in diverse urban settings.
3	Acquire skills in sustainable water management practices, emphasizing efficient irrigation techniques for urban gardens
4	Cultivate problem-solving skills to address common issues related to soil and water in urban garden management.

Knowledge, understanding and professional skills

1	Acquire an in-depth understanding of soil microbiology, encompassing the diversity and functions of microorganisms in urban soil ecosystems.
2	Acquire knowledge base on bacteria, fungi, and other soil microorganisms in nutrient cycling, organic matter decomposition.
3	Develop expertise in integrated water resource management, integrating hydrological principles, and sustainable water practices for urban garden environments

Cultivation and care: essentials of urban garden management

Oana Venat

Summary

In the realm of urban horticulture, the selection and management of soil and substrates play pivotal roles in fostering plant growth and sustainability within urban environments. The choice of a suitable soil matrix is crucial, with factors such as texture, structure, and nutrient content influencing plant health. Urban soils often contend with anthropogenic stressors, necessitating an understanding of their physical and chemical characteristics. Substrates, commonly utilized in container gardening, merit attention due to their ability to influence water retention, aeration, and nutrient availability. A judicious mix of organic and inorganic components in substrates enhances their overall performance, addressing the unique challenges posed by urban settings.



In this delicate interplay between plants and their growing medium, considerations of pH levels, microbial diversity, and nutrient cycling emerge as essential components in optimizing urban horticultural systems. Scientifically informed decisions regarding soil and substrates contribute significantly to the sustainability and productivity of urban plant habitats, aligning with the overarching goals of urban horticulture in enhancing biodiversity and fostering resilient ecosystems (Smith et al., 2020; Johnson & Brown, 2018; White & Weil, 2021).



Unit 5.1 Soil and substrates

Oana Venat, Marian Muşat, Mariela Marinova,
Milena Yordanova

According to **Urban Soils Institute**, “soil is the habitat of several animals and organisms such as bacteria and fungi and thus sustain biological activity, diversity and productivity. It is the habitat for seed dispersion and dissemination of the gene pool and a platform for urban settlement also used as materials for construction”.

To make sure that the soil is fertile and good enough for plant growth and safe for human health, tests and laboratory analyzes must be done. For some of them, it is necessary to call a specialist or to take samples in a precisely established order, while with others everyone will deal easily at home.

Laboratory soil analyzes will give a clear assessment of qualities such as pH, nutrient content (N, P, K, Mg, Ca, Mn, Fe, etc.) as well as heavy metals for example. Sampling must follow the protocol established by the selected laboratory that will perform the analyses.

Microbiological analyzes will find out whether there are microorganisms in the soil on the territory of the future urban garden - beneficial ones, but also those proven to be harmful to human health (E. coli, Salmonella, others). These analyzes are

performed with sterile instruments, decontaminated vessels and in strict compliance with the rules for storage and transportation of the samples.

A list of soil analysis laboratories in the European Union and more information about them can be found here: <https://www.fao.org/global-soil-partnership/glosolan/en/>

More information and shared experiences can be found here:

<https://clu.in.org/ecotools/urbangardens.cfm>

<https://www.mdpi.com/2071-1050/15/10/7924>

<https://core.ac.uk/download/pdf/185315522.pdf>

<https://eutropian.org/urban-soil-4-food/>

Current participants in already established urban gardens around the world advise that the building of a new garden should start first by doing some research on the ground:

- asking the neighbors (this is a way of getting to know each other and why not start gardening together?);
- seeking information and help from the municipality;
- looking at the weeds, that are present on the plot, because they can be indicators of the condition of the soil.

Here are a few questions, the answers to which, would guide new gardeners whether the soil of the terrain, chosen for an urban garden is suitable for growing plants:

Was there a building (or other) on the site, what function did it perform, when was it destroyed/removed, how and why?

What ameliorative and reclamation measures have been taken?



Have there been in the recent past (5-10 years back in time) loading and unloading activities of a construction or industrial nature?



If yes, then check what aggregates have been poured, is it possible to clean them by hand, is it necessary to remove all the soil and replace it with a new, more fertile one, etc. (also applies to the above point). Mandatory soil and microbiological analysis!



Are there pets and stray animals in the neighborhood?
a. If so, ask if this is a place they usually use for the toilet, because, especially for small children who do not yet have hygiene habits and like to put everything in their mouths, it is especially possible to catch some dangerous parasites.

More information on parasites can be found here:
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10126391/>
<https://www.who.int/news-room/fact-sheets/detail> and
here:

<https://www.frontiersin.org/articles/10.3389/fpara.2023.1197956/full>



Was the land used or is it currently used for parking?

a)

If it has been used in the past, it is very likely that various fluids and lubricants from the cars have entered the soil.

In such a case, it is best to consider replacing it or to build raised beds.

b)

If it is currently in use, it is very likely to have problems with the residents of the neighborhood, because as we know, finding a parking space in a densely populated residential complex is difficult. And if by creating a garden the possibilities for this are even reduced, the anger of the neighbors will be awakened. It is possible for them to show understanding and enthusiasm for the construction of the future green area, even to help, as well as to express their disagreement verbally or through insidious actions. Be prepared for both reactions. The more arguments in favor of creating the garden are put forward, the easier will be the winning of a like-minded people.

One of the most important questions is whether the residents of the neighborhood would be involved in building and caring for the garden, so make sure to ask it!



Good examples, shared experience and free manuals for building a garden in inter-block spaces, kindergartens, schools and others from Bulgaria:

1. <https://gorichka.bg/resources/GardeningManual.pdf>
2. https://gradinka.zaedno.net/sites/gradinka.zaedno.net/files/Resursi/Permaculture_Gradinki_narachnik_2015.pdf
3. https://mcusercontent.com/65072252a2513b371c337d0d2/files/b94a0f3e-a4d0-ff48-3e3abaac469bee7a/Napravi_si_sam_vertikalna_gradinka_City_Zen_op.pdf

5.1.1 Soil tests and soil preparation

Marian Muşat, Zhelyu Avramov,
Mariela Marinova



Quite easily and without much investment, the following tricks will give enough guidance on whether and how to proceed with soil from here on:

Living soil



The best indicator of soil health and fertility are precisely the creatures living beneath its surface - worms, grubs, beetles, centipedes, woodlice and other living creatures. The more they are, the more 'alive' the soil is and for sure it is suitable for gardening. There should be at least 10 earthworms in one square meter of soil (Sharma et al., 2017), <https://ahdb.org.uk/knowledge-library/soil-macrofauna-earthworms>; <https://www.earthwormsoc.org.uk/earthworm-ecology>).

Research on the benefits and harms the insects and animals found on site will be of great benefit for the future garden.

Jar test

The jar test is a reliable and easy way to find out what particles the soil is made of and whether their ratio is suitable for growing plants. The three main parts are sand, silt, and clay, and to them are added organic matter, water, air, and living organisms. In order the test to be conducted, a jar, marker, ruler, and water are necessary. The steps are as follows:

- 1) Soil sample must be taken with a shovel and cleaned of stones, leaves, sticks, roots and other impurities;
- 2) The jar needs to be filled with the soil sample up to 1/3.;
- 3) then water should be added up to 2-3 centimeters below the neck (also add a tablespoon of liquid soap);
- 4) The mixture should be shaken for a few minutes, then left in order to settle the soil particles;
- 5) After 24-48 hours, the concealed layers are measured using a ruler or tape measure.
- 6) Additional information and a method for computing the percentage content of clay and sand can be found within the provided link. <https://hgic.clemson.edu/factsheet/soil-texture-analysis-the-jar-test/> this will show if there is a need to add any materials to improve the soil structure.

In short - the heaviest particles - gravel or coarse sand, will sink to the very bottom. Above them will be the smaller sand and then are silt particles, with clay at the very top of the jar. Depending on the predominant fraction, the structure of the soil is determined.

Knowing the structure of the soil is important, because it tells which plants are suitable for the garden. The soil can be rich in clay, silty, sandy or, in most cases, some kind of combination. Basic information of the texture of the soil can help determine how the soil absorbs water and is it necessary to add organic matters, compost, mulch or other soil amendments. Bronick, C. J., & Lal, R. (2005).

Soil texture refers to the size and quantity of the soil particles. (Daniels, W. L., et al (2006). The table shows how to identify the structure, what that means and what to add to improve it in general

Soil particle size	Soil type	How to tell?	What that means?	How to improve it?
Large	Sandy	Sand sinks on the very bottom of the jar. The water seems clean.	Sandy soils drain quickly and don't hold nutrients	Add organic matter until reaching the perfect balance
Small to very small	Clay or Silt	The water is cloudy with a thin layer on the bottom. Clay particles settle very slowly.	Clay soils doesn't drain well. This may cause root problems and nutrient issues	Add organic matter and sand with different fractions for the same reason
Floating	Organic	Many floating particles with different sizes. Organic materials are lighter than water	This soil is rich in nutrients, holds water well and is suitable for most of the plants. Must check pH!	There is no need to add anything, but take care to maintain fertility
Fine	Loamy	The water is clear with a layered sediment on the bottom. Finest particles are on the top.	Loamy soil is considered to be ideal for gardening	There is no need to add anything, but care should be taken to maintain fertility
White fragments	Chalky	Grit-like fragments in white or grayish color on the bottom and in water	This soil is alkaline and not very nutritional. It is prone to drying.	Add materials with low pH or use such fertilizers

If the garden is small, one average sample from several points is enough. But if the garden is larger, two or more jar tests are needed depending of the amount of soil.

The ideal combination is 40 % sand, 40 % silt and 20 % clay for most of the plants, regardless whether they are herbs, flowers, vegetables, berry species, fruit trees, vines and etc.

<https://indico.ictp.it/event/a06222/material/4/22.pdf>

<http://eagri.org/eagri50/SSAC121/lec08.pdf>

<https://www.farmingforabetterclimate.org/resource/assess-your-soil-structure/>

Acidic or neutral

It's important to understand what the pH is. Soil pH makes nutrients accessible or not for the plants. For example when pH is too high phosphorus and iron may become less available and the plants reactions are well known deficiencies.

Hartemink, A. E., & Barrow, N. J. (2023).

<https://www.agric.wa.gov.au/soil-acidity/effects-soil-acidity?page=0%2C1>

Another reason to test pH and fertility is to know is it necessary to invest in fertilizers or not and what product to choose. Healthy soil provides good results and better plants with little effort.

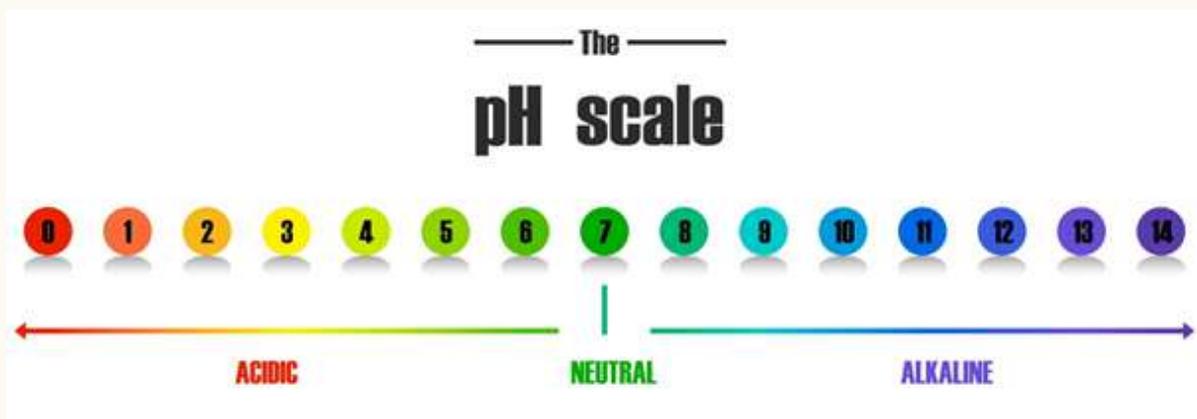
Every gardener would confirm it. Healthy soil leads to healthy plants!

Gardaners can buy test kits or pH meters. They don't cost much and are easy to use in just a few steps. Each set has its own instructions.

The simplest way to test soil pH at home includes vinegar or baking soda.

1) put some soil in a bowl or other container, add vinegar until it moistens the soil well. If the mixture fizzes, the soil is alkaline. If it doesn't fizz, that doesn't mean that the test isn't working. It means that the soil is acidic.

2) baking soda will tell for sure if the soil is acidic. Put soil in bowl, add water and then add soda. If the mixture fizzes, the soil is acidic. If the soil does not react to the test, its pH is neutral.



Source [here](#)

More information and more tests can be found here:

<https://www.clapplibrary.org/wp-content/uploads/2020/04/SoilSample.pdf>

<https://www.nbchg.org/wp-content/uploads/2017/04/pH-test-for-garden-homemade-recipes-April-2017.pdf>

<https://www.gkvks.com/top-3-soil-ph-testing-methods-hacks-for-garden-baking-soda-vinegar-litmus-test/>

5.1.2 Working with the soil and for the soil

Marian Muşat, Oana Venat,
Roxana Ciceoi



Every gardener should know that the production of plant-based food begins in the soil. According to the Food and Agriculture Organization of the United Nations, 95% of our food is produced directly or indirectly thanks to the soil (<https://www.fao.org/3/i4405e/I4405E.pdf>).

However, in addition to grain, fruit and vegetables that we humans eat, it is also the "factory under the sky" in which more feed for farm and other animals is produced, as well as alternative fuels, raw materials for construction, industry and etc.

In order to produce healthy food, it is necessary for the soil to be healthy. Besides a foundation, it is also a reservoir for nutrients, water, air, seeds, and also for carbon dioxide, thereby helping to mitigate climate change. Spanner, J., & Napolitano, G. (2015).



Caring for it like a living organism so it can function properly is vital for the future. To sustain life in the soil we must protect every creature, every microorganism, every pore in it. This is the only way it will be a beneficial environment for plants, it will maintain and improve the quality of water and air as a filter. Doran, J.W. (2002)

All the factors that characterize the different types of soil - content of organic matter, clay, sand, silt and soluble salts, as well as the ways of their formation, serve to classify them. There are two internationally accepted soil classification systems - the World Reference Base (IUSS) and the Soil Taxonomy (USDA). Many countries have also developed their own national classification systems. Index, D.J.S. (2010).

The most important for gardeners are the physical and chemical properties of soils, the content of organic matter, the ability to retain water and nutrients.

Physical properties are inextricably linked to chemical properties. The former are the result of the parent rock, relief, climatic phenomena, available vegetation and weather. Changing one factor affects both structure and chemical properties. A well-structured soil is characterized not only by its particle size, but also by its porosity. It is in the pores that water and air move and distribute relatively evenly. It is in the pores that the root hairs of plants develop and grow.

Organic matter plays the role of "glue" for soil particles, turning them into aggregates, and is of great importance for soil health and life. It is due to the dying vegetation, root exudates, as well as waste products from the vital activity of microorganisms, insects and animals. A cycle is observed between living and non-living matter. Mineralization takes place, as a result of which nutrients available to plants are obtained. This is how hummus is made. It is considered the most important component of soil. The more organic matter it contains, the more suitable its physical and chemical properties are for horticulture. C. Gasch, J. DeJong-Hughes, (2019).

Adequate levels of organic matter improve the absorption and retention of water in the soil, reduce water and wind erosion, improve fertility, due to the presence of nutrients in a form easily digestible by plants. In order to keep this cycle in balance, mineralization must be ongoing. Abaye, A.O., et al. (2006).

Humans can influence all these qualities of the soil through their desire to control everything they can. In a garden (in an urban, suburban or non-urban environment) the most common practice is to grow crops using well-known methods such as ploughing, discing, milling, cultivating and others. Their goal is to bring the soil to the so-called garden condition, in which the structure becomes loose,

relatively uniform and without any vegetation that competes with the cultivated plants. Knott, J.E. (1957).

Soil treatments (mechanized or manual) must be adapted to soil moisture. “SOILpak for vegetable growers” offers a simple test for soil moisture and when and if it is suitable for processing. Also, treatments should do more good than harm.

Figure D7-1. Soil moisture test for tillage

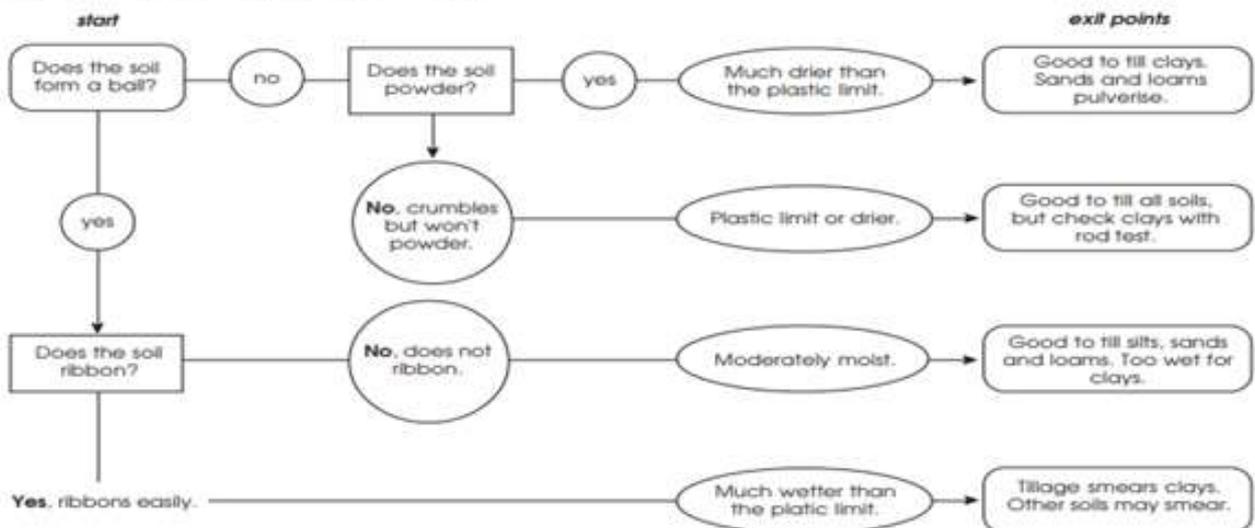


Photo: screenshot from

<https://www.dpi.nsw.gov.au/agriculture/horticulture/vegetables/sil-management/soilpak>

Benefits of tillage



Pest control including:

- o Weeds, as competitors of crop plants for water, nutrients, light and other environmental factors vital for growth and development in qualitative and quantitative terms.

o Insect and non-insect enemies overwintering in the soil or those whose life cycle or part of it takes place in the soil. By treating the surface layer of soil, their shelters are destroyed or the larvae are exposed to unfavorable conditions, which significantly reduces their populations.

o Soil-dwelling pathogens;



Reduces compaction

which is often a problem in structureless soils. It hinders the development of the root system, especially in young plants and seedlings.



Prevents the evaporation of moisture from the soil by breaking the capillaries in it.

Disadvantages of tillage:



Destruction of the soil structure, which leads to:

- Confusion and displacement of the soil layers, as a result of which many microorganisms fall into an unfavorable environment;
- Reduction of organic matter;
- With prolonged processing at the same depth, a plow heel is formed, which makes it difficult for the root system to grow as soon as the hairs reach it;
- Erosion;
- Degradation;

In order to reduce the harmful effects of treatments, they must be approached with understanding and reason, elementary rules must be observed for terms, current humidity, depth, and others. SOILpak for vegetable growers According to the modern Gardener Huw Richards' (2022) hands are the best tools for work. But in real life without elementary tools it is almost impossible to work the soil.

Depending on the size of the garden, as well as the methods practiced in it, the most necessary tools are:

Gloves

to protect the hands from mechanical injuries during many garden activities. Gloves can be disposable or reusable, but must be the correct size.

Shovel

there are mainly two types - a straight shovel for tilling the soil to a depth of about 20-25 cm and turning the layer and a simple shovel for raking a mass of earth or another with larger dimensions. Both have a place and a role in the garden.

Pitchfork

with three or four tines, the pitchfork is an indispensable assistant when turning compost, collecting and transporting plant residues, picking tuber and root vegetables from the soil, for aeration and many other activities.

Hoe

there are many types and the sizes of their blades depend on the operation for which they are intended. With a large hoe,

the soil is worked more finely, the reliefs of the beds are formed, while with small hoes, the plants are dug around, weed control is carried out, and the shallow layer is aerated.

Rake

has many uses - it collects fallen leaves or grass clippings, but also forms beds, levels the soil surface, creates a nice bed for seeds, etc.

Small tools (shovels, rakes, hoes, etc.) serve when planting seedlings, transplanting plants, for opening furrows when sowing seeds, etc.



Link [here](#)

To build a bed directly in the soil can be approached in many ways. One of them is by deep tilling and turning the soil layer with a spade, followed by finer tillage with a hoe and rake. The soil is saturated, aerated and brought to a garden condition that is most suitable for growing all (or almost all) types of crop plants. It takes about 2-3 hours of work to build such a bed with dimensions between 5 and 10 square meters.



[Link here](#)



[Link here](#)

Another method widely practiced by urban gardeners to build a bed directly on the soil surface is to cover the terrain with cardboard boxes, papers and other degradable materials, and on them to pour and shape fertile soil or a mixture of soil, peat, compost and others. Building is much faster and easier. And the results are excellent.



[Link here](#)



[Link here](#)

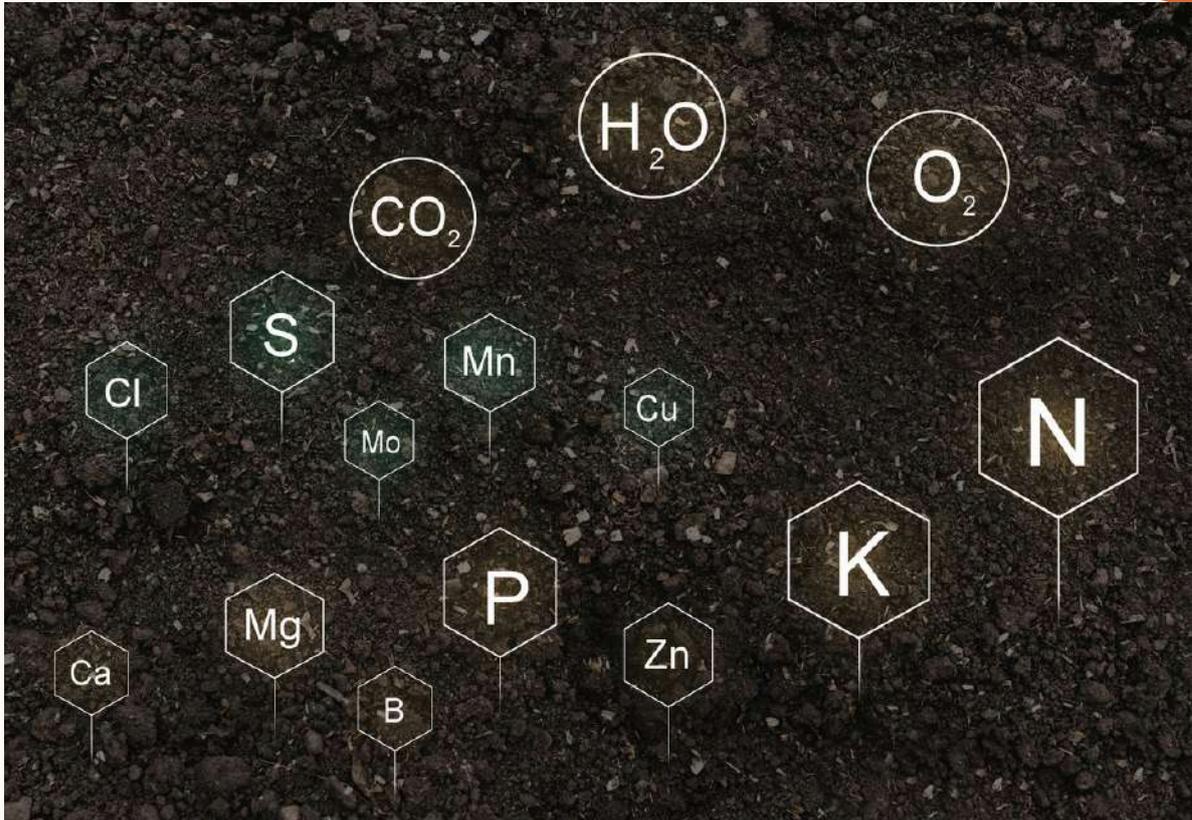
5.1.3 Types of substrates

Milena Yordanova, Oana Venat,
Viorica Lagunovschi-Luchian



The reasons why resources such as fertile soil and clean water are already limited in many parts of the world are many. Climate change is among them. Soilless plant cultivation systems not only offer the opportunity to save water, but also the opportunity to build urban gardens in areas such as inter-block spaces, roofs, balconies, vertical walls and other surfaces. Fussy, A., & Papenbrock, J. (2022).

Most annual crops, such as most vegetables, spices, flowers and herbs, have high requirements for the soil and its characteristics in order for the plants to be healthy and the produce to have high qualities. However, when it is not suitable for cultivation, for growing edible plants, or there is none at all (for example, on the balcony or on a concrete platform), the easiest solution is to create the garden by building raised beds or using other types of containers. They can be filled with different substrates, according to the needs of the plants - the so-called soilless gardening or its type of form.



Most annual crops, such as most vegetables, spices, flowers and herbs, have high requirements for the soil and its characteristics in order for the plants to be healthy and the produce to have high qualities. However, when it is not suitable for cultivation, for growing edible plants, or there is none at all (for example, on the balcony or on a concrete platform), the easiest solution is to create the garden by building raised beds or using other types of containers. They can be filled with different substrates, according to the needs of the plants - the so-called soilless gardening or its type of form.

Choosing the right substrate is crucial for successful plant growth and development. It is important to pay particular attention to factors such as physico-chemical properties, water

holding capacity, aeration, nutrient availability and pH levels. Atzori G, et al. (2021)

An effective and high-quality nutrient medium chosen as a soil substitute for growing plants must have a physical structure that creates an appropriate balance of air and water for good root development, as well as providing effective access to the necessary nutrients for plant roots. This balance must be maintained throughout the growing season of crops - from a few weeks to more than a year. Last but not least, the substrates must meet the practical and economic requirements - to be affordable in terms of cost and resource, and also to be easily manipulated. Barrett, G.E., et al. (2016).

Many substrates have already established themselves, and opportunities are constantly being sought to introduce new materials on a global scale. Substrates are generally classified as organic and inorganic. They can originate from natural sources or from recycled materials, a waste product from another production, be synthetic (e.g. polyurethane) or natural organic substances (e.g. peat, wood-based substrates, etc.). Papadopoulos, A.P., et al. (2008).

The use of different substrates has a number of advantages, but also disadvantages.

The desired properties are:

- to have low density and, if possible, mass;
- to be a good reservoir for easily accessible water and nutrients;
- to have good aeration properties;
- to be able to rehydrate easily after drying;
- their structure should be stable;
- to have a good buffer capacity for optimal pH;
- to have appropriate acidity;
- to be homogeneous from batch to batch;
- not to contain phytotoxic compounds;
- to ensure low microbial activity
- to be decontaminated and certainly free from pests, pathogens, weed seeds, etc. Tripepi, R. R. (2011).

The most commonly used substrates are:

Manure-soil mixture

it is composed of various parts of garden soil and sieved, well-rotted manure. Most often the ratio is 70:30 or 60:40. The advantages of this mixture are that it combines the characteristics of the soil with the benefits and abundance of nutrients that are released slowly and are in a form easily available to the plants of the manure. Unfortunately, in today's modern times, a paradox occurs - there are few animal breeders or their farms are quite far from the city. They wonder what to do with the manure, but distance and logistics prove to

be a major problem. On the other hand, fertile garden soil with a high organic content, as it turned out, is also in short supply. Transporting large quantities over long distances makes both resources prohibitively expensive. Another downside is that they are quite heavy, which makes them extremely unsuitable for use on roofs, balconies, decks or other surfaces.

Peat

Made by different types of peat can be distinguished according to their botanical origin, degree of decomposition and particle size. Peat is formed as a result of the partial decomposition of sphagnum, other mosses and plants under specific conditions. Different types of peat differ in the degree of decomposition and are mainly divided into light, dark and black.

Whether the peat is fine or coarse is due to its greater water-holding or aeration capacity. The differences are mainly due to the following three factors.

- degree of decomposition;
- method of obtaining and drying process;
- the processes involved in the production, processing and packaging of the nutrient medium. Michel, J.C. (2010).





Source [here](#)



Source [here](#)

Peat is an essential ingredient in substrates because its characteristics make it ideal for growing plants.

It ensures good moisture holding capacity and aeration, while allowing easy control and change of stocking and pH by regular supply of nutrients in suitable forms, almost no need for physical improvers. It is considered extremely suitable for container growing of all kinds of crops. It is decontaminated and free of weed seeds. Its price is relatively reasonable, and it is claimed that it will be available as a raw material in the future. Schmilewski, G. (2008).

The coarsest peat fraction is suitable for container gardening and growing plants with an increased risk of root rot or high gas exchange requirements in the root zone. Most often, these are exotic plants with decorative qualities originating from warm countries, rain forests, etc. When using such peat, special attention should be paid to the water regime, because coarse particles provide better aeration, but not moisture retention.

Medium fractions are suitable for growing a large range of plants including all suitable for urban gardening, and if some are explicitly known to prefer a very acidic or alkaline reaction of the soil solution, then the choice of a specialized substrate and suitable fertilizers are recommended. Medium fractions provide a good balance between water and air in the root layer. When drying out, strong compaction, clumping and separation from the walls of the container is possible, which makes it difficult

and hurts the roots. It is not desirable to allow. Water retention quickly leads to asphyxiation of the roots and loss of the plant. Abundant watering can lead to the removal of fine particles along with the water at the bottom of the container, which is not desirable.

The finest fraction is suitable for sowing seeds, growing seedlings, rooting cuttings. Particle sizes do not inhibit seed germination and root system development. These are the main reasons why it is preferred for growing young plants. Also, as with medium fractions, drying or water retention should not be allowed.

Disadvantages of peat

- compaction and separation from the walls of the pot due to drying;
- suffocation of the root system, as a result of waterlogging;
- deficiency of nutrients, if they are not specifically included;
- insufficient weight of the substrate and the root system, which can lead to falling from the inside because of wind or other forces, if large-sized plants are grown;

Advantages of peat

- because it is light, it is extremely suitable for container gardening;
- has a good water retention capacity;
- has good aeration;
- excellent retention and preservation of nutritional elements;

In order to achieve an optimal result and minimize the shortcomings, it is common practice to add various components of mineral, organic or synthetic origin materials to the peat substrate. For example, perlite, sand, coconut fiber, vermiculite, zeolite, others.

Compost - see Unit 4.6

Complements rather than independent substrates follow. Their function is to improve the characteristics of the main components or to create a mixture of more than 3.

Perlite

This is a volcanic mineral which, as a result of heating at high temperatures, loses the water in itself and increases its volume several times. A light, porous material is obtained, which is used in the construction and cosmetic industries, as well as in horticulture.

It is used as a structural enhancer, and less commonly as a sole component, primarily in hydroponic systems, vertical gardening, etc. It can be used to root cuttings.

It influences the aeration and drainage properties in the medium, while also making it much lighter. Due to its porosity, it helps the penetration of the roots and facilitates their access to nutrients.



It is produced in various fractions, the most common being 0–2 and 1.5–3.0 mm in diameter. An important property of perlite is that it can hold 3-4 times more water than its own weight. The smaller the fraction, the less water it can hold.

Perlite has a neutral reaction, no buffering and no nutrients. May become a carrier of pathogens or enemies if reused. Papadopoulos, A.P., et al. (2008).

Disadvantages include the fact that it dusts easily and that it floats to the surface when watering.

Vermiculite

another mineral that finds application in several industries. It expands in volume when warmed, can hold up to 4 times its volume in water. The light structure allows better aeration to the substrates. Does not affect pH. It is rarely used as a stand-alone nutrient medium.

Vermiculite is odorless, sterile or can be decontaminated easily, therefore it does not carry diseases, insects and weed seeds. It is preferred in mixtures in which more moisture-loving crops will be grown. Finer to medium size fractions are recommended for gardening. It can also be used as a type of mulch in seedling production or on young plants known to suffer from cutting.



It is important to wear protective clothing (gloves, a fine filter mask and goggles) when working with vermiculite (and also with perlite) because it is possible to inhale particles that can cause lung problems. Otherwise, the materials are harmless and non-toxic.

<https://alliancechemical.com/blog/a-guide-to-vermiculite-benefits-applications-and-safety-tips/%20>

<https://www.vermiculite.org/blog/horticulture/perlite-vs-vermiculite-fully-explained%20>

<https://geologyscience.com/minerals/phosphates/vermiculite/>

Zeolite

Another mineral, known for its unique crystal structure and properties. Widely applicable in industries including pharmaceutical.

Zeolite is used in horticulture because of its porosity, its positive ionic charge, its strong adsorption capacity and its special cell lattice. Baudoin, W., et al. (2017). It is used to purify water and soil from heavy metals, ammonia Mondal M, et al. (2021), radioactive substances and environmental cleanup. It is interesting to note that it releases the water it contains when heated.



Also, compared to other two- or multi-component substrates, those containing zeolite have a significantly higher temperature than those without.



Zeolites : Minerals, Properties, Occurrence, Uses

Zeolites are a group of naturally occurring minerals and synthetic materials known for their unique crystalline structure and remarkable properties. These minerals are often used in a wide range of industrial applications due to their exceptional...

Geology Science · Jun 27, 2019

Farmers have used it for years to improve water holding capacity and regulate soil response. When incorporated, zeolite improves yields and plant performance. Slowly degradable fertilizers, insecticides, fungicides, herbicides and others can be imported through it. Kulasekaran, R., et al. (2011), Mumpton, F.A. (1985).

Pumice

a rock of igneous origin, also called a mineraloid, with an extremely porous structure. It is obtained during eruption and rapid cooling of magma. It is also used in many industries as well as in horticulture.



<https://geology.com/rocks/pumice.shtml>

Pumice stone is used as a decorative ground cover in landscape designs. The larger blocks also serve as ornaments. More importantly, it finds a place in substrates as an improver of drainage properties. It is also used as a clean substrate in hydroponic gardening.



Source [here](#)

The porous nature of pumice allows it to hold water and vital plant nutrients in its microscopic surface pores. It can even be soaked in a nutrient solution before being added to the substrate. Since it is inorganic, it does not decompose or break down over time, making it a good investment. Pumice stone can be considered as a good substitute for other cheaper but short-lived soil and substrate improvers.

<https://hesspumice.com/downloads/PDFs/informational/Pumice-Improves-Soil-Texture.pdf>

<https://hesspumice.com/downloads/PDFs/informational/knowledgeBriefs/Conditioning-Soil-with-Pumice-KB.pdf>

Tuff also has similar properties.

Keramzit/hydroton or expanded clay

The properties of this material are very similar to those already listed. It comes in different fractions and has different uses. When it comes to gardening, hydro and aquaponics are the biggest users. Transplantation, planting and harvesting of plants are extremely facilitated, irrigation systems are not clogged.

When expanded clay is embedded in a substrate, it can be part of the mix to improve the air-gas regime or be used as drainage at the bottom of containers. The structure allows the development of microbial colonies and a significantly improved nutritional regime as a result. Unfortunately, the ability to retain water, like perlite for example, is not as good.

<https://university.upstartfarmers.com/blog/pros-cons-hydroton-hydroponics%20>

<https://www.youtube.com/watch?v=vl6bMJavpUk>

Coir/ coco substrate

This is an organic material obtained from the waste products of the product part of the plant. The processing method

involves soaking in water to soften the fibers (salts are sometimes added, which requires the substrate to be soaked before use and the water to be changed several times).

Usually, this substrate is commercially available in the form of blocks of various sizes in a dehydrated state. To make it usable, it must be soaked in water and can absorb several times (about 10) its weight. At the same time, it still provides oxygen to the roots. It also multiplies its volume.

It is said to have fungicidal properties and is stimulate the growth of beneficial microorganisms.



It is not recommended for independent use precisely, because of its high water-holding capacity, but rather as an enhancer or alone in hydroponic systems. A disadvantage that is pointed out is that it can absorb iron, magnesium and calcium, and plants will experience a deficiency of these elements.

In addition to fine fraction or pure fiber, coconut is also commercially available in the form of chips. Added to the substrate, they become a kind of air pockets, thereby improving gas exchange.

<https://plantly.io/plant-care/coco-coir-fiber-and-gardening/>
<https://cococoirglobal.com/coco-peat-for-plants/>

To improve the characteristics of the substrates, other waste with plant origin can be used - wood chips, bran and shavings, the chaff of some cereal crops (rice, rye), crushed corn cobs, straw, etc.

For formulating substrates, it is important to remember the four functions of a substrate.

Substrates must:

1. Support plants
2. Provide aeration
3. Provide nutrients
4. Retain water

Source: Owen, W. G., & Lopez, R. G. (2016).

Table 1. Examples of common substrate "recipes" growers can formulate to produce greenhouse and nursery crops.

Crop(s)	Greenhouse Substrate Formulation		
	Volume Ratio	Substrate Component(s)	Additives ¹
Germination and young plants	2:1	sphagnum peat moss ² : perlite ³	limestone
Annual bedding plants	2:1:1	sphagnum peat moss: perlite: vermiculite	wetting agent
Herbaceous perennials	3:1:1	sphagnum peat moss: perlite: vermiculite	starter charge fertilizer
Vegetables			slow-release fertilizer
Potted flowering crops	2:1:1	sphagnum peat moss: pine bark: vermiculite	
	2:1:2	pine bark: perlite: vermiculite	
Specialty crops (Orchids)	6:1:1	pine bark: perlite: charcoal	
	1:1:1:1	sphagnum peat moss: pine bark: perlite: charcoal	
Herbaceous perennials	100%	pine bark	
Nursery / Woody ornamentals			

¹ Substrate additives such as limestone, wetting agent, and starter charge or slow-release fertilizers may be incorporated to adjust substrate pH, to help "wet" the substrate, or to provide nutrition to young transplants (seedlings or cuttings) or established plants, respectively.

² May be substituted with coconut coir (coir) or shredded wood.

³ May be substituted with parboiled rice hulls (PBH), pine wood chips (PWC), growstones, light expanded clay aggregates (LECA), or expanded polystyrene beads (EPS).

Screenshot:

https://www.researchgate.net/publication/292995410_Evaluating_Container_Substrates_and_Their_Components/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6Il9kaXJlY3QiLCJwYWdlIjoiX2RpcmVjdCJ9fQ

GENERAL CONTAINER SOIL MIX RECIPE



- 2 parts peat, coco coir (pre-moistened), or potting soil
- 2 parts compost or composted manure
- 1 part perlite
- 1/4-1/2 parts vermiculite

SOILLESS CONTAINER POTTING MIX RECIPE



- 2 parts peat, coco coir (pre-moistened)
- 1 part perlite
- 1/4-1/2 parts vermiculite

GOOD MEDIA MIXTURES FOR CONTAINER VEGETABLES



- 50% soilless mix + 50% compost
- Topsoil should only be added to very large containers and not exceed 5-10% of the volume

<https://extension.umd.edu/resource/growing-media-potting-soil-containers/>



Source [here](#)



Source [here](#)

Unit 5.2 Irrigation of plants

Vera Petrova, Roxana Ciceoi,
Okray Orel, Yasemin Sabahoglu

Introduction



The increasing demand for water resources amidst their scarcity poses a significant challenge for humanity. Irregular rainfall patterns, coupled with rising temperatures, present formidable barriers to plant preservation and growth, leading to increased instances of water scarcity. To address this, various soil monitoring and irrigation control systems have emerged, aiming to enhance the efficiency of water usage in recent times.

Effective irrigation stands as a crucial aspect of tending to urban gardens. The very essence and quality of vegetables and fruits, including their flavours, hinge upon the water's quality utilized for cultivation. Water serves as the fundamental element for nurturing and cultivating plants. However, incorrect irrigation methods or using unsuitable water sources may harm plant growth. To circumvent such issues, implementing valuable watering techniques tailored for urban gardens can ensure optimal plant care, as outlined in this article.

Several factors can affect irrigation, but perhaps the most significant factor is soil moisture content. Soil moisture levels determine when and how much water plants need. Other essential factors include:

Soil Type

Soil absorbs and holds water in much the same way as a sponge. Different soil types have varying water-holding capacities. Sandy soil drains quickly, requiring more frequent watering, while clay soil retains moisture longer, necessitating less frequent irrigation.

When preparing to plant your urban garden, consider the soil type where you'll sow the seeds. The characteristics of the soil dictate the frequency and quantity of water needed. Sandy soil requires more frequent irrigation as it doesn't retain moisture effectively. Conversely, with clay soil, caution is necessary to avoid excessive watering. Overwatering clay soil can lead to overly humid conditions, risking root rot for the plants.

The easiest method to ascertain soil type involves taking a moist soil sample and squeezing it in your hand. Extract the sample from a part of the site that accurately represents the area, at a depth similar to your intended

watering depth. For instance, if you plan to water to a depth of 6 inches (15 cm), dig down to that depth to retrieve your soil sample.

Amend soil with compost or organic matter to improve its water retention capacity. Healthy soil retains moisture better, reducing the need for frequent watering.

Plant Type and Growth Stage

Different plants have different water requirements at various growth stages. Young plants or seedlings typically need more frequent watering to establish roots compared to mature plants.

Group plants with similar water needs together. This allows you to water efficiently based on the requirements of each grouping rather than uniformly watering the entire area.

Choosing drought-resistant plants for your garden offers numerous benefits, especially in regions prone to water scarcity or drought conditions.

Understanding the specific water needs of plants in your urban garden is crucial for effective irrigation. Not all plants require the same amount of water, so arranging them based on their water needs can be beneficial:

Leafy vegetables such as spinach, lettuce, cauliflower, and Swiss chard have high water requirements. They benefit from more frequent watering to maintain their growth.

Fruiting vegetables like tomatoes, zucchini, cucumbers, and capsicums need moderate watering, especially during their flowering stage. Excessive watering during flowering might hinder their growth. Once these plants bear fruit, revert to regular irrigation.

Vegetables like onions, garlic, and similar varieties typically require moderate watering.

During dry seasons or in summer, it's advisable to increase the frequency of irrigation in your urban garden to prevent water-related issues like dry leaves or plant damage. Watering early in the morning or late in the evening helps shield plants from the harsh effects of the sun. This timing minimizes water loss due to evaporation and allows plants to absorb moisture more effectively. Adjusting watering schedules based on plant needs and seasonal variations ensures optimal growth and helps maintain a healthy urban garden.

Always you have to take it into account the depth of the root zone. Deep-rooted plants may access water from deeper soil layers, requiring less frequent surface watering compared to shallow-rooted plants.

Understanding the typical root zone depth for the plants in your garden helps in effective watering practices. Watering at the appropriate depth encourages deeper root growth, leading to healthier and more drought-resistant plants. However, it's important to note that while certain plants have general trends in root depth, individual variations can occur based on specific growing conditions and plant health.

By using plants that require less water, you contribute to water conservation efforts in your community. This is particularly beneficial in regions where water resources are limited or during times of water restrictions. When selecting drought-resistant plants, consider their suitability for your specific climate, soil type, and sunlight conditions. Incorporating these plants into your garden not only promotes sustainability but also creates a beautiful and resilient landscape while reducing water consumption.

Weather Conditions

Temperature, humidity, wind, and sunlight impact soil moisture levels. Hotter, drier conditions increase evaporation rates, leading to faster soil drying and potentially requiring more frequent watering. Adequate rainfall can reduce the need for supplemental irrigation. However, heavy rainfall can oversaturate the soil,

potentially leading to waterlogging and root rot in some plants. Low humidity levels in the air contribute to faster soil moisture evaporation. High humidity might reduce the need for frequent watering as it slows down water loss from the soil.

Weather conditions are essential for successful gardening. Adjusting watering schedules, choosing appropriate plants, and employing efficient irrigation methods based on prevailing weather conditions contribute to maintaining healthy plants and conserving water resources.

Water Quality

The quality of water used for irrigation can affect plant health. Water with high salinity or chemical content might hinder plant growth.

Applying the previously outlined irrigation guidance is crucial for optimal results, yet using chlorinated water could hinder these efforts. The presence of chlorine in water affects the quality of fruits and vegetables, compromising their desired taste and overall quality.

Most municipal water supplies contain chlorine, a disinfectant used to eliminate harmful bacteria and viruses, notably during warmer months. The distinct odour and

taste in our tap water confirm its chlorine content. If we're cultivating our own produce for genuine, organic, and flavourful fruits and vegetables, irrigating them with chlorinated water contradicts this goal. Achieving organic results and authentic taste necessitates the use of high-quality, chemical-free water.

Beyond compromising the final quality of vegetables, irrigating with chlorinated water can lead to plant growth issues, such as root damage, yellowing leaves, and compost problems. To ensure superior water quality, devoid of chemicals and pesticides, consider employing water filtration systems. These systems can eliminate chlorine by up to 99% and reduce herbicides, pesticides, and other contaminants.

Additionally, high mineral concentrations in water (hard water) can adversely affect plant health and the quality of produce. Addressing this issue involves installing a garden reverse osmosis system, capable of removing up to 95% of dissolved salts and heavy metals from the water.

These filtration and reverse osmosis systems offer seamless connections for indoor and outdoor use, attaching easily to taps, garden hoses, and water tanks.

They can adapt to various irrigation systems and are available in different capacities, suitable for small, medium, or larger gardens.

If you use collected rainwater for irrigation several hazards may occur. While the quality of rainwater collected from rooftops is generally good, it may contain a range of disease-causing (pathogenic) microorganisms including bacteria and parasites. These may arise from the faeces of birds, reptiles, amphibians and mammals that have access to the roof or tank, or be free-living environmental organisms.

Animal faeces can carry pathogenic bacteria including *Campylobacter* and *Salmonella* species and parasites such as *Cryptosporidium* and *Giardia* that are infectious to humans. These microorganisms have been associated with disease outbreaks from rainwater tanks and are considered the most significant risk to human health. Consideration also needs to be given to the potential for some microorganisms to grow within rainwater tanks, or in pools of stagnant water within the rainwater system. While most human pathogens are unlikely, or unable to grow in rainwater tanks, there are some bacterial pathogens such as *Legionella* and *Pseudomonas*, which can grow in water

under the right conditions. This growth is generally dependant on the availability of nutrients and the water temperature. Treatment of rainwater to address potential microbial risks is recommended for uses with a moderate risk of ingestion such as personal washing. Treatment is not likely to be necessary for lower exposure uses.

The advice for rainwater treatment in response to microbial contamination. Algae and cyanobacteria (also called blue-green algae) may also grow in rainwater tanks if they allow sufficient light in and the rainwater contains sufficient nutrients. Many algae species can affect the taste, appearance and odour of the water and some species of blue-green algae can produce toxins that may cause skin irritation and illness.

Chemical hazards and hazardous events is also possible. Chemical hazards may contaminate rainwater via the following:

- dust, atmospheric deposits and leaf litter on roof surfaces
- leaching from roofing, guttering and plumbing materials, or materials used to manufacture the storage tank
- discharges from roof-mounted appliances (such as air conditioners, hot water services and flues)

- air pollutants from industrial or domestic discharges, motor vehicle exhaust fumes and horticultural chemicals used at farms or in home gardens.

The risk of chemical contaminants in rainwater causing harm, when the rainwater is used for purposes other than drinking and food preparation, is likely to be low in most circumstances.

Basic controls will further reduce these risks. An individual assessment of chemical risks is recommended for all schemes where rainwater is used for purposes with a moderate risk of ingestion.

In addition to direct health risks associated with the ingestion of rainwater, rainwater tanks may pose indirect health risks by providing breeding sites for mosquitoes, which can transmit disease.

Although rainwater tanks have not been associated with outbreaks of mosquito-borne disease in Victorian urban areas to date, increasing numbers of rainwater tanks in urban areas may provide additional breeding sites for mosquitoes and increase the likelihood of disease transmission.

Control measures should be identified for all significant risks. When identifying control measures, you should consider the multiple barrier approach. The strength of this approach is that if one control measure (or barrier) fails, the remaining control measures will minimise the likelihood of contaminants passing through the entire system and being present in sufficient amounts to cause harm to rainwater users.

Control measures for rainwater systems would typically include:

- roof catchment protection and maintenance
- correct material selection and installation of the rainwater storage, distribution and plumbing
- treatment, such as filtration and disinfection, where deemed necessary
- regular inspection and maintenance of the supply system (pipes, tanks, pumps and other elements).

Despite the above, the use of rainwater for irrigation is not risky, especially if applied as a subsurface.

Irrigation System Efficiency

The type of irrigation system used (drip, sprinklers, hand watering) and its efficiency impact how effectively water is delivered to plants. Understanding these factors and

adjusting irrigation practices accordingly ensures that plants receive the right amount of water, promoting healthy growth while conserving water resources.



5.2.1 Frequency of watering (depending on growing conditions and using methods)



Vera Petrova, Roxana Ciceoi

The irrigation rate represents the volume of water given per unit area for a specific irrigation of a particular crop. It is measured in m^3/da ; m^3/ha or mm.

There are two main requirements in determining irrigation rate:

- Accurate calculation of the water** requirement based on climatic conditions and the crop's growth stage.
- Monitoring soil moisture** to confirm the correctness of the determined irrigation norms and as an indicator to determine the frequency of watering.

Evaluating the frequency of watering for plants involves various methods and considerations:

Soil Moisture Testing

Use a soil moisture meter or probe to measure the moisture content in the soil. Insert the meter into the soil at different depths around the plant. If the soil is dry a few inches below the surface, it might be time to water.

Visual Inspection

Observe the plants for visible signs of water stress. Wilting, drooping leaves, or changes in leaf colour (yellowing or browning) can indicate the need for water.

Manual Testing

Use the "finger test." Insert your finger into the soil near the plant. If the soil feels dry an inch or so below the surface, its likely time to water.

Pot Weight

For container plants, lift the pot. If it feels noticeably lighter than when wet, it might indicate the need for watering. Once you get familiar with the weight when dry versus when adequately watered, it becomes a helpful indicator.

Environmental Factors

Consider external factors like weather conditions, temperature, humidity, and wind. Hot, dry weather increases water evaporation, potentially requiring more frequent watering.

Plant Type and Growth Stage

Different plants have varying water needs. Young plants or newly planted ones might need more frequent watering to establish roots compared to established plants.

Observation over Time

Keep a gardening journal noting watering schedules and plant responses. This helps understand specific plant needs and fine-tune watering schedules accordingly.

Technology and Sensors

Unlike mineral nutrient elements, the amount of available moisture in a field changes relatively quickly, and operational information about the presence of moisture and its utilization by the vegetation directly in the garden is necessary to regulate plant moisture levels. In addition to the requirement for it to be a rapid method, the possibility of an electrical signal output and its integration into an automatic irrigation management system also provides an opportunity to increase water use efficiency. This helps avoid yield reduction due to moisture deficit or plant stress from overwatering and allows for the release of water for watering additional areas.

To account for the dynamics of water in the soil, sensors recording the respective parameters are placed at different depths. The depth and spacing of these sensors primarily depend on the root zone of the cultivated crop. It's advisable to have sensors at 45 cm in the areas adjacent to the emitters to gather data regarding the lateral movement of irrigation water. This method monitors the progression front of applied fertilizers.

Combined sensors for moisture and electrical conductivity yield better results. These sensors allow monitoring not only moisture levels but also fertilizer distribution.

For improved results, sensors can be placed in other parts of the root zone and at multiple locations across the field.

Soil moisture sensors, whether volumetric or in weight percentages, are typically provided by the manufacturer without necessary calibration. This necessitates mandatory calibration of the devices for the specific soil type in which soil moisture will be tracked.

Soil moisture sensors connected to irrigation systems can provide real-time data, automatically adjusting watering based on soil moisture levels.

By combining these methods and regularly monitoring your plants, you can develop a watering schedule tailored to the specific needs of your garden, promoting healthy plant growth while conserving water.

5.2.2 Possibilities to reduce watering

Okray Orel, Yasemin Sabahoglu,
Gergő Gyurcso



Water management involves the efficient and responsible use, distribution, and conservation of water resources. It encompasses various practices and strategies to ensure the sustainable and optimal utilization of water.

Water harvesting (WH) and small-storage technologies are key water-related interventions with the potential to contribute to rapid improvements in the yields of rain fed crops. WH and small-storage technologies can also help provide water for domestic use, livestock, fodder and tree production, and – less commonly – fish and duck ponds.

Water Harvesting (WH) is best described as the “collection of runoff for its productive use”

(Critchley & Siegert. 1991) and can be categorized into two groups: (1) rainwater harvesting: the practice of harvesting runoff from natural surfaces as well as artificial surfaces such as roofs; and (2) floodwater harvesting: the practice of harvesting the discharge from ephemeral watercourses (Critchley, & Siegert. 1991).

Three categories of storage can be distinguished:

1. Groundwater storage;
2. Soil moisture storage;
3. Surface storage.



Harvesting rainwater helps the environment in more ways than many are aware.

The more stored rainwater is used, the less water is needed to be pumped around by the local city or town. This means there are fewer carbon emissions being released into the atmosphere as not as much energy is being used

- Collecting rainwater means there isn't as much runoff into the sewer system during a storm. Flash flooding is less likely and in turn there's a reduced incidence of raw sewage being discharged.
- There are no added chemicals or treatments in rainwater; this makes it better for the soil when used in

gardening

- Collecting rainwater means that reservoirs, streams and rivers don't need to drain and dry.

Storing rainwater isn't difficult; it's about having the best system in place that can collect the water and to then hold it for as long as it's needed. What is vital is that the storage tank keeps the water hygienic, bug-free, that there's no harmful metals leaching into it and there's no chance that an unexpected leak will occur and all the good work goes to waste.



For those considering large stores of water; because of a rural location perhaps or the danger of a forest fire, the thought of having huge tanks over ground may be off-putting. Losing parts of a garden or a view from a window being blocked because of a tank could put the benefits in the shade a little but with underground tanks being very popular, this solves the issue. An underground storage tank is permanently in place, doing the job it's designed for and other than remembering to maintain every now and again, it's out of mind.



Rainwater can be stored in a tank made from any one of a range of materials; plastic, stone, metal or wood. None of these are completely suitable though and the answer is to use one engineered from concrete.

The rains are here. With the prolonged dry season we have experienced as a country, the rainy season has come to settle the dust. This is not a time to celebrate but a time for action,

not strategy. Strategies should have been already made when we had the dry season especially since the country has a Ministry of Water and Irrigation. Most buildings have gutters that are positioned accurately to let rainwater from the roof flow to the ground. This is not a government issue but an individual solution.



How can we harvest rainwater at home for domestic use, at work, in our farms and even in the natural habitats for wild animals?

For a successful rainwater harvest method, we need to consider where rainwater falls; from the highest point to the lowest point. The highest point, in most cases, will be the roof of a house. Observing where water flows during a rainstorm

to where it will penetrate into the soil which is important for long-term storage of water.

Gutters and downspouts

This is always the first step when starting to harvest rainwater. This method involves installing gutters on the roof of a building and maximizing the surface area of the roof to collect rainwater. If your house or building does not have this



already, you should consider installing them. Gutters and downspout can direct water to storage water systems near the house. They can also be used to direct water to a garden. Let us look into this options.

Rain barrels



A rain barrel is a medium sized to a large container which collects water like a big bucket. The barrel can be customised with fittings such as a lid to prevent objects from getting in and sometimes a tap. A water barrel can be made from an old or unused trash can and even a drum. This is a simple and affordable way to store rainwater. Although this method is short term, one can choose to invest in many connecting drums or several drums around the homestead.

Water tank

For large roofs, buildings can have water tanks which will store rainwater in thousands of litres. This can be outside water tanks or underground water tanks. A water tank does not have to be the conventional plastic one. They can also be built from concrete underground or above ground. Due to its large size, a water tank should be placed on a stable ground to prevent unwanted damage.



Bladder tank

Much like a rural biogas collector, we can use this large tubes to store rainwater that falls on our roofs.

Rain reservoir system



This system will benefit huge enterprises such as apartments and hotels. Consider collecting the rainwater that falls on the rooftop, whether a flat roof or a slanted one, run through pipes to a storage facility like a tank. This water is then filtered to purify the larger particles then stored in designated rainwater harvest tanks. This stored rainwater can be used for washing cars, watering gardens and even flushing toilets, minimising the use of underground water. Both the economy and the environment will benefit from this system as the energy bill will be minimised and energy saved respectively.

Create a rain garden

Do you have space in your compound? Use this space to create a rain garden. This is a sunken landscape that uses local plants, local soil, and mulch to remove pollutants from water, and allows it to percolate into the ground. Not only will it look good all year round, it will also have a positive impact on the environment. If every homestead had a rain garden, think of the water that will infiltrate into the ground and add to the groundwater system.

Rain saucer



A rain saucer is a free-standing rain collection system. A roof is not required for this, neither are gutters. All you need is a drum and a saucer-like collection system much like an upside-down umbrella unfolding to form a funnel. This is very effective in rural areas or a farm with limited roofs. This can be a self-made project to work on during this raining season. No excuses.

Bore wells and recharge pits

A bore well is an open dug well which can be used to replenish underground aquifers ensuring the continuous supply of water during the dry season. We can replenish our Aquifers through Recharge. This is achieved by artificially constructed chambers known as Recharge Pits which facilitate the percolation of water back to the water table. Aquifers, springs and other water-bearing formations are identified and recharge pits are built around them to specially replenish their water content through rainfall and seepage.

Green roof

Green roof systems or living roofs are roofs that are able to manage storm water runoff by reducing and delaying the water flow. This system is also able to keep the rainwater clean.



For a roof garden, one needs to put down a liner to protect the roof, and install a drainage system for excess runoff which is diverted into a barrel or storage tank. The plants to be planted should be of low-maintenance plants.

Ponds and pans

An excavated pond and pan are small reservoirs not more than 3 m deep which are usually dug of-stream with raised and compacted banks all around. Their purpose is to collect and store runoff water from various surfaces including from hillsides, roads, rocky areas and open rangeland. Ponds are constructed where there is some groundwater contribution or a high water table while pans receive their water wholly from surface runoff. These two methods of water harvesting are essential in national parks and reserves as well as farms and grazing regions for domestic animals.



When you have the necessary water amount, there is various way to apply water in your garden.



The irrigation systems suited for urban gardens, and the choice depends on factors like plot size, plant distribution, and watering needs. Selecting the right system ensures your urban garden thrives in optimal conditions.

Garden hose irrigation

Ideal for small spaces like terraces or tiny yards, this method is cost-effective. Ensure gentle watering akin to a soft rain to prevent soil nutrient loss. Avoid watering plant leaves, as it can be counterproductive.



Sprinkler irrigation



Suited for larger urban gardens, this system employs sprinklers to distribute water like rainfall. It requires adequate water pressure to cover the entire area. Programmable, it ensures uniform water distribution among plants. This system requires adequate water pressure to ensure uniform water distribution among plants.

Sprinklers are suited best for sandy soil with high infiltration rates although they are adaptable to most soil types. The average application rate of the sprinklers (in mm/hour) is set lower than the basic infiltration rate of the soil so that surface ponding and runoff can be avoided. Sprinklers are not suitable for soils that easily form a crust or in case of risk of salinization. Moreover, they can easily clog with the presence of sediments or debris. If sprinkler irrigation is the only method available, light fine sprays should be used. Sprinklers producing larger water droplets should be avoided.

Advantages

- No terracing required
- Suitable to all types of soil except heavy clay
- Suitable for irrigating crops where the plant population per unit area is very high
- Influences greater conducive micro-climate
- Areas located at a higher elevation than the source can be irrigated
- Possibility of using soluble fertilizers and chemicals

Disadvantages

- Incurs high operation expenses due to the energy needed for pumping, labour and relatively large investment in equipment: sprinklers and pipes
- Sensitivity to wind, causing evaporation losses
- The unavoidable wetting of foliage in field crops results in increased sensitivity to diseases

- Debris and sediments can cause clogging
- Capital cost is high with greater operational costs due to higher energy requirements

Overall, sprinkler irrigation is a suitable method for urban gardens, especially for larger areas, and it can be programmed to ensure efficient water distribution among plants.

Drip irrigation

Highly recommended for urban gardens due to its optimal water usage and nutrient preservation in the soil. This automated system delivers water efficiently to plant roots through a network of pipes, allowing controlled drips throughout the garden.



Drip irrigation is a highly efficient watering technique used in urban gardening, offering several advantages:

Water Efficiency

Drip systems deliver water directly to the plant's root zone, minimizing water loss due to evaporation or runoff. This targeted approach ensures efficient water usage, conserving this precious resource.

Consistent Moisture

By providing a slow and steady supply of water to the roots,

Highly recommended for urban gardens due to its optimal water usage and nutrient preservation in the soil. This automated system drip irrigation helps maintain consistent soil moisture levels. This promotes healthier plant growth and reduces stress caused by fluctuations in soil moisture.

Reduced Weed Growth

Water is delivered directly to the plant base, reducing moisture in surrounding areas where weeds might typically thrive. This can help in weed control and management.

Customizable and Flexible

Drip systems can be tailored to fit various garden layouts and plant types. They can be adjusted based on specific watering needs, such as different water flow rates for various plants.

Prevents Foliage Wetting

Unlike sprinkler systems, drip irrigation targets the soil near the plant roots, minimizing water contact with foliage. This reduces the risk of fungal diseases that can result from consistently wet leaves.

Conservation of Resources

Drip systems can be paired with timers or moisture sensors, ensuring water is only applied when needed. This helps conserve water, making it an environmentally friendly option.



However, some considerations include the initial setup cost and potential clogging of the drip emitters due to mineral deposits or debris in the water. Regular maintenance and periodic checks are necessary to ensure the system functions optimally.

Overall, drip irrigation stands out as a water-efficient, precise, and effective method for nurturing plants in urban gardens, making it a popular choice for many gardeners seeking sustainability and optimal plant health.

Based on your garden's size, available resources, and time constraints, each system offers its advantages.



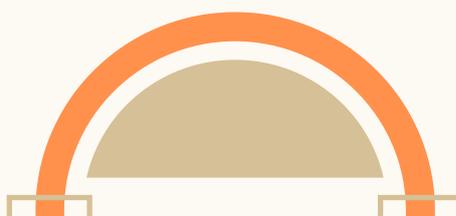
Unit 5.3 Ecological and biodynamic preparations and infusions

Zhelyu Avramov, Roxana Ciceoi

Introduction

A substantial body of research, increasingly revisited today, demonstrates that plants are not passive organisms requiring constant external protection. They represent integrated living systems equipped with evolutionarily developed mechanisms of self-defence in hostile environments. Beyond mechanical and morphological adaptations such as thorns, unpleasant odours, or specific coloration, plants possess a well-defined biochemical capacity to synthesize compounds that protect them against insects, phytopathogens, and vertebrate pests. These very biochemical substances can be used to design ecologically sound plant protection strategies suitable for urban horticulture.

This perspective reframes plant protection from an external, input-dependent practice to one grounded in the intrinsic defensive chemistry of plants themselves. Understanding how plants regulate and deploy phenolics, alkaloids, terpenes, glycosides, and other secondary metabolites



under stress allows practitioners to align protection measures with natural physiological processes rather than override them. In urban horticulture - where environmental sensitivity, limited space, and human proximity restrict the use of synthetic pesticides - such knowledge becomes not only relevant but necessary for developing preventive, low-impact, and biologically coherent protection approaches.



5.3.1 New trends in phytopharmacy: plant decoctions and pests control



Zhelyu Avramov,
Roxana Ciceoi

Under stress conditions, plants express two principal categories of defence:

- A) non-specific, pre-infection defence mechanisms,
- B) specific, post-infection defence responses;

Non-specific defence relies on compounds that are naturally present in plant tissues, regardless of pest attack. According to Nikolov (2017), these include:

Proteins and amino acid derivatives

3,4-dihydroxyphenylalanine (DOPA), present in the seeds of certain legumes, inhibits the enzyme tyrosinase, which is essential for cuticle formation in insects. This compound is highly toxic to insects. Beta-cyanoalanine, found in seeds of certain wild species, protects plants from rodent damage. Kwanalin also exhibits protective activity against mammals.

Cyanogenic glycosides

These compounds are not inherently toxic, but when acted upon by specific enzymes, they release hydrogen cyanide

(HCN), which inhibits cytochrome oxidase and acts as a potent respiratory toxin. Linamarin in flax provides protection against *Gloeosporium limeticola*. Amygdalin, present in stone fruits, clover, and other species, has a similar defensive role.

Glucosinolates

Characteristic of the family *Brassicaceae*, these compounds yield isothiocyanates which, through enzymatic conversion, form thiocyanates highly toxic to pests. This group includes the glycoside sinigrin which, under the action of myrosinase, is converted into allyl-isothiocyanate and phenyl-isothiocyanate (responsible for the pungent taste of mustard). These compounds exhibit strong fungicidal activity against *Plasmodiophora brassicae* and act as effective repellents against mammals.

Alkaloids

Solanine in potato (*Solanum tuberosum*) can be extracted from plant biomass and used in organic agriculture against pests. In tomato (*Solanum lycopersicum*), tomatine shows activity against the Colorado potato beetle. Solanine present in potato leaves contributes to the natural resistance of the plant to *Helminthosporium carbonum*.

Phenols are formed through the oxidation of 3,4-dihydroxyphenol, resulting in o-phenol, a compound toxic to

many pests. In plant tissues, phenols can be further oxidized enzymatically into quinones with strong fungicidal properties. Chlorogenic acid is also involved, contributing to resistance against phytopathogens such as *Fusarium* and *Verticillium* in fruit trees and powdery scab in potato.

Saponins are structurally complex glycosides, typically white, water-soluble substances occurring in plants together with lipids, essential oils, and resins. Enzymatic hydrolysis splits them into a sugar moiety and an aglycone (sapogenin). They exhibit specific activity against pests as well as grazing animals. An example is medicagenic acid in alfalfa (*Medicago sativa*) leaves, associated with resistance to phytopathogens. Well-known saponins include those found in horse chestnut (*Aesculus hippocastanum*) seeds, recognized for fungicidal activity, limonene-associated compounds effective against bean weevil, and hypericin with activity against fungal pathogens.



These and many other compounds of varied chemical structure are collectively referred to as phytoncides, also described as plant antibiotics. Chemically, they are often terpenes - highly volatile compounds that create a spatial protective barrier around plant tissues (Stancheva, 2004).

Recent developments in organic agriculture increasingly emphasize the practical use of phytoncides (Ayzerman et al., 1984; Grainge & Ahmed, 1987; Regnault-Roger et al., 2008). Phytoncides participate in both non-specific and specific plant defence. The boundary between these forms of defence is not strict, as the penetration of pathogens into host tissues progressively enhances the synthesis of pre-infection defensive substances.

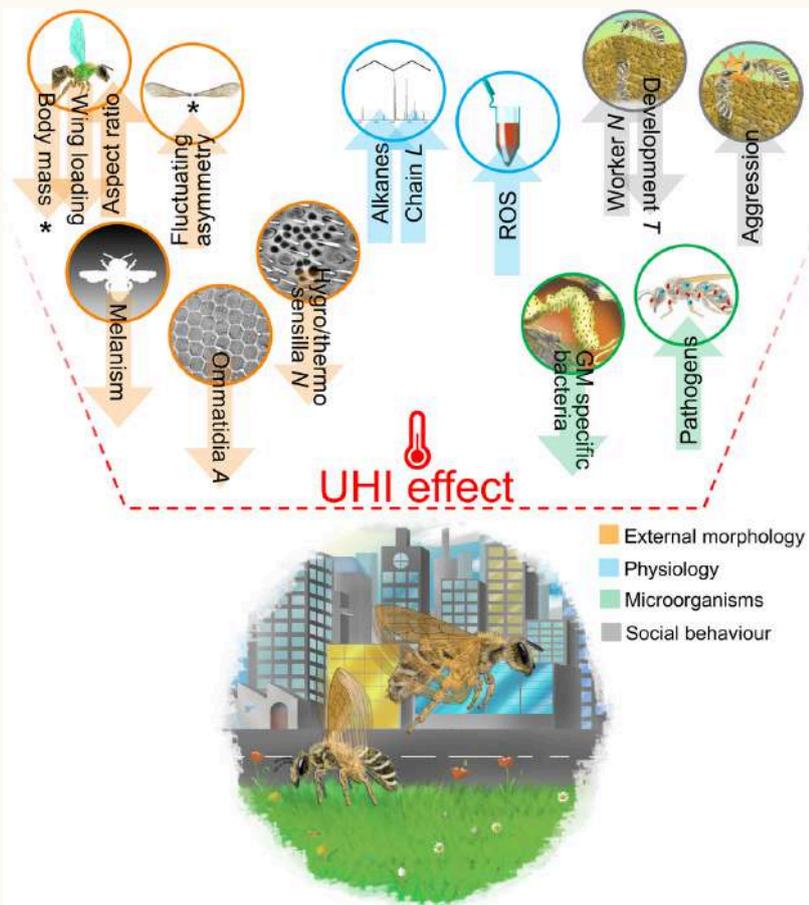
Entomological relevance of plant secondary metabolites in Urban horticulture

While plant-derived metabolites are traditionally discussed from a phytopathological perspective, their role in regulating insect populations is equally significant, particularly in urban horticultural systems where synthetic pesticide use is restricted.

Secondary metabolites such as alkaloids, phenolics, terpenoids, and glucosinolates interfere with insect physiology at multiple levels. Their effects include:

- disruption of midgut epithelial integrity,
- inhibition of digestive proteases,
- interference with detoxification enzymes (cytochrome P450 monooxygenases, glutathione-S-transferases, esterases),
- alteration of feeding behaviour,
- reduction in fecundity and longevity.

Research demonstrate that plant allelochemicals frequently act through sublethal mechanisms, affecting insect development rate and reproductive output rather than causing acute mortality (Després et al., 2007).



Polidori, C., Ferrari, A., Ronchetti, F., Tommasi, N., Nalini, E., 2023. Warming up through buildings and roads: what we know and should know about the urban heat island effect on bees. *Frontiers in Bee Science* 1..
<https://doi.org/10.3389/frbee.2023.1269600>

Urban environments create additional complexity. Elevated temperatures associated with the urban heat island effect accelerate insect developmental cycles, potentially increasing the number of generations per year (Meineke et al., 2013). Under these conditions, reliance on broad-spectrum chemical insecticides may destabilize trophic networks. In contrast, plant-derived compounds often maintain ecological selectivity.

Importantly, plant metabolites rarely act as single-target toxins. Instead, they exert multi-site physiological pressure, which reduces the probability of rapid resistance evolution compared with synthetic insecticides targeting a single receptor pathway (Isman, 2020). In urban horticulture, where biodiversity conservation is essential, this biochemical diversity represents not merely a defensive strategy of plants but a framework for ecologically balanced pest management.

When pests penetrate plant tissues, the so-called **Systemic Acquired Resistance** (SAR, SDH) is triggered. This phenomenon was first described in 1961 by Ross, who demonstrated that a localized infection can induce resistance not only to the primary pathogen but also to a broad spectrum of other pests. This resistance initially manifests locally at the infection site and subsequently spreads systemically throughout plant tissues. Although the mechanisms differ, SAR can be compared conceptually to immunization in humans.

In natural conditions, plants are continuously exposed to pest pressure, and SAR provides a significant evolutionary advantage. For example, cucumbers infected with anthracnose develop SAR effective against various other fungal and bacterial pathogens. The time required for SAR to develop depends on both plant species and the pathogen. In

cucumber, resistance has been observed approximately seven hours after infection with *Pseudomonas syringae*, whereas in tobacco infected by *Peronospora parasitica*, SAR becomes evident two to three weeks after the onset of infection. Once established, this type of resistance may persist for several weeks. The development of SAR in tissues distant from the infection site is mediated by specific signalling molecules, in some cases still unidentified, produced at the infection site and activating defence mechanisms throughout the plant.

Induced resistance mechanisms such as SAR and ISR also have profound entomological implications. Beyond pathogen suppression, activation of jasmonic acid (JA) and salicylic acid (SA) signalling pathways modifies volatile organic compound (VOC) emission profiles.

Herbivore-induced plant volatiles (HIPVs) function as ecological signals attracting parasitoids and predators of herbivorous insects, establishing tritrophic interactions essential for sustainable pest suppression (Turlings & Erb, 2018).

In urban horticulture, where habitat fragmentation often reduces natural enemy abundance, enhancement of HIPV-mediated attraction can partially compensate for biodiversity loss.

However, cross-talk between JA and SA pathways may create trade-offs: activation of pathogen resistance may transiently reduce defence against chewing insects (Pieterse et al., 2012).

Therefore, the use of plant-based preparations should not be viewed solely as direct insecticidal tools but as modulators of ecological signalling networks within the agroecosystem.



Pest attack has also been shown to activate SAR through the action of rhizobacteria colonizing the rhizosphere, where resistance is induced in leaves and stems. This demonstrates that rhizobacteria can protect plants systemically without causing harm. This mechanism is termed Induced Systemic Resistance (ISR). According to more recent studies (Bhawsar, 2014), SAR and ISR represent distinct phenomena with specific plant responses following pest attack: ISR corresponds to a hypersensitive-type response, while SAR represents the development of a plant immune system.

An important component of this defence network is the **synthesis of phytoalexins**. These were first investigated by Müller and Börger in 1940; the first phytoalexin isolated from pea leaves was named pisatin. The term phytoalexin was introduced to describe molecules produced or released by plants in response to pest attack or abiotic environmental factors. Today, phytoalexins are defined as plant antibiotics synthesized under the influence of biotic factors (microorganisms, fungi, bacteria, viruses) as well as abiotic stress (Ingham, 1973). To date, more than 350 phytoalexins have been identified across over 30 botanical families (Ahuja et al., 2012). Phytoalexins are species-specific and may exert pesticidal activity against a range of pathogens. Depending on concentration, their effect may be fungicidal or fungistatic. They have been isolated from nearly all plant organs: leaves, stems, roots, and fruits. Most are phenolic compounds synthesized via the shikimic acid pathway; others arise from acetate-mevalonate and acetyl-malonate pathways (Benhamou, 2009).

A representative example is the stilbene compound resveratrol (3,4,5-trihydroxystilbene). In vineyards, following infection by *Botrytis cinerea* or *Plasmopara*, or under stress conditions, transferase enzymes synthesize this phytoalexin, inhibiting phytopathogen development. Exogenous application of resveratrol has been shown to inhibit

cytochrome reductase and monooxygenase enzymes (Martinez, 2012).

Based on these processes and mechanisms, ecological vegetable production employs, alongside widely recognized copper- and sulfur-based products, various plant decoctions. These preparations differ in their source materials because the content of glycosides, alkaloids, essential oils, and phytoncides varies among plant species and is influenced by phenological stage and growing conditions.



5.3.2 Rules for preparing decoctions and select ecological plant protection measures



Roxana Ciceoi, Zhelyu Avramov

The effectiveness of alternative pest control methods in urban agriculture depends on the correct preparation of recipes and appropriate application. The raw materials for decoctions are collected from different plant organs at specific stages of the vegetation cycle, such as:



leaves collected before and during the flowering period of the species



flowers collected at the beginning of flowering;



roots collected in early spring or autumn;



fruits harvested at maturity.

The effect becomes visible after several treatments. Prepared working solutions must not be stored. Three preparation methods are distinguished: decoction, infusion, and maceration.

A decoction is prepared by boiling the collected plant material for 3 - 5 minutes in a closed vessel. It is then left to steep for a period between 1 and 12 hours. During this time, the solution must be homogenized, and before use it is filtered through a sieve lined with cotton.

An infusion is obtained by pouring hot water over the plant material. The mixture must stand for at least one hour, after which it is filtered and allowed to cool before use.

A maceration is prepared by soaking plant material in cold water in a closed container. The resulting concentrates are stored in a cool, dark place. Homogenization is recommended.

Before use, all extracts are diluted 1:1 with water to obtain working solutions and to avoid phytotoxic effects on treated plants. Additionally, 5 mL of liquid soap is added per liter of working solution. These preparations act by contact, therefore precise spraying is required, repeated 2–3 times at intervals of 7 - 8 days. It is important to note that these extracts remain effective even against insects that have developed resistance to synthetic plant protection products. This method provides a dual benefit: no environmental contamination; ecologically clean produce.



Recipes of various extracts

Plant species	Plant part used	Preparation method	Raw material per 1 L water	Target pest
<i>Allium sativum</i> (garlic)	cloves, skins	maceration, 96 h	20 g	aphids, scale insects, greenhouse whitefly
<i>Urtica dioica</i> (nettle)	stems, leaves	decoction, 3 min	80 g	aphids
<i>Allium cepa</i> (onion)	dry skins	maceration, 8 h	15 g	mites, aphids, scale insects, greenhouse whitefly
<i>Aesculus hippocastanum</i> (horse chestnut)	fruit	infusion, 3 h	50 g	Colorado potato beetle, aphids, greenhouse whitefly
<i>Nicotiana tabacum</i> (tobacco)	leaf, inflorescence	maceration, 46 h	40 g	aphids, greenhouse whitefly, spider mite
<i>Helleborus</i> (hellebore)	roots, stems	maceration, 48 h	variable	Colorado potato beetle, aphids, greenhouse whitefly
<i>Cotinus coggygria</i> (smoke tree)	leaves	decoction, 5 min	40 g	aphids
<i>Euphorbia</i> (spurge)	flowers, stems, leaves	maceration, 72 h	50 g	spider mite, aphids, greenhouse whitefly
<i>Achillea millefolium</i> (yarrow)	flowers, leaves, stems	infusion, 2 h	50 g	aphids
<i>Taraxacum officinale</i> (dandelion)	root, leaves	infusion, 2 h	50 g	scale insects, aphids, spider mite
<i>Citrus spp.</i> (orange, lemon, mandarin)	peels	infusion, 72 h	—	aphids, scale insects

Ecological validation of botanical and behavioural control methods in orchard systems

Field studies conducted in organic apple orchards demonstrated that behavioural control methods such as mating disruption significantly reduced populations of *Cydia pomonella*, a key lepidopteran pest in temperate fruit systems. Seasonal flight monitoring revealed up to a tenfold reduction in male captures in orchards treated with pheromone dispensers compared to conventional systems (Bujdei et al., 2016). Fruit damage levels were maintained below 1% under combined use of pheromone disruption and protective net systems (Bujdei et al., 2018). These results confirm that behavioural interference can replace repeated insecticide applications in well-managed systems.

However, non-selective monitoring tools may produce unintended ecological effects. Observations showed that sticky traps significantly reduced beneficial entomofauna, including predatory insects, when used indiscriminately (Bujdei et al., 2016). In urban horticulture, where biodiversity services are critical, monitoring strategies must prioritize selectivity.

Additionally, physical barriers such as anti-hail nets reduced total insect abundance by up to 80%, but altered microclimatic conditions, increasing humidity and potentially favouring fungal pathogens. This illustrates the necessity of integrated decision-making rather than isolated application of control measures.

Urban horticulture therefore benefits from a multi-layered strategy combining:

- induced plant resistance,
- botanical extracts,
- behavioural disruption,
- physical exclusion methods,
- conservation of natural enemies.



Control Strategy	Target Pest	Application Rate	Observed Effect	Ecological Selectivity	Limitation
Mating disruption (pheromone dispensers)	<i>Cydia pomonella</i>	500–800 units/ha	Up to 10× reduction in male captures	High	Requires area-wide implementation
Anti-hail protective net	Multiple flying insects	Full canopy coverage	~80% reduction in insect presence	High (physical barrier)	Increased humidity, fungal risk
Sticky traps	Monitoring of flying insects	Canopy placement	Pest detection	Low (captures beneficial insects)	Should be used selectively

Ecological performance of behavioural control

Metabolite group	Mode of action in insects	Primary target	Ecological implication
Alkaloids	Neurotoxicity, digestive disruption	Nervous system, midgut	Feeding deterrence
Glucosinolates / Isothiocyanates	Protein modification	Gut enzymes	Reduced larval survival
Phenolics / Quinones	Oxidative stress induction	Midgut epithelium	Growth inhibition
Terpenoids	Repellence, endocrine disruption	Olfactory receptors	Reduced oviposition

Functional effects of major plant metabolites on insect physiology



Rules for preparing Bordeaux mixture

The fastest preparation method is gravimetric, using pre-weighed materials. To obtain 10 liters of 1% Bordeaux mixture, proceed as follows: dissolve 100 g of copper sulfate (blue vitriol) in 9 liters of water in a non-metallic container. In a second container, dissolve 100 - 150 g of slaked lime in 1 liter of water to obtain lime milk.

The lime milk is then poured slowly, in a thin stream, into the diluted copper sulfate solution under continuous stirring. With these quantities of lime, the resulting solution reaches a pH of approximately 8 - 8.3.

Bordeaux mixture is a colloidal suspension with particle diameters of 3 - 4 microns. It has very good adhesion, limited wetting capacity, and good suspension properties. During prolonged standing, particles sediment; therefore, the mixture must be thoroughly homogenized and filtered before each use. Its stability and usability do not exceed 24 hours.

Bordeaux mixture destroys zoospores and germinating spores of many fungi, as well as certain bacteria. For this reason, spraying must be performed preventively, before plant infection occurs.

Copper-based solutions provide effective protection against downy mildews, smuts, and rusts. They are not effective against powdery mildews and are not recommended for cucurbit crops. Due to their bactericidal effect, they are used against angular leaf spot in cucumber, walnut bacteriosis, black rot in sesame, bacterioses in beans, and others.

Copper compounds exhibit phytotoxicity toward peach, apricot, cucurbits, gooseberry, and some cultivars of apple, pear, and plum.

For winter spraying of fruit trees, concentrations of 1 - 2% are used. For spring and summer applications on green foliage, concentrations of 0.5 - 1% are recommended. In grapevine, the optimal concentration is 1%. According to some studies (Novoa et al., 1996), the last two treatments at 1.5% concentration suppress mycelial development of grey mold and partially that of powdery mildew. The same concentration is effective against excoiiose and anthracnose of grapevine when applied at the appropriate phenological stage.

In vegetable crops such as tomato and potato, Bordeaux mixture is applied against late blight, "target spot," bacterioses, and alternaria at concentrations of 0.5-1%, avoiding the flowering stage.

Rules for preparing lime - sulfur solution

Sulfur has been used as a fungicide, insecto-acaricide, and fertilizer for nearly two centuries. It was first applied in 1821 as a disinfectant for wine vessels against mold. Later, in 1840, trials were conducted in England to treat vineyards against powdery mildew. In 1855, Henri Becquerel succeeded, after purification and refining, in obtaining high-purity sulfur and used it effectively against powdery mildew in grapevine.

To prepare 10 liters of solution, 2.4 kg of powdered sulfur and 2.4 kg of slaked lime are required. In an iron vessel with a capacity of 10–15 liters, the quantity of quicklime is mixed

with 3 - 4 liters of water.

The vessel is placed over heat and, under gentle heating, the mixture is homogenized until a thick lime milk is obtained.

Sulfur is then added gradually, with constant stirring, until the mixture reaches the consistency of a thick paste. During heating, part of the water evaporates and must be replenished continuously. After the sulfur is incorporated into the lime milk, water is added to reach a final volume of 10 liters. It is essential that the volume does not fall below this level during preparation.

The heat is then increased, and boiling continues for 30–40 minutes. During this time, the solution darkens, changing from orange-red to green-black, and the sulfur froth disappears.

The resulting solution is left to cool and clarify. On the following day, only the clear liquid is decanted, and the sediment is discarded.

The lime–sulfur solution is a transparent liquid with an orange-red color and a characteristic hydrogen sulfide odor. Stored in glass containers, plastic barrels, or covered with a layer of mineral oil, it can be preserved for long periods, provided it does not freeze during winter.

Lime-sulfur solution must not be mixed with Bordeaux mixture.

It is used for winter treatments of pome fruits and some stone fruits, diluted with water at a ratio of 1:6, and for more sensitive stone fruits and grapevine at 1:10. During vegetation, it is applied at dilutions between 1:50 and 1:100. For spraying apple, pear, quince, and plum, it is recommended before flowering at a concentration of 2%, and during and after flowering at 1.6 - 1.8% (Hristov, 1969).

Sulfur-based preparations are effective against the agents of powdery mildews, many ascomycetes, molds, and rusts, but they do not affect downy mildews. Recent studies indicate that, beyond preventive and contact action, sulfur also exhibits curative activity against powdery mildew in grapevine by inhibiting spores and mycelial growth for up to five days after treatment (Decoin, 1999).



5.3.3 Rules for spraying and routes of application

Roxana Ciceoi, Zhelyu Avramov

Rules for spraying plants

Plants may become infected by diseases and pests that must be controlled to prevent decline. Control of harmful insects relies on products applied with sprayers. The wide range of equipment available in specialized stores allows selection of devices appropriate for the garden and comfortable to carry during treatment. The quantity of product used and the quality of application are critical.

The success of any treatment depends on observing the following rules during spraying:

During treatment, protective work clothing and personal protective equipment must be used in accordance with European legislation (Dir 89/656/EEC; 89/391/EEC; (EU) 2019/1832) regarding minimum safety and health requirements when using personal protective equipment:

- a) chemical-resistant gloves;
- b) protective work suit;
- c) work footwear;
- d) head covering;
- e) protective goggles;
- f) respiratory mask.

After treatment, disposable protective items must be discarded in designated places.

Before treatment, the external condition of the sprayer must be inspected. The nozzle must be checked for cleanliness and rinsed with clean water if necessary.

The droplet size produced by the nozzles must be determined. This is done by placing white sheets of paper on different parts of a plant and performing a trial spray with water. If necessary, the nozzle openings are adjusted before preparing the working solutions.

Working solutions must be prepared only in quantities that will be used on the same day.

Working solutions are prepared in the following sequence: in a small container, the required quantity of product (decoction, infusion, maceration, or other) is diluted with water. Liquid soap or another detergent is then added while stirring (0.5 mL per liter of working solution). A small amount of water (about one-tenth of the final volume) is added to the sprayer tank. The solution from the small container is poured in a thin stream into the sprayer while continuously stirring. The small container is rinsed several times, and the rinsing water is also added to the sprayer.

The remaining quantity of water is then added. Emulsion solutions must never form an oily film on the surface.

During winter treatments against overwintering pest stages, defoliated trees are sprayed abundantly with working solution using large droplets.

The objective is complete wetting of the entire plant surface. During the vegetation period, spraying is carried out with small quantities of solution and the finest possible droplets. When contact-action products are used, thorough coverage of both the upper and lower leaf surfaces is required (particularly important for fungicides, acaricides, and herbicides). This is less critical when using products with penetrating or systemic action.

When applying plant protection products, the recommended dose must be strictly respected (for example, herbicides are dosed per hectare). Overlapping previously sprayed strips must be avoided. On overlapped areas, double quantities accumulate, which can cause undesirable phytotoxic effects during the current or subsequent seasons. This explains why herbicide recommendations are often expressed in grams per area rather than as percentages of working solution.

Spraying should be performed when wind speed does not exceed 3 m/s, and the operator should always remain with their back to the wind.

Instructions for use written on the product label must always be read carefully, and concentrations and timing of

application (according to plant growth stage and pest type) must be strictly followed. During spring and summer, spraying is performed before 9 - 10 a.m. and after 8 p.m. to avoid leaf burn, which can occur even with clean water if spraying is done during the hottest hours. Treatments are suspended when temperatures exceed 20 °C. During summer, night treatments after 10 p.m. are recommended.

Smoking and food consumption during treatment are not recommended. After treatment, the sprayer tank, hoses, and nozzles must be rinsed three times.



[Sustainable use of pesticides.](#)
[Easing the way for a chemical-free horticulture](#)

REFERENCES

- Abaye, A. O., Basden, T. J., Beegle, D. B., Binford, G. D., Daniels, W. L., Duiker, S. W., ... & Taylor, R. W. (2006). The Mid-Atlantic nutrient management handbook.
- Atzori G, Pane C, Zaccardelli M, Cacini S, Massa D. The Role of Peat-Free Organic Substrates in the Sustainable Management of Soilless Cultivations. *Agronomy*. 2021; 11(6):1236. <https://doi.org/10.3390/agronomy11061236>
- Barrett, G. E., Alexander, P. D., Robinson, J. S., & Bragg, N. C. (2016). Achieving environmentally sustainable growing media for soilless plant cultivation systems—A review. *Scientia horticultrae*, 212, 220-234.
- Baudoin, W., Nersisyan, A., Shamilov, A., Hodder, A., Gutierrez, D., PASCALE S, D. E., ... & Tanny, J. (2017). Good Agricultural Practices for greenhouse vegetable production in the South East European countries-Principles for sustainable intensification of smallholder farms (Vol. 230, pp. 1-449). FAO.
- Bronick, C. J., & Lal, R. (2005). Soil structure and management: a review. *Geoderma*, 124(1-2), 3-22.
- Bujdei, A., Ciceoi, R., Stanica F. (2018). The Behavior of Gala, Jonagold, Golden Delicious And Granny Smith Apple Varieties In Organic Farming System. *Scientific Papers-Series B-Horticulture*, 62: 191-195, WOS:000449533400033, ISSN: 2285-5653, <http://horticulturejournal.usamv.ro/pdf/2018/Art33.pdf>
- Bujdei A., Ciceoi R., Mardare E. Ş., Stănică F., (2016). Methods of pests prevention and control applied in two organic apple orchards, *Journal of Horticulture, Forestry and Biotechnology*, vol. 20(4):28-32, ISSN 2066-1797; <https://www.cabdirect.org/cabdirect/FullTextPDF/2017/20173321423.pdf>
- C. Gasch, J. DeJong-Hughes, (2019), Soil Organic Matter Does Matter, NDSU
- Critchley, W., Siegert, K. and Chapman, C. (1991) Water Harvesting, A Manual Guide for the Design and Construction of Water Harvesting Schemes for Plant Production. FAO, Rome.
- Daniels, W. L., & Haering, K. C. (2006). Concepts of basic soil science. *The Mid-Atlantic Nutrient Management Handbook*, 31

- Després, L., David, J.-P., & Gallet, C. (2007). The evolutionary ecology of insect resistance to plant chemicals. *Trends in Ecology & Evolution*, 22(6), 298–307, <https://doi.org/10.1016/j.tree.2007.02.010>
- Doran, J. W. (2002). Soil health and global sustainability: translating science into practice. *Agriculture, ecosystems & environment*, 88(2), 119-127.
- Fussy, A., & Papenbrock, J. (2022). An Overview of Soil and Soilless Cultivation Techniques-Chances, Challenges and the Neglected Question of Sustainability. *Plants* (Basel, Switzerland), 11(9), 1153. <https://doi.org/10.3390/plants11091153>
- Hartemink, A. E., & Barrow, N. J. (2023). Soil pH-nutrient relationships: the diagram. *Plant and Soil*, 486(1-2), 209-215
- Huw Richards (2022), *Grow food for free/Да отгледаме храна безплатно*, ISBN:9786192290849
- Index, D. J. S. (2010). Frequently asked questions. Retrieved May, 4.
- Knott, J. E. (1957). *Handbook for vegetable growers* (No. SB321 K49). Wiley.
- Kulasekaran, R., Reddy, D. D., Biswas, A. K., & Rao, A. S. (2011). Chapter four-zeolites and their potential uses in agriculture. *Advances in Agronomy*, 113, 215-236.
- Meineke, E.K., Dunn, R.R., Sexton, J.O., Frank, S.D., 2013. Urban Warming Drives Insect Pest Abundance on Street Trees. *PLOS One* 8, e59687.. <https://doi.org/10.1371/journal.pone.0059687>
- Isman, M.B., 2020. Botanical Insecticides in the Twenty-First Century—Fulfilling Their Promise?. *Annual Review of Entomology* 65, 233–249.. <https://doi.org/10.1146/annurev-ento-011019-025010>
- Turlings TCJ, Erb M. Tritrophic Interactions Mediated by Herbivore-Induced Plant Volatiles: Mechanisms, Ecological Relevance, and Application Potential. *Annu Rev Entomol.* 2018 Jan 7;63:433-452. doi: 10.1146/annurev-ento-020117-043507. PMID: 29324043.

Michel, J. C. (2010). The physical properties of peat: a key factor for modern growing media. *Mires and Peat*, 6(2), non-paginé.

Mondal M, Biswas B, Garai S, Sarkar S, Banerjee H, Brahmachari K, Bandyopadhyay PK, Maitra S, Brestic M, Skalicky M, et al. Zeolites Enhance Soil Health, Crop Productivity and Environmental Safety. *Agronomy*. 2021; 11(3):448.

<https://doi.org/10.3390/agronomy11030448>

Mumpton, F. A. (1985). Using zeolites in agriculture. *Innovative biological technologies for lesser developed countries*, 127-158.

Owen, W. G., & Lopez, R. G. (2016). Evaluating container substrates and their components. *Purdue Ext. Bul. HO-255-W*. <http://www.extension.purdue.edu/extmedia/HO/HO-255-W.pdf>. Accessed July 9.

Papadopoulos, A. P., Bar-Tal, A., Silber, A., Saha, U. K., & Raviv, M. (2008). Inorganic and synthetic organic components of soilless culture and potting mixes. *Soilless culture: theory and practice*, 505-544.

Papadopoulos, A. P., Bar-Tal, A., Silber, A., Saha, U. K., & Raviv, M. (2008). Inorganic and synthetic organic components of soilless culture and potting mixes. *Soilless culture: theory and practice*, 505-544.

Pieterse CM, Van der Does D, Zamioudis C, Leon-Reyes A, Van Wees SC. Hormonal modulation of plant immunity. *Annu Rev Cell Dev Biol*. 2012;28:489-521. doi: 10.1146/annurev-cellbio-092910-154055. Epub 2012 May 3. PMID: 22559264.

Schmilewski, G. (2008). The role of peat in assuring the quality of growing media. *Mires & Peat*, 3.

Sharma, D. K., Tomar, S., & Chakraborty, D. (2017). Role of earthworm in improving soil structure and functioning. *Current Science*, 1064-1071

SOILpak for vegetable growers, ISBN for the SOILpak series 0 7310 9848 X, ISBN for the title 0 7347 1168 9

Spanner, J., & Napolitano, G. (2015). Healthy soils are the basis for healthy food production.

Tripepi, R. R. (2011). What is your substrate trying to tell you. Plant Science Division, University.

Council Directive 89/656/EEC of 30 November 1989 on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace (third individual directive within the meaning of Article 16(1) of Directive 89/391/EEC).

Commission Directive (EU) 2019/1832 of 24 October 2019 amending Annexes I, II and III to Council Directive 89/656/EEC as regards purely technical adjustments.

www.fao.org/docrep/u3160e/u3160e07.htm

<http://growmaxwater.com/blog/en/tips-for-watering-your-urban-garden/>

<https://aggie-horticulture.tamu.edu/ornamental/greenhouse-management/growing-media/>

https://efotg.sc.egov.usda.gov/references/Agency/FL/Archived_MIL_Handbook_Ch04_150209.pdf

<https://nperlite.com/perlite/agriculture-horticulture/>

[https://www.geo.fu-](https://www.geo.fu-berlin.de/en/v/iwrm/Implementation/technical_measures/Irrigation-systems/sprinkler/applicability_advantages_disadvantages/index.html)

[berlin.de/en/v/iwrm/Implementation/technical_measures/Irrigation-systems/sprinkler/applicability_advantages_disadvantages/index.html](https://www.geo.fu-berlin.de/en/v/iwrm/Implementation/technical_measures/Irrigation-systems/sprinkler/applicability_advantages_disadvantages/index.html)

<https://www.ndsu.edu/agriculture/ag-hub/publications/soil-organic-matter-does-matter>

<https://www.rainbird.com/sites/default/files/media/documents/2019-08/SpecNews-IrrigationDesignTip-Soil-2019.pdf>

<https://www.seattleurbanfarmco.com/blog/2016/4/20/drip-irrigation>

<https://university.upstartfarmers.com/blog/pros-cons-hydroton-hydroponics%20>

<https://www.youtube.com/watch?v=vl6bMJaypUk>

Remain In Touch



UNIVERSITY
OF AGRONOMIC SCIENCES
AND VETERINARY MEDICINE
OF BUCHAREST

☎ 021 318 2266

🌐 <https://hortgreen.com/>

📍 Address: Bulevardul Mărăști 59, București 011464

