Technical guide

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Organic seedling production for medicinal and aromatic plants

FiBL

CARITAS Schweiz Suisse Svizzera Svizra

Austrian Development Cooperation

Production of medicinal and aromatic plants has continuously increased in the last years in Kosovo. By offering high levels of income per hectare, these crops are particularly popular among small producers. However, the precision required at sowing and the challenging management of weeds can result in considerable production losses. These challenges can be overcome by using seedlings to establish the perennial crops.

Seedling production requires a lot of knowledge and practical experience, beginning with the choice of the cultivation method to mixing the right substrate, applying the suitable sowing technique, ensuring optimal growth conditions, and optimising preventive plant protection measures.

This guide aims to provide useful information to those who want to start with seedling production. It helps to choose the most suitable system and – to those who are already growing seedlings – to provide valuable recommendations for improvements.

Content

Seedling production for medicinal and aromatic plants in Kosovo

Diverse production of medicinal and aromatic plants

In 2020, mainly nine species of medicinal and aromatic plants (MAPs) are cultivated in Kosovo (see table 1). The species and quantities are produced according to the demand of the market. In total, about 280 tons of MAPs are produced annually with chamomile being the main crop. 143 producers are involved in the production of the different MAPs.

Key role of collection centres in seedling production

The main companies involved in seedling production for MAPs are the collection centres (CCs). They are the contracting buyers of the raw material. The CCs are often growing MAPs themselves, too. The collection centres produce seedlings for their own use and for their providers. Some collection centers also produce seedlings for external markets. Some farmers buy seedlings from specialised providers, who also produce other seedlings, mainly for vegetable production.

Technical support for farmers

All MAP producers profit from technical support. The main providers of technical advice are the Association Organika and IADK. Some support is provided from NGOs, private experts and companies. State experts are not involved in the advisory system for medicinal and aromatic plants.

In addition to advisory services, farmers and trainers find information on MAP production in booklets and brochures prepared by local organisations. However, specific technical information is still in need.

Table 1: Production of medicinal and aromatic plants in Kosovo in 2020

Species	Quantity
Chamomile *(Matricaria chamomilla)*	130 tons
Nettle *(Urtica dioica)*	45.5 tons
Peppermint *(Mentha piperita)*	40.7 tons
Oregano *(Origanum vulgare)*	36.9 tons
Common mallow *(Malva sylvestris)*	11.7 tons
Sunflower *(Helianthus annuus)*	4.6 tons
Pot marigold *(Calendula officinalis)*	4.1 tons
Cornflower *(Centaurea cyanus)*	3 tons
Lemon balm *(Melissa officinalis)*	2 tons

Table 2: Seedling production from cuttings in 2021[1]

Species	Quantity
Oregano *(Origanum vulgare)*	62.000
Peppermint *(Mentha piperita)*	35.500
Lemon balm *(Melissa officinalis)*	30.000
Lavender *(Lavandula angustifolia)*	5.000
Rosemary *(Rosmarinus officinalis)*	1.500

Table 3: Seedling production from seeds in 2021[1]

Species	Quantity
Basil *(Ocimum basilicum)*	125.000
Pot marigold *(Calendula officinalis)*	121.000
Cornflower *(Centaurea cyanus)*	115.000
Common mallow *(Malva sylvestris)*	104.500
Sage *(Salvia officinalis)*	5.000
Rosemary *(Rosmarinus officinalis)*	5.000
Sunflower *(Helianthus annuus)*	3.000
Chamomile *(Matricaria chamomilla)*	150

Table 4: Seedling production from roots in 2021[1]

Species	Quantity
Nettle *(Urtica dioica)*	140.000

[1] Approximate quantities as collected in a survey among the main producers; quantities from independent farmers who produce their own propagating material are not taken into account.

How to decide about farm-own seedling production?

Organic seedlings must meet highest quality standards – whether they are purchased or grown on the farm. Weak or diseased seedlings inevitably lead to crop failures.

Requirements for farm-own seedling production

- Are suitable growing rooms available?
- Are the necessary facilities available?
  - Good ventilation, heating, tables/racks, irrigation system
  - Space for pressing, filling, sowing
  - Covered space in the outdoor climate area for hardening-off
- Is there enough manpower for the peak periods in spring?
- Is there enough knowledge for good quality seedling cultivation?
- Can the investment be amortised?

Table 5: Advantages and disadvantages of farm-own seedling production

Advantages	Disadvantages
Farm-own production	
• Better use of existing expensive infrastructure • Free choice of varieties and scheduling of production (subject to package sizes) • Proper hardening-off of seedlings possible • No expenses for the purchase of the seedlings (higher value creation in the farm)	• High investments necessary • Additional work and stress • The production risk must be borne by the farmers. • Production of cut soil press pots not possible (too expensive) • Additional costs for license and administration • Additional costs for capacity development and provision of services
Purchase of seedlings	
• No investments needed • No competition for space with greenhouse crops • Less work peaks in spring • Professionally grown seedlings • Timely delivery • No risk of failure in cultivation	• Limited choice of varieties • No 'buffer occupation' for bad weather periods • Combination of farm-own production and purchase possible (purchase of seedlings from warm cultivation, farm-own production of young plants from cold cultivation) • Investments in facilities and material (e. g. pots, presses, seeders and crates) cannot be used optimally. • High cash outlay for seedlings (liquidity bottleneck)

Legal requirements for certified organic seedling production

Standards and regulations

Until end of 2021, the organic production of seedlings in the UE had to comply with the requirements of **EU regulation 834/2007** on organic production and labelling of organic products. The new EU Bio regulation for seed and seedling production that was expected for the beginning of 2022 will bring some changes.

For organic production, processing and handling of seedlings according to the guidelines of **Bio Suisse,** the specific requirements are defined in the Bio Suisse Regulation Part II, Chapter 3.6.2 on ornamental plants and potted herbs (for further information see international.bio-suisse.ch/en).

Changes in the new EU regulation

In the new regulation, a new term will be introduced: Plant Reproductive Material (PRM). It refers to any type of plant material that is capable of producing plants: seeds, seedlings and cuttings.

Organic plant production – perennial crops
Paragraph 1.8.2 Annex II Part I of the BR 2018/848
For organic certified plants, the rootstock must be derived from a mother plant that has been managed organically for at least 2 growing seasons. In regulation 834/2007, rootstocks do not need to be organic.

Marketing of PRMs during conversion
Articles 10.4.a and 30.3 of IR 2018/848
PRM from plots in conversion can be marketed as 'In conversion' after 12 months of organic management. However, plants produced in pots (e. g. tomato plants) cannot be marketed as in-conversion products.

Requests for derogations for PRMs
For derogations from the use of untreated PRM, three levels are distinguished:

- **Level 1:** Plant species subgroups that are available in quantities deemed sufficient > No derogation will be granted.
- **Level 2:** Plant species subgroups available in quantities considered insufficient > A derogation can be justified according to factual and determined criteria.
- **Level 3:** PRM of subgroups of plant species with little or no availability > A notification must be sent to the inspection body for the varieties concerned.

Any non-organic PRM used with derogation must be untreated or treated with authorised substances only.

Seeds for seedling production
The new regulation introduces the notion of 'seedlings' as young plants resulting from the germination of a seed and not from a cutting operation (Annex III of the BR 2020/464). For organic seedlings, organic seeds must be used. However, in case of insufficient availability of suitable organic seeds, a derogation for the use non-organic untreated seeds can be requested. The resulting seedling will be an 'organically usable' instead of an 'organic' seedling.

Table 6: Differences between EU Bio and Bio Suisse standards in seedling production

	Bio Suisse	EU Bio
Origin of purchased seedlings	Bio Suisse certified seedlings or maximum 5 % EU Bio certified seedlings with special authorisation	Use of non-organic seedlings prohibited
Seeds	• Organic certified seeds • If no organic seeds are available, untreated seeds are allowed • Non-organic seeds are generally prohibited	• Untreated conventional seeds in case of proved non-availability of organic seeds
Vegetative reproduction material	Bio Suisse certified	Reproduced on EU Bio certified land or in conversion for more than 12 months
Maximum peat ratio in substrates for press pots	70 % (60 % from 2025 on)	100 %
Maximum peat ratio in growing media for pots	50 % (30 % from 2025 on)	100 %
Minimum compost ratio in growing media for pots	10 %	100 %
Addition of nutrients	Authorised inputs except for easily soluble trace elements	Organic inputs only
Steam treatment	For growing media only	No restriction
Heating and lighting	No restriction	No restriction

Seedling production techniques

Techniques	Press pots	Seedling tray	Superseedling
			
Casting technique	Pressed peat pot	Plastic cell plate	Polystyrene cell plate
Characteristics	• Good stability • High volume of substrate diminishes drying risk and humidity excess.	• Less substrate than for pressed peat pots • Round or square cells	• 'Pre-casted' little pots • Optimal irrigation and aeration possible thanks to the holes • Reduced need of substrate and space • Stronger seedlings thanks to longer growth period
Diameter (cm)	3 / 4 / 5	3 / 4 / 4.5	1.8 to 2 (approx. 4 cm deep)
Need of substrate (cm^3 per pot)	54 / 128 / 250	20 / 55 / 90	18
Number of plants per m^3 of substrate	18.500 / 7.800 / 4.000	50.000 / 18.000 / 11.000	55.500
Number of plants per plate	200 / 150 / 96	150 / 77 / 48	200 to 300 (to 600)
Number of plants per m^2	625 / 370 / 280	880 / 450 / 280	1.000
Pressing strength	Strong	Light or none	Medium
Substrate	• With less than 70 percent of peat by volume • Moulding with automatic press	• Possible to use peat-free substrate replacing peat with e. g. compost, bark compost, coconut fibres and clay	• With less than 70 percent of peat by volume • Pressing required
Mechanisation	• From simple manual press to automatised press for 9'000 to 50'000 pots per hour	• Filling by hand • Expensive machines	• Automatic seeder machine in fully mechanised production line
Irrigation	• Good water holding capacity • Easy re-wetting after planting in the field • Reduced water and air capacity when pressed too hard	• The lower the peat content, the more often watering is required.	• Low water retention capacity because of low amount of substrate per pot
Fertilisation	• Once	• Can require liquid fertilisation.	• Low nutrient storage capacity • Requires liquid fertilisation.
Seeding technique	Mechanical or manual with coated or precision seeds	Manual or partially mechanical with coated or precision seeds	Automatic seeder in production line
Handling	• Easy, due to stackable boxes	• Difficult, in case of trays • Not stackable without additional use of boxes • Risk of demoulding even if adequate tools are used	• Low space requirement • Low weight • Only stackable in boxes
Application	For all herbs grown from seeds	For all herbs grown from seeds, cuttings or roots, and to be planted by hand	Seeds and cuttings
Risk of losses during growth	Low	Low to medium	Low to medium
Maximum storage duration before planting	Around 10 days with irrigation	Limited, irrigation facility required	Fertilisation and irrigation required
Planting technique	• Diverse machines available • Semi-automatic planting possible if the pots are cut	• Manual or mechanical planting possible, if pots are well pressed	• Possible with automatic planter • Rational plantation possible with semi-automatic machines
Costs	• High investments • Low costs per seedling	• Low investments • Much manual labour compared to press pots	• High investments

	Speedy	Pricking	Techniques
			
	PVC or PEHD cell plates	Directly into the soil or in plates	**Casting technique**
	• Non-pressed substrate in the plate • Pots with a slightly conical form • Reduced need of substrate and space • Stronger seedlings thanks to longer growth period	• Direct sowing in the field or sowing in growing beds or plates • Seedlings are pricked without substrate	**Characteristics**
	1.8 to 2 (approx. 4 cm deep)	–	**Diameter (cm)**
	16	–	**Need of substrate (cm^3 per pot)**
	62.500	–	**Number of plants per m^3 of substrate**
	200 to 300 (to 600)	–	**Number of plants per plate**
	900	150 to 700	**Number of plants per m^2**
	Light or none	–	**Pressing strength**
	• With peat-free substrate or substrate with less than 70 percent of peat by volume	• Well-drained, light soil with low weed pressure	**Substrate**
	• Partial mechanisation possible if manual filling	• Possible mechanisation of sowing and soil preparation • False seedbed with gas-burner and harrows	**Mechanisation**
	• Low water retention capacity because of low amount of substrate per pot	• Weather dependent • Requires irrigation in case of drought.	**Irrigation**
	• Low nutrient storage capacity • Requires liquid fertilisation.	• 80 to 100 kg N per ha	**Fertilisation**
	Automatic seeder in production line or partial mechanisation	Precision seeder (mono- or multi-rows)	**Seeding technique**
	• Low space requirement • Low weight • Only stackable in boxes	• Easy handling once plants are picked out	**Handling**
	Seeds (pots, e. g. marigold)	Leek, mint, nettle	**Application**
	Low to medium	High	**Risk of losses during growth**
	Fertilisation and irrigation required	Possible in the soil, irrigation required	**Maximum storage duration before planting**
	• Possible with automatic machines • Rational plantation possible with semi-automatic machines	• Requires special machines	**Planting technique**
	• High investments	• Low costs	**Costs**

Procedures for seedling production

Production of seedlings from seeds

Most commonly, seedlings are produced from seeds, as the process is easier to handle and to mechanise, and because risk of disease contamination is lower compared to using roots or cuttings as source material.

Table 7: Source materials used for the most common herb species

Species	Direct sowing to the field	Sowing into press pots	Trans-planting of roots into pots or to the field	Planting of cuttings into pots
Chamomile	×	×		
Oregano	×	×	×	
Basil				
Mallow	×	×		
Mentha			×	×
Nettle		×	×	×
Cornflower	×	×		
Pot marigold	×	×		

Basil seedlings grown from seeds in pots.

Procedure (ex.: pot marigold and nettle)

- About 4 to 6 weeks before planting (in March), the seeds are sown into trays or pressed pots.
- For nettle *(Urtica dioica)*, sow 8 to 10 seeds per pot, for pot marigold *(Calendula officinalis)* 1 to 2 seeds per pot.
- Place the trays or pressed pots into a germination room or the trays individually into black bags (garbage bags) to maintain 98 % of relative air humidity and a stable temperature of 20 °C until the seeds have germinated (up to 15 days).
- If no germination environment is available: place the trays and pots outside and give the seeds the time to germinate. However, do not forget to irrigate the seedlings regularly. This procedure is slow and the germination rate will not be 100 %, but it is inexpensive and easy.
- After germination of the seeds, place the trays and pots for the growing phase into a tunnel or a greenhouse where they are protected from frost.
- At least 1 week before transplanting, harden the seedlings off outdoors. For this, expose the plants gradually to the outdoor conditions, protecting them from wind and sun in the first few days.
- When the plants are 7 to 10 cm tall and show first leaves, transplant them to the field.

Production of seedlings from roots

Production of seedlings from roots bears a certain risk of success, because the state of health of the roots is difficult to determine. In multiplication through stolons diseases can be transmitted to the planting material.

Stolons can either be transplanted directly to the new field, or they are first planted into trays or pots. The latter allows to select the healthy plants that have grown from the stolons only. In addition, seedlings in pots and trays have a significant growth advantage on the weeds.

Procedure for direct transplanting of stolons to the field (ex.: peppermint)

- In March, dig-out the roots from 1 are for a new field of 1 hectare (with 10 roots per m^2).
- Pay particular attention to the health status of the mother field. Observe the condition of the plants during the previous season, and carefully select and mark the area from which you will take stolons for the new field.
- Alternatively to marking a sector of a field, dig out stolons from selected individual plants with a healthy white aspect for transplanting.
- Transplant the stolons using a planting machine with a ploughshare to open the soil 3 to 4 cm deep and with wheels closing the furrow behind.
- Pay attention to keep the soil moist for 4 to 6 weeks. However, too moist soil may increase the risk of rotting. This risk is reduced on well-drained soils.
- 1 to 2 weeks after planting when the points of the first leaves are appearing, burn the soil surface with a gas burner.
- When controlling the weeds with harrows, hoes and brushes, work as near as possible to the rows.

Procedure for pricking stolons into seedling or speedy trays

- In March, cut about 10 cm long pieces from healthy stolons with about 2 bud eyes and plant them into trays or individually into pots.
- Place them in a tunnel or a greenhouse to grow and harden the seedlings off at least 1 week before transplanting.
- Transplant the seedlings to the field after the last frost at the end of April.

Direct planting of roots.

Production of seedlings from cuttings

- Select young and healthy shoots in active growth as soon as possible in spring. The cuttings are best collected in the morning or on a cloudy day for maximum turgidity.
- For harvesting the cuttings, use a sharp and clean cutter. Cut pieces of 4 to 5 cm length with 2 to 4 leaves.
- Plant the cuttings directly into the planting substrate in seedling trays or speedies with 150 plants or less, a diameter of 2 to 3 cm, and a depth of 4 cm.
- Do not prick the cuttings deeper than 1 to 2 cm into the substrate, as root formation on the callus requires a lot of oxygen.
- Use clean seedling trays and high quality substrate.
- Ensure optimum growth conditions with a temperature of the substrate of 22 to 25 °C, and an air temperature of 20 to 23 °C. If no heated table is available, maintain an air temperature of 25 to 27 °C.
- A slightly reduced light intensity of 14’000 to 16’000 lux in the beginning using shading nets can encourage root growth.
- In the primary phase of 4 to 10 days (depending on the species), when the roots start to grow, an air humidity of 98 % is ideal.
- During root development of 2 to 7 days, air humidity can be reduced and light intensity can be increased.
- After 2 weeks, the cuttings start to grow.
- At least 1 week before transplanting to the field, the seedlings must be hardened off.

Cutting with a sharp and clean cut.

After 4 to 10 days, roots start to develop.

Equipment for seedling production

Greenhouses and germination rooms

Germination rooms

A separate air-conditioned germination room that can be heated and cooled provides optimal germination conditions and ensures high germination rates. An empty cooling room with a small hot air generator fulfils these requirements perfectly. A thermometer and a hygrometer in the room are mandatory.

In small-scale seedling production, the seedling trays can be wrapped into black plastic bags in order to maintain an elevated temperature and humidity during germination.

Rooms with dehumidifiers that can maintain a controlled atmosphere and are not used much during the low season can be used as germination chambers, provided that the floor is protected against dirt and deformation to allow the use of tables. The temperature can be easily increased and controlled with a small electric heat generator.

View into a germination room.

A drying room that can be used as a germination room.

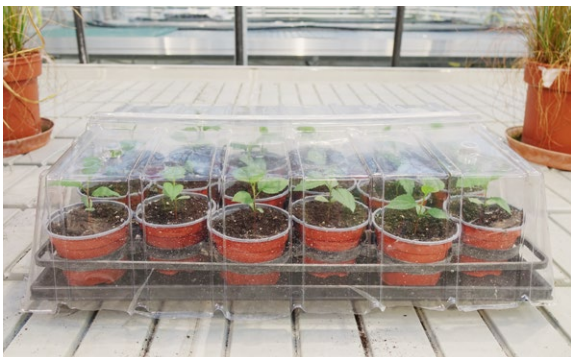
Tray in a black bag to enhance germination.

Choosing the right growing room

- The possibility of climate control decreases in the following order: glasshouse – foil house – tunnel.
- Construction costs decrease in the same order.
- Energy consumption is lowest in double foil houses and well-equipped glasshouses with energy screens.
- Cold frames are only suitable for hardening off seedlings. The manual labour that is required for ventilation and irrigation is too high for proper seedling production.
- Outdoor seedling production is only suitable for hardening-off of grown seedlings.
- The growing rooms should be as shade-free and bright as possible.
- Choose cover materials with high light transmission and clean them regularly.
- Various types of glass, foil and plexiglas are available on the market with a high UV permeability. Such materials shorten the duration of seedling production and increase the quality of seedlings.
- Cultivation houses must be equipped with a very good ventilation. Ideally, ridge, side and gable ventilation are combined. The ridge ventilation area should make up at least 25 to 30 % of the roof area. The side ventilation should be continuous.
- For small-scale seedling production, small boxes with transparent covers for each seedling tray can also provide ideal conditions for seedlings.

Classic greenhouse for growing seedlings

Cold frames



Germination box with transparent cover

Setting up the growing room

Ground cover

- **Level the ground and cover it** with ribbon fabric (Mypex) to prevent waterlogging, weed growth and growth of the seedling roots into the soil. Fabric dries quickly and contributes to prevention of fungal diseases.
- **Ensure 'warm feet':** If possible, grow the seedlings on tables with under-table heating with a constant temperature of 20 °C. This enhances optimal mineralisation of the substrate with low energy consumption according to the principle 'warm feet, cool head'.
- If seedlings are grown on the ground, a soil heating system or at least a heating system installed on the ground should be available.
- If possible, **distinguish different temperature ranges**: Through the different growth periods, temperature requirements of most crops decrease. For this reason, it makes sense to have a warmer and a cooler temperature area in the seedling greenhouse.
- **Use an appropriate watering system:** In smaller greenhouses, a water sprayer is usually sufficient for a targeted supply of water to the individual seedling sets.
- **Insulation:** Good insulation and air tightness of greenhouses save energy and avoid temperature drops. The larger a greenhouse, the more consistent temperature and air humidity.

Heated table

The seedlings should not be in direct contact with grown ground.

Special equipment

Tray fillers

- Available with different levels of automation
- High cost, thus only for professional operations
- High capacity starting at 500 trays per hour
- Consistent substrate quality due to adjustable substrate compaction
- Second hand pieces can be good opportunities to upscale an existing equipment.

Substrate mixing and tray filling facility

Complete seedling line with a pneumatic seeder

Manual seeders

- Broad range of types
- From pot-to-pot to whole tray seeding
- Suitable for small and mid-size operations
- Adapted to all kinds of seeds

Manual seeder

Complete seedling production line

- Easiest way to produce press-pots
- Can combine pot pressing or tray filling, seeding and quartz covering.
- Very consistent seeding quality with very even germination and growth
- Enables large capacity one-man operations.
- High cost, thus only for professional operations
- Second hand pieces can be good opportunities to upscale an existing equipment.

Automatically seeded seed plate

Seedling substrate

Composition and quality requirements

Farm-made substrates are particularly suitable for trays. Like commercial substrates, they also require highest quality raw materials for good seedling growth.

Commercial substrates are selected based on the nutrient requirements of the crop, the consistency and availability of the product, its water absorption and rewetting capacity, the proportion of coarse particles and the price. The peat content should be viewed critically for nature conservation reasons.

Bulk compost

Authorised raw materials for farm-made substrates

Black peat

- Strongly decomposed peat
- pH 3–4
- Must have been frozen
- For pressed pots substrate with 70 % black peat

White peat

- Little to moderately decomposed peat
- pH 3–4
- Gross fibre with higher porosity (and thus higher water holding capacity) than black peat
- For seedling tray substrates with about 50 % white peat

Compost

- Cheapest ingredient
- 20–30 % in the substrate provide all the necessary nutrients except nitrogen.
- Use only mature, well-aerated and woody green waste compost with low conductivity (salt content) and low heavy-metal content.
- For seedling tray substrates, sieve compost particularly finely with a grit size of <10 mm.
- In case of own compost production, ensure a hygienisation of the material by turning the compost heap frequently during the heat phase to destroy weed seeds and pathogens.
- Avoid drying-out of peat-compost substrate mixtures.

Peat and sustainability in organic production

Phasing out peat extraction and peat use has received increasing attention in Europe while the importance of peatlands as habitats supporting vital biodiversity of flora and fauna, for helping with natural flood management, for improving water quality, and as one of the world's most significant carbon sinks are now widely recognised and the urgency for ending further drainage of peat bogs and peat extraction has been highlighted.

In organic horticulture, peat is rarely used as a soil improver, but considerable quantities are used for casings in mushroom production and there is still a high reliance on peat in seedling production. Wood material and compost have promising characteristics for replacing peat in growing media, but more work is still required to design completely peat-free alternatives which can compete with peat-based products.

With compost the challenge is commonly a too high content of nutrients, which may lead to leaching and may also restrict the plant growth. Composting is a cheap technology which can be applied both by private growers and professionals. The product can be mixed into other materials, e. g. sand, to dilute nutrient concentration and pH and increase the bulk density.

Characteristics of a good compost

- **Salt content:** <2 microSiemens per cm (in 1.5 volume extract)
- **pH value:** <7.5
- **Ratio between nitrate-N and ammonium-N:** at least 20 : 1
- **Positive cress test:** high germination rate of the cress in a half-filled, hermetically closed pot with compost
- **Good leaf and root development of the cress seedlings** in an airtight glass or cup half-filled with compost (closed cress test). More information at the link below (in German): shop.fibl.org > 2501

Peat substitutes and suitability

Coconut fibres, coconut peat

- Low nitrogen fixation
- Good water and air carrying properties
- Suitability: ●●●○○

Hemp fibres

- Similar stability as coconut fibres
- Relatively difficult to add (hemp crumbles and woody parts are not suitable as they fix a lot of N)
- Add to compost 2 weeks before pressing the pots.
- Suitability: ●●○○○

Wood fibres and bark humus

- Very good mix of components
- Do not fertilise with urea (or any other synthetic chemical N fertilisers).
- Suitability: ●●○○○

Rice husks

- Very stable in degradation and structure
- Can hardly store water, therefore add at most 10 %.
- Suitability: ●○○○○

Mineral aggregates

Vermiculite, perlite

- Expanded silicate rocks
- Good structural and water-holding properties
- Particularly suitable as an admixture for sowing soil (prevention of waterlogging)
- High energy input for production

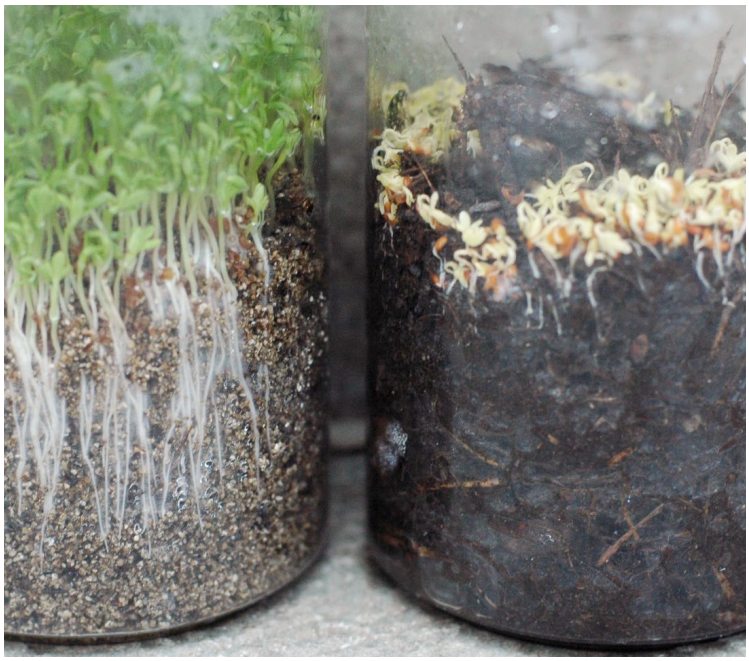
Clay

- Heavy aggregate
- Stores nutrients and water
- Improves structure
- Can partially buffer a high salt content.

Ground soil

- Similar properties to clay (depending on origin)
- May contain weed seeds.

In organic seedling substrates, raw materials are mixed in a way to create optimal growing conditions for the young plants as well as to meet ecological requirements.



Closed cress test of commercial substrate (left) and unripe compost (right). Unripe or not fully sanitised compost manifests itself in disturbed seedling growth or the development of seedling diseases.

Covering materials

Covering materials are used to cover the seeds in substrate trays or pressed pots, to ensure the necessary moisture for germination, and to avoid high temperature. Covering materials should be easy to handle and spread in regular layers. Small seeds should only be lightly covered.

Quartz sand

- Reflects light well.
- Is relatively heavy and will not blow away.

Vermiculite

- Available in various sizes.
- Reflects light moderately well.
- Stores water.
- Young sprouts grow well through it.

Compost

- Has disease-suppressing potential.
- Very fine sieving necessary.
- Less suitable for seedlings which need lots of light to germinate.

Styrofoam sheets

- Especially suitable in summer as insulation for heat-sensitive seeds

Vermiculite

Quartz covering material

Producing substrates yourself?

It is difficult to make own soil press substrates, as good quality black peat without addition of fertiliser and lime is hardly available in the market. In contrast, it is easy to mix substrates for trays on the farm.

- Mixtures with 30 % compost (more not recommended), 30 to 70 % peat, and 30 to 70 % peat substitutes are successful.
- The conductivity should be <1.5 microSiemens per cm.
- The smaller the pots, the finer the substrate should be sieved.

Storage of substrate

- Store substrate bags in a cool and dry place out of direct sunlight.
- Use substrate as soon as possible.
- If a longer storage period is unavoidable, mix substrate again one to several days before use and add 1 to 2 kg of horn powder per m^3 (= 130 to 260 mg N per l of substrate; depending on the salt sensitivity of the crop).

Rotary screen for sieving the compost or the final substrate

Pests and disease management

Infested seedlings usually cause problems after planting in the field, whereas healthy seedlings help minimise pest and disease control measures after planting, saving time and costs, and reducing production risks. In addition, pesticides allowed in organic farming do not penetrate the treated plants and degrade quickly. This explains their generally lower effectiveness compared to chemical-synthetic agents. Some organic plant protection products are also harmful to beneficial organisms.

As nurseries can be a major source of infection, major attention should be paid to pest and disease management in seedling production.

Hygiene – the most important preventive measure

- Keep the seedling areas, growing plates and pots clean. Clean them preferably with hot water before reusing them, especially if they have been in contact with diseased plants.
- Regular cleaning in the greenhouse and on the growing tables with a high-pressure cleaner and soda water (sodium bicarbonate) removes fungal spores.

Selected approved cleaning agents

- Biodegradable surfactants (biological cleaning agents)
- Hydrogen peroxide / peracetic acid
- Benzoic acid ('MennoFlorades'; countercheck with the certification body)
- Alcohol
- Citric and acetic acid

Perfect hygiene is essential to ensure healthy seedlings.

General preventive measures

- Choose resistant or tolerant varieties.
- Use substrates with good air and water balance.
- Sprinkle seedlings with quartz sand (reduces damping-off diseases and substrate aphids).
- Immediately after emergence, place seedlings in the light to avoid long and thin shoots.
- Prevent dew formation on the plants by heating up to daytime temperature before sunrise, maintaining a small temperature difference between day and night and by dry heating.
- Ventilate regularly, intensively in the case of dense plant stands (e. g. superseedlings). If necessary (e. g. if there is a risk of infection by downy mildew), ventilate with the heating on.
- Ensure a balanced supply of nutrients.
- Hang up yellow (cabbage pests, whiteflies) and blue (thrips) colour traps for pest monitoring.
- Use protective nets for crops with regular pest problems (especially during hardening-off).

Important

- Clarify the approval of every input for the corresponding crop.
- Consult the current EU Regulation and the guidelines of the relevant label organisations.
- Consult the EU input list or the national input list at www.inputs.eu.

For mass trapping of pests, glue-coated bands about 30 cm wide are more suitable than cards. However, yellow traps can also catch beneficial insects.

Table 8: Primary pests and their control

Pests	Measures	Comments
Aphids, whiteflies, thrips	• Release of beneficial insects	• Use open beneficial insect breeding.
	• Plant-based insecticides • Potash soap	• Follow the instructions of the suppliers.
	• Insect-protection netting and fleeces	• Only suitable for growing beds. Use fleeces only up to a temperature of 25 °C. • Remove the nets/fleeces 1 week before planting to harden-off the seedlings.
Flea beetles *(Psylliodes)* (cabbage)	• Insect-protection netting and fleeces	• Mesh size <1.5 mm ('earth flea nets')
Substrate gnat (sciarid)	• Follow the hygiene rules.	
	• Cover the seedlings with quartz sand.	• The drier substrate surface hinders egg laying.
	• Cultivate young plants dry.	• Water with restraint, especially in winter.
	• Hang up yellow cards.	• To control and trap flying insects.
	Release of natural enemies: • Beneficial insects • Nematodes (e. g. *Steinernema feltiae*) • *Bacillus thur.* var. *israelensis* • Predatory mites (e. g. *Hypoaspis miles*)	• Add to the water or substrate. • Nematodes: Apply with <2 bar pressure and nozzle opening >1 mm. Check whether the nematodes are alive. Keep the plants moist for 4 weeks. Spread predatory mites mainly as a preventive measure.
Cabbage fly and Leek leaf miner fly	• Insect-protection netting and fleeces	
Soft skin mites	Release predatory mites: • *Amblyseius cucumeris* • *Amblyseius bakeri*	• Follow the instructions of the suppliers.
	• Application of plant oils	• Be careful to avoid leaf damage.
	• Application of tansy tea *(Tanacetum vulgare)*	
	• Sulphur treatments	• Damage the predatory mites.
Slugs	• Mechanical defence	• Surround the seedling beds with a slug fence. • Keep the growing rooms tight at ground level. • Place the seedlings on tables. • Use concrete display areas. • Regularly mulch the surrounding areas.
	• Running ducks	• Allow grazing of the ducks around the green-house, tunnels and display areas.
	Use of beneficial insects: • Nematodes *Phasmarhab-ditis hermaphrodita*	• Only effective against small snails. • Only useful in delimited areas. • Expensive.
Mice	• Mechanical defence	• Use close-meshed wire mesh, crop protection nets or fleece.
	• Traps	• Place baits outside the growing rooms.

Table 9: Primary diseases and their control

Diseases	Indirect measures	Direct measures
Seedling and fall diseases (*Fusarium* sp., *Pythium* sp., *Phoma* sp., *Verticillium* sp. etc.)	• Use healthy seeds only. • Use high-quality compost only. • Clean the seedling containers carefully. • Ensure optimum growing conditions (optimum temperature and humidity, sufficient ventilation).	• Use fungal antagonists such as *Trichoderma* species, *Pythium oligandrum*, *Bacillus subtilis*, *Talaromyces flavus*, *Streptomyces rimosus*, etc. as dressing, dipping and sprinkling agents or for mixing into substrates.
Downy mildew	• Select resistant or tolerant varieties. • Avoid long periods of leaf moisture with appropriate watering and ventilation.	• Remove infested plants early. • Use copper preparations. • Apply plant-strengthening agents (e. g. stone powder, plant preparations and mixtures of both) as a preventive measure.
Powdery mildew	• Select tolerant varieties.	• Apply plant strengthening agents, fennel oil, lecithin or sulphur preparations as a preventive measure.
Leaf spot diseases, grey rot, rust	• Use healthy seeds, cuttings and stolons only. • Select tolerant varieties. • Ensure sufficient distance between potted plants. • Avoid long periods of leaf moisture with appropriate watering and ventilation.	• Apply plant-strengthening agents as a preventive measure. • Use copper preparations.

Use suitable clean sprayers to apply organic plant protection products.

The release of parasitic or predatory insects and mites is an important direct control measure in seedling production.

Fertilisation and irrigation of seedlings

Fertilisation

Usually, substrates provide enough nutrients to the seedlings without additional fertilisation. However, in certain cases it can be necessary to apply a top dressing with vinasse during cultivation.

Recommendations for optimum nutrient supply

Nitrogen (N)

- **Sources:** horn products, plant proteins
- **Average N-requirements:** 300 mg of N per litre of substrate (= 2.5 to 3 kg of horn or 6 kg of malt germ fertiliser per m^3 of substrate).
- **N-requirements of greenhouse crops:** up to 500 mg of N per litre of substrate (= 4 to 5 kg of horn per m^3 of substrate).
- **Dosage of vinasse:** 4.5 to 6 litres of vinasse per m^3 of substrate (with an N content of 5 or 7 %) diluted in 3 to 7 litres of water (corresponds to 300 mg of N per litre of substrate).
- **Substrate temperature:** In order to ensure a sufficient mineralisation of nutrients, maintain a minimum substrate temperature of 14 °C.
- **Substrate humidity:** Ensure alternating wet and dry periods to stimulate nutrient mineralisation. Permanently over-moistened or too dry substrates do not mineralise well.
- **Shading and aeration:** In summer, when the sun is shining, aerate and shade the seedling rooms to prevent excessive mineralisation.

Phosphorus (P_2O_5)

- **Sources:** compost, poultry manure from organic farms, and N-P fertilisers such as Phytopearls
- **Average P-requirements:** 100 to 200 mg P_2O_5 per litre of substrate
- Organic substrates with a proportion of 20 % compost contain sufficient P.
- P-uptake by plants is poor at pH >7 and temperatures below 12 °C.
- Compost-free substrates do not require additional P, if an N fertiliser with a high phosphorus content (e. g. Phytopearls) or soft-earth rock phosphate are included.

Potassium (K_2O)

- **Sources:** compost, potash sulphate from mining, by-products from sugar beet processing
- **Average K-requirements:** 200 mg K_2O per litre of substrate

Magnesium (Mg)

- **Sources:** compost, potash magnesia (Patentkali), dolomite or seaweed lime
- Organic substrates with a proportion of 20 % compost contain sufficient Mg.
- **Substrate temperature:** Maintain a minimum substrate temperature of 14 °C to ensure the availability of magnesium.

Horn products are an important nitrogen source in organic horticulture.

Vinasse or vinasse-based products are widely used liquid organic nitrogen fertilisers.

Patenkali (potassium sulfate with magnesium)

Trace elements

- Adding synthetic trace elements to substrates is not permitted.
- With the exception of copper (Cu), all the important trace elements are abundant in compost. Cu deficiency is hardly a problem in seedling production.
- Clay minerals and stone powder contain trace elements.
- At pH above 7, most trace elements are poorly available with the exception of molybdenum, which is less available at low pH.

pH value

- Ideal range: pH 6–6.5
- A compost content of 30 % in the substrate usually results in an ideal pH value.
- Black peat buffers pH better than white peat.
- Addition of carbonic acid or algal lime is necessary depending on the buffering capacity (substrate with 30 % compost: 0 to 2 kg/m^3; substrate without compost: 5 to 10 kg/m^3). Measure pH value after addition.

Plant-based alternatives to horn products

- Plant-based malt germ fertiliser and vinasse have proved successful.
- Potato protein (available in the animal feed market) and Phytopearls, a by-product of starch production, are emerging as alternative substrate fertilisers.
- Most other plant-based fertilisers can have a germination-inhibiting effect. Adding them 2 weeks before using the substrate significantly reduces risks.

Irrigation

Irrigation of young plants from sowing to hardening off is crucial to successful seedling production:

- **After sowing**, the substrate must remain sufficiently moist to allow rapid and uninterrupted germination.
- **After emergence of the seedlings**, careful watering is required to keep the soil humid while maintaining the atmosphere and the foliage dry to avoid leaf diseases. A thin quartz cover on the substrate from sowing onwards reduces evaporation and limits spreading of disease spores towards the foliage.
- The substrate should never dry out too much, as it makes rehydration very difficult because of the physical properties of peat.
- Ideally, the seedlings are watered in the morning with an irrigation method that produces fine drops. This minimises the leaf wetting time, reduces transmission of spores to the leaves and avoids damages to the seedlings.

Appropriate irrigation technology

- Sprinklers make watering easier, but require much maintenance. As dripping nozzles can lead to considerable water losses, only thin nozzles with drop stop should be used.
- The best technology for large greenhouses is a watering trolley, a mobile watering line which is slowly pulled over the crops. A watering trolley offers a much better and more even distribution of water and does not cause dripping. The watering trolley also allows a more precise dosage of the amount of water. However, it is relatively costly and therefore only worthwhile to large seedling producers.

Hygiene

- Prevent algae formation on the irrigation mat by covering it with a black, robust micro-perforated plastic fabric (do not use non-perforated fabric).
- Regularly remove lime deposits in the drip hose by rinsing the hoe with water with 5 % of citric acid. Ideally, the water can remain for some hours in the hose.

Direct seeding or purchase of seedlings?

Basically, all MAPs that are multiplied by seeds can be sown directly in the field. The decision whether or not to sow directly in the field depends on the following criteria:

- **Type of soils:** Heavy soils hamper the preparation of a fine seedbed or precision seeding.
- **Seed germination rate:** Species with a very low germination rate (e. g. nettle) may result in very poor or uneven stands when sown directly.
- **False seedbed preparation:** False seedbed preparation can be key to weed management in direct sowing. However, this technique requires the availability of time and suitable mechanisation.
- **Possibility of irrigation:** In most regions, seedling production requires a proper irrigation system.
- **Availability of equipment:** Economical seedling production of more than a few ares requires a suitable planting machine.

Table 10: Pros and cons of purchased press pots

Pros
• Advantage on weeds of crops with a slow germination
• Starting with seedlings results in an earlier crop.
Cons
• High costs for the purchase of the seedlings
• Less developed root system in early growth compared to direct sowing

Successful planting of seedlings requires appropriate irrigation.

Planted seedlings allow earlier weed control and faster coverage of the rows.

Planting of the seedlings in the field

Soil preparation

Soil cultivation must be done with care to preserve soil structure and protect the soil organisms. Deep ploughing of wet soil must be avoided as it can damage soil structure and result in nutrient losses. Intensive soil preparation with rotating tools should be kept to a minimum, as it has great negative impact on both, soil structure and soil organisms. However, direct sowing requires a fine seedbed (the smaller the seeds, the finer the seedbed should be).

In a first passage, the field can be refined and levelled with a power harrow.

Final seedbed preparation is commonly managed with a rotavator. A too fine tilth can have negative impacts on soil structure and soil biology.

Timing

- **In sandy or mainly loamy soils:** Ploughing in spring about one month before sowing or planting
- **In clay or heavy soils:** Ploughing in autumn for planting in spring, or at least 2 months before planting for establishment of MAPs in late summer. Early soil tillage facilitates the preparation of a fine seedbed with a good structure and depletion of the weed seed bank.

Objectives of early soil preparation

- Provision of optimum conditions for seed germination or recovery of seedlings after planting
- Incorporation of fertilisers
- Mobilisation of nutrients
- Control of weeds and soil-borne pests
- Improvement of the physical, chemical and biological properties of the soil
- Levelling of the soil surface

Table 11: Key data for planning of sowing of main MAPs

Crop	Location	Light germinator	Sowing depth	Germ. temperature	Germination period	Seedling planting density	Seedlings per are	Seeds for 1.000 seedlings
Chamomile	• Sunny, semi-shady • Sandy, nutrient poor soils better	Yes	1–2 cm	20 °C	7–14 days	15 × 30 cm	470–1000	1 g
Oregano	• Sunny • Average, well-drained soil	Yes	0.5 cm	16–20 °C	10–15 days	25 × 30 cm	470–1000	
Basil	• Sunny, semi-shady • Warm, humus- and nutrient-rich soil	Yes	max. 0.5 cm	20–25 °C	10–20 days	30 × 30 cm	830	3 g
Mallow	• Light, humus-rich soil • Warm, sheltered, and well-ventilated exposure	Yes	0.6–0.7 cm	15–20 °C	7–14 days	30 × 30 cm	470–750	6–8 g
Mint	• Semi-shady • Nutrient-rich, loose and moist soil	– (sterile seeds)	3–5 cm (stolons)	–	–	30 × 30 cm	470–750	–
Nettle (similar to parsly)	• Sunny, semi-shady • Loose, nutrient- and humus-rich and moist soil	Yes	1.5 cm	12–21 °C	15–25 days	30 × 30 cm	470–750	2–5 g
Cornflower	• Sunny • Humus-rich and well-drained soil	Cold germinator!	0.5 cm	15–18 °C	10–14 days	30 × 30 cm	470–1000	
Pot marigold		Yes	0.2 cm	10–25 °C	10–14 days	25 × 70 cm	570	15 g

Planting

Apart from small areas, planting is commonly done with a 2- or 3-row planter. The seedlings are transported in trays to the field and placed on the planter.

Requirements to plant quality

- Organic production
- Varietal authenticity with guaranteed varietal identity on the invoice
- Healthy plants free of pathogens and pests
- Appropriate growth stage (neither too developed nor too small) to ensure good recovery.

Planting

- Ensure that the planter is aligned horizontally with the soil surface when in working position.
- Choose a standard row spacing that is adapted to the weeding equipment (hoe, cultivator, tractor wheel spacing).
- Organise the logistics for planting in a way to minimise exposure of seedlings to the sun.
- Make sure the irrigation system is working before you start planting.

Semi-automatic planting of peppermint seedlings.

- Adjust the machine to ensure that the seedlings are pressed firmly into the ground.
- If a drip irrigation system is installed at planting, ensure that it is buried deep enough to allow mechanical weeding.

Planting equipment

Soil-block planter dibbler

- Only for manual planting
- Ensures regular spacing in and between the rows
- For very small areas

Clamp transplanter

- Semi-manual planting machine with 1 man per row
- Suitable for seedlings with bare roots, as well as conically, pyramidally and cubically shaped clods
- Universal planter due to its flexibility
- Easy to use even by unskilled labour
- Adjustable, precise and constant plant spacing
- 2000 to 2500 plants per hour and operator
- Requires tractor with a crawling speed gearbox.

Semi automatic planting machine

3-rows carrousel-cup transplanter

Automatic transplanter

Carrousel-cup transplanter

- Simultaneous operation of two rows per person
- Up to 6.000 plants per hour and operator (3,000 per row)

Automatic transplanter

- Operation of the machine by one person
- For trays of different sizes and materials (hard plastic, foam, disposable)
- Suitable for very large farms/surfaces only
- Up to 8,000 plants per hour and row
- Possibility of square-planting, thus enabling hoeing in two directions.

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