The ABCs of Microgreens

Microgreens are young and tender edible greens produced by sprouting the seeds of a variety of vegetable species and herbaceous plants, including aromatic herbs and wild edible species.

Swiss chard rainbow microgreens mix ready to harvest. Photo: Francesco Di Gioia, Penn State

Definition and Species to Grow

Depending on the species selected (Di Gioia and Santamaria 2015) and the growing conditions microgreens can be harvested from 7 to 21 days after germination, when the cotyledon leaves have fully developed, and the first true leaves have emerged.

Microgreens should not be confused with sprouts which are produced germinating seeds that have been soaked in water, often in the dark, and for which the edible portion is constituted by the whole sprout including the seedling, the radicles, and often what remains of the seeds. In the case of microgreens, the edible portion is constituted by single shoots with the cotyledon leaves and/or the first true leaves which are harvested cutting the young seedlings at the base right above the growing medium.

Commonly used by chefs of fine restaurants to garnish and sign their plates, more recently microgreens have gained great popularity for their nutritional properties gaining the appellative of ‘superfood’. Microgreens are in fact a great source of fibers, essential minerals, vitamins, and antioxidant compounds (Xiao et al. 2012, Di Gioia et al. 2017). Microgreens are normally consumed raw and can be used to prepare salads, appetizers, and sandwiches or to accompany any meat or fish dish, and even as a topping for your pizza, providing bright colors and intense taste to any dish (Di Gioia and Santamaria 2015).

Because of their size and short growth cycle, microgreens can be grown in a tiny space with very limited inputs, without the use of fertilizer or of any spraying, and may be comfortably grown at home on a window ledge, on a porch or balcony, and even on a shelf in the kitchen (Di Gioia et al. 2019).

What species are suitable to grow as microgreens?

Many edible plant species can be used to produce microgreens. Among the standard vegetable species, the most popular ones are those belonging to the broccoli family (Brassicaceae) such as broccoli, radish, cauliflower, arugula, cabbage, kale, kohlrabi, mustard, mizuna, cress, broccoli raab, etc. which are characterized by a very short growth cycle (7–8 days maximum) and by the typical pungent taste of cole crops which is primarily due to their content of glucosinolates, natural compounds considered anti-cancer per excellence.

Broccoli microgreens ready to harvest. Photo: Francesco Di Gioia, Penn State
Red giant mustard microgreens ready to harvest. Photo: Francesco Di Gioia, Penn State

Arugula microgreens ready to harvest. Photo: Francesco Di Gioia, Penn State

Red garnet amaranth microgreens ready to harvest. Photo: Francesco Di Gioia, Penn State

Pea shoots ready to harvest. Photo: Francesco Di Gioia, Penn State

Sunflower shoots ready to harvest. Photo: Francesco Di Gioia, Penn State

Scallion microgreens. Photo: Francesco Di Gioia, Penn State

Red beet microgreens ready to harvest. Photo: Francesco Di Gioia, Penn State
Other vegetable species commonly grown as microgreens include beet, Swiss chard, spinach, amaranth, lettuce, chicory, endive, carrot, celery, fennel, leek, onion, and cucumber. Microgreens are produced by also sprouting cereals such as barley, oats, wheat, corn, and pseudo-cereals like quinoa, legumes such as pea, alfalfa, bean, fava bean, lentil, clover, chickpea, and fenugreek, and even oleaginous and fiber species like sunflower and flax, respectively.

Interesting microgreens are produced also using the seeds of aromatic herbs such as basil, cilantro, dill, chives, and cumin, or using the seeds of some wild edible species such as borage (Borago officinalis L.), wild chicory (Cichorium intybus L.), common dandelion (Taraxacum officinale Weber), sea asparagus (Salicornia patula Duval-Jouve), etc.

In some cases, mixes of different species are used with the purpose of obtaining specific color or taste combinations. When mixes are used it is very important to balance the seed density as well as to make sure that seeds of different species or cultivars will germinate and grow at the same time.

All these species characterized by very different shape, color, and taste are an expression of our rich agrobiodiversity and largely vary for their content of minerals and phytonutrients. The inclusion of a mix of these species in the diet in the form of microgreens may provide a variety of colors and nutrients for a weekly healthy diet as recommended by the 2015-2020 Dietary Guidelines for Americans.

What species are not suitable to grow as microgreens?

Some common vegetable crops like tomato, pepper, eggplant, and potato are not edible at the seedling stage and are not suitable to produce microgreens because they contain alkaloids which at high levels are toxic for humans. If using wild species, it is very important to recognize the plants from which seeds are collected because many spontaneous species contain toxic compounds while they may look like edible plants. Therefore, if you are not a plant expert refrain from using wild plants to produce microgreens. Also, you should exclude any species for which you may have an allergic reaction.

Seed Source and Seed Density Calculation

Seeds are the basic ingredient for growing microgreens. The following instructions will provide basic information on where to source seeds, seed quality, and a step-by-step guide to calculate the amount of seeds needed for a given growing area.

Where to source seeds for microgreens?

Several seed companies in the US have a specific seed catalog for microgreens. It is enough to search online for "microgreens seeds" and you will find multiple options. Most of the seed companies offer quick shipping options and some of them sell also microgreens growing kits which include seeds, growing trays, growing media, and the instructions to use the kit.

It is important to use seeds of high quality characterized by good germinability, that have not been treated with chemicals or coated in any way, and that are specifically marketed to produce sprouts and microgreens which should guarantee that they have been produced and processed following high food safety standards and regulations to avoid any microbial contamination.

The best seed companies will provide information on the quality of the seeds reporting a lot number, the average number of seeds per pound, germinability, date of germination test, and eventually some recommendations on the optimal germination and growing conditions and an indication of the number of days required from germination to harvest.

If the information on seed germinability is not available, it may be worth doing your own germination tests. Once you get the seeds, place them in a dry and sealed container, date the bag, and possibly store the container in a fridge or fresh environment until you use the seeds.
Optimal seed density and relative calculations

Once you have defined what microgreens species you would like to grow, it is important to define the optimal seed density and calculate the amount of seeds needed for a given growing area. To do this properly, you will need a few basic information:

- Area of your growing tray, container, or mat
- Optimal seed density for the species selected
- Average weight of your seeds
- Seeds germinability

To make calculating seed density for growing microgreens easy, we have developed a Microgreens Seed Density Calculator. This is a very simple Excel application tool that allows you to select the species you would like to grow from a drop-down menu. The calculator will define the optimal seed density for the species you selected based on our small database, and after you enter information on the germinability of your batch of seeds (optional), and on the size of your growing tray or container (required) the calculator will define the suggested amount of seeds needed for a single growing tray or container.

The calculator offers the possibility to calculate the area for square, rectangular, and circular planting containers or growing trays. Calculations are based on the average seed weight measured for each species in previous experiments. Average seed weight may change from batch to batch for a given species however we assume that the variation is relatively small within the same species.

If you prefer to do the calculations on your own here is a simple step-by-step guide for your calculations.

1. Measure the size of your growing trays/containers and calculate the growing area using the following formulas:
   - **For growing trays or containers with a square or rectangular shape:** Area of a rectangular container = Width × Length
   - Example: 5 in. × 6 in. = 30 sq. in.
   - **For growing trays or containers with a circular shape:** Area of a circular container = π × diameter ² ÷ 4
   - Example: 3.14 × 7 in. × 7 in. ÷ 4 = 38.5 sq. in.

2. Define the optimal seed density for your species (number of seeds per square inch). Since seeds have different sizes the amount of seeds required for a given planting area varies accordingly. Species that have larger seeds like pea and sunflower produce larger shoots and should be seeded at a lower density. Instead, species with smaller seeds like broccoli and other brassicas develop relatively smaller shoots and should be seeded more densely. As a general rule, the optimal seed density ranges from 2 seeds per square inch for larger seeds up to 12 seeds per square inch for the smaller seeds (from 1 to 6 seeds per cm ² if you prefer the metric system).

Knowing the optimal number of seeds per unit area, the total optimal number of seeds per tray is calculated by multiplying the optimal number of seed per square inches for the area of the planting tray. For example, assuming an optimal seed density of 2 seeds per square inch, a planting tray of 30 sq. in. the total number of seeds per tray needed is calculated as follows:

- Total optimal n. of seed per tray = optimal seed density × area of the tray
- Example: 2 seed/sq. in. × 30 sq. in. = 60 seeds

3. At this point is important to know and take into account the germinability of your batch of seeds. The germinability is usually expressed as the percentage of seeds that are viable and will germinate and is an important seed quality parameter. If seeds are characterized by a low germinability level, the total optimal number of seeds calculated in the previous step should be adjusted considering the actual seed germinability.

For example, assuming we want a final density of 60 seeds per tray and the seeds have a germinability of 90% the actual seed number we need will be calculated according to the following formula:

- Adjusted total n. of seeds = Total optimal n. of seeds ÷ % of germinability
- Example: 60 seeds ÷ 90 × 100 = 66.7

The additional number of seeds will compensate for the number of seeds that may not germinate thus assuring, in the end, you have the optimal shoot density.

4. Once you define the total number of seeds per tray, instead of counting the seeds, by knowing the average seed weight it is possible to determine the equivalent amount of seeds per tray by weight or volume. Knowing the weight of 1,000 seeds or the average number of seeds per pound (this information is generally provided by the seed company) it is possible to calculate the average seed weight and then the amount of seed per tray. For small trays, it is easier to use the number of seed per gram.

- Assuming we have pea seeds and each pound contains on average 3,000 seeds, with a simple transformation we can calculate the number of seeds per gram.
- Example: 3,000 (seeds/lb) ÷ 453.592 (g/lb) = 6.6 seeds/g
- At this point knowing that we need 66.7 seeds per tray and each gram has 6.6 seeds it is possible to calculate the amount of seed per tray in grams.

**Example of a seed germination test. Photo: Francesco Di Gioia, Penn State**
• Example: $66.7 + 6.6 = 10.1$ g per tray
• Finally, measuring the volume of 10.1 g of seeds with measuring cups you could approximate the amount of seed per tray using measuring cups.

Example of seed density used for brassica microgreens. Photo: Francesco Di Gioia, Penn State

Example of seed density used for amaranth microgreens. Photo: Francesco Di Gioia, Penn State

Example of seed density used for sunflower shoots. Photo: Francesco Di Gioia, Penn State

References


Authors

Francesco Di Gioia, Ph. D.
Assistant Professor of Vegetable Crop Science
fxd92@psu.edu
814-865-2571

extension.psu.edu

Penn State College of Agricultural Sciences research and extension programs are funded in part by Pennsylvania counties, the Commonwealth of Pennsylvania, and the U.S. Department of Agriculture.

Where trade names appear, no discrimination is intended, and no endorsement by Penn State Extension is implied.

This publication is available in alternative media on request.

Penn State is an equal opportunity, affirmative action employer, and is committed to providing employment opportunities to all qualified applicants without regard to race, color, religion, age, sex, sexual orientation, gender identity, national origin, disability, or protected veteran status.

© The Pennsylvania State University 2022
Code: ART-6397