Microgreens - biologically complete product of the XXI century

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Abstract. Microgreens are a new functional food crop that can facilitate adaptation to urbanization and global climate change, and improve human health. The research was carried out in 2021 at the Department of Landscape Architecture of the Kuzbass State Agricultural Academy. The aim of the research was to study the technology of cultivation of microgreens of the *Brassicaceae* family on an aqueous substrate. The objects of research were the seeds of cultivated plants of the *Brassicaceae* family: Brassica oleracea Broccoli Group broccoli or asparagus, Fortuna, Raphanus sativus radish, Violetta, Lepidium sativum, watercress, Dansky, and Eruca versicaria, arugula, Sicily. It was revealed that microgreens can be obtained from seeds of the *Brassicaceae* family in 6-12 days. Such a product does not have time to accumulate harmful substances from the atmosphere in a short period of time. When growing microgreens, it is not necessary to use mineral fertilizers, pesticides and, thus, it is possible to obtain environmentally friendly, biologically useful products with low material costs. It was found that, depending on the seeds of the studied crops and their genotype, the cycle of growing microgreens lasts from 6 to 10 days after germination. Depending on the type of culture, the sprouts reached a height of 5-10 cm. The laboratory germination rate was 96-98%.

1 Introduction

Studies by Kyriacou et al. (2016), Galieni et al. (2020), Turner et al. (2020) show that microgreens are a new class of foods that are gaining popularity. These are seedlings of edible plants, harvested 7-14 days after sowing, when the first true leaves begin to appear.

Verlinden (2019) defines microgreens as small lettuce greens grown from fully developed cotyledons that include one or two true plant leaves. There are many definitions of microgreening, but based on a review of the literature, it can be assumed that the above simple definition is quite broad. Microgreens are harvested without roots and seed coat and are therefore less likely to be exposed to two pathways of contamination during sprout production: the nutrient medium and the seeds themselves.

Microgreens are a new functional food crop that can sustainably diversify global food systems, facilitate adaptation to urbanization and global climate change, and improve human health. Microgreens are characterized by high quality, minimal environmental impact and wide consumer acceptance, according to Michell et al (2020).

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Microgreens have become popular in the past two or three decades as a culinary aid to improve texture, color, flavor, aroma and visual appeal in a range of foods, and more recently they have been promoted as a beneficial dietary supplement. Microgreens are mainly used in the restaurant industry to decorate dishes and are most often consumed fresh in salads, soups and sandwiches.

A series of microgreen cultivation studies were conducted by Kyriacou et al. In 2016, scientists argue that interest in fresh, functional foods is growing, driven by growing consumer interest in health-promoting diets. The researchers emphasize that microgreens have tremendous potential to enhance the nutritional value of the human diet.

Chronic illness is a serious health problem. Accumulating evidence suggests that eating vegetables can significantly reduce the risk of many chronic diseases. Microgreens, despite their small size, have a delicate texture, characteristic flavor and a variety of nutrients. Because microgreens are rich in nutrients, smaller amounts can provide similar nutritional benefits compared to more mature vegetables (Choe U., Yu L.L., Wang T.T.Y., 2018).

According to Meyerowitz (2010), microgreens are nutritious functional foods. According to his research, soybean sprouts have the highest protein level (28%), followed by lentil and pea sprouts at 26% (Meyerowitz 2010). It has been found that soybean sprouts contain twice as much protein as chicken eggs.

Marton et. al. (2010) found that during seed germination, polysaccharides under the action of enzymes and water are hydrolyzed into oligo- and monosaccharides, fats into free fatty acids, proteins to oligopeptides and free amino acids. Therefore, sprouting can be considered as a type of pre-digestion that helps to break down high molecular weight complex organic substances into low molecular weight building blocks (Marton et. al. 2010).

Caracciolo et al. (2020) note that microgreens enrich the human diet with important nutrients. The nutritional composition primarily depends on the crop being grown, but also on the growing conditions. Young plants have a significantly higher vitamin content than mature plants. Due to the higher level of phytochemicals, microgreens are classified as functional foods (Sharma et al., 2012; Izhmulkina et al., 2020).).

Based on an analysis of the literature, Verlinden (2019) showed that most of the work on microgreens focuses on the effect of light during production to increase the level of mineral and bioactive compounds. Other publications focus on the microbial safety of this type of product. Most of the work indicates that microgreens are safer from a microbiological point of view than seedlings.

Microgreens are usually produced using soilless growing systems. The soil is replaced with a substrate or the plants are grown in an aquatic environment containing all the elements necessary for life. The production of microgreens can be carried out in a variety of environments and can be carried out commercially using modern techniques necessary to ensure continuity of production and good product quality or as a hobby, for self-consumption, using very simple methods and techniques and very limited spaces, e.g. windowsill. While growing microgreens for your own consumption can be fairly straightforward, commercial production of microgreens is not easy and requires specialized technology.

Scientists mainly investigate species belonging to the families *Brassicaceae, Asteraceae, Chenopodiaceae, Lamiaceae, Apiaceae, Amarillydaceae, Amaranthceae* and *Cucurbitaceae* for microgreens. Methods for improving bioactivity and principles of human health promotion, use, storage after harvest and microbial safety are considered.

The aim of our research was to study the technology of cultivation of microgreens of the *Brassicaceae* family on an aqueous substrate.

2 Material and research methods

The research was carried out in 2021 at the Department of Landscape Architecture of the Kuzbass State Agricultural Academy. The objects of research were the seeds of cultivated plants of the Brassicaceae family: broccoli variety *Fortuna*, radish variety *Violetta*, watercress variety *Dansky*, and arugula variety *Sicily*.

The experiment used calibrated seeds, without diseases and pests, which were not treated with chemical preparations. Sowing of seeds was carried out on March 10. The seeding rate was 5 g per 75 cm^2. Plants were grown at a temperature of +18 ... $+24^0C$ without additional lighting on the windowsill. Mineral fertilizers were not applied. For the cultivation of microgreens, a hydroponic plant was used using a two-channel compressor on tap water, which did not contain heavy metals, pollutants and pathogenic microorganisms (Escherichia coli, Salmonella). To ensure good germination of the root system and optimal growth and development of seedlings, the level of aeration was 20-30% of the total volume. The microgreen medium had a pH of 5.5 to 6.5.

Germination energy was determined for broccoli and radish cabbage at 3 days, watercress - at 4 days and arugula - at 7 days; laboratory germination of broccoli and watercress seeds was determined at 10, radishes at 7 and arugula at 14 days in accordance with GOST 12038-84.

The color, smell, taste of microgreens were determined according to GOST R 54692-2011 (for broccoli), GOST 34216-2017 (radish), GOST 34215-2017 (watercress and arugula).

The sowing density (pcs/cm^2) was also determined.

The microgreens were harvested on day 10 and their yield was determined.

Dry matter in roots and shoots was determined according to GOST 33977 - 2016.

Mathematical processing was carried out according to B.A. Dospekhov.

3 Results and discussion

In the production of microgreens, the quality of the seeds is of great importance, since the speed and uniformity of germination, as well as the final result of the growing cycle, depend on their quality. To avoid weed infestation, which may be inedible or poisonous, the seeds were clean and 100% pure. We have studied the sowing qualities of the seeds of the studied crops. The research results are presented in table 1.

Table 1. Germination energy and laboratory germination of microgreen seeds, %

Crop	Variety	Germination energy	Laboratory germination
Broccoli	Fortuna	94±2,0	98±2,0
Radish	Violet	86±1,5	96±1,5
Watercress	Dansky	89±3,0	98±3,0
Arugula	Sicily	93±2,0	98±2,0

Analysis of the results of determining the quality of seeds of the studied crops made it possible to reveal that the indicators of germination energy and laboratory germination vary within 86-94% and 96-98%, respectively, which indicates a high bioenergetic potential of the seed. The highest values of laboratory seed germination were observed in broccoli and arugula, and the lowest in watercress.

In the course of analyzing the yield of plants used for growing microgreens, it was found that it depends on the type of crop. The maximum yield was obtained with broccoli.

Indicators of dry matter content in shoots and roots of this culture amounted to 3.3 g/m^2 (Table 2).

Table 2. Yield productivity of microgreens

Crop	Variety	Sowing density, pcs/cm^2	Phytomass, g/m^2		Dry matter content, g/m^2	
			Shoots	Roots	Shoots	Roots
Broccoli	Fortuna	12	5,6±0,01	1,1±0,005	2,8±0,01	0,5±0,005
Radish	Violet	6	3,7±0,01	0,5±0,005	1,9±0,01	0,3±0,005
Watercress	Dansky	11	2,4±0,01	0,5±0,005	1,2±0,01	0,3±0,005
Arugula	Sicily	12	1,3±0,01	0,3±0,005	0,7±0,01	0,1±0,005

The minimum yield was observed on the arugula cultivar Sicily (Fig. 1). The raw phytomass of this crops and dry matter were 1.6 g/m^2 and 0.8 g/m^2, respectively. It was revealed that in all variants of the experiment, the water content in the shoots and roots of microgreens is 2 times higher than in the dry phytomass in each test culture.

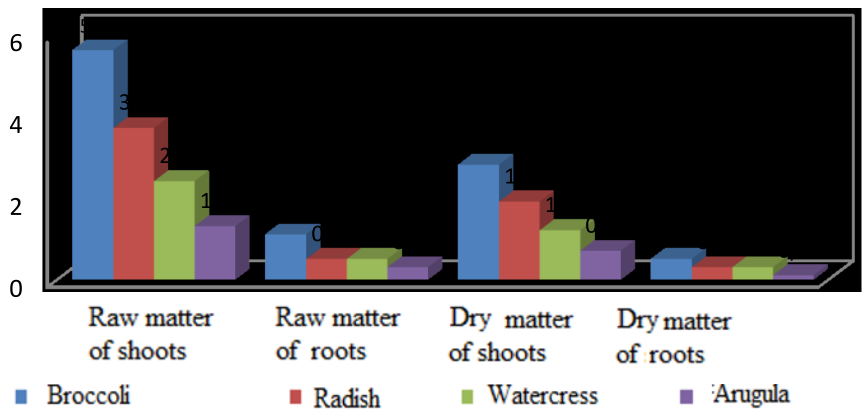

Fig. 1. Yield productivity of microgreens, g/m^2

Table 3. Coefficient of variation on average by types of crops

Indicators	max	min	среднее	V, %
Sowing density	12	6	10,25	50,0
Raw phytomass	6,7	1,6	3,85	76,1
Dry matter content	3,3	0,8	1,95	75,7

There was a strong variation in wet weight and dry matter content by crop. Thus, the studied parameters varied greatly depending on the genotypic characteristics.

It was found that the smell and taste of microgreens of all studied crops was characteristic of these botanical varieties, without any foreign smell and/or taste. The research results are presented in table 4.

Table 4. Organoleptic assessment, germination time, harvest time of microgreens of the *Brassicaceae* family

Crop	Color	Taste	Germination time, days	Harvesting, days
Broccoli	Leaves are bright green, stems are slightly pink	slight bitterness	1-2	7-10
Radish	Leaves are green, stems are white	spicy	1-2	6-7
Watercress	Leaves are green, stems are yellowish-white	peppery, spicy	3-5	5-7
Arugula	Leaves are pale green, stems are light purple	spicy	2-3	7-10

Previously studied indicators of the biological value of microgreens indicate that broccoli, radishes, watercress and arugula are rich in complete proteins, carbohydrates and have a low calorie content (Table 5).

Table 5. The content of proteins, fats and carbohydrates in microgreens

Crop	Content, g/100g			Energy value, kcal
	proteins	fats	carbohydrates	
Broccoli	3,0	0,4	7,0	34,0
Radish	1,1	0,1	2,4	14,9
Watercress	2,6	0,7	5,5	32,0
Arugula	2,6	0,7	2,1	25,0

During cultivation, the maximum accumulation of proteins and carbohydrates was noted in broccoli microgreens. Fat accumulates during the growing season, a small amount in the studied crops from 0.1 g to 0.7 g per 100 g of the product. The calorie content per 100 g of the product is, depending on the type of culture, from 14.9 kcal to 34 kcal. In addition, according to Xiao et. al. (2019), *Brassicaceae* microgreens are a good source of antioxidant phytochemicals, although there are significant differences within and between species. It is a valuable source of ascorbic acid, phylloquinone, carotenoids, tocopherols, glucosinolates and polyphenols. In general, microgreens contain more nutrients and trace elements beneficial to human health than their mature counterparts.

4 Conclusion

As a result of scientific research, it has been established that microgreens can be obtained from seeds of the Brassicaceae family in 6-12 days. Such a product does not have time to accumulate harmful substances from the atmosphere in a short period of time. When growing microgreens, it is not necessary to use mineral fertilizers, pesticides and, thus, it is possible to obtain environmentally friendly, biologically useful products with low material costs.

It was found that, depending on the seeds of the studied crops and their genotype, the cycle of growing microgreens lasts from 6 to 10 days after germination. Depending on the type of culture, the sprouts reached a height of 5-10 cm. The laboratory germination rate was 96-98%.

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