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GROWTH POSSIBILITY OF JAPANESE BASIL IN ORGANIC HYDROPONICS

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As a result of preliminary research, the possibility of obtaining organic plant raw material in hydroponic conditions has been confirmed. It was found that among organic fertilizers added to volcanic slag and gravel mixture, application of manure was the most effective. And when using two doses of manure and guano, maximum yield of fresh leaves of Japanese basil and essential oil output was observed. Identical results were also obtained when the plants were nourished with two doses of manure, guano and biohumus. Under these conditions, the yield of the leaves exceeded the other variants 1.5-3.5 times, but was inferior to soil plants 1.9 times. Minimum essential oil content was observed in control variants and when nourishing the plants with only gunao.

Volcanic slag – gravel – manure – guano – biohumus – essential oil

Նախնական հետազոտությունների արդյունքում հաստատվել է օրգանական հիդրոպոնիկայի պայմաններում բուսահումքի ստացման հնարավորությունը: Պարզվել է, որ հրաբխային խարամի և գլաքարի խառնուրդին ավելացված օրգանական պարարտանյութերից արդյունավետ է եղել գոմաղբի կիրառումը, իսկ գոմաղբի և թռչնաղբի կրկնակի չափաքանակների կիրառման դեպքում դիտվել է ճապոնական ռեհանի թարմ տերևների առավելագույն բերքատվություն ու եթերայուղի ել: Նույնատիպ արդյունք է գրանցվել նաև գոմաղբի, թռչնաղբի և կենսահումուսի կրկնակի քանակներով բույսերը սնուցելիս: Այս դեպքում, տերևների բերքը գերազանցել է մյուս տարբերակներին 1.5-3.5 անգամ, սակայն զիջել է հողային բույսերին 1.9 անգամ: Միայն թռչնաղբով բույսերի սնուցման դեպքում և ստուգիչ տարբերակներում դիտվել է տերևներում եթերայուղի նվազագույն պարունակություն:

Հրաբխային խարամ – գլաքար – գոմաղբ – թռչնաղբ – կենսահումուս – եթերայուղ

В результате предварительных исследований установлена возможность получения растительного сырья в условиях органической гидропоники. Выяснилось, что из органических удобрений, добавленных в смесь вулканического шлака и гравия, эффективным было применение навоза. При использовании двойной дозы навоза и птичьего помета наблюдалась максимальная урожайность свежих листьев японского базилика и наибольший выход эфирного масла. Идентичный результат получен также при подпитывании растений двойными дозами навоза, птичьего помета и биогумуса. В этих условиях урожайность листьев превосходила другие варианты в 1.5-3.5 раз, но уступала почвенным растениям в 1.9 раз. При подпитке растений только птичьим пометом и в контрольных вариантах наблюдалось минимальное содержание эфирного масла.

Вулканический шлак – гравий – навоз - птичий помет – биогумус – эфирное масло

Organic agriculture is aimed at producing ecologically clean plant raw material, as well as improving and promoting agricultural production from environmental, social and economical viewpoint. Organic fertilizers such as manure, guano, compost, biohumus, ash, peat, as well as green fertilization are used instead of mineral fertilizers [1, 7, 10, 14].

In the countries of the European Union the priority is given to creating appropriate legal basis concerning organic agriculture. In December, 1999 a regulation (№2092/91) came into force by the European Commission according to which organic products grown in the territory of the EU must be labeled [1]. The regulation aims at providing fair competition both for consumers and farmers.

Economically developed countries such as the USA, Canada, Australia, Argentina, Italy and others are among the leaders in the field of organic agriculture. They are major producers of food obtained without chemicals. The number of both producers and consumers of organic food is increasing rapidly in the world. According to many consumer studies, people generally buy organic food because it is seen to be healthier and more natural than its non-organic equivalents. For example, a recent study by the NZ Vegetable Growers Federation (VegFed), found that nearly 40% of people who purchase organic food do so because they believe it is pesticide-free [4].

There are almost 13,000 certified organic farms in the United States with a sales value of over $3.1 billion. In the northeastern United States, more than 3,200 farms are certified organic and have a sales value of over $300 million [11]. In terms of organic sowing areas the first place in the unit weight of lands suitable for agriculture belongs to Liechtenstein – 26.4%, the second is Austria 11.6%, the third is Switzerland 10.0%, then Italy 8.0%, Finland 7.0% and Denmark 6.6% [1].

Organic hydroponics. The main advantage of soilless culture or hydroponics is that the plants are easily provided with all macro- and micro-elements, which they obtain from the soil. The worldwide market value of hydroponically produced food will show sustained strength with a 6.5% compound annual growth rate (CAGR) over the five-year forecast period 2013-2018, beating the IMF estimated growth forecast of 3.6% for 2014. Producer value will increase from $17.7 billion to $24.3 billion [9].

Hydroponics is an ideal growing method for producing culinary and medicinal herbs. Not only do hydroponic herbs grow faster, they have significantly more flavor and aroma than herbs grown in soil [3]. According to research performed at the University of Minnesota, it is a known fact that herbs grown hydroponically have 20-40% more aromatic oils than field grown. Therefore, a small hydroponic herb garden can provide a continuous harvest of gourmet-quality produce in a relatively small space [12].

Hydroponics has the opportunity to fill the gap between traditionally grown produce and organics. It's the alternative to traditional field cropping and uses IPM (Integrated Pest Management) to its maximum [6]. Unlike traditional hydroponics, organic fertilizers such as manure, guano, compost, biohumus, etc. are used in organic hydroponics.

Geoff Wilson reports there are 800 million people practicing urban agriculture, and that inorganic and organic hydroponic technologies can play an increasing role in feeding the world's poorest countries, as well as the mega cities: "In my view, future urban agriculture will be based on space-saving, water-efficient food production systems that use both inorganic and organic hydroponics" [15].

The objective of the work – cultivation peculiarities of common basil (*Basilicum sativum* L.) in soilless culture – are very well studied [5, 8]. Japanese basil (*Perilla frutescens* v. *crispa*) has been introduced to soilless culture recently. It is a herb of Japanese extraction and is commonly cultivated as a vegetable in Japan. The green leaves can be served as tempura, in salads and with sashimi. It is also ground and used to flavor sauces, added to ponzu (a soya sauce, dashi (fish stock) and daidai juice sauce), used in nabe (Japanese stews) and Japanese-style spaghetti dishes.

The leaves can be soaked in soya sauce for a year and wrapped around rice to make a tasty onigiri (Japanese rice ball), or chopped up, boiled in soya sauce and sugar and left to ferment to make tsukudani, which is eaten as a side-dish to accompany rice.

Taking into account the wide use of Japanese basil in food, our objective is to study the production possibility of this new culture in organic hydroponics, to reveal the optimal conditions for productivity, high yield and high quality of biomass for food.

Materials and methods. Seedlings grown by us with hydroponics method have been used as planting material which were planted in 0.25 m^2 hydroponics pots (fig. 1) with 20 plants/m^2 planting density. 3-15 mm diameter particles of volcanic slag and gravel mixture with 1:1 ratio have been used as a hydroponic substrate.

a b

Fig.1. Japanese basil in organic hydroponics (a) and in soil (b)

Different quantity of manure, guano, biohumus was used in the experiments (1 dose of manure (M) – 800g, 1 dose of guano (G) – 75g, 1 dose of biohumus (B) – 300g). Water streaming (75 ml water/plant) was done 5-6 times a day. At the same time root and foliar feeding of plants was done. Root nutrition was done with Bio (Dunger Universal-Germany, 5ml /L water, 50ml nutrient solution was given to each plant) and AZC (Azoceovit-1, Armenia, 5ml/L water, 50ml nutrient solution was given to each plant) and foliar feeding with BPF fertilizers (Bioplantflora, Russia, 2.5ml/L water). The frequency was once in 12 days for each fertilizer, with 4-day intervals.

The content of essential oil in dried leaves was determined with steam distillation method [2]. A statistical analysis of collected data was carried out using GraphPad5 software program.

Results and Discussion. The research results have shown that organic fertilizers have a significant influence on biomass accumulation of plants and biosynthesis intensity of essential oil in the leaves in case of separate or combined application (tabl. 1).

A minimum yield of Japanese basil leaves was observed when the plants were watered with only water and obtained foliar feeding, as well as in case of applying 1 or 2 doses of guano.

Gradual increase of manure dose promoted yield increase of the leaves. In case of 2 and 3 doses a relatively high yield of leaves was observed which exceeded control variants (C1 and C2) 2.0-2.3 times and guano variants (1G, 2G and 3G) 1.4-2.3 times. It should be noted that in case of applying 3 doses of only guano a significant difference of leaf yield was observed compared to control variants (C1 and C2).

In case of combined applying 2 doses of manure and guano (2M2G+FF) maximum yield of leaves was observed, which exceeded the control variants 3.1-3.4 times. Maximum yield was also obtained in case of combined use of manure, guano and biohumus 2 doses (2M2G2B+FF).

Table 1. Scheme of the experiments

№	Variants	№	Variants
1.	C1 – control 1 (only water)	8.	3G + FF – 3 doses of guano + foliar feeding
2.	C2 + FF – control 2 (only water +foliar feeding)	9.	1M1G+FF – 1 dose of manure + 1 dose of guano + foliar feeding
3.	1M + FF – 1 dose of manure + foliar feeding	10.	2M2G+FF – 2 doses of manure + 2 doses of guano + foliar feeding
4.	2M + FF – 2 doses of manure + foliar feeding	11.	1M1G1B+FF – 1 dose of manure +1 dose of guano + 1 dose of biohumus + foliar feeding
5.	3M + FF – 3 doses of manure + foliar feeding	12.	2M2G2B+FF – 2 doses of manure +2 doses of guano +2 doses of biohumus + foliar feeding
6.	1G + FF – 1 dose of guano + foliar feeding	13.	S-soil
7.	2G + FF – 2 doses of guano + foliar feeding		

Maximum yield was also obtained in case of combined use of manure, guano and biohumus 2 doses (2M2G2B+FF). It should also be noted that adding 1 dose of biohumus to manure and guano (1M1G1B+FF) has considerably increased the leaf yield (1.6 times compare to 1M1G+FF), however, adding 2 doses of biohumus (2M2G2B+FF) was not essential compared to 2M2G+FF variant.

Table 2. Productivity of Japanese basil (fresh mass) in organic hydroponics and soil

№	Variants	Leaf, g/plant	Stem, g/plant	Root, g/plant	Above-ground mass, g/plant	□ plant, g/plant	Essential oil, □
1.	C1	23.0^{a}	12.1	13.4	35.1	48.5	0.6±0.03
2.	C2 + FF	21.3^{a}	16.1	20.1	37.4	57.5	0.83±0.05
3.	1M + FF	27.9^{ab}	17.1	16.4	45.0	61.4	0.69±0.04
4.	2M + FF	45.6^{c}	21.0	23.5	66.6	90.1	0.92±0.05
5.	3M + FF	48.6^{c}	22.0	21.2	70.6	91.8	1.0±0.05
6.	1G + FF	20.7^{a}	13.1	14.4	33.8	48.2	0.48±0.03
7.	2G + FF	24.6^{a}	12.5	20.3	37.1	57.4	0.58±0.04
8.	3G + FF	31.5^{b}	15.1	17.0	46.6	63.6	0.6±0.04
9.	1M1G + FF	28.4^{ab}	13.2	16.8	41.6	58.4	0.67±0.04
10.	2M2G + FF	72.0^{d}	37.1	29.6	109.1	138.7	0.83±0.04
11.	1M1G1B + FF	46.3^{c}	22.3	21.5	68.6	90.1	1.0±0.06
12.	2M2G2B + FF	72.1^{d}	27.6	19.1	99.7	118.8	0.88±0.05
13.	S	135.4^{e}	67.8	34.8	203.2	238	0.92±0.05

[abcde]Tukey's Multiple Comparison Test ($P<0.05$)

As supposed the leaves of soil plants considerably exceeded all the tested organic hydroponics variants: 1.9 times the best variants (2M2G+FF and 2M2G2B+FF) and 2.8-6.5 times other variants.

It turned out that FF nutrition promoted only root system development which however didn’t lead to leaf weight increase (C2+FF). In these variants, as well as in case of separate application of guano and manure 1 dose (1M+FF and 1G+FF) the least percentage share of leaves was observed in the whole plant and above-ground biomass (fig. 2 and 3).

Minimum content of roots was observed in the whole biomass of the plant in the best variants of organic hydroponics (2M2G+FF and 2M2G2B+FF) and in soil. The amount of active roots was probably high in these variants (fig. 2).

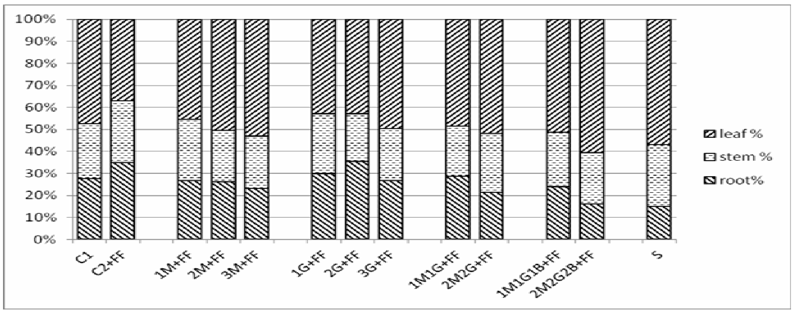

Fig.2. Ratio of leaves, stems and roots of Japanese basil in conditions of organic hydroponics, %

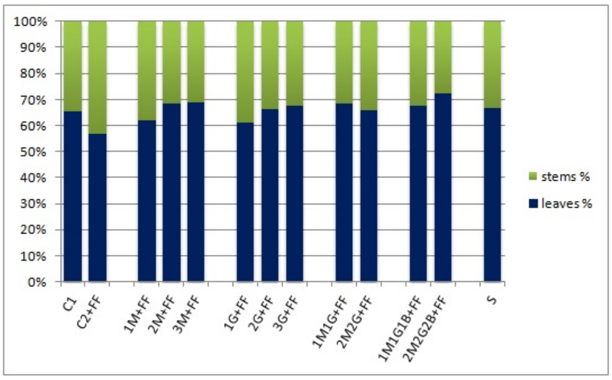

Fig.3. Ratio of stems and leaves of Japanese basil above ground mass, %

The results of biochemical analysis of the leaves have shown that a minimum content of essential oil in dry leaves was registered in the control and only in case of applying different doses of guano (1G+FF, 2G+FF and 3G+FF).

Plants nourished with 2 and 3 doses of manure as well as 2M2G+FF, 1M1G1B+FF and 2M2G2B+FF variants had maximum amount of essential oil in the leaves.

It turned out that essential oil biosynthesis was more intensive in plants nourished with manure. The essential oil content in the leaves of the variants which were nourished with only manure exceeded those nourished with only guano 1.4, 1.5 and 1.7 times. It also turned out that adding biohumus also promoted essential oil synthesis. Adding 1 dose of biohumus intensified biosynthesis of essential oil by about 40% and in case of 2 doses by more than 10%.

The same content of essential oil was observed in the leaves of the best variants of organic hydroponics 2M2G+FF and 2M2G2K+FF and soil plants.

Plants of control variants and plants nourished with only 1 and 2 doses of guano excelled with minimum essential oil output.

2M2G+FF and 2M2G2K+FF variants are notable for maximum output of essential oil, however they conceded soil plants about 2.3 times.

It should be noted for comparison that in classical hydroponics conditions (nourished twice a day with normal Davtyan’s nutrient solution) the yield of Japanese basil fresh leaves was 270g/plant, with 8.5% essential oil content. Essential oil output was 377mg/plant [13]:

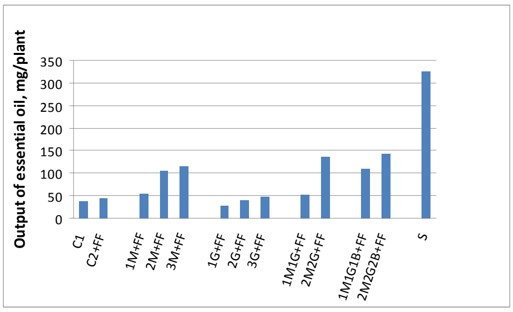

Fig.4. Essential oil output of Japanese basil in conditions of organic hydroponics, %

The results of preliminary investigations have shown that production of plant raw material in organic hydroponics is possible and can be very promising. In case of combined application of manure and guano, it is possible to grow biomass which is not inferior to soil plants with its quality.

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