UDC 34.31.21

D.Yu. Sirman[1], G.B. Kozhanova[1], A.N. Potechina[1], S.U. Tleukenova[1],
M.K. Abdresheva[1], E.N. Martynova[2], G.T. Almusin[2]

[1]*Ye.A. Buketov Karaganda State University, Kazakhstan;*
[2]*JSC «Shubarkol Komir», Karaganda, Kazkahstan*
(E-mail: den-diatoma@mail.ru)

Influence of the sodium humate of production of JSC «Shubarkol komir» on the accumulation of crude and dry mass of sprouts at cultivation on various substrates in the conditions of hydroponics

Method of hydroponic growing of the plants is currently the most widely implemented for a year-round production of vegetative biomass. It has a number of advantages over traditional methods of growing, especially within the regulation of physiological processes depending on the final quality of the product. This article is devoted to the study of the accumulation of crude and dry bio mass of plants grown in the hydroponics conditions. As the nutrient medium available composition of the macronutrients of Murashige and Skoog medium (MS) is used. As the activator and regulator of physiological processes sodium humate production of JSC «Shubarkol komir» was used. The results of growing lettuce, cucumbers, tomatoes, as well as the influence of various substrates on the accumulation of dry and crude bio mass in plants are studied. The results of experiments indicated a positive effect of sodium humate on the accumulation of dry and crude weight of plants in hydroponics conditions. Also there was a close relationship between the type of substrate and the accumulation of raw and crude mass of plants.

Keywords: hydroponics, substrates, MS nutrient medium, crude and dry mass, humate, perlite, basalt wool, burner.

Introduction

The use of hydroponic systems for green crops has recently become very widespread [1, 2]. At the same time, many researchers recognized that plants grown in this way have a number of advantages over plants obtained by traditional soil methods. So, T.V. Sedykh, S.V. Pogrebnyak showed that the harvest of cucumbers obtained by the method of small hydroponics is much higher than the harvest obtained by growing cucumbers in standard greenhouse complexes [3].

The advantage of hydroponics is that the plant can be grown on different types of substrates, which in turn affects not only their growth rates, but also the final harvest. So, M. Seregin revealed that the harvest of plants grown on the substrate expanded clay was significantly higher than the harvest of plants grown on coconut fibers [4].

However, the choice and use of the substrate should be based solely on varietal and species preferences grown plants. Bykova's studies have shown that due to the use of vermiculite influenced on nutrient solution, changing its composition and sometimes increasing pH until 11. This was due to the high ion exchange capacity of the substrate [5], which could lead to increased osmotic pressure of medium and plant death. Yu.K. Zemskova with co-authors in studies of salad cultures found that the optimal acidity of the nutrient medium could vary in the range of 2.8–6.1 [6].

The main factor for the successful cultivation of plants in hydroponics is the composition of medium. During optimization of medium composition for the cultivation of tomato revealed that decreased in the concentration of nitrogen, phosphorus and potassium did not lead to a decreasing intensity of the growth and plant development [1].

At the same time, minor changes in the balance of micro- and macro elements could lead to changes in growth processes, in particular, to the accumulation of crude and dry bio mass. So, comparative study of B.R. Kuluev with two nutrient solutions (1 % solution of Hogland-Arnon (further HA) medium) showed that the crude mass of the roots was bigger when on MS in 1.8 times. Also, the leaves of plants growing on the MS medium were dark-green, and plants growing on the HA medium were light-green [7].

The ratio of elements in nutrient solutions also has a significant effect. Thus, one of the most important ratios is the content of calcium and potassium ions in the solution. Studies of L.S. Kubareva showed influences of ratio calcium and potassium on harvest of tomato. So, increasing in the ratio 3:1 or a decreasing to 0.3 led to decreasing of harvest on 12–18 % [8].

Growth promoters are playing an important role in development of seedlings and growing of the plants. Recently, wide using stimulators are humates. They gave multiplicative effects. So, M.Yu. Ishmuratova and D.Yu. Sirman studied influence of humates on seed germination of the flower crops, when increased this parameter on 15–20 % [9]. In this case, the maximum effect is achieved with a minimum seed treatment time. The same effect humates rendered in the hydroponic system [10].

As a result of all the above, the aim of our study was to study the effect of sodium humate on the growth performance of the main salad and vegetable crops in hydroponic conditions.

Methodology

Researches were performed at the laboratory of biotechnology and molecular genetics of Ye.A. Buketov Karaganda State University.

The object of the study was the nutrient media of different composition, prepared on the basis of standard biotechnological MS-media with the addition nutrients for hydroponic systems (Table 1).

Table 1

The composition of nutrients used in the solution

The mineral substance	Content in the solution, g/l
KNO_3	0.8
$CaCl_2 \cdot 2H_2O$	0.22
KH_2PO_4	0.17
$MnSO_4 \cdot 4H_2O$	0.11
$NaMoO_4$	0.025
$MgSO_4 \cdot 7H_2O$	0.37

For the production of an alternative nutrition medium was used the solution of mineral concentrate produced by «General Hydroponics» (France, series Floragro) in a concentration of 2 ml/l.

We planted some seeds of salad and vegetable crops: arugula sort «Gourmet», arugula sort «Sicily», tomato sort «Novichok», cucumber sort «Herman».

Pre-sowing treatment of seeds was carried out by soaking during one day at temperature +24 ºC.

In researches several types of substrates are used: perlite, mineral wool for hydroponic systems, burner (product of self-combustion of oxidized coal of JSC «Shubarkol komir». So, 15 different combinations of substrate and nutrient medium were studied (Table 2).

Table 2

Variations of a combination of substrates and nutrient media

No. variant	Substrate	Nutrition medium	No. variant	Substrate	Nutrition medium
1 variation	Pearlite	½ MS+HUMATE AO SHK	9 variation	Mineral wool	Floragro + HUMATE
2 variation	Pearlite	½ MS	10 variation (control)	Mineral wool	Distillate water
3 variation	Pearlite	½ MS	11 variation	Burner	½ MS + HUMATE
4 variation	Pearlite	Floragro + HUMATE	12 variation	Burner	½ MS
5 variation (control)	Pearlite	Distillate water	13 variation	Burner	½ MS
6 variation	Mineral wool	½ MS+HUMATE	14 variation	Burner	Floragro + HUMATE
7 variation	Mineral wool	½ MS	15 variation (control)	Burner	Distillate water
8 variation	Mineral wool	½ MS			

After the soaking seeds were planted in trays filled with substrate. The effectiveness of the influence of nutrition medium was determined by the following indicators: A) accumulation of crude mass; B) accumulation of dry mass.

Results of experiments are calculated by comparison of using table of N. Plohinskii. Statistical processing of the results was performed using the Microsoft Excel 2007 application package.

Results and their discussion

The primary analysis of crude and dry mass showed the relationship between the type of substrate and the mass of crude mass, especially for plants grown on the substrate — perlite.

So, largest mass of arugula sort «Gourmet» was recorded on the substrate perlite in variant 5 (Table 3).

Table 3

Crude and dry bio mass of arugula sort «Gourmet»

No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass
1	0.31 ±0.04	0.022 ±0.003	7.10	6	0.12 ±0.01	0.013 ±0.001	10.83	11	0.32 ±0.06	0.029 ±0.002	9.06
2	0.46 ±0.11	0.037 ±0.001	8.04	7	0.18 ±0.04	0.041 ±0.001	22.78	12	0.27 ±0.02	0.024 ±0.001	8.89
3	0.33 ±0.05	0.028 ±0.002	8.48	8	0.25 ±0.06	0.040 ±0.004	16.00	13	0.39 ±0.01	0.039 ±0.001	10.00
4	0.35 ±0.04	0.026 ±0.001	7.43	9	0.31 ±0.01	0.030 ±0.001	10.00	14	0.41 ±0.04	0.044 ±0.002	10.73
5	0.56 ±0.08	0.039 ±0.002	6.96	10	0.16 ±0.18	0.023 ±0.003	14.38	15	0.31 ±0.03	0.033 ±0.003	10.65

This result was higher on 44.6 % comparing to control data. The highest dry biomass was noted for plants grown on the substrate in variant 14 — burner and nutrient solutions. Plants, grown on this variant of nutrient solutions, are characterized by high dry bio mass. The reliability of the results of experimental variants varied from 0.05 till 0.001.

Comparison of the results of the accumulation of crude weight of plants arugula sort «Sicily» revealed that the greatest accumulation of bio mass was observed on the substrate perlite in variant 4 (Table 4).

Table 4

Crude and dry bio mass of arugula sort «Sicily»

No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass
1	0.42 ±0.06	0.035 ±0.003	7.10	6	0.28 ±0.01	0.011 ±0.003	3.93	11	0.44 ±0.06	0.043 ±0.003	9.06
2	0.48 ±0.08	0.036 ±0.003	8.04	7	0.23 ±0.06	0.040 ±0.003	17.39	12	0.37 ±0.09	0.037 ±0.002	8.89
3	0.38 ±0.02	0.029 ±0.002	8.48	8	0.23 ±0.01	0.044±0. 002	19.13	13	0.52 ±0.04	0.043 ±0.002	10.00
4	0.56 ±0.04	0.041 ±0.003	7.43	9	0.42 ±0.05	0.045±0. 002	11.25	14	0.46 ±0.04	0.045 ±0.001	10.73
5	0.54 ±0.06	0.037 ±0.002	6.96	10	0.24 ±0.04	0.029±0. 003	12.08	15	0.29 ±0.01	0.039 ±0.003	10.65

The analysis of dry bio mass showed that the highest results were recorded on the basalt wool in variant 9 and on burner in variant 14. It is noted that the accumulation of dry bio mass for arugula «Sicily» was higher than for sort «Gourmet». So, for arugula sort «Gourmet» was only 3 variant of dry bio mass over 0.040 grams. For arugula sort «Sicily» weight of dry bio mass over 0.040 grams was recorded in 7 variants.

The analysis of the absolute data of dry bio mass showed that the highest results were recorded on basalt wool in variant 9 and on burner substrate in variant 14.

On the substrate perlite there were no significant differences between the 4th and 5th variants. In variant 1 there was a significant variation of crude bio mass in relation to the control at the level of $p < 0.01$. The greatest reliability ($p < 0.001$) was observed between the 3rd and 5th variants. On the substrate basalt wool, the significant difference between variant 9 and control was $p < 0.001$.

The maximum bio mass of tomato plants sort «Novichok» on the substrate perlite was recorded for variant 4. It was more on 84.4 % than the maximum crude bio mass received on basalt wool (variant 6), and on 73.1 % more than the maximum bio mass on substrate burner (variant 15). Also on the substrate perlite relative difference between variant 4 and control variant was 73.1 %. Data of crude bio mass on basalt wool (variant 6) exceeded control variant on 40 %. The maximum of dry bio mass was fixed in control variant (Table 5).

Table 5

Crude and dry bio mass of tomato sort «Novichok»

No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass
1	0.83 ±0.05	0.070 ±0.002	8.43	6	0.77 ±0.05	0.061 ±0.001	7.92	11	0.46 ±0.04	0.045 ±0.006	9.78
2	0.67 ±0.08	0.053 ±0.003	7.91	7	0.59 ±0.08	0.058 ±0.003	9.83	12	0.68 ±0.08	0.059 ±0.004	8.68
3	0.43 ±0.06	0.031 ±0.003	7.21	8	0.74 ±0.11	0.063 ±0.003	8.51	13	0.73 ±0.04	0.061 ±0.002	8.36
4	1.42 ±0.07	0.112 ±0.004	7.89	9	0.47 ±0.06	0.053 ±0.002	11.28	14	0.71 ±0.07	0.066 ±0.003	9.30
5	0.82 ±0.04	0.061 ±0.003	7.44	10	0.55 ±0.04	0.045 ±0.002	8.18	15	0.82 ±0.09	0.065 ±0.006	7.93

Variant of nutrition media 4 recorded the highest dry bio mass among all studied variants; the best result for dry mass was shown substrate basal wool (variant 9).

Analysis of the reliability of tomato bio mass on different media revealed that on the substrate burner only one variant (variant 11) there was a significant deviation in comparison with control (variation 10).

For substrate basalt wool all variations had significant differences of crude weight comparison with control (variant 7 — $p < 0{,}05$; variants 6, 8, 9 $p < 0.001$).

On perlite substrate in 3 experimental variants weight of crude bio mass had a significant difference $p < 0.001$ in comparison with control (variant 5). At the same time, in variants 2 and 3 plant bio mass were significantly lower than for control data; but bio mass in variant 4 was significantly higher than in control.

The result of the reliability of indicators differences of crude weight showed the highest values of this parameter in different media. So, on substrate perlite (variant 4) and basalt wool (variant 6) significant differences were $p < 0.001$; variation between variants 4 and 15 was at the level of $p < 0.01$.

Comparison of the results of the accumulation of crude mass of cucumber sort «Herman» on different substrates revealed that the greatest weight had plants obtained on the substrate perlite variant 4 (Table 6).

Table 6

Crude and dry bio mass of cucumber sort «Herman»

No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass	No. variant	Crude weight (g.) (M±m)	Dry mass (g) (M±m)	% of dry mass
1	4,31 ±0,43	0,362 ±0,03	8,42	6	4,74 ±0,49	0,404 ±0,023	8,52	11	4,2 ±0,11	0,314 ±0,02	7,48
2	3,85 ±0,12	0,327 ±0,04	8,49	7	3,14 ±0,06	0,197 ±0,005	6,27	12	3,9 ±0,35	0,279 ±0,03	7,15
3	3,93 ±0,17	0,335 ±0,02	8,59	8	3,70 ±0,61	0,252 ±0,003	6,81	13	5,0 ±0,27	0,282 ±0,01	5,64
4	7,55 ±0,26	0,590 ±0,04	7,81	9	2,91 ±0,14	0,272 ±0,022	9,31	14	4,1 ±0,33	0,338 ±0,03	8,24
5	6,07 ±0,11	0,415 ±0,03	6,84	10	2,43 ±0,23	0,176 ±0,001	7,24	15	4,8 ±0,26	0,284 ±0,01	5,92

On a substrate of basalt wool, the highest weight of plants was observed for variant 6. The bio mass of this variant was lower than for similar data on substrate perlite (variant 4).

The maximum bio mass of plants was fixed on Firestone medium in variant 13. The crude bio mass of this variant was on 33.8 % lower than the crude bio mass on perlite substrate (variant 4).

The highest rate of dry bio mass was in variation 4 on the perlite substrate. At the same time, it was found that the highest % of dry bio mass observed in variant 9 on basalt wool.

For cucumber sort «Herman» on the substrate perlite all four variants shew significantly different with control indicators ($p < 0.001$). At the same time, variants 1, 2 and 3 on substrate perlite had results significantly lower than the control data, and in variant 4 the results were significantly higher than in control.

On substrate basalt wool, all four variants also had significant differences for crude bio mass compared with control. However, on this substrate all experimental variants had shown parameters significantly higher than in the control variant. The results obtained in variant 6 with maximum crude bio mass were recorded on this substrate, that were significantly lower ($p < 0.001$), in relation to the results obtained in variant 4 on the perlite substrate.

Comparing the results of accumulation crude bio mass, we can conclude that the biggest influence on this criterion had mineral medium Floragro with addition humate (Shubarkol komir). Additional of humates activate growth of metabolic processes that can be explain with increasing of concentration of sodium ions and increasing of nutrition of vegetative cells.

The overall effect of sodium humate on the accumulation of crude bio mass is noted. The best results of bio mass were in variants with sodium humate. In seven cases from eight indicators of crude biomass was significantly higher than in control variant.

Analysis of the results of accumulation of dry weight showed that in eight variants from twelve the maximum data were observed on mineral media Floragro with the addition of humate. Thus, the vast majority of greatest dry bio mass was observed in variant containing humate.

As was earlier mentioned, the indicator of dry bio mass was not a criterion that characterizes the influence of factor on the development of plants in the initial stages. It can be concluded that sodium humate is an effective stimulant of absorption of the main mineral components.

The comparison of the results of accumulation of dry bio mass on different substrates revealed that the arugula sort «Hermann», tomato sort «Novichok» and cucumber sort «German» had the greatest accumulation of dry weight on the substrate — basalt wool. The arugula sort «Sicily» had the highest dry bio mass on the substrate basalt wool.

References

1 Степуро М.Ф. Оптимизация состава питательного раствора при выращивании томата по гидропонной технологии/ М.Ф. Степуро, А.В. Ботько, Н.Ф. Рассоха // Гавриш. — 2013. — № 3. — С. 15–19.

2 Антипова О.В. Влияние активаторов воды на питательные растворы и развитие растений зеленых культур при выращивании на гидропонике / О.В. Антипова // Гавриш. — 2013. — № 3. — С. 30–35.

3 Седых Т.В. Рост и продуктивность огурца в зимних теплицах в осенне-зимнем культурообороте на малообъемной гидропонике ООО «СИБАГРОХОЛДИНГ» / Т.В. Седых, С.В. Погребняк // Вестн. ОмГАУ. — 2016. — № 3 (23). — С. 53–58.

4 Серёгин М.В. Урожайность листового салата в зависимости от вида фиксирующего субстрата и способа проращивания семян / М.В. Серёгин // Таврический научный обозреватель. — 2017. — № 2 (19) — С. 135–137.

5 Иванова Л.А. Физико-химическая трансформация минерала вермикулита в субстрат для выращивания растений / Л.А. Иванова, В.В. Котельников, А.Е. Быкова // Вестн. МГТУ — 2006. — Т. 9, № 5.— С. 883–889.

6 Земскова Ю.К. Особенности гидропонной технологии в получении продукции салата / Ю.К. Земскова, Э.А. Лаперье, И.А. Александров // Молодые ученые — сельскому хозяйству: материалы студ. конф. — Саратов, 2017. — [ЭР]. Режим доступа: http://agroconf.sgau.ru/wp-content/uppload s/2017/07/14.-Земскова-Гидропонная-технология.pdf

7 Кулуев Б.Р. Гидропонное и аэропонное выращивание одуванчика Taraxacum Kok-saghyz Robin / Б.Р. Кулуев, З.А. Бережнева, А.В. Чемерис // Биомика. — 2017. — Т. 9, № 2. — С. 96–100.

8 Кубарева Л.С. Влияние соотношений калия и кальция в питательной среде на развитие и продуктивность томатов и фасоли: автореф. дис. … канд. с.-х. наук: спец. 53.30.00 — «Агрохимия» / Л.С. Кубарева. — М., 1969. — 17 с.

9 Ишмуратова М.Ю. Оценка влияния полигуминовых удобрений на всхожесть семян некоторых цветочных культур / М.Ю. Ишмуратова, Д.Ю. Сирман, З.Г. Аккулова, Г.Т. Альмусин // Экология және биотехнологияның өзекті мәселелері: Халықарал. ғыл. конф. материалдары. 26–28 қазан 2016 ж. — Караганда, 2016. — С. 54–57.

10 Антипова О.В. Технологическое обоснование культурооборотов в гидропонных рассадных комплексах: автореф. дис. … канд. с.-х. наук: спец. 06.06.06 — «Общее земледелие» / О.В. Антипова. — М., 2010. — 184 с.

Д.Ю. Сирман, Г.Б. Кожанова, А.Н. Потехина, С.У. Тлеукенова,
М.К. Абдрешева, Е.Н. Мартынова, Г.Т. Альмусин

Гидропоника жағдайында түрлі субстраттарда өсіру кезінде өскіндердің шикі және құрғақ массасының жиналуына «ШұбаркөлКөмір» АҚ өндірісінің натрий гуматының әсері

Қазіргі уақытта өсімдіктерді өсірудің гидропонды әдісі өсімдік шикізатын жыл бойы алудың ең кең енгізілген тәсілі болып табылады. Бұл әдіс өсімдіктерді өсірудің дәстүрлі әдістеріне қатысты бірқатар артықшылықтарға ие, әсіресе өнімнің соңғы сапасына әсер ететін физиологиялық процестерді реттеу шеңберінде кең қолданылады. Мақала гидропоника әдісімен өсірілген өсімдіктерде құрғақ және шикі массаның жинақталуын зерттеуге арналған. Қоректік орта ретінде Мурасига-Скуга қоректік ортасының құрамына кіретін макроэлементтердің кең қолжетімді құрамы қолданылды. Физиологиялық үдерістердің активаторы және реттегіші ретінде «ШұбаркөлКөмір» АҚ өндірісінің натрий гуматы қолданылды. Салат, қияр, қызанақ өсіру зерттеулерінің нәтижелері, сондай-ақ өсімдіктерде құрғақ және шикі массаның жинақталу процесіне әртүрлі субстраттардың әсері келтірілген. Зерттеу нәтижелері гидропоника жағдайында өсімдіктердің құрғақ және шикі массасының жинақталу процестеріне натрий гуматының оң әсерін көрсетті. Сондай-ақ зерттеу барысында субстрат түрі мен өсімдіктерде шикі және құрғақ массаның жинақталуы арасындағы тығыз байланыс атап өтілді.

Кілт сөздер: гидропоника, субстраттар, МС қоректік ортасы, шикі және құрғақ масса, гумат, перлит, базальтты мақта.

Д.Ю. Сирман, Г.Б. Кожанова, А.Н. Потехина, С.У. Тлеукенова,
М.К. Абдрешева, Е.Н. Мартынова, Г.Т. Альмусин

Влияние гумата натрия производства АО «ШубаркольКомир» на накопление сырой и сухой массы проростков при выращивании на различных субстратах в условиях гидропоники

Гидропонный метод выращивания растений в настоящее время является наиболее широко внедряемым способом круглогодичного получения растительного сырья. Данный метод имеет ряд преимуществ по отношению к традиционным методам выращивания растений, особенно в рамках, регуляции физиологических процессов влияющих на конечное качество продукта. Настоящая статья посвящена исследованию накопления сухой и сырой массы в растениях, выращенных методом гидропоники. В качестве питательной среды был использован широко доступный состав макроэлементов, входящих в состав питательной среды Мурасиге-Скуга (МС). В качестве активатора и регулятора физиологических процессов использовался гумат натрия производства АО «ШубаркольКомир». Приведены результаты исследований выращивания салата, огурцов, помидор, а также влияние различных субстратов на процесс накопления сухой и сырой массы в растениях. Результаты исследования свидетельствуют о положительном воздействии гумата натрия на процессы накопления сухой и сырой массы растений в условиях гидропоники. Также при исследовании была отмечена тесная связь между типом субстрата и накоплением сырой и сухой массы у растений.

Ключевые слова: гидропоника, субстраты, питательная среда МС, сырая и сухая масса, гумат, перлит, базальтовая вата.

Reference

1 Stepuro, M.F., Botko, A.V., & Rassokha, N.F. (2013). Optimizatsiia sostava pitatelnoho rastvora pri vyrashchivanii tomata po hidroponnoi tekhnolohii [Optimization of the composition of the nutrient solution for growing tomatoes in hydroponic technology]: *Gavrish — Gavrish, 3*, 15–19 [in Russian].

2 Antipova, O.V. (2013). Vliianie aktivatorov vody na pitatelnye rastvory i razvitie rastenii zelenykh kultur pri vyrashchivanii na hidroponike [Influence of water activators on nutrient solutions and development of green crops plants during hydroponic cultivation]: *Gavrish — Gavrish, 3*, 30–35 [in Russian].

3 Sedykh, T.V., & Pogrebnyak, S.V. (2016). Rost i produktivnost ohurtsa v zimnikh teplitsakh v osenne-zimnem kulturooborote na maloobemnoi hidroponike OOO «SIBAHROHOLDINH» [Growth and productivity of cucumber in winter greenhouses in autumn-winter crop rotation on low-volume hydroponics (SibAgroholding LLC)]. *Vestnik OmHAU. — Bulletin of Omsk State Agrarian University, 3(23)*, 53–58 [in Russian].

4 Seregin, M.V. (2017). Urozhainost listovoho salata v zavisimosti ot vida fiksiruiushcheho substrata i sposoba prorashchivaniia semian [Leaf lettuce Yield depending on the type of fixing substrate and the method of seed germination]. *Tavricheskii nauchnyi obozrevatel — Taurida scientific observer, 2(19)*, 135–137 [in Russian].

5 Ivanova, L., Kotelnikov, V.V., & Bykova, A.E. (2006). Fiziko-khimicheskaia transformatsiia minerala vermikulita v substrat dlia vyrashchivaniia rastenii [Physical and chemical transformation of the mineral vermiculite in the substrate for growing plants]. *Vestnik MGTU — Bulletin of Moscow State Technical University, 9(5)*, 883–889 [in Russian].

6 Zemskova, Ju.K., Laper'e, Je.A., & Aleksandrov, I.A. (2017). Osobennosti hidroponnoi tekhnolohii v poluchenii produktsii salata [Features of hydroponic technology in the production of lettuce]. Proceedings from Young scientists to agriculture: *Studencheskaia konferentsiia — Student conference*. Saratov. Retrieved from: http://agroconf.sgau.ru/wp-content/upploads/2017/07/14.-Земскова-Гидропонная-технология.pdf [in Russian].

7 Kuluev, B.R., Beresneva, Z.A.,& Chemeris, A.V. (2017). Hidroponnoe i aeroponnoe vyrashchivanie oduvanchika Taraxacum Kok-saghyz Robin [Hydroponic and aeroponic cultivation of dandelion Taraxacum Kok-saghyz Rodin]. *Bionika — Bionica, 9(2)*, 96–100 [in Russian].

8 Kubareva, L.S. (1969) Vliianie sootnoshenii kaliia i kaltsiia v pitatelnoi srede na razvitie i produktivnost tomatov i fasoli [Influence of potassium and calcium ratios in the nutrient medium on the development and productivity of tomatoes and beans]. *Extended abstract of candidate's thesis*. Moscow [in Russian].

9 Ishmuratova, M.Ju., Sirman, D.Ju., Akkulova, Z.G., & Almusin, G.T. (2016). Otsenka vliianiia polihuminovykh udobrenii na vskhozhest semian nekotorykh tsvetochnykh kultur [Evaluation of the effect of polygumin fertilizers on the germination of seeds of certain flower crops]. Proceedings from Topical issues of ecology and biotechnology: *Khalyqaralyq gylymi konferentsiiasy — International Scientific Conference* (pp. 54–57). Karaganda [in Russian].

10 Antipova, A. (2010) Tekhnolohicheskoe obosnovanie kulturooborotov v hidroponnykh rassadnykh kompleksakh [Technological justification of the cultivation in the seedling hydroponic systems]. *Extended abstract of candidate's thesis*. Moscow [in Russian].