Effect of organic – mineral substrates on tomato fruits biochemical composition and yield in low volume hydroponic growing in a South-east Kazakhstan

Guljan Kusainova

Abstract: *The article presents results of scientific research of mineral, organic and organic-mineral mixes substrates effect on quality, yield and economical efficacy of tomato crop in greenhouse growing. Studies have shown an advantage to domestic import substrates.*

Key words: *tomato, greenhouse, mineral, organic, organic – mineral, substrates*

INTRODUCTION

Now in agrarian manufacture by the primary goal introduction resource-saving, ecologically safe technologies of agricultural crops cultivation is. Use of elements resource-saving technologies at cultivation of agricultural crops gives the chance to lower essentially expenses of energy for unit of made production.

1. MODERN LINES AND PROSPECTS

Building of greenhouses in Kazakhstan, last years, has got a steady tendency to steady development of greenhouse vegetable growing. The overwhelming area of the protected ground is presented by winter greenhouses in which cultivation of vegetables all year long is possible. The primary goal of greenhouse vegetable growing of Kazakhstan is the increase in manufacture of vegetables during out-of-season time.

Along with a traditional soil substratum (the cespitose earth, humus, manure) the increasing quantity of economy masters technology of vegetable plants cultivation on artificial substrats - organic and mineral.

Traditional hydroponic technology (the pools filled with a substratum and periodically impounded by a nutritious solution) last years it is replaced with a method of cultivation of vegetables on low-volume technology. Its essence consists in placing in a greenhouse of the narrow trays filled by substrates on which from above the nutritious solution periodically moves [1].

Now for cultivation on a low-volume hydroponic method use various substrates. Most widespread of them is peat. But in Kazakhstan peat is not extracted; it is imported, basically, from Russia, Ukraine, Belarus. The second place, on use for hydroponic, mineral cotton wool imported of Finland, the Netherlands occupies. The third place in this list belongs to a coconut shaving which is imported from Sri Lanka, the Netherlands.

Use in low-volume hydroponic the substrata set forth above has also essential lacks. So, recycling of mineral cotton wool after its use is rather problematic. Mineral cotton wool, peat and a coconut shaving – imported materials, their cost and expenses on transportation are imposed on production cost price. Thereof there is a rise in price of vegetable production, and the possible profit on acquisition of substrata remains outside of republic.

Therefore there was a necessity of search of the cheapest substrata, it is preferable from local raw materials. These substrata will be cheap and can be effectively utilised after use.

Last years the tendency to transition of vegetable cultures cultivation in winter greenhouses on various substrata is accurately traced. The working out offered by us will be contribute to maintenance of the population of Kazakhstan with the fresh out-of-season vegetables which have been grown up on substrata from domestic raw materials. Thus one of important questions – import substitution will be solved.

For the first time in Kazakhstan for low volume hydroponic technology of use of cheap substrata from local raw materials is offered. The domestic substrata are established, allowing to receive high, non-polluting crops of a tomato on low-volume hydroponic.

2. SELECTION OF OPTIMUM SUBSTRATA

The hydroponic method of vegetable cultures cultivation has a number of conclusive advantages, however along with them are available also problem among them selection of optimum substrata for root zone.

The material used as a substratum should answer what requirements? It should be substance with following properties:

• Structure with large enough particles which would not get enough sleep between laths of lathing or between grid cells;

• Capable to absorb and keep a water considerable quantity that it was not required to humidify with its nutritious solution daily;

• Steady against decomposition and not capable to rot;

• Chemically neutral, that is such which does not allocate any products, capable to damage to plants, and in any other measure does not influence a nutritious solution [2].

The market economy has not left also a trace from once powerful Soviet agricultural mechanical engineering and years of the turned out scientifically-practical base, - on change by it send the foreign equipment and technologies.

For cultivation on a low-volume hydroponic method various substrata are used. Most widespread of them is peat. However in Kazakhstan peat is not extracted and imported, basically, from Russia, Ukraine and Belarus. On the second place on application for hydroponic mineral cotton wool which is imported from the Netherlands, Denmark, Finland is. The third place in this list belongs to a coconut shaving which is imported from Sri Lanka, the Netherlands and other countries.

Recycling of mineral cotton wool after its use is rather problematic. Besides mineral cotton wool, peat and a coconut shaving - imported materials, their cost and expenses on transportation are imposed on production cost price. Owing to it there is a rise in price of vegetable production, and the possible profit on acquisition of substrata remains outside of republic.

Advancement of foreign technologies has led to that the Kazakhstan greenhouses are completely supplied only with the foreign equipment and materials most volume of which is the substratum. Basically as a substratum mineral cotton wool and a coconut shaving is used, and use of import substrata finally lays down on the cost price of grown up vegetables.

In Russia to this problem have paid attention for a long time. Now the Russian greenhouse economy successfully use as substrata for hydroponic local materials - riding peat from Leningrad region, vermiculite which extract in Murmansk area etc.

In Kazakhstan available and under construction greenhouse complexes basically are calculated on work with the substrata imported from distant and the near abroad. Meanwhile, in Kazakhstan there is a set of sources of mineral and organic substrates.

Now work on selection and definition of an optimum kind of a mineral and organic substrates for tomato cultivation in low-volume hydroponic conditions, providing for the account import substitution, decrease in the cost price and increase of efficiency of a tomato is spent. For the purpose of an establishment of such substrata us in 2012-2014 in a winter film greenhouse of the Kazakh scientific research institute of potato and vegetable growing of manufacture of firm of South Korea «Bokyng greenhouses ltd» which is located on northern slope of Zailijsky Ala Tau at height of 1000-1050 m above sea level was experience is put. Experience was put in a winter greenhouse on cultivation technology by a low-volume hydroponic method.

The agricultural technician in experiences standard for low-volume conditions.

Experience has been spent by the standard classical technique.

Substrata mineral and organic, both import and local manufacture were objects of research. For experience the hybrid of greenhouse tomato F1 of Querido the companies «Rijk Zwaan» (Netherlands) is taken. The mineral have been picked up and prepared: mineral cotton wool, perlite, keramzit; and organic substrata: a coconut shaving, wood sawdust, a rice peel, and also organic-mineral mixes: perlite+ coconut shaving (1:1), perlite+wood sawdust (1:1), perlite+rice peel (1:1), perlite + coconut shaving (1:2), perlite + wood sawdust (1:2), perlite + rice peel (1:2).

Substratum - one of hydroponic method components. Modern hydroponic systems have passed a long way of perfection, beginning from use of river gravel and sand in the very first systems. The ideal environment is capable to keep about an identical quantity of water and air. For a plant it is necessary both oxygen, and a food. Ability of a substratum to keep water and air is defined by space between granules or substratum fibres.

Each of used in low-volume hydroponic substrates can separately be used or in a combination with others for achievement of the best result. For example, the coconut shaving mixed in a proportion 50:50 with perlite, can keep more air, than a pure shaving.

The relative density of mineral substrates equal 2,1-2,8 t/m^3 in 2-2,5 time exceeds relative density of plastic that is reached by swollen degree raw materials at roasting. Porous mineral environments receive or from clay (keramzit, agro perlite), or from firm rock (perlite, vermiculite) by roasting in special furnaces at temperature 1100-1300 ^0C [3].

The nutritious solution in capillaries of porous materials is late better, than in not porous, and is more uniform used by plants.

Water-retaining ability of a substrates depends on quantity, the size and the form of capillaries. In porous substrata besides an open intermodular both intramodular time contain and the closed time isolated in granules which are not informed with an external solution. Especially it is a lot of close pores at perlite; keramzit contains them much less, but concedes vermiculite and porous plastic on volume of through open capillaries. The total amount opened and close pores gives the total porosity which size is closely connected with volume weight root zone.

In Kazakhstan the big natural stocks of perlite, vermiculite; rice manufacture gives, practically anywhere not used, a waste - a rice peel. In a considerable quantity there is also wood sawdust. Therefore search of the vegetable plants of substrates most suitable to growth from local raw materials is rather actual problem of low-volume hydroponic in Kazakhstan.

Carrying out of phenological supervision has revealed distinctions in time of approach of the next phases of tomato plants development depending on a substratum kind. Cultivation of a tomato plants on mineral substrates has shown that at cultivation on mineral cotton wool the introduction into the next phases of development was for 2-3 days later, than on perlite and keramzit.

At cultivation on organic substrates, backlog in the beginning of the next phases of development of plants is noted on a rice peel in comparison with a coconut shaving and wood sawdust.

Tomato cultivation on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) has not revealed distinctions in terms of approach of the next phases of development, and at a parity 1:2 development phases for 1-2 days came in a variant perlite + a coconut shaving earlier.

Studying of biochemical full value of tomato fruits has revealed distinctions in the maintenance of solid, sugars, acids, nitrates and metals depending on a kind of a substratum (table 1). The greatest maintenance of solid, at cultivation on mineral substrates, was in tomato fruits grown on keramzit - 5,6 %, the least - on mineral cotton wool (5,3 %).

Table 1 - the Maintenance of solid, sugars, acids, nitrates and metals in grocery bodies of tomato F1 of Querido on various substrates, (2012-2014)

Variant	Solid, %	Sugar, % on crude substance	Askorbic acid, mg of %	General of acidity on apple acid, %	Nitrates mg/kg	Zinc, mg/kg	Copper, mg/kg
Mineral cotton wool (control)	5,3	3,22	14,44	0,53	32,6	1,03	0,71
Perlite	5,5	3,10	16,27	0,60	32,6	0,98	0,76
Keramzit	5,6	2,77	14,44	0,53	33,5	1,24	0,74
coconut shaving	5,8	2,78	15,94	0,52	32,4	0,91	0,70
wood sawdust	5,3	2,77	15,49	0,52	31,2	1,17	0,71
rice peel	5,4	2,97	16,55	0,54	32,7	1,24	0,81
perlite + coconut shaving (1:1)	6,3	2,99	13,71	0,62	31,8	1,09	0,72
perlite + wood sawdust (1:1)	5,3	2,75	12,74	0,51	33,0	1,12	0,71
perlite + rice peel (1:1)	5,0	2,91	13,98	0,65	34,3	0,94	0,70
perlite + coconut shaving (1:2)	6,0	3,28	10,12	0,58	32,1	0,99	0,80
perlite + wood sawdust (1:2)	7,5	3,22	11,43	0,72	34,5	1,09	0,71
perlite + rice peel (1:2)	7,4	3,66	16,59	0,70	33,7	1,17	0,80

The least maintenance in tomato fruits of ascorbic acid, at cultivation on mineral substrates, was in a variant with mineral cotton wool - 14,44 mg of %, and maximum - in a variant with perlite (16,27 mg of %). At tomato cultivation on organic substrates the minimum maintenance of ascorbic acid was in a variant with wood sawdust - 15,49 mg of %, and maximum - in a variant with a rice peel (16,55 mg of %). Cultivation of tomato plants on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) has shown that the minimum maintenance of ascorbic acid in tomato fruits was in a variant with wood sawdust (12,74 mg of %), and maximum - in a variant with a rice peel (13,98 mg of %). Mix use perlite with a coconut shaving, wood sawdust a rice peel (1:2) promoted accumulation increase in fruits of ascorbic acid in a variant perlite + rice peel - 16,59 mg of %; The least maintenance of ascorbic acid was in a variant perlite + coconut shaving (10,12 mg of %).

Admissible level of the maintenance of nitrates, according to San PiN - 42-123-4619 - 88 and the Dignity PiN 4.01.71.03 [62] in a tomato from the protected ground - 300 mg / kg.

The maintenance of nitrates in the fruits of the tomato which has grown on various substrata in 8,7 - 9,6 times below maximum permissible concentration (maximum concentration limit).

At cultivation of plants on mineral substrates of less zinc accumulated tomato fruits on perlite - 0,98 mg/kg, and it is more - on keramzit (1,24 mg/kg). Cultivation on organic substrates has shown that more zinc accumulated tomato fruits in a variant with a rice peel - 1,24 mg/kg, and it is less - in a variant with a coconut shaving (0,91 mg/kg). The minimum maintenance of zinc in fruits of the plants which are grown up on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) was in a variant perlite + a rice peel - 0,94 mg/kg, and maximum - in a variant perlite + wood sawdust (1,12 mg/kg). Mix use perlite with a coconut shaving, wood sawdust, a rice peel (1:2) promoted accumulation

increase in zinc fruits in a variant perlite + a rice peel (1,17 mg/kg); the least maintenance of zinc was in a variant perlite + a coconut shaving (0,99 mg/kg).

The least maintenance of copper in tomato fruits, at cultivation on mineral substrates, was in a variant with mineral cotton wool - 0,71 mg/kg, and the greatest - in a variant with perlite (0,76 mg/kg). From organic substrates smaller accumulation in tomato fruits of copper was promoted by a coconut shaving - 0,70 mg/kg, and greatest - rice a peel (0,81 mg/kg). Cultivation of a tomato plants on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) has shown that the minimum maintenance of copper collects in variant perlite + rice peel - 0,70 mg/kg, and maximum - in a variant perlite + coconut shaving (0,72 mg/kg). Mix use perlite with a coconut shaving, wood sawdust, a rice peel (1:2) sposobst-vovalo to increase in copper fruits in a variant perlite + coconut shaving and perlite + rice peel - 0,80 mg/kg; the least maintenance of copper was in a variant perlite + wood sawdust (0,71 mg/kg).

Last years with deterioration of an ecological situation, actual there are requirements to reception of non-polluting production of vegetable cultures which do not accumulate some salts of heavy metals, such as lead and cadmium. These metals in the tomato fruits which has grown on various substrates, it is not revealed.

The analysis of the received crop has shown that at tomato cultivation on mineral substrates, the greatest crop in early gathering is received in a variant with perlite - 4,8 kg / м^2, at cultivation on organic substrates - on a coconut shaving (4,5 kg/m^2); at cultivation on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) - in a variant perlite + coconut shaving - 5,3 kg/m^2, are a bit less - in a variant perlite + wood sawdust - 5,1 kg/m^2; at cultivation on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:2) - in a variant perlite + coconut shaving - 6,7 kg/m^2 (table 2).

The yield for vegetation, at tomato cultivation on mineral substrates, the greatest was in a variant with perlite (19,2 kg/m^2), at cultivation on organic substrates - on a coconut shaving (22,7 kg/m^2); at cultivation on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) - in a variant perlite + coconut shaving (23,8 kg/m^2); at cultivation on a mix perlite with coconut shaving - which, wood sawdust, a rice peel (1:2) - in a variant perlite + coconut shaving (32,8 kg/m^2). Mathematical processing of the received data has shown reliability of increases of a crop.

At tomato cultivation on various substrates the average weight of a fruit changed also. So, at cultivation on mineral substrates the largest fruits were on perlite (in early gathering 159 г, for vegetation 121). At tomato cultivation on organic substrates the largest fruits were on a coconut shaving and slightly less - on wood sawdust. At tomato cultivation on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) - in a variant perlite + coconut shaving (in early gathering 139 г, for vegetation - 111); on a mix perlite with a coconut shaving wood sawdust, a rice peel (1:2) - in a variant perlite + coconut shaving (in early gathering 150 г, for vegetation - 106), almost same indicators on weight of a fruit in a variant perlite + wood sawdust (in early gathering 151 г, for vegetation - 103).

Economic efficiency calculation has shown that at tomato cultivation on mineral substrates the greatest net profit is received in a variant with perlite - 2729 tenge/m^2; at cultivation on mineral cotton wool the income has made 5 tenge/m^{2}since expenses for cultivation were almost also, as a gain from production realization. At cultivation on organic substrates the greatest net profit is received, in a variant with wood sawdust (1845 tenge/m^2); in a variant with a coconut shaving and a rice peel of the income it is not received. At cultivation of tomato plants on a mix perlite with a coconut shaving, wood sawdust a rice peel (1:1) the greatest net profit is received in a variant perlite + wood sawdust - 2241 tenge/m^2, and the least in a variant with a rice peel (1528 tenge/m^2). At tomato cultivation on a mix perlite with a coconut shaving wood sawdust, a rice peel (1:2) the greatest net profit is received in a variant perlite + coconut shaving (3465 tenge/m^2).

Table 2 - Productivity of tomato F1 of Querido and its structure (2012-2014)

Variant	Yield from 1 m^2				Yield increase, kg/m^2		Weight of a fruit, g	
	for 3 gathering		for vegetation					
	kg	%	kg	%	the early	for vegetation	in early gathering	for vegetation
Mineral cotton wool (control)	4,3	100	16,0	100	-	-	139	108
Perlite	4,8	111,6	19,2	120,0	0,5	3,3	159	121
Keramzit	2,7	62,8	13,5	84,4	-	-	115	88
coconut shaving	4,5	104,6	22,7	141,9	0,2	6,7	143	102
wood sawdust	4,0	93,0	16,9	105,6	-	0,9	124	94
rice peel	3,4	79,0	11,8	73,8	-	-	111	89
perlite + coconut shaving (1:1)	5,3	123,3	23,8	148,8	1,0	11,8	139	111
perlite + wood sawdust (1:1)	5,1	118,6	17,9	111,9	0,8	1,9	131	102
perlite + rice peel (1:1)	3,6	83,7	16,1	100,6	-	0,1	126	96
perlite + coconut shaving (1:2)	6,7	155,8	32,8	205,0	2,4	16,8	150	106
perlite + wood sawdust (1:2)	3,4	79,1	21,1	131,9	-	5,1	151	103
perlite + rice peel (1:2)	3,5	81,4	16,9	105,6	-	0,9	129	96
HCP 0,5 Sx, %	0,09-0,11 2,1-2,6		0,68 – 0,91 4,1-5,8					

The least cost price of received production of a tomato, at cultivation on mineral substrates, differed perlite - 223,3 tenge/kg; the greatest was in a variant with mineral cotton wool (366,4 tenge/kg). At cultivation on organic substrates the least cost price of a tomato was in a variant with wood sawdust - 253,7 tenge/kg, and the greatest - in a variant with a coconut shaving (381,6 tenge/kg). Cultivation of plants of a tomato on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) has shown that the least cost price of production was in a variant perlite + wood sawdust (239,6 tenge/kg) (table 3).

From mineral substrates the greatest profitability the variant with perlite - 63,6 % differed; profitability at tomato cultivation on keramzit has made 12,5 %, and cultivation on mineral cotton wool has appeared is not profitable. At tomato cultivation on organic substrates are profitable there was wood sawdust (43,0 %) and a rice peel (2,4 %). Tomato cultivation on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:1) has shown that the greatest profitability was in a variant perlite + wood sawdust (52,2 %); at cultivation on a mix perlite with a coconut shaving, wood sawdust, a rice peel (1:2) approximately identical profitability is received in a variant perlite + a coconut shaving (44,9 %) and perlite + wood sawdust (38,5 %). Minimum there was a profitability in a variant perlite + wood sawdust - 46,4 %.

Table 3 - Economic efficiency of tomato F1 Querido cultivation on various substrates (2012-2014)

Variant	Yield, kg/m^2	Gain, tenge/m^2	Expenses for cultivation, tenge/m^2	Net profit, tenge/m^2	Cost price of 1 kg, tenge	Profitability , %
Mineral cotton wool (control)	16,0	5867	5862	5	366,4	-
Perlite	19,2	7017	4288	2729	223,3	36,6
Keramzit	13,5	4826	4288	538	317,6	12,5
coconut shaving	22,7	8207	8662	-	381,6	-
wood sawdust	16,9	6133	4288	1845	253,7	43,0
rice peel	11,8	4393	4288	105	363,4	2,4
perlite + coconut shaving (1:1)	23,8	8576	6476	2100	272,1	32,4
perlite + wood sawdust (1:1)	17,9	6530	4289	2241	239,6	52,2
perlite + rice peel (1:1)	16,1	5817	4289	1528	266,4	35,6
perlite + coconut shaving (1:2)	32,8	11175	7710	3465	235,1	44,9
perlite + wood sawdust (1:2)	21,1	7020	4794	2226	227,2	46,4
perlite + rice peel (1:2)	16,9	5780	4794	986	283,7	20,6

THE CONCLUSION

Thus, tomato cultivation on mineral cotton wool and a coconut shaving has appeared economically not effectively in view of high cost of these imported substrates, and on a rice peel - because of low productivity.

THE LITERATURE

[1]. Bentleys M, Industrial hydroponic, translation from English. M.:Колос, 1965.-p 30
[2]. KazAgroMarketing, the Forecast of the vegetable cultures market development, Astana 2010
[3]. Gerasimovich L.S., etc. Low-volume technology of tomato cultivation on mineral substrates. - Minsk, 2004. - p 38-39.

For contacts:
Kusainova G. S. the candidate of agricultural sciences, the professor, the Kazakh national agriculture university, Almaty, Kazakhstan, e-mail: gulzhan56@yandex.ru

Докладът е рецензиран.