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The influence of various substratum on the quality of cucumber seedlings and photosynthesis parameters

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Cucumber hybrids 'Mandy' were grown in the greenhouse covered with double polymeric film at the Lithuanian Institute of Horticulture in 2004–2006. Cucumber seedlings were grown in different substratum: peat, peat + perlite (1 : 1), peat + perlite (2 : 1), peat + zeolite (1 : 1), peat + zeolite (2 : 1). During the experiment seedling biometrical measurements were carried out, the amount of dry matter and pigments in seedling leaves, photosynthesis productivity was established, cucumber yield calculations were fulfilled. Seedlings grown in peat are higher, have bigger leaf area than the seedlings grown in peat-perlite, peat-zeolite substratum, but in leaves and roots they accumulate less dry matter and plant fresh weight also is smaller. When the amount of zeolite and perlite in peat is smaller, cucumber seedlings accumulate in leaves more photosynthesis pigments. When zeolite is mixed into peat substratum, seedling photosynthesis productivity becomes bigger than this of the cucumbers grown in peat. Nevertheless, the mixing of zeolite and perlite into seedling substratum do not have positive influence on cucumber yield.

Key words: cucumber, dry matter, yield, peat, perlite, photosynthesis pigments, photosynthesis productivity, seedlings, zeolite.

Introduction. Substratum selection is important factor, influencing seedling quality. For the seedling growing, peat of high type most often is used. When growing plants in peat substratum it isn't easy to keep the optimal air-water regime. In order to create the more favourable air-water regime for plants, peat is mixed with perlite, vermiculite et al (Sawan, Eissa, 1996). Zeolites are crystalline, hydrated aluminosilicates of alkali and earth metals that possess infinite, three-dimensional crystal structures. This is ecologically clean, inert and non-toxic substance. It has the ability to absorb and hold plant nutrients due to its crystal lattice structure (Mumpton, 1999). Perlite is derived from siliceous volcanic rock that is crushed and heated to in a furnace 982 °C until it expands to form the white particles that make up perlite. These expanded particles provide for air-filled pore space in a substratum, provide little water-holding capacity, have a negligible cation-exchange capacity and have a pH of approximately 7.5. Perlite is considered chemically inert and has little effect on substratum pH (Thomas, Thomas, 1988).

In the opinion of Russian scientists, one of the most perspective trends of plant-growing is the use of natural zeolite as substratum for seedling and vegetable growing (Перфильева, 1988; 1991). In Russia there are created technologies of cucumber,

tomato and greens growing in zeolite substratum (Постников et al, 1991). Studies with zeolite substratum were carried out in other countries – Bulgaria, Greece, Yugoslavia, UK, etc. (Harland et al, 1999; Mumpton, 1999; Stamatakis et al, 2001). Markovic et al compared different substratum for pepper seedling production – compost, peat and enriched zeolites (Markovic et al., 1994). Manolov and other scientist investigated the possibilities for growing of vegetable seedlings in zeolite substratum based on Jordanian zeolitic tuff and compared it with zeolite substratum based on Bulgarian zeolite (Manolov et al, 2005). Cattivello investigated the possibilities of zeolite use for the growing of vegetable seedlings and pot plants. Zeolite didn't influence positively the quality of lettuce, tomato, and melon seedlings and the earliness of yielding. Cyclamen and primroses grew better when 7 % of zeolite was mixed into substratum (Cattivello, 1995).

Perlite is widely used for the rooting of decorative plants, flower growing, also in the mixture with peat when growing flower seedlings and in small-volume vegetable growing technology (Arenas et al., 2002; Grillas et al., 2001). The possibilities of the use of zeolite and perlite as the ingrediens of substratum for seedling growing, are still not investigated in Lithuania.

The aim of the study is to establish the influence of zeolite and perlite mixed into peat substratum on the development of cucumber seedlings, photosynthesis productivity and total yield.

Object, methods and conditions. Investigations were carried out in the greenhouse covered with polymeric film at the Lithuanian Institute of Horticulture in 2004–2006. Cucumber seedlings were grown in polymeric pots with prepared peat substratum. Sowing time – the beginning of February. Cucumber seedlings were grown in seed-plot on boards, the duration of growing – 30 days. The object of investigation – hybrid 'Mandy'. Seedlings were grown in different substratum: a_0 – peat, a_1 – peat + perlite (1 : 1), a_2 – peat + perlite (2 : 1), a_3 – peat + zeolite (1 : 1), a_4 – peat + zeolite (2 : 1). Seedlings were planted in the greenhouse in the middle of March. In the greenhouse plants were grown in 25 l capacity peat bags (1 bag – 2 plants). Plant density – 2.5 plant. m^{-2}. In the greenhouse cucumbers were fertilized with "Nutrifol" (green and brown), magnesium sulphate, calcium and ammonium nitrate taking into account the stage of growth. For water souring there was used nitrogen acid. Salt concentration in the nutritional solution – EC 2.5–2.8, acidity – pH 5.5–5.8. The end of cucumber vegetation – the middle of June. Area of record plot – 4.8 m^2. The trial was established in randomized block design with three replications.

During investigation seedling biometrical observations were carried out, amount of pigments and dry matter in seedling leaves and photosynthesis productivity were established. The amount of photosynthesis pigments in fresh weight was established preparing 100 % acetone extracts and analyzing them by spectrophotometrical Wettstein's method (Wettstein, 1957). There was used spectrophotometer Genesys 6 (Thermospectronic, JAV). Assimilation area was measured with leaf area measurer CI-202 (CID Inc., USA). Plant dry weight was established drying at the temperature of 105 °C.

Pure photosynthesis productivity (F_{pr}) was calculated according to the formula:

$F_{pr} = 2(M_2 - M_1) / (L_1 + L_2)T$ (1)

Here $(M_2 - M_1)$ – increase of dry weight during certain period; L_1 and L_2 – leaf area at the beginning and at the end of the period; T – duration of period 24 h (Bluzmanas et al, 1991). There was carried out cucumber yield calculation. Cucumbers were picked for three times per week and sorted into standard and not standard. Yield data was processed by statistical methods (Tarakanovas, Raudonius, 2003).

Results. Cucumber seedlings grown in peat were 36.5 % higher than the seedlings grown in peat-zeolite (2 : 1) substratum (essential difference) and 30.1 % higher than the seedlings grown in peat-zeolite (1 : 1) substratum (Table 1). Cucumber seedlings grown in peat also were higher than the seedlings grown in peat-perlite substratum. They were 35.7 % higher then seedlings grown in peat-perlite (2 : 1) substratum (essential difference) and 17.0 % higher than the seedlings grown in peat-perlite (1 : 1) substratum. The lowest seedlings were of plants grown in peat-zeolite (2 : 1) substratum. The biggest number of leaves formed the seedlings, which were grown in peat-perlite (1 : 1) substratum. Seedlings grown only in peat formed the biggest leaf area. When it was mixed perlite and zeolite into peat substratum, leaf area was smaller thant this of seedlings grown in peat. But when perlite was inserted into peat substratum, leaf area was bigger than this of seedlings grown in peat-zeolite substratum. Seedlings grown in peat enriched with zeolite and perlite (with the exception of peat-perlite (2 : 1) substratum) produced the bigger plant and root fresh weight.

Table 1. Biometric data of cucumber seedlings grown in the different substratum

1 lentelė. Agurkų daigų, augintų skirtinguose substratuose, biometrija

Indices Rodikliai	Peat Durpė	Peat + perlite Durpė + perlitas (1 : 1)	Peat + perlite Durpė + perlitas (2 : 1)	Peat + zeolite Durpė + ceolitas (1 : 1)	Peat + zeolite Durpė + ceolitas (2 : 1)	LSD_{05} R_{05}
Plant height Augalo aukštis (cm)	39.38	33.65	29.01	30.26	28.84	10.23
Diameter of steam Stiebo skersmuo (cm)	6.88	6.60	6.60	6.56	6.71	0.31
Number of leaves (unit) Lapų skaičius, vnt.	5.80	5.73	6.16	5.5	5.49	0.96
Leaf area Lapų asimiliacinis plotas (cm^2)	598.90	534.25	529.09	525.07	518.93	133.18
Fresh weight of plant Žalioji augalo masė (g)	50.87	54.71	45.74	55.8	53.99	13.95
Root weight Šaknų masė (g)	13.22	21.64	15.01	22.36	22.65	13.89

Cucumber seedlings grown in peat-zeolite (1 : 1) substratum the biggest amount of dry matter accumulated in leaves and roots (Fig. 1). Their amount was correspondingly 3.7 % bigger than this in the leaves of seedlings grown in peat and 1.6 times bigger than in the roots of seedlings grown in peat. Cucumber seedlings grown in peat-zeolite and peat-perlite substratum accumulated in roots more dry matter than these grown in peat. Seedlings grown in peat-perlite (2 : 1) substratum accumulated the least amount

of dry matter. Seedlings grown in peat-perlite substratum accumulated in roots more dry matter than these grown in peat-zeolite substratum.

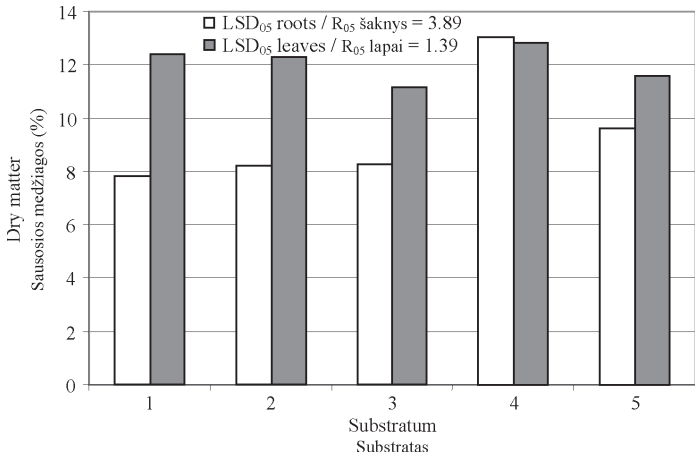

Fig. 1. The amount of dry matter in leaves and roots of cucumber seedlings grown in the different substratum: 1 – peat; 2 – peat + perlite (1 : 1); 3 – peat + perlite (2 : 1); 4 – peat + zeolite (1 : 1); 5 – peat + zeolite (2 : 1)

1 pav. Sausųjų medžiagų kiekis agurkų daigų, augintų skirtinguose substratuose, šaknyse bei antžeminėje dalyje: 1 – durpė; 2 – durpė + perlitas (1 : 1); 3 – durpė + perlitas (2 : 1); 4 – durpė + ceolitas (1 : 1); 5 – durpė + ceolitas (2 : 1)

Seedlings grown in peat-zeolite (2 : 1) substratum accumulated in leaves the biggest amount of chlorophylls (Table 2).

Table 2. Chlorophyll contents in the leaves of cucumber seedlings grown in different substratum

2 lentelė. Chlorofilų kiekis agurkų daigų, augintų skirtinguose substratuose, lapuose

Treatment Variantas	Chlorophyll contents, mg g^{-1} fresh weight Chlorofilų kiekis, mg g^{-1} žalios masės			
	a	*b*	*a* + *b*	*Ca* / *Cb*
Peat Durpė	0.98 abc	0.33 ab	1.31 abc	3.03 ab
Peat + perlite Durpė + perlitas (1 : 1)	0.86 a	0.28 ab	1.14 a	3.14 ab
Peat + perlite Durpė + perlitas (2 : 1)	0.93 abc	0.30 ab	1.23 abc	3.19 b
Peat + zeolite Durpė + ceolitas (1 : 1)	0.93 abc	0.30 ab	1.23 abc	3.11 ab
Peat + zeolite Durpė + ceolitas (2 : 1)	1.12 ac	0.37 b	1.49 c	3.05 ab

* – Values indicated by the same letters within the columns are not statistically different at $P \geq 0.05$.

* – Tomis pačiomis raidėmis skiltyse pažymėti skaičiai iš esmės nesiskiria, kai $P \geq 0,05$.

There was more 13.7 % of them than in the leaves of seedlings grown in peat. Nevertheless, the ratio of chlorophylls *a* and *b* was the same as in the leaves of cucumbers grown in peat. Cucumber seedlings grown in peat-perlite and peat-zeolite

(1 : 1) substratum accumulated in leaves less chlorophylls than seedlings grown in peat. Nevertheless, the ratio of chlorophylls *a* and *b* was the bigger in the leaves of cucumber grown in various substratum than this in the leaves of seedlings grown only in peat.

The amount of carotenoids in the leaves of cucumber seedlings grown in peat-zeolite substratum (2 : 1) was 11.4 % bigger than this in the leaves of seedlings grown only in peat (Fig. 2). In the leaves of cucumber grown in peat-perlite (2 : 1) substratum there was as much carotenoids as in the leaves of seedlings grown in peat, but after insertion of the bigger amount of perlite (1 : 1), the amount of carotenoids in leaves decreased.

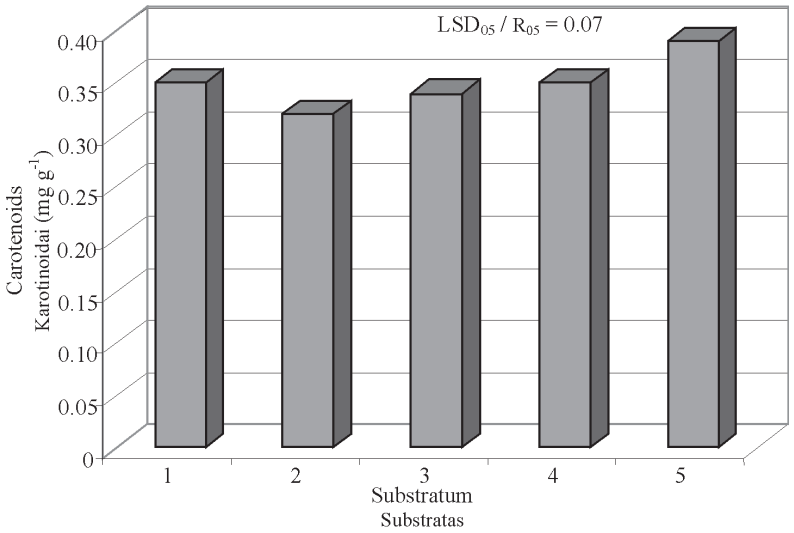

Fig. 2. Carotenoid content in the leaves of cucumber seedlings grown in the different substratum: 1 – peat; 2 – peat + perlite (1 : 1); 3 – peat + perlite (2 : 1); 4 – peat + zeolite (1 : 1); 5 – peat + zeolite (2 : 1)

2 pav. Karotinoidų kiekis agurkų daigų, augintų skirtinguose substratuose, lapuose: 1 – durpė; 2 – durpė + perlitas (1 : 1); 3 – durpė + perlitas (2 : 1); 4 – durpė + ceolitas (1 : 1); 5 – durpė + ceolitas (2 : 1)

The bigger amount of zeolite and perlite (1 : 1) determines the fact that cucumber seedlings accumulate in leaves smaller amount of pigments, i. e. chlorophylls and carotenoids, but in roots and leaves accumulate more dry matter. When the amount of zeolite or perlite in peat is less (2 : 1), cucumber seedlings accumulate in leaves more pigments and less dry matter.

Photosynthesis productivity was the biggest one of the seedlings grown in peat-zeolite (1 : 1) substratum (Fig. 3). It was 1.5 times bigger than this of seedlings grown in peat. Photosynthesis productivity of seedlings grown in peat-zeolite (2 : 1) and

peat-perlite (1 : 1) substratum also was bigger than this of seedlings grown in peat. Photosynthesis productivity of seedlings grown in peat-perlite (2 : 1) substratum was almost the same as this of seedlings grown in peat. When there was mixed bigger amount of perlite and zeolite into peat substratum (1 : 1), seedling photosynthesis productivity was bigger than in the case of smaller amount of zeolite and perlite in peat, i. e. 2 : 1.

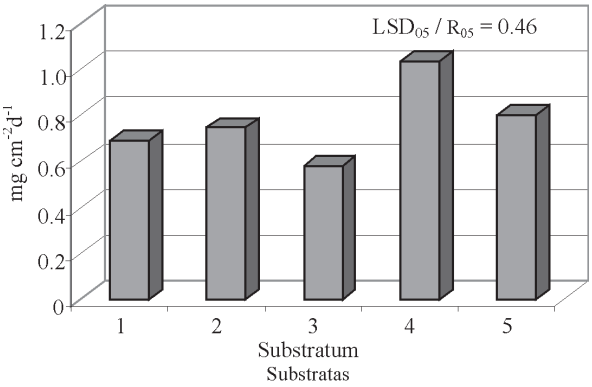

Fig. 3. Photosynthesis productivity of cucumber seedlings grown in the different substratum: 1 – peat; 2 – peat + perlite (1 : 1); 3 – peat + perlite (2 : 1); 4 – peat + zeolite (1 : 1); 5 – peat + zeolite (2 : 1)

3 pav. Agurkų daigų, augintų skirtinguose substratuose, fotosintezės produktyvumas: 1 – durpė; 2 – durpė + perlitas (1 : 1); 3 – durpė + perlitas (2 : 1); 4 – durpė + ceolitas (1 : 1); 5 – durpė + ceolitas (2 : 1)

The mixing of perlite and zeolite into peat substratum didn't influence positively cucumber yield (Fig. 4).

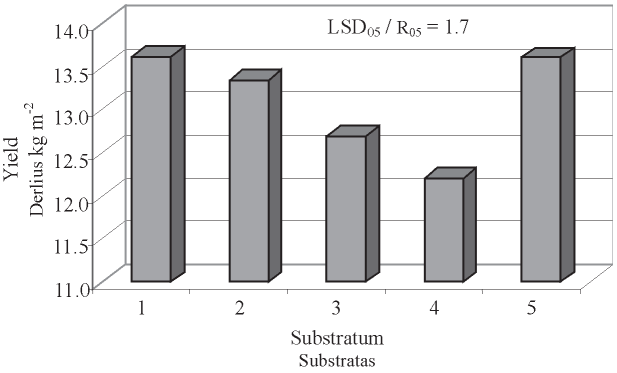

Fig. 4. Total yield of cucumbers which seedlings were grown in different substratum: 1 – peat; 2 – peat + perlite (1 : 1); 3 – peat + perlite (2 : 1); 4 – peat + zeolite (1 : 1); 5 – peat + zeolite (2 : 1)

4 pav. Agurkų, kurių daigai auginti skirtinguose substratuose, suminis derlius: 1 – durpė; 2 – durpė + perlitas (1 : 1); 3 – durpė + perlitas (2 : 1); 4 – durpė + ceolitas (1 : 1); 5 – durpė + ceolitas (2 : 1)

The yield of cucumber, which seedlings were grown in peat-zeolite (2 : 1) substratum, was the same as this of the plants, which seedlings were grown in peat. The yield of cucumber, which seedlings were grown in peat-zeolite (1 : 1) and peat-perlite (2 : 1) substratum, was smaller than this of cucumber, which seedlings were grown only in peat.

Discussion. The selection of substratum influences not only seedlings quality, but also plant yield, the earlines of their yielding and fruit quality (Lopez et al., 2004). Zeolite and perlite is used as the addition of other peat substratum. According to the data of Arenas and other scientists, the mixing of perlite, vermiculite, coco fibers into peat substratum influenced tomato development. Seedlings grown in peat-vermiculite and peat-perlite substratum had bigger root weight, stem diameter, leaf area (Arenas et al., 2002). The data of other scientists showed that the highest seedling quality was achieved using the mixture of substratum, peat (2/3) and enriched zeolite (1/3) (Markovic et al., 1995). Pepper seedlings grown in peat substratum, enriched with 1/3 zeolite, were higher, had more leaves and dry matter (Markovic et al., 2000). The amount of zeolite also influences seedling growth and development. Stem diameter, leaf area and dry weight of seedlings increased with the increased amount of zeolite (Song et al., 2004). According to the data of Güler et al, tomato seedlings grown in peat-perlite and other substratum and grown only in peat were the same (Güler, Büyük, 2007). According to the data of Eltez and other scientists, the seedlings of aubergine and pepper grown in peat-perlite substratum didn't differe from seedlings grown in peat (Eltez et al., 1994). According to the data of Demirer and Kuzucu investigations, perlite positively influenced the growth and development of lettuce, cucumber, tomato seedlings (Demirer, Kuzucu, 2000). According to the data of our investigation, zeolite and perlite, mixed into peat substratum influenced biometrical parameters of seedlings. Cucumber seedlings grown in peat-perlite and peat-zeolite substratum were lower and had smaller leaf area thant the seedlings grown in peat. Seedlings grown in peat-perlite and peat-zeolite substratum had bigger fresh weight.

In order to evaluate the influence of the used substratum on seedlings it was established the amount of photosynthesis pigments in green cucumber leaves. The amount of chlorophylls in plant leaves is one of the parameters of potential productivity. It is often used in order to established as some method of growing and environmental conditions influence plant photosynthesis system. If growth conditions aren't suitable chlorophylls concentration and the ration of chlorophylls *a* and *b* decreases. Chlorophyll *a* is more important to photosynthesis process. It more quickly reacts to the changing environmental conditions (Gabryś et al., 1998; Hay, Andrew, 1989). Addition of zeolite to the substratum also had some effects on the photosynthetic pigment contents, photosynthetic parameters (Song et al., 2004). According to the data of Güler and other scientists, the amount of chlorophylls in the leaves of cucumber seedlings grown in peat-perlite (1 : 1) substratum was smaller than this of the leaves of seedlings grown in peat (Güler, Büyük, 2007). In our investigations the addition of perlite in peat also slightly inhibited the synthesis of photosynthesis pigments. Small amount of zeolite (peat:zeolite 2 : 1) stimulated the synthesis of these pigments in the leaves of cucumber seedlings. The amount of perlite and zeolite in peat influenced the amount of photosynthesis pigments in leaves. When the bigger amount of zeolite was mixed into

peat substratum (1 : 1), cucumber seedlings accumulated in leaves more carotenoids. When zeolite and perlite was mixed into peat (ratio 1 : 1), the amount of chlorophylls in cucumber leaves was smaller. When the ratio of peat and zeolite was 2 : 1, the amount of chlorophylls in leaves was bigger than this in the leaves of seedlings grown in peat. The mixing of zeolite into peat substratum increased net photosynthesis productivity. The amount of photosynthesis pigments and photosynthesis productivity are one of plant productivity parameters, which influence their final productivity. According to the data of some scientists, when zeolite is mixed into seedling substratum, there was obtaines bigger pepper yield (Markovic et al., 2000). According to the data of our investigations, seedling growing in peat-zeolite substratum didn't increase cucumber yield. Even though cucumber seedlings grown in peat-perlite substratum didn't distinguished themselves with bigger amount of photosynthesis pigments or photosynthesis productivity, the yield of these seedlings was similar to this one of plants, which seedlings were grown in peat.

Cucumber seedlings grown in peat-perlite and peat-zeolite substratum are compact, have smaller leaf area, but their above-ground and root weight is bigger than this of seedlings grown in peat. The bigger amount of zeolite and perlite (1 : 1) in peat determines the fact that cucumber seedlings accumulate in leaves smaller amount of pigments, but in roots and leaves accumulate more dry matter. When the amount of zeolite or perlite in peat is less (2:1), cucumber seedlings accumulate in leaves more pigments and less dry matter.

Conclusions. 1. Cucumber seedlings grown in peat substratum were higher, had bigger leaf area than the seedlings grown in peat-perlite and peat-zeolite substratum, but the seedlings grown in peat-zeolite (1 : 1 and 2 : 1) and peat-perlite (1 : 1) substratum had bigger fresh weight and root weight.

2. Cucumber seedlings grown in peat-zeolite and peat-perlite substratum accumulated in leaves and roots more dry matter than the seedlings grown only in peat.

3.The addition of perlite in peat decreased the synthesis of photosynthesis pigments, and small amount of zeolite (peat:zeolite 2 : 1) stimulated the synthesis in the leaves of cucumber seedlings.

4. The biggest photosynthesis productivity was in the substratum of seedlings grown in peat-zeolite (1 : 1).

5. The mixing of perlite and zeolite into substratum of seedlings didn't influence positively cucumber yield.

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Parengta spausdinti 2008 04 28

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Įvairių substratų įtaka agurkų daigų kokybei bei fotosintetiniams rodikliams

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Santrauka

Darbo tikslas – nustatyti ceolito bei perlito, įmaišyto į durpių substrata, įtaką agurkų daigų vystymuisi bei fotosintezės produktyvumui ir suminiam derliui. 2004–2006 m. Lietuvos sodininkystės ir daržininkystės institute dviguba polimerine plėvele dengtame šiltnamyje auginti ‘Mandy’ hibridiniai agurkai. Agurkų daigai auginti skirtinguose substratuose: durpė, durpė + perlitas (1 : 1), durpė + perlitas (2 : 1), durpė + ceolitas (1 : 1), durpė + ceolitas (2 : 1). Bandymo metu atlikti daigų biometriniai matavimai, nustatytas sausųjų medžiagų, pigmentų kiekis daigų lapuose, nustatytas fotosintezės produktyvumas, atlikta agurkų derliaus apskaita. Daigai, auginti durpėje, yra aukštesni, turi didesnį lapų asimiliacinį plotą negu daigai, auginti durpių-perlito, durpių-ceolito substratuose, tačiau jie lapuose ir šaknyse kaupia mažiau sausųjų medžiagų, žalia augalo masė taip pat yra mažesnė. Kai ceolito ir perlito kiekis durpėje yra mažesnis, agurkų daigai lapuose kaupia daugiau fotosintezės pigmentų. Į durpių substratą įmaišius ceolitą, daigų fotosintezės produktyvumas didesnis negu augintų durpėje. Tačiau ceolito bei perlito įmaišymas į daigų substratą neturi teigiamos įtakos agurkų derliui.

Reikšminiai žodžiai: agurkai, ceolitas, daigai, derlius, durpės, fotosintezės pigmentai, fotosintezės produktyvumas, perlitas, sausosios medžiagos.