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Influence of growth regulators on seed germination energy and biometrical parameters of vegetables

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Influence of growth regulators on seed germination energy and biometrical parameters of vegetables was investigated at the Lithuanian Institute of Horticulture in 2007. The seeds of cucumber 'Krukiai' F1, red beet 'Joniai', radish 'Babtų žara', tomato 'Arvaisa' F1 were soaked in the solutions of growth regulators Biojodis, Biokal 01, Bioforce, Agronom effect, Inzar, Oksichumat, Penergetic p. Control – the seeds soaked in water. After soaking seeds were sown into multicell flats, in which plants were grown for 30 days in greenhouse. It was established seed germination energy and seedling biometrical measurements (plant height, weight, leaf number, leaf area) were carried out. Plant growth regulators Oksichumat, Agronom effect, Bioforce, Penergetic p positively influenced seed germination energy of radish, tomato and the growth and development of cucumber, red beet, tomato and radish seedlings.

Key words: biometrical parameters, cucumber, germination energy, growth regulator, radish, red beet, seedlings, seed soak, tomato.

Introduction. Plant growth regulators are widely applied in the integrated plant growing for seed soaking. In vegetable growing, growth regulators also became more popular: for seed soaking, inflorescences spraying, shoot and plant watering or spraying through leaves. Growth regulators improve seed germination power, increase yield, plants become resistant to diseases and unfavourable growth conditions, produce yield earlyer, the yield becomes more qualitative (Halter et al., 2005; Kadiri et al., 1997; Papadopoulos et al., 2006; Saglam et al., 2002; Гущина, Кърдев, 1987). There are a lot of various growth regulators: Ivin, Natrium gumat, Uetinas, Ambiol, Biozin, Gibersib, Epin, Silk, ЭБФ-5, Oxydat, Penergetic p. They are of natural orign or synthetic. Kadiri et at. (1997) investigated the influence of natural growth regulators Indole-3-acetic, Gibberellic acid and Coconut milk on plant height, yield and the amount of vitamin C in fruits. It was established that applying these growth regulators plants were higher and the yield increased (Kadiri et al., 1997). According to the data of investigations, growth regulator Atonic not only increased the yield of sweet pepper, but also improved seed quality (Panajotov, 1997).

Plant growth regulators are being used in greenhouses too. It was established that spraying tomatoes with Ruvit for three times during vegetation they started earlyer

produce yield, the early and total yield increased (Гущина, Кърдев, 1987). In greenhouse spaying plants with Kinetin, the yield becomes more abundant and fruits – bigger (Papadopoulos et al., 2006). According to the data of the other investigators, the application of various biostimulators on cucumber in greenhouses positively influences plant growth (Boehme et al., 2005). There was investigated the influence of growth regulators mixed into fertilizator solution on plant productivity (Bugbee, White, 1984; Lopez-Elias et al., 2005). Moreover, there was investigated the influence of different growth regulators and their mixtures on plant productivity (Brocklehurst et al., 1982). Besides, growth regulators are being widely used for vegetable and flower seed soaking (Brigard et al., 2006; Magnitskiy et al., 2006; Pasian, Bennett, 1999).

The aim of the study – to establish the influence of various natural growth regulators on vegetable seed germination power and shoot development.

Object, methods and conditions. Investigations were carried out at the Lithuanian Institute of Horticulture, in greenhouse covered with double polymeric film in 2007. The object of investigation – vegetable seeds: cucumber 'Krukiai' F_1, red beet 'Joniai', radish 'Babtų žara', and tomato 'Arvaisa' F_1. For seed soaking these organic praparations were used: Biojodis, Biokal 01, Bioforce, Agronom effect, Inzar, Oksichumat, Penergetic p. Control – seeds soaked in water. Biojodis – preparation made on the basis of biohumus water extract, enriched with biologically active iodine, biotransformators and microelements. Biokal 01– fertilizer made out of medicinal herbs (57 %), biohumus extracts (38 %), mineral water, essential oils, macro- and microelements (5 %). Oksichumat – 10 % solution of huminic acids obtained out of peat or brown carbon. Penergetic-p – bioactivator, which activates plant cells participating in metabolism. Bioforce – extract out of *Ascophyllum nodosum* sea herbs. Agronom effect – plant growth stimulator, in the composition of which there is not less than 700 g kg^{-1} of huminic acids salt, also silicon salt and microelements. Inzar – growth regulator, in the composition of which there is not less than 100 g 1^{-1} of Maidenhair tree (*Ginkgo biloba*) extract.

Preparation of solutions for seed soaking and duration of seed soaking. 0.5 g of Agronom effect preparation was dissolved in 2 l of water and seeds were soaked in this solution for 6 h. 1 ml of Oksichumat was purred into 1 l of water and seeds were soaked in this solution for 10 h. Biokal 01 solution was prepared as follows: 3 parts of Biokal 01 solution + 10 parts of water. In this solution seeds were soaked for 48 h. 2 g of Penergetic p were solved in 1 liter of water and in this solution seeds were soaked for 10 h. In Biojodis solution seeds were soaked for 10 h. 0.8 ml of Bioforce was purred into 1 l of water and seeds were soaked in this solution for 8 h. 1 ml of Inzar was purred into 0.5 l of water and seeds were soaked in this solution for 8 h.

There was established germination energy of seeds soaked in the investigated solutions. Seeds were put into Petri plates (10 seeds per each) and moistened with the prepared solutions. After five days there were calculated germinated seeds. Seed germination energy was expressed in percents. After soaking the remained seeds were dried. Multicell flats (cup volume – 60 ml, in the flat – 64 cups) were filled with the prepared peat substratum (deacidified pH 5.5–6.5with fertilizers) and vegetable seeds soaked in various solutions were sown in them. Plants were grown in flats for 3 weeks. Then there was measured plant height, leaf assimilation area; there were calculated

leaves and plant fresh weight established (weighting them). Leaf assimilation area was measured with leaf area measurer Win DIAS (Delta-T Devices, England). There were measured 10 plants per each variant. Experiment was carried out in three replications. Data processed by statistical methods (Tarakanovas, Raudonius, 2003).

Results. Plant growth regulators didn't influence positively germination energy of cucumber 'Krukiai' F_1 and tomato 'Arvaisa' F_1 seeds (Table 1). Nevertheless, germination energy of radish seeds soaked in plant growth regulator solutions was better than this of seeds soaked in water. Radish seeds soaked in solutions Bioforce, Biokal, and Penergetic p were distinguished for faster germination energy than seeds soaked in water.

Table 1. Germination energy of vegetable seeds soaked in growth regulator solutions (%)
1 lentelė. Daržovių sėklų, mirkytų įvairiuose augimo reguliatoriuose, dygimo energija, %

Growth regulator Augimo reguliatorius	Cucumber Agurkai 'Krukiai' F_1	Red beet Raudonieji burokėliai 'Joniai'	Radish Ridikėliai 'Babtų žara'	Tomato Pomidorai 'Arvaisa' F_1
Water Vanduo	100	90	70	100
Agronom effect	100	100	70	100
Biojodis	100	100	100	100
Bioforce	90	20	70	100
Biokal 01	100	20	90	100
Inzar	100	10	90	90
Oksichumat Oksigumatas	90	70	80	40
Penergetic p	100	90	90	40

Cucumber, which seeds were soaked in solutions Agronom effect, Biojodis, Bioforce, Inzar and Penergetic p, developed slightly faster than these, which seeds were soaked in water. They already had third real leaf, while cucumber, which seeds were soaked in water, had only two real leaves. Growth regulators Agronom effect, Bioforce, Inzar and Penergetic p mostly influenced cucumber height, fresh weight and leaf assimilation area (Table 2). Cucumber shoots, which seeds were soaked in solution Agronom effect, were 33 % higher, their fresh weight was 43.4 % bigger, and leaf assimilation area was two times bigger than this of schoots, which seeds were soaked in water.

Red beet, which seeds were soaked in solutions Agronom effect, Bioforce, Inzar and Penergetic p, were correspondingly 20.9 %, 32.9 %, 21.9 % and 14.2 % higher than shoots, which seeds were soaked in water (Table 2). The biggest fresh weight and leaf assimilation area was of shoots, which seeds were soaked in solutions Biojodis and Bioforce. It was correspondingly 31.9 and 10.8 %, 19.9 and 21.9 % bigger than this of shoots, which seeds were soaked in water. Red beet, which seeds were soaked in these solutions, developed faster: they already had third real leaf, while other shoots had only two real leaves.

Table 2. Biometrical data of seedlings, which seeds were soaked in growth regulator solutions

2 lentelė. Daržovių daigų, kurių sėklos mirkytos skirtinguose augalų augimo reguliatorių tirpaluose, biometrija

Growth regulator Augalų augimo reguliatorius	Plant height Augalo aukštis (cm)	Fresh weight of plant Augalo žalioji masė (g)	Leaf assimilation area Lapų asimiliacinis plotas (cm^2)
1	*2*	*3*	*4*
	Cucumber Agurkai 'Krukiai' F_1		
Water Vanduo	12.11 c*	4.22 c	51.80 c
Agronom effect	16.17 e	6.05 f	103.97 f
Biojodis	9.69 b	3.76 b	53.70 c
Bioforce	14.30 a	5.74 e	87.36 e
Biokal 01	9.05 b	2.33 a	41.97 b
Inzar	12.75 c	5.19 d	98.50 f
Oksichumat Oksigumatas	5.92 a	1.53 a	24.70 a
Penergetic p	13.50 c d	5.73 e	68.40 d
	Red beet Raudonieji burokėliai 'Joniai'		
Water Vanduo	12.75 b	1.66 c	35.08 d
Agronom effect	15.42 c	0.88 b	22.45 b
Biojodis	13.05 b	2.19 e	38.88 de
Bioforce	16.95 d	1.99 d	42.78 f
Biokal 01	10.62 a	0.83 b	17.73 b
Inzar	15.54 c	1.09 b	23.98 b
Oksichumat Oksigumatas	9.67 a	0.59 a	13.51 a
Penergetic p	14.56 c	1.58 c	28.42 c
	Radish Ridikėliai 'Babtų žara'		
Water Vanduo	14.51 d	2.77 c	87.50 c
Agronom effect	14.49 cd	2.45 a	73.31 b
Biojodis	14.27 cd	2.54 ab	80.83 c
Bioforce	15.20 e	2.75 c	74.95 b
Biokal 01	12.27 b	2.25 a	65.08 a
Inzar	16.22 a	3.48 e	118.10 e
Oksichumat Oksigumatas	13.65 c	3.25 d	126.60 e
Penergetic p	15.40 e	3.73 f	111.65 d

1	2	3	4
	Tomato Pomidorai 'Arvaisa' F_1		
Water	11.87 c	2.38 d	58.57 d
Vanduo			
Agronom effect	14.85 f	2.42 d	57.01 d
Biojodis	11.65 c	2.22 c	68.38 e
Bioforce	13.40 e	2.48 de	57.85 d
Biokal 01	7.80 b	1.06 b	42.81 b
Inzar	12.75 d	2.45 e	42.09 b
Oksichumat	6.25 a	0.60 a	29.65 a
Oksigumatas			
Penergetic p	12.42 d	2.11 c	51.69 c

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

* Ta pačia raide pažymėtos reikšmės statistiškai nesiskiria, kai $P \leq 0,05$

Radish, which seeds were soaked in the investigated plant growth regulator solutions, grew and developed equally in comparison with these, which seeds were soaked in water. Radish, which seeds were soaked in solutions Bioforce, Inzar and Penergetic p, were correspondingly 4.7 %, 11.8 % and 6.1 % higher than these, which seeds were soaked in water (Table 2).

The biggest fresh weight was of the plants, which seeds were soaked in solution Penergetic p. The biggest rootcrop produces plants, which seeds were soaked in solutions Biojodis and Inzar (Fig.).

It was correspondingly 15.1 % and 16.4 % bigger than this of plants, which seeds were soaked in water. The biggest leaf assimilation area was of plants, which seeds were soaked in solution Oksichumat. It was 44.7 % bigger than this of plants, which seeds were soaked in water.

Agronom effect, Bioforce, Inzar, Penergetic p positively influenced shoot height and fresh weight of tomato 'Arvaisa' F_1, but the biggest leaf assimilation area was of tomato shoots, which seeds were soaked in Biojodis solution (Table 2). The height of shoots, which seeds were soaked in preparations Agronom effect, Bioforce, Inzar, was correspondingly 25.3 %, 13.1 %, 7.6 % and 4.8 % bigger than this of shoots, which seeds were soaked in water. Seed soaking in plant growth regulator solutions didn't influence positively tomato leaf assimilation area: it was smaller than this of shoots, which seeds were soaked in water (with the exception of shoots, which seeds were soaked in Biojodis solution). Leaf assimilation area of shoots, which seeds were soaked in Biojodis solution, was 16.7 % bigger than this of shoots, which seeds were soaked in water.

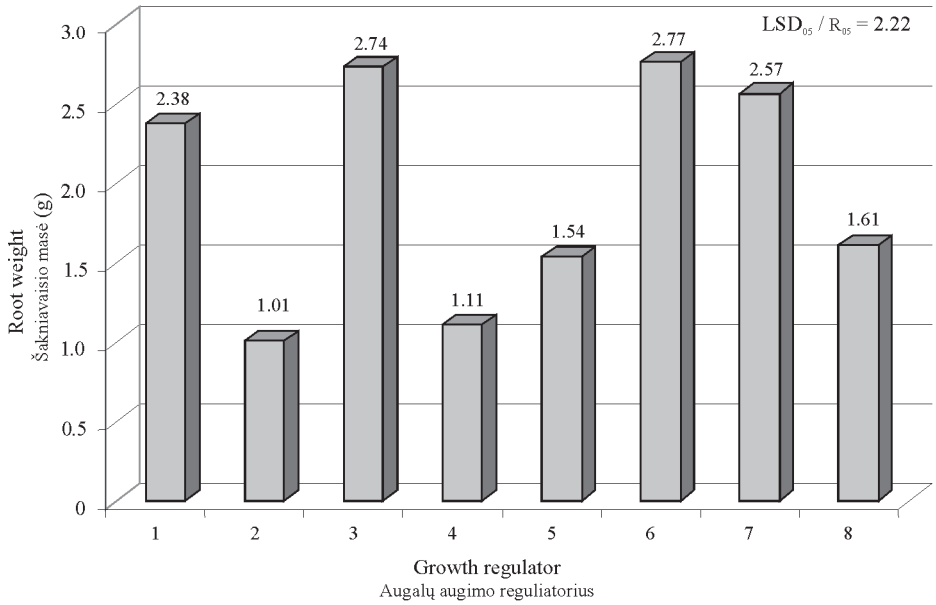

Fig. Root weight (g) of radish, which seeds were soaked in solution of growth regulator: 1 – water; 2 – Agronom effect; 3 – Biojodis; 4 – Bioforce; 5 – Biokal 01; 6 – Inzar; 7 – Oksichumat; 8 – Penergetic p.

Pav. Ridikėlių, kurių sėklos mirkytos įvairiuose augalų augimo reguliatorių tirpaluose, šakniavaisio masė, g: 1 – vanduo; 2 – Agronom effect; 3 – Biojodis; 4 – Bioforse; 5 – Biokal 01; 6 – Inzar; 7 – Oksigumatas; 8 – Penergetic p.

Discussion. In order vegetable seeds germinated as evenly and quickly as possible, it is necessary correspondingly to prepare them for the sowing. One of the methods of seed preparation for sowing is seed soaking. Seeds of some vegetables do not germinate for a long time and after soaking them in water they germinate sooner. In order to improve vegetable seed germination power and to increase yield, their seeds are soaked in plant growth regulator solutions. It was established that soaking celery seeds in growth regulators, i. e. Giberelin and others, they germinate sooner (Brocklehurst et al., 1982). Tomato ant sweet pepper seeds processed with plant growth regulators also germinate sooner and more evenly (Andreoli, Khan, 1999). According to the data of Lada and other scientists (2005), when carrot seeds were soaked in the solutions of Ambiol, Glycinebetaine and Bioprotect 2 growth regulators their germination power increased significantly. The data of our investigation showed that not all the investigated plant growth regulators positively influenced vegetable seed germination power. Out of the investigated growth regulators, growth regulator Bioforce had the the biggest positive influence on seed germination power. When seeds were soaked in it germination energy of red beet and raddish seeds increased 10–30 %.

Seed soaking in plant growth regulator solutions not only improves their germination power, but also shoots became more luxurant, had stronger roots. Plant growth

regulators influence shoot biometrical parameters (Passian, Bennett, 1999). It was established that after seed soaking in growth regulator solution or their mixtures, seeds not only germinated sooner, but plant overground weight was bigger (Brocklehurst et al., 1982). According to the data of Ugur and Kavak (2007), tomato shoots, which seeds were soaked in the solutions PP 333 and CCC, were lower. Our investigations revealed that not all the growth regulators positively influenced shoot height, leaf assimilation area and fresh weight. Some growth regulators positively influenced plant height, but didn't increase plant fresh weight. Agronom effect increased plant height and fresh weight of cucumber hybrid 'Krukiai' and tomato hybrid 'Arvaisa'. The same regulator increased cucumber shoot leaf assimilation area. Plant growth regulator Bioforce increased plant height and fresh weight of red beet and tomato hybrid. Biojodis increased red beet plant height and fresh weight.

Seed soaking in Agronom effect, Bioforce and Penergetic p solutions had the biggest influence on cucumber, red beet, tomato and raddish shoot growth and development.

Conclusions. 1. Plant growth regulator Bioforce had the biggest positive influence on red beet and radich seed germination energy. After seed soaking in this regulator, germination energy of these vegetable seeds increased 10–30 %.

2. Cucumber, red beet, tomato and radish seed soaking in Agronom effect, Bioforce and Penergetic p solutions had the biggest influence on the growth and development of these shoots: Agronom effect increased shoot height and fresh weight of cucumber and tomato hybrids and cucumber shoot leaf assimilation area, Bioforce increased shoot height and fresh weight of red beet and tomato, Penergetic p increased the height of cucumber, radish and red beet and fresh weight of radish was the biggest one.

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Augimo reguliatorių įtaka daržovių sėklų dygimo energijai ir daigų vystymuisi

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Summary

2007 metais Lietuvos sodininkystės ir daržininkystės institute tirta augalų augimo reguliatorių įtaka daržovių sėklų dygimo energijai ir biometrijai. Agurkų 'Krukiai' F_1, burokėlių 'Joniai', ridikėlių 'Babtų žara' ir pomidorų 'Arvaisa' F_1 sėklos mirkytos augimo reguliatorių Biojodis, Biokal 01, Bioforse, Agronom effect, Inzar, Oksigumatas, Penergetic p tirpaluose. Kontroliniame variante sėklos mirkytos vandenyje. Po mirkymo sėklos pasėtos į polimerines kasetes, kuriose augalai auginti 30 dienų šiltnamyje. Nustatyta sėklų dygimo energija, atlikti daigų biometriniai matavimai (augalų aukštis, masė, lapų skaičius, asimiliacinis plotas). Augalų augimo reguliatoriai Oksigumatas, Agronom effect, Bioforse bei Penergetic p darė teigiamą įtaką ridikėlių, pomidorų sėklų dygimo energijai bei agurkų, burokėlių, pomidorų ir ridikėlių daigų augimui bei vystymuisi.

Reikšminiai žodžiai: agurkai, augimo reguliatoriai, biometrija, burokėliai, daigai, dygimo energija, pomidorai, ridikėliai.