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THE CONTENT OF NUTRIENTS AND THE ACIDITY OF THE SUBSTRATE FOR GROWING CONTAINERIZED SEEDLINGS OF PINE AND SPRUCE

The results of studies of the content of mobile forms of phosphorus and potassium, ammonia nitrogen, mobile iron compounds and the sum of exchangeable bases of calcium and magnesium in the substrate at the beginning and end of the growing season when seedlings of Scots pine and Norway spruce in containers. The content of nutrients in the substrate to the end of the growing season has decreased significantly. The number of mobile forms of phosphorus has decreased in 2.3 times, potassium 2 times, ammonia nitrogen up to 19 times exchangeable bases of calcium and magnesium in 1.5 times. This is due to the consumption of the seedlings of nutrients, as well as their leaching from the substrate during irrigation. Therefore, to maintain the necessary balance of nutrients in the substrate during the vegetation period it is necessary to observe a scientific system of fertilization.The acidity of the substrate also decreased from 5.2 to 6.3 pH. Water for irrigation has the acidity close to neutral (pH = 7.1). To maintain the optimum acidity of the substrate, the pH of irrigation water should be in the range of not higher than 5.5 to 6.0. Therefore, when using irrigation water with neutral acidity is necessary to carry out activities according to its acidification.

Key words: substrate, nutrients, biometric parameters, seedling, acidity.

Introduction. An important place at planting stock cultivation with the closed root system is taken by the mineral nutrition mode in connection with the container limited volume and fast usage of food reserve contained in substrate. And nutrients presence in plants available forms is very important. Nutrients absorbency and growth and development of plants are influenced by numerous factors, among which the important role is played by substrate humidity degree and quality of water for watering.

In the course of planting stock growth the changes of substrate chemical properties take place with nutrients consumption because of absorption by seedlings root systems. Also at intensive watering some nutrients are washed away by water from substrate of cartridges. Besides, part of the compounds containing nutrients are destroyed and absorbed by microorganisms which are in the substrate.

Available nutrients content in the substrate is formed at the expense of the introduced basic fertilizer, extra nutritionintroduced in the course of growth, and an insignificant part at the expense of decomposing of organic matter and liberation of available elements.

Application of various kinds of fertilizers influences the peat substrate in different ways and leads to an essential change of its acidity. Besides, acidity change is influenced also by properties of the water used for watering. In peat substrates a part of nutrients is bound by its organic part and becomes unavailable to plants. Therefore general rules of provision of plants mineral nutrients at the expense of fertilizers cannot be applied to peat substrates to the full extent. Thereupon, it is important to track the nutrients content change in the substrate at the beginning and at the end of the growing season to determine optimum doses of fertilizers introduction.

Main part. Researches were made in the hothouse enterprise SFI “Ostrovetsky forestry”. Substrate for seedlings cultivation on the basis of high-moor peat with addition of mineral fertilizers was prepared in the Republican forest breeding-seed-growing center, cartridges were filled by this substrate and seeds of pine and spruce were sowed. The spruce seeds sowed containers were put in a hothouse at the beginning of May, and the pine seeds sowed containers – in the middle of June. In the middle of June it is impossible to reach optimum conditions for seeds germination and initial growth of seedlings owing to high temperature of air and substrate in the conditions of the covered ground. Frequent watering to reduce air temperature can even aggravate the situation in view of the substrate over wetting and nutrients washing away from it.

To find out the change of substrate chemical properties at the beginning and at the end of vegetation period the mixed samples in 3-fold replication were taken from different cartridges. At seedlings cultivation in a hothouse at the end of the vegetation period their height differentiation was observed which was noted visually and proved to be true by measurements of biometrical indexes. To determine the reason of different growth indexes in different cartridges the substrate samples were taken for comparison from cartridges cells with seedlings with high and low biometrical indexes. Variants of substrate sampling from cartridges are given in Table 1.

Table 1

Variants of the substrate sampling from cartridges with seedlings with the covered root system

Samples variants	Samples characteristics
Substrate samples at the beginning and at the end of the vegetation period	
1	Substrate from the cartridges cells with seedlings of Norway spruce (sampling 04.05.2015)
2	Substrate from the cartridges cells with seedlings of Norway spruce (sampling 14.08.2015)
Substrate sample sfrom the cartridges with high and low biometrical indexes of seedlings (sampling 23.09.2015)	
3	Substrate from the cartridges cells with seedlings of Norway spruce with high biometrical indexes
4	Substrate from the cartridges cells with seedlings of Norway spruce with low biometrical indexes
5	Substrate from the cartridges cells with seedlings of common spruce with high biometrical indexes
6	Substrate from the cartridges cells with seedlings of common spruce with low biometrical indexes

Substrate humidity was determined according to the standard procedures [1]. The following research methods were used to determine the substrate chemical properties: pH value – with the help of pH-meter in salt extract KCl [2]; metabolic potassium – according to method of A. D. Maslova on a flame photometer [3]; mobile forms of phosphorus – according to method of A. T. Kirsanov by colorimetric method in a muriatic extract [4]; mobile ammonia nitrogen – by colorimetric method in a muriatic extract [5].

The peat used for substrate preparation, has a very high saturation capacity and can keep moisture several times more than mass of dry peat. The mass ratio of moisture contained in peat to the total mass of peat or to the dry matter mass, expressed in percentage, is called peat humidity.

Determination results of the substrate moisture in cartridges at the beginning and at the end of the vegetation period are given in Table 2.

As it is clear from Table 2, the humidity of substrate in containers with seedlings at the beginning and at the end of vegetation is approximately equal. At the beginning of vegetation the substrate humidity at calculation on dry weight was 133.3%, and on wet weight – 70.0%, and it is slightly more than optimum (60%), but was acceptable. At the end of the vegetation period the absolute humidity of substrate was 115.3%, and the relative one – 63.5%, and it practically corresponds to the optimum value. On the basis of researches it is possible to conclude that the substrate humidity in the course of cultivation was kept at the necessary level and that watering was carried out regularly with the necessary norms.

Table 2

Results of substrate moisture determination in the cartridges

Sampling time	Humidity on dry sample, %	Humidity on humid sample, %
At the beginning of vegetation (04.05.2015)	133.3	70.0
At the end of vegetation (23.09.2015)	115.3	63.5

Results of chemical analysis of the basic nutrients contents in the substrate samples are given in Table 3.

As it is clear from the given data, the nutrients contents in the substrate by the end of the vegetation period decreased considerably. So, the content of phosphorus mobile forms became 2.3 times less, potassium – 2 times, ammonia nitrogen – 19 times, metabolic foundations of calcium and magnesium – 1.5 times.

It is connected both with nutrients consumption by the seedlings, and with their washing away from the substrate at watering. Therefore to keep the necessary nutrients balance in the substrate it is necessary to increase the quantity of extra nutriations and the fertilizers application norm at their carrying out.

Table 3

Change of the substrate chemical properties at the beginning and at the end of the vegetation period at cultivation of common spruce seedlings

Sampling date	pH in KCl	P_2O_5	Fe^{3+}	K_2O	NH_4^+	$Ca^{2+} + Mg^{2+}$
		mg-eq/100 g of dry substrate				mg-eq/100 g of substrate
04.05.2015	5.2	197.3	4.0	65.0	773.3	60.0
14.08.2015	6.3	87.0	3.0	31.0	40.3	39.0

Acidity of the substrate also decreased from 5.2 to 6.3 pH. The optimum acidity for the spruce seedlings growth is 5.0–5.5 pH. If at the cultivation beginning the substrate acidity value corresponded to the norm, at the end of vegetation it left the optimum limits. It is possible to explain such change by properties of the water used for watering (Table 4). Water for watering has neutral acidity (pH = 7.1), and to maintainthe optimum acidity of substrate the acidity of water for watering should be within the limens not exceeding 5.5–6.0 pH. Therefore using water for watering with neutral acidity it is necessary to acidify it. Thus, it is necessary to consider that the water acidity indexes during the growing period can change, therefore it is important to carry out periodically control of its acidity.

One of water quality indexes is it conductivity (electroconductivity of water). Conductivity depends on concentration of ions dissolved in water which increase its electroconductivity. Their quantity is in direct proportion to water electro conductivity. Conductivity of water for watering should not exceed 0.5 μS/cm, or 500 μS/cm [6].

It is clear from Table 4 that water has conductivity of 438 μS/cm and according to this index it comes nearer to the level of qualitative water (500 μS/sm). Content of the dissolved salts (215 mg/l) is also high and in this connection a significant concentration of cations of Ca (72 mg/l) and Mg (27.6 mg/l) is observed.

Chemical properties of the substrate in cartridges with high and low biometrical seedlings indexes are given in Table 5.

In the first variant the analyses results of substrates from cartridges with high indexes of seedlings growth are given, and in the second variant – with low biometrical indexes.

From the data of Table 5 it is clear that difference in content of metabolic foundations of calcium and magnesium between variants is not more than 2.5–2.6 mg-eq/100 g of substrate, andit is insignificant.

Content of mobile forms of ammonium nitrogen also has no essential differences in substrates of seedlings of common spruce and common pine with high and low biometrical indexes. Some excess of NH_4^+ content is only noted in substrate of seedlings of common pine with high indexes of growth.

Content of mobile forms of phosphorus between variants differsconsiderably. In the substrate of seedlings of common spruce with low biometrical indexes it is 9.4 times less, and in substrate of pine seedlings – 4.5 times less.

There is also content difference of metabolic potassium in the substrate of seedlings with high and low biometrical indexes. In the substrate samples of common spruce seedlings in the first variant the potassium content is 2.6 times higher, and of pine – 1.3 times higher in comparison with the second variant.

Thus, seedlings with good growth grow in cartridges with a high content of mobile forms of phosphorus and potassium, and seedlings with low content of these elementsin the substrate have low indexes of growth. Difference in growth indexes of seedlings between different cartridges is possible to explain only by non-uniform distribution of nutrients in the substrate.

Table 4

Characteristic of water used for seedlings watering in a hothouse

pH	HCO^{3-}, mg-eq/l	EC, μS/cm	TDS, mg/l	$Ca^{2+} + Mg^{2+}$, mg-eq/l	Ca^{2+}, mg/l	Mg^{2+}, mg/l	Al^{3+}	
							mg-eq/l	mg/l
7.1	0.134	438.0	215.0	5.9	72	27.6	0.16	1.44

Table 5

Chemical properties of the substrate in cartridges with high and low indexes of seedlings growth

Variants	Species	$Ca^{2+} + Mg^{2+}$, mg-eq/100 g of substrate	NH^{4+}	P_2O_5	K_2O
			mg/100 g of substrate		
Substrate from the cartridge cells with seedlings with high biometric indexes					
1	Spruce	48.4	34.76	95.3	30.5
	Pine	45.4	41.91	121.8	8.4
Substrate from the cartridge cells with seedlings with low biometric indexes					
2	Spruce	50.9	32.10	10.1	11.8
	Pine	48.0	35.64	27.1	6.6

Conclusion. In the course of seedlings growth there are changes of chemical properties of the substrate with consumption of nutrients because of absorption by the seedlings root systems. Also at intensive watering part of nutrients is washed away by water from the substrate. The nutrients content in the substrate of containers with seedlings by the end of the vegetation period decreased considerably. So, the mobile forms content of phosphorus became 2.3 times less, of potassium – 2 times less, of ammonia nitrogen – 19 times less, of metabolic foundations of calcium and magnesium – 1.5 times less. That is why to maintain the necessary nutrients balance in the substrate it is necessary to observe the science-based system of extra nutritions during the vegetation period, and also norms of watering to preventthe excessive washing away of water-soluble fertilizers. Thus, special attention should be paid to timeliness and regularity of carrying out root extra nutritions and top-dressings.

Substrate acidity also decreased. At the beginning of cultivation the substrate acidity value corresponded to the norm and was equal to 5.2 pH, and at the end of vegetation it left the optimum limits and became 6.3 pH. Therefore, it is necessary to supervise acidity of water for watering and if necessary to acidify it by organic and inorganic acids.

Watering has a great influence on seedlings growth. Substrate humidity in the course of cultivation should be kept at the necessary level and make 60−70%. For this purpose watering should be carried out according to the necessary norms and it is necessary to achieve uniform distribution of water. At non-uniform watering one cartridges get more water, and others get less, and that influences the seedlings growth.

Good seedlings growth was observed in cartridges with high content of mobile forms of phosphorus and potassium, and seedlings with low content of these elementsin the substratehadlow indexes of growth. Difference in the seedlings growth between different cartridges is possible to explain by the non-uniform distribution of nutrients in the substrate and of water at watering.

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