Anastasia Vaigel, Aminat Umarova, Maria Suslenkova, Marina Butilkina, Anna Kokoreva, Olga Suhaia

SPECIALIZED SOIL CONSTRUCTIONS: TECHNOLOGIES, PROPERTIES, FUNCTIONING

Lomosonov Moscow State University, Soil Science Faculty, Moscow, Russia,
a.umarova@gmail.com , Tel : +74959392542

Abstract. Gardening of urban areas is often connected with a need of formation of a soil cover – konstruktozem. During its creation, as usual, use soil layers, which are highly contrasted in the physical and chemical properties such as: sand, peat, soil (lowermineral horizons). Similar layers united in a general system have new properties and modes. In the process of their functioning soil constructions are exposed to fast transformation. And, changes of properties concern not only quickly changing phases, but also slowly changing firm phase of soils. Similar evolution of soil constructions conducts to their degradation. Creation of steady soil constructions is an important problem of their use, in particular in city gardening. In 2012 on the territory of the Moscow State University were created 28 soil designs of a different structure and they were sowed by grassy vegetation of Festuca Rubra and Olium Perenne. At all constructions identical conditions were supported. Regular researches of physical and chemical properties and modes of soils were conducted. It is established that specifications of a structure of a soil profile significantly influence on growth and development of plants. Changes in properties of components of a firm phase are found.

Keywords: soil constructions, physical properties, rheological properties of soils, temperature mode of soils, biomass, city gardening.

INTRODUCTION

Growth of the areas of urban areas, their high anthropogenous loading and dense population conducts to need of improvement of quality of life in these difficult conditions. This task is carried out by gardening of urban areas, creation of parks, squares, gardens. Due to high degree of impurity of urban areas, high cost of the city earth, existence of various underground and land communications, growth of a demand of specialized long-term soil designs, first of all for plants, the grassy of herbs and flower cultures is observed (Kurbatova and Gribkova, 2006). Rather often for creation of similar soil designs as reproduction of the natural soil horizons use soil layers, which are highly contrasted in the physical and chemical properties such as: sand, peat, soil (lowermineral horizons). The system of gardening created in this way in the course of functioning undergoes various changes and is transformed that conducts to other functioning of soils. Speeds of change of artificial soils in the first years after their creation will be maximum and to have fading character because the soil system will come to an equilibrium state with environment (Umarova, 2012). In this regard, the purpose of this work was studying of physical and chemical properties of specialized soil constructions of various structures, functioning in absolutely identical conditions, in long-term experiment. The following tasks were set: 1) to create constructions of a different structure by a laying of a long-term field experiment on the soil experimental field of the Moscow State University; 2) to investigate the main physical and chemical the initial soil horizons; 3) to study transformation of soils constructions in the course of their functioning; 4) to study elements of water and temperature modes of soils in an annual cycle; 5) to investigate dynamics of biomass of grassy plants of soils constructions of a different structure.

MATERIAL AND METHODS

In the territory of a soil experimental field of the Moscow State University in July 2012 was created the complex of monitoring soil constructions with different structures. For

[1]Work is executed with financial support of grants РФ ФИ 12-04-01806, РНФ №14-16-00065

their formation the ditch of 30 cm in depth was dug out. All taken-out soil, representing the top humic arable horizon, further it is designated as soil, was carefully mixed for homogeneity of its properties. The bottom of a ditch was leveled on level. Then the taken-out soil was laid on its surface with consolidation, the power of this layer made 12 cm. On a surface the special wooden designs, representing square boxes without a bottom, 18 cm high and of 0,25 square m were established. Further they were filled with various soil horizons. Three options of soil constructions with the following structures of profiles were created: (1) A_{arable} (soil); (2) A_{arable}(0-6 cm), peat lowlying (6-12 cm), sand (12-18 cm) (layered); (3) the mixed construction from three components (Mix). When laying the soil condensed to characteristic values. Constructions are isolated on warm and moisture-proof on perimeter, the space between them is filled with the soil. On all platforms identical external conditions were supported: they were sowed by mix the grass of herbs (0,05 г seeds/cm^2): the Festuca rubra and Lolium perenne, in the ratio 9:1, was made a hairstyle the grass of herbs and having watered with identical volumes of water.

The following determination of properties of soils was carried out: density of a firm phase pycnometer method; measurement of pressure of soil moisture by a tenziometer method, determination of rheological properties, determination of rheological properties of soils on the Reotest 2 viscosimeter (The theory and methods of soil physics, 2007); definition of the content of carbon by a method of kulonometerшc titration on the AN-7529 analyzer; monitoring of a temperature mode by means of programmable temperature Termochron sensors.

RESULTS AND DISCUSSION

The main chemical properties of initial samples and samples of 2013 are presented in tabel 1. Values of pH soils in samples 2012 (initial) and 2013 were in optimum range for the grass of herbs. Peat and the mixed sample when placing them in a constructions had naturally high content of carbon. So far its quantity in these horizons sharply decreased, especially in the mixed designs (variant 3) . The same regularity is observed and for nitrogen. On D. S. Orlov's classification (Vorobyova, 2006) in all variants of constructions the carbon ratio to nitrogen belongs to category very low (more than 14 %). The highest sizes of water-soluble phosphorus and potassium are found for initial the arable and mixed horizons. So far concentrations close to initial samples are observed in the arable horizon of a layered construction (variant 2).

Table 1 - Chemical properties of the soil horizons

Soil samples Horizon/depth	pH	C, %	N, %	C/N	P_2O_5, mg / 100g soils	K_2O, mg / 100g soils
initial samples						
Aarable	7.08	2.24	0.11	20.79	14.60	28.87
mix	6.55	12.75	0.34	37.31	7.06	8.14
Peat	6.18	42.7	0.98	43.40	1.18	1.61
sand	6.87	1.08	0.02	48.69	1.08	1.65
variant 1. Soil						
0–5 cm	6.92	2.68	0.14	18.62	1.18	12.44
5 – 10 cm	7.38	2.17	0.12	17.63	1.08	10.60
10 – 20 cm	5.85	2.21	0.10	22.17	3.01	13.27
variant 2. Layer						
Aarable (0-6cm)	6.63	2.79	0.14	20.11	12.16	26.72
Peat (6-12 cm)	6.95	18.3	0.30	60.45	3.16	2.21
sand (12-18 cm)	6.18	0.65	0.01	44.14	2.28	1.95
variant 3. Mix						
0 – 5 cm	6.90	1.83	0.11	17.11	6.88	11.42
5 – 10 cm	7.32	1.93	0.07	28.72	0.39	9.92
10 – 20 cm	7.09	1.55	0.12	13.36	2.23	8.18

The smallest values of density of the soil and density of a firm phase are characteristic for peat, high values at sand. Small decrease in porosity of soils in a soil design is now observed. Practically its size in a layered construction and a design from mix didn't change. Initial consolidation of soils promoted rather steady condition of soils on density and porosity, even in the peat horizon. As for dispersion of soils, some changes of a specific surface and granulometric structure are observed. Most considerable differences in silt fraction are found between initial samples and samples from constructions, which functioned during 1 year. Profile differentiation is observed. Definition of granulometric structure of soils showed that the horizon Aarable contained low number of silt fraction, dusty particles prevailed. The mix formed by hashing of peat, sand and the horizon Aarable, included many large fractions of the organic and mineral nature.

Table 2 - Physical properties of the soil horizons

Soil samples Horizon/depth	ρ_s, g/cm^3	ρ_b, g/cm^3	ε, cm^3/cm^3	The specific surface on nitrogen S, m^2/g	Content of silt, %
initial samples					
Aarable	2.51	1.20	0.52	10.6	5.7
mix	2.35	1.38	0.41	9.1	0.9
Peat	1.00	0.31	0.69	0.2	-
sand	2.37	1.63	0.31	1.1	0.7
variant 1. Soil					
0–5 cm	2.41	1.28	0.47	7.5	6.3
5 – 10 cm	2.53	1.34	0.48	7.4	6.9
10 – 20 cm	2.51	1.31	0.48	10.6	9.1
variant 2. Layer					
Aarable (0-6cm)	2.40	1.16	0.52	8.6	5.4
Peat (6-12 cm)	1.18	0.40	0.66	0.3	-
sand (12-18 cm)	2.56	1.72	0.33	2.0	0.9
variant 3. Mix					
0 – 5 cm	2.31	1.35	0.42	1.0	3.1
5 – 10 cm	2.49	1.40	0.41	1.1	2.6
10 – 20 cm	2.45	1.42	0.42	0.7	2.1

Now all layers of all studied options were enriched with thin fractions, is especially noticeable in the superficial horizons and in the sandy layer located under horizon Aarable and peat. Decrease in values of the specific surface determined by a method of low-molecular adsorption of nitrogen, in the top layers of variant 1 is so far observed, at a depth of 10-20 cm the specific surface of the soil kept the sizes. In variant 2 (layered) decrease value only in the most top layer also is observed. Most considerable changes are found in variant 3 (mix), and it is connected with mutual influence of the horizons at their hashing.

Rheological characteristics are very sensitive to changes of physical and chemical properties of soils. Therefore on Reotest the main rheological curve (MRC) for the high-concentrated suspensions (HCS) was defined at humidity of a daily allowance capillary. Three cycles were carried out, they consisted of forward and reverse motion. Time interval for each speed made 1 minute, only 12 speeds. Cycles were carried out without stops. In figure 1 the main rheological curves of initial samples and the samples which have been selected in the fall of 2013 are presented.

The MRC form horizon Aarable has an appearance peculiar to liquids, and at peat and sand – firmer. Feature of mix is that in a form its curves of a forward stroke, at increase in speed of shift, are similar to peat and sand curves for a forward stroke. Reverse motion of mix at reduction of speed of shift is similar to curves of the arable horizon at reverse motion. The maximum values of tension shift were observed in mix and made 200-1300

Pas, peat (200-700 Pas), sand (100-500 Pas) and the smallest in Aarable (5-150 Pas). Peat has a great impact on behavior of mix, and at the small – sand in which changes happen only at the initial stage of deformation.

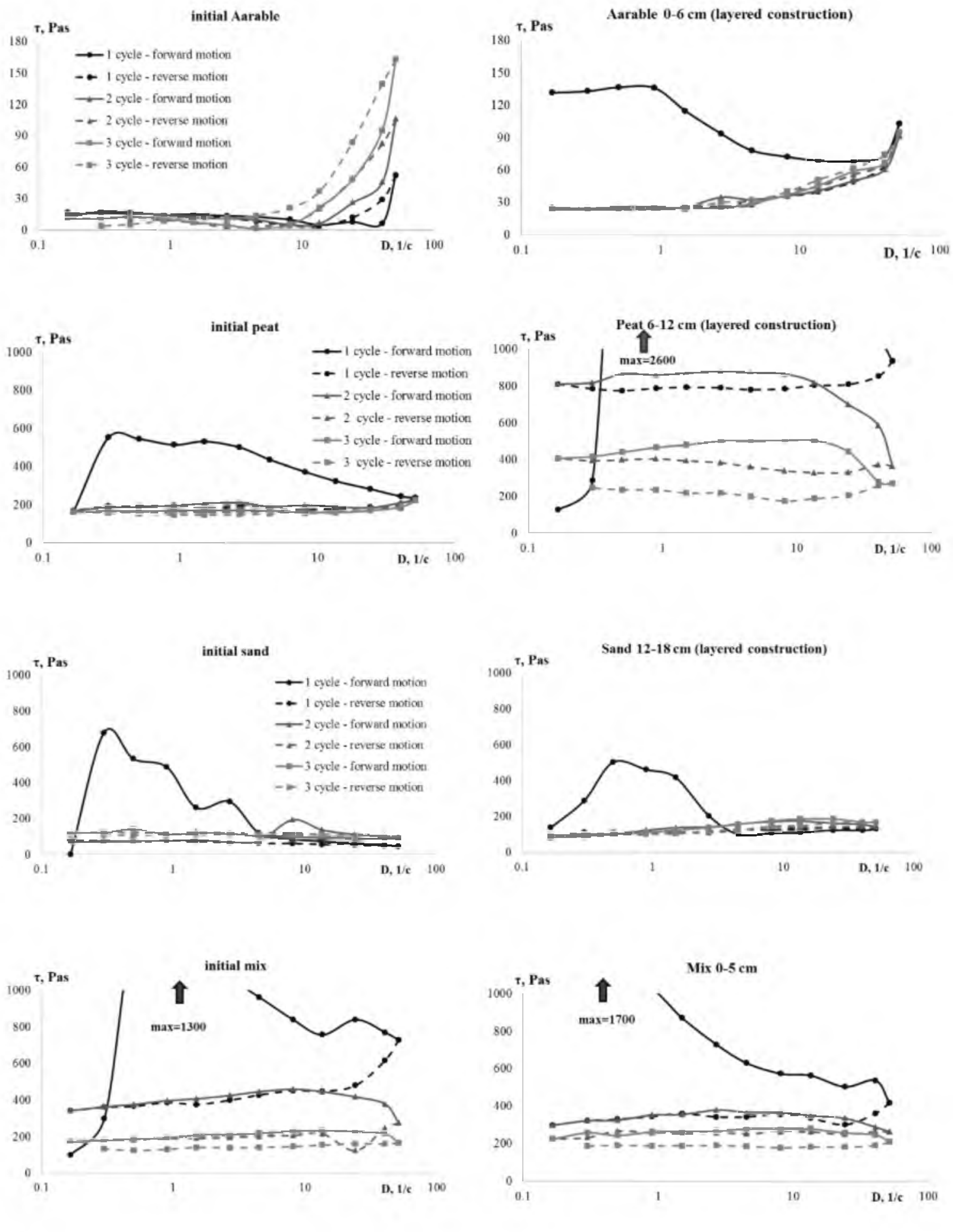

Figure 1 - Main rheological curve of soil samples: a) A_{arable}; b) peat; c) sand d) mix

After 2 years of functioning as a part of soil constructions changes in a form and an arrangement of rheological curve (figure 1), especially in the superficial horizons are noticeable. In the horizon A there was an increase in viscosity of suspension, and the from bigger depth the sample is selected, the its suspension (there is a hysteresis in curves of direct and return cycles earlier) starts flowing earlier. From all options of placement the arable horizon underwent the greatest transformation as a part of a layered construction in which shift durability increased by 10 times in comparison with an initial sample A arable. In a peat layer at a depth of 6-12 cm, also there were changes of rheological properties. After two years' functioning the shift durability of peat from 600 Pas increased to 2600 Pas, and also viscosity several times increased, but forms of curves remained the same. In this layer there was microstructure growth, on what specify dispersion of curve 3 cycles. It is required big efforts for its destruction. Least of all rheological properties in a sandy layer which is located at a depth of 12-18 cm changed. Shift durability didn't change almost, but in the MRC form there was more flat. In constructions from mix curves the MRC of initial samples and the samples which have been selected in 2013, have very interconnected forms. Thus, rheological properties were very sensitive to changes of characteristics of a firm phase: to changes of density of a firm phase of soils, content of carbon.

Throughout the entire period of functioning of constructions the optimum mode of humidity by regular watering of platforms depending on weather conditions was supported. Control of humidity of soils was exercised by measurements of pressure of soil moisture by the tensiometer method and humidity of a radical layer by the electric method.

We paid the main attention to a temperature mode. During the summer period layered constructions most quickly got warm; they kept heat in the top part of a profile more long and had the highest temperature of a surface.

We will consider in details the period with the warmest days (figure 2). Layered constructions were characterized by the highest temperatures of a surface of soils and the smallest depth of daily fluctuations of temper-

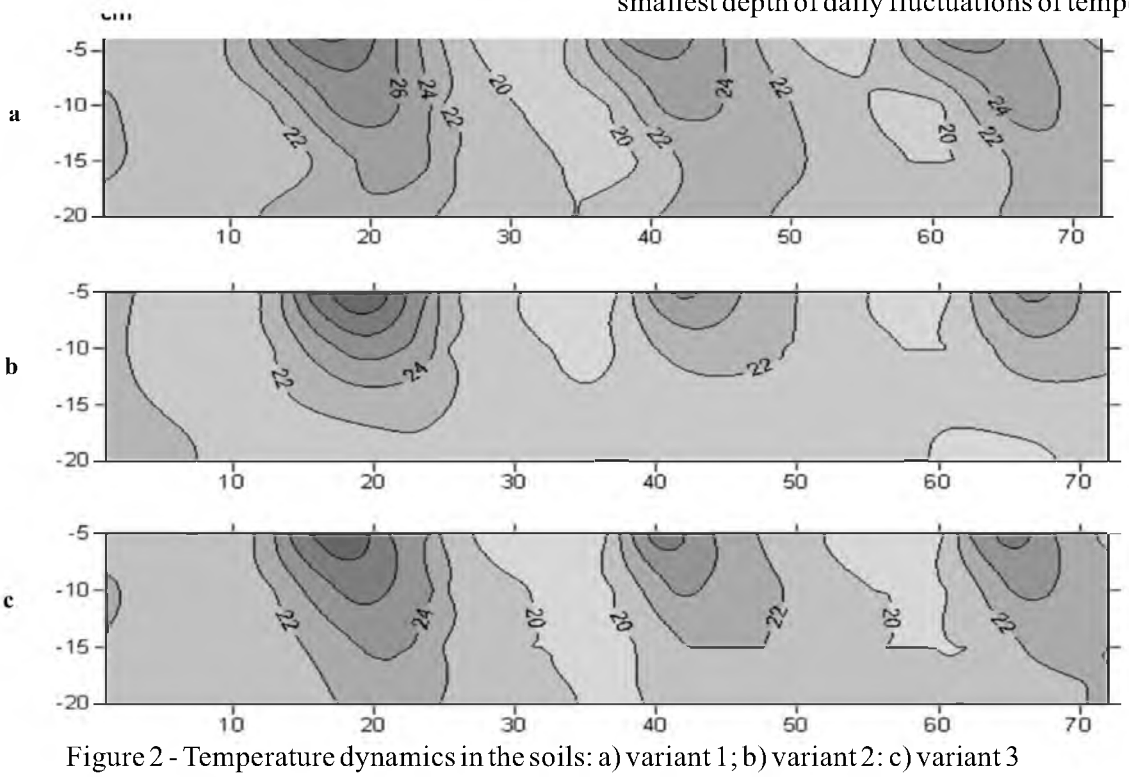

Figure 2 - Temperature dynamics in the soils: a) variant 1; b) variant 2: c) variant 3

atures which weren't exceeding depth of 15 cm. They were cooled at night less. Gradients of temperatures are identical to all options. Variant 1, representing the homogeneous horizon Aarable, differed the most intensive warming up of soil thickness in the afternoon. The variant 3 mix is intermediate between 1 and 2 variants.

Autumn fall of temperature in layered designs came more slowly, than in designs from mix, because of differentiation of a profile. It led to that on these platforms more high temperature of the top thickness remained for a long time. On a profile soil designs from mix, because of uniform distribution of peat in a soil profile had the smallest gradient of temperatures.

Thus, distinctions in a temperature mode of studied soils of designs are revealed, during the warm period got warm quicker and more long held warmly layered designs, during colder period in them slow cooling of the top layers, because of a high lag effect of a peat layer was observed.

The structure of a soil profile, property of soils of designs and temperature mode had strong impact on growth and development of grassy plants. Researches of dynamics of land biomass the herbs by weekly beveling were conducted. Layered designs had the greatest gain of herbs and its biomass. The low maintenance of weed plants is probable because of rapid growth the grass of herbs. It was distinctly fixed visually. Biomass of herbs layered designs exceeded by 1,5-3 times biomass of herbs of other options of designs, especially in the first year of supervision. In fig. 3. stores of cumulate a gain of crude and dry land biomass are presented.

a) gain biomass, g/cm^2*days

b) gain biomass, g/cm^2*days

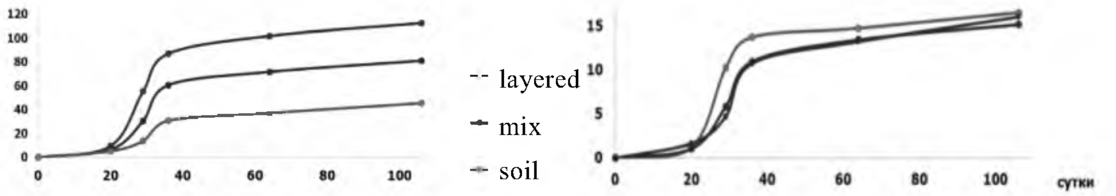

Figure 3 - Cumulate of a gain crude (a) and dry (b) biomass in research options

Cumulate of crude biomass differed in research options. The maximum gain the grass of herbs was noted in layered designs, minimum – in soil. However, curve a gain of dry biomass the grass of herbs of all platforms are located closely to each other. Apparently, it is connected with features of water consumption of these plants. In spite of the fact that humidity of soils of all platforms was in the range of optimum values, features of a structure of soils and distribution of their properties on a profile have the strongest impact on quality of a grass covering, its decorative effect.

CONCLUSIONS

- The structure of a soil profile has considerable impact on properties and modes of soils and further of their transformation.
- The conducted researches of physical and chemical properties of soils showed decrease in the content of carbon, nitrogen and phosphorus practically on all profile of the studied soils.
- Changes of rheological properties of the soil horizons depending on option and depth are found. In the arable horizon changes of forms and an arrangement of the main rheological curves were observed. In peat the increase in microstructures is observed. The sandy horizon least changed on this indicator.
- Studying of a temperature mode of soil constructions showed that the warmest during the summer period are layered

platforms, they during the autumn period keep heat more long than other options. Biomass the grass of herbs had high values on platforms with a layered construction that was distinctly fixed visually and quantitatively.

REFERENCES

Vorobyova L.A. Theory and practice of the chemical analysis of soils / M.: GEOS, 2006, 400 pages.

Kurbatova A.S. Gribkova S. I. Creation of steady system of green plantings in the city /M - Smolensk, "Madzhenta", 2006. 152 pages.

Theories and methods of physics of soils / under the editorship of Shein E.V. Karpachevsky L.O. Tula: Grifand K. 2007 . 616 pages.

Umarova A.B. Specialized soil constructions for city gardening //Materials of XV International practical conference "Problems of Gardening of the Large Cities". M, WWC. 2012. Page 106-108

РЕЗЮМЕ

А. Вайгель, А. Умарова , М. Сусленко, М. Бутылкина, А. Кокорева, О. Сухая

СПЕЦИАЛИЗИРОВАННЫЕ ПОЧВЕННЫЕ КОНСТРУКЦИИ: ТЕХНОЛОГИИ, СВОЙСТВА, ФУНКЦИОНИРОВАНИЕ

Московский Государственный Университет им. М В. Ломоносова, Факультет Почвоведения. Кафедра физики и восстановления почв, a.umarova@gmail.com , Тел : +74959392542

Озеленение городских территорий зачастую связано с необходимостью формирования почвенного покрова – конструктоземов. При его создании, как правило, используются почвенные слои, которые являются резко контрастными по своим физическим и химическим свойствам: песок, торф, грунт (нижние минеральные горизонты). Подобные слои, объединенные в общую систему, имеют новые свойства и режимы. В процессе их функционирования почвенные конструкции подвергаются быстрой трансформации. Причем, изменения касаются свойств не только быстроизменчивых фаз, но и медленно изменяющейся твердой фазы почв. Подобная эволюция почвенных конструкций ведет к их деградации. Создание устойчивых почвенных конструкций является важной проблемой их устойчивого использования, в частности в городском озеленении. В 2012 г. на территории МГУ были созданы 28 почвенных конструкций разного строения и засеяны травяннстой растительностью Festuca rubra и Olium perenne. На всех площадках поддерживались одинаковые условия. Проводились регулярные исследования физических и химических свойств и режимов почв. Установлено, что специфика строения почвенного профиля существенно влияет на рост и развитие травянистых растений, на температурный режим почв. Обнаружены изменения в свойствах твердофазных компонентов почв, которые традиционно считаются чрезвычайно медленно изменяющимися: гранулометрическом и агрегатном составах почв, реологических свойствах.

Ключевые слова: почвенные конструкции, физические свойства почв, реологические свойства почв, температурный режим почв, биомасса, городское озеленение.

ТҮЙІН

А. Вайгель, А. Умарова , М. Сусленко, М. Бутылкина, А. Кокорева, О. Сухая

АРНАЙЫ ТОПЫРАҚ ҚЫРТЫСТАРЫ: ТЕХНОЛОГИЯЛАР, ҚАСИЕТТЕРІ, ҚЫЗМЕТІ

Ломоносов атындағы Мәскеу мемлекеттік университеті, топырақтану факультеті, Мәскеу, Ресей, a.umarova@gmail.com , Тел : +74959392542

Қалалық аумақтарды көгалдандыру көбінесе топырақ қыртысын құру қажеттігімен байланысты. Әдетте, оны құру кезінде құм, торф, топырақ (төменгі минералды қабаттар) секілді физикалық және химиялық қасиеттер бойынша қарама-карсы болып келетін топырақ қабаттары қолданылады. Мұндай қабаттар жаңаша қасиеттер мен режімдерге ие ортақ жүйеге біріктіріледі. Олардың қызмет етуі

барысында топырақ қыртыстары тез өзгеріске ұшырайды. Қасиеттердің өзгеруі жылдам өзгеретін топырақ қабатына ғана емес, баяу өзгеретін қатты қабатына да қатысты. Топырақ құрылымының осылайша өзгеріске ұшырауы салдарынан аза бастайды. Төзімді топырақ қабатын құру оларды пайдалануда, оның ішінде қаланы көгалдандыруда маңызды мәселе болып табылады. 2012 жылы Мәскеу мемлекеттік университеті аумағында құрылымы әртүрлі 28 топырақ қыртысы құрылып, оларға Festuca Rubra және OliumPerenne шөптесін өсімдіктері егілді. Барлық топырақ қыртысы үшін бірдей жағдай жасалды. Топырақтың физикалық-химиялық қасиеттері мен режімдеріне жүйелі зерттеу жүргізіліп отырды.

Топырақ құрылымының қасиеттері өсімдіктердің өсуі мен дамуына айтарлықтай ықпал ететіні анықталды. Қатты қыртыс құрамының қасиеттерінде өзгерістер анықталды.

Кілтті сөздер: топырақ құрылымы, физикалық қасиеттері, топырақтың реологиялық қасиеттері, топырақтың температуралық режімі, биомасса, қаланы көгалдандыру.