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Perspective Approaches to the Directional Selection of Plant Species for Revegetation of Ore Mining Dumps of Kursk Magnetic Anomaly

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Abstract: The researchers have grounded the perspective approaches to the directional selection of plant species for revegetation of ore mining piles of Kursk Magnetic Anomaly (KMA), developed on the basis of multi-year researches of man-induced transformed ecotopes. They consist in preliminary estimate of the parameters of recultivated ecotopes and of the ecological-biological properties allowing for their bio-indicator characteristics. Successful recruitment of phytobiota in these conditions assumes to use differentiated selection of species for various mosaic environmental conditions.

Key words: Revegetation, ore mining dumps, kursk magnetic anomaly, culture-phytocenosis, introduced species, ecological resistance of species

INTRODUCTION

Phytoremediation intended for improvement and formation of recultivated soils by means of growth of herbaceous, shrubby, woody plants is one of the most effective ways of reclamation of industry-deteriorated soils. Number of plants currently used for remediation of some anthropogenic ecotopes is only 5-10 species. Equally important is the development of approaches to the preliminary directional selection of assortment of perspective plants for phytorecultivation depending on prior defined characteristics of substrata of the dumping places and well-known ecological and biological characteristics of species.

The objects of our research are plant aggregations and plant species grown on non-recultivated dumps of overburden rocks of KMA in model ecotopes of Lebedinsky GOC (The Belgorod region, the town of Gubkin). The explored dumps differentiated by the parameters of soil texture, consisted of mosaic, disperse, sandy, argillaceous, cretaceous and clumpy deposits and their combinations. The aim of our research is the approach development to the directional selection of plant species for phytorecultivation of ore mining dumps of KMA.

MATERIALS AND METHODS

The methods that are used for forest stands exposed to the impact of industry have been applied to estimate the state of woody plants (Alekseyev, 1989). The main diagnostic indicators of the plants are: general plant habitus, rate of vermin and disease damage, growth rate (amount of growth) and also the capacity of various species to reproduce and disseminate about the dumping territories. Winter resistance and drought resistance have been assessed according to five-level scale where the highest level indicates the highest degree of plant characteristics. The species planted out on experimental areas have been observed regularly for 2 years (Ogorodnikov, 1993).

The complex of methods that use GIS-technologies and the methods of multivariate statistics have been applied to preliminarily estimate the condition of man-induced transformed ecotopes and to develop the projects of their ecological restoration.

The main body: As a result of field studies and GIS-explorations of ore mining dumps of KMA, we have distinguished various types of ecotopes:

- The areas with recently formed surface soil that are characterized by initial stage of formation of plant cover
- The areas with completely formed surface soil where mainly perennial plant species grow and woody vegetation is absent
- The areas with completely formed surface soil covered with plant aggregation of perennial and woody plant species

Our exploration has shown that there the anthropogenic ecotopes are successfully overgrown with plants on the rock areas with low content of sand, clay, debris of rich black soil as distinct from the ecotopes formed with only hard rock. The cretaceous and chalky marlaceous areas of explored dumping places refer to those territories that are the least exposed to overgrowing.

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The cheapest and most effective way of phytorecultivation of such slowly overgrown areas is therefore, the filling of the loamy and sandy soils with thin layer (5-10 cm). As a result of such measures, the complex substrata that are more suitable for being overgrown with plants have been formed. Its formation allows to accelerate the process of vegetational fluctuation proceeded under these conditions. But such method nevertheless does not guarantee prompt self-regeneration of plant cover. It is perspective for being used in local conditions of individual territories, though, it requires the control of possible appearance and spontaneous dissemination of adventive and even quarantine plant species in these conditions.

Our multi-year exploration shows that it should be used perennial plants that are capable of forming turf and discontinuing substratum weathering in order to get the herbage of sanitary and hygienic purpose on the dumps. To such species of cereals in the conditions of explored mining piles refer: *Festuca rubra* L., *Bromopsis inermis* Leys., *Elymus trachycaulon* (Link) Gould et Shinners. For these purposes, of legumes, it is reasonable to use biennial plants that are characterized by good seed reproduction: *Medicago sativa* L., *Melilotus albus* Desr., *Trifolium repens* L.

Effective selection of adapted plant species to various mosaic microclimatic conditions should be performed via preliminary ecological estimate of recultivated ecotopes and ecological and biological plant properties that fit these conditions (Martynova and Tokhtar, 2011). Here, one should take into account the peculiarities of self-overgrowing of the dumping territories that are heterogeneous according to their genesis and chronology of the filling that allows to correct the species selection for the purpose of revegetation in concrete environmental climatic conditions.

The ecological properties of the species have been estimated on the basis of bioindicative ecological scales of Ellenberg (1974) and Landolt (1977). The major criterion for species selection is the ratio of the plants to the main limiting their growth and development factors of moisture and soil acidity, illumination and shading, to the soil rich in mineral elements, to humus content and various soil texture. Besides, winter-resistance should be taken into consideration (Tokhtar *et al*., 2003; Tokhtar and Wittig, 2001; Petin *et al*., 2014).

RESULTS AND DISCUSSION

The researches to have been carried out allow to offer 155 perspective species of woody plants of different geographical origin that can be used successfully for culture-phytocenosis on the dumps and quarries formed in the process of development work of ore-dressing and processing enterprises in the Belgorod region's territory. The most number of species that are perspective for revegetation of the studied dumps are the European (33%) and American (26%) plants. They are not only resistant to unfavourable environmental factors and fit them by ecological and biological properties but are capable of natural disseminating in these conditions.

For validating the developed approaches of the directional selection of species for phyto reclamation of ore mining dumps, we have studied the states of plants empirically selected with regard to their ecological and biological properties. They have been transplanted on the experimental grounds of Lebedinsky ore-dressing and processing enterprises also sloping and plane dumping places have een sown with herbage.

We have established that the following sown herbaceous plants germinate only on flat and plane dumping places: *Medicago sativa* L., *Linum usitatissimum* L., *Bromopsis inermis* (Leys.) Holub and *Trifolium repens* L. Spring young growth measurements of these species have shown that the average height of purple medic (*Medicago sativa*) is 30 cm, white clover (*Trifolium repens*) 14 cm, *Bromopsis inermis* (Leys) 5 cm, *Linum usitatissimum* 10 cm. Linum and medic have blooming stage that is indicative of their successful adaptation to the growth conditions.

In Table 1, the characteristics of life state of woody introducers in the ore mining dumps in the course of conducted experiment.

Summary: Thus in the course of our research, it has been established that effective ore mining revegetation activities suppose complex step-by-step researches to be carried out. The peculiarities of overgrowing of anthropogenic ecotopes in different conditions should be taken into account (Martynova and Tokhtar, 2011; Petin *et al*., 2014; Wittig and Tokhtar, 2003; Strzyszcz, 1996). This allows to correct the selection of perspective plants for their recultivation in mosaic environmental conditions. The most important point in the directional selection of effective plants for revegetation is on the one hand studying the soil parameters, on the other hand, ecological and biological, indicated plant properties with regard to the factors limiting their development. The most plant establishment of disseminated herbage is characteristic for purple medic, white clover and also linum usitatissimum and Bromopsis inermis. On the sloping dumping areas herbage dissemination is essential to carry out with additional mulching materials and stabilizers that prevent washing-out and blowing the seeds.

In revegetation of ore mining dumps one is to use fast-growing deciduous species of plants as basic. The use of the cuttings of some plants as planting stock considerably simplifies and speeds up transplanting work.

Table 1: Estimate of life condition of the plants bed out on the experimental grounds of ore mining dumps

Explored species	Life-form of species*	Origin of species	Winter resistance	Drought resistance	Ecological state of plants
Caragana frutex (L.) C. Koch.	S	Central Asia	5	5	Satisfactory
Chaenomeles japonica (Tunb.) Lindl.	S	East Asia	4	5	Good
Cornus alba L.	S	Povolzhye, Siberia	4	5	Satisfactory
Elaegnus commutata Bernth.	T	North America	5	5	Excellent
Gleditsia triacanthos L.	T	North America	4	5	Good
Juniperus sabina L.	S cr.	The Crimea, the Caucasus	4	5	Satisfactory
Ligustrum vulgare L.	S	the Caucasus	4	5	Satisfactory
Physocarpus opulifolius Maxim.	S	North America	4	5	Good
Pinus mugo Mill.	T	Europe	4	4	Satisfactory
Populus simonii Carr	T	East Asia	4	5	Good
Rhus typhina L.	T	North America	5	5	Good
Rosa canina L.	S	Aboriginal, Europe	5	5	Good
Rosa woodsii Lindl.	S	North America	5	5	Excellent
Salix babylonica L.	T	China	4	5	Good
Salix matsudana Rehd	T	East Asia	4	5	Satisfactory
Salix purpurea L.	S	Europe, the Crimea, the Caucasus	5	5	Good
Spiraea latifolia Borckh.	S	North America	4	5	Good
Thuja occidentalis L.	T	North America	5	5	Good

*Notational conventions; T: Trees; S: Shrubs; S cr.: creeping Shrubs

The most resistant plants in the studied conditions are vegetative versatile north American and European species that are able to give substantial amount of growth in the conditions of anthropogenic dumps of KMA.

CONCLUSION

Phenological observations and analysis of life state of plants show the perspective use of the group of offered plants for revegetation of the studied dumps.

Expansion of the species assortment used for reclamation of anthropogenic disturbed soils, application of various effective approaches and their combination in different conditions allow to decrease not only anthropogenic impact on the environment but considerably advance in revegetation of natural ecosystems in ecotopes created by the activity of mining enterprises.

Experimental data on result check, obtained by means of empirical approaches, give an opportunity to confirm the obtained results, to develop ways of planting, to reduce labour expenditure and to considerably cheap the processes of phytorecultivation.

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