Network of experimental sites for the study of survival of trees and shrubs in the North of Western Siberia

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Abstract. Development of the North of Western Siberia is progressing rapidly. It is accompanied by the growth and emergence of new settlements. Creating green spaces in the harsh conditions of the North is a responsible thing. To work out a sustainable trees and shrubs assortment 15 experimental sites were laid in 2013-2016. They are located in different climatic conditions of the North of Western Siberia (in tundra, forest-tundra, northern and middle taiga). More than 6400 specimens of trees and shrubs of 313 taxa (species, varieties) and cultivars (28 families) were tested over the period. The experience showed that the mass loss of plants was associated with the underestimation of some agrotechnical features and with weather conditions. Using only the experimental test data for the development of a plants sustainable assortment is not effective. The combination of ecogeographical analysis and observations gives good results. The establishment and maintenance of experimental sites network is an important element of successful work to create a sustainable assortment of woody plants for territories with harsh climate.

1. Introduction

The North of Western Siberia is one of the important economic regions of Russia. One of the world largest development of hydrocarbon deposits is located here. The hydrocarbon extraction works and construction of related infrastructure are carried out in a rapid pace. New settlements are emerging and existing ones are expanding significantly. The recreational zones, which include green areas, are important for temporary workers and residents. Creating sustainable and efficient green spaces in the harsh conditions of the Far North is no easy task.
The introduction works in the North of Western Siberia were mostly spontaneous without a system approach before our experiment. In the 1920-ies D M Chubynin, and in the 1950-70ies N I Chernykh [1] conducted work on plants acclimatization in Salekhard (forest-tundra). Y F Rozhdestvenskiy performed experimental plantings of native and non-native species in Labytnangi in the 1970’s and 80’s [2]. Comprehensive study of plants and green spaces condition in the cities of Western Siberia was undertaken by T B Srodnykh in 1994-2005 [3]. It was done for some settlements (Tarko-Sale, Gubkinsky, Beloyarsky, Khanty-Mansiysk, Surgut, Langepas, Nizhnevartovsk) in forest zone (southwards of treeline). These works provided the recommendation of several species of trees and shrubs.

Preliminary ecogeographical analysis accomplished in 2011 showed that the potential of the territory for cultivation of introduced trees is much higher [4]. So the aim of the study is to develop a sustainable assortment of trees and shrubs for landscaping settlements in the Yamalo-Nenets Autonomous District (YNAD), North of Western Siberia. To test this assortment experimental sites were planned.

From 2013 to 2016, a series of experimental sites for trees and shrubs testing was laid on the territory of the North of Western Siberia in 3 climatic zones: arctic, subarctic and temperate. The work was mainly carried out by the team of authors, but a number of experimental sites were created by colleagues and school biological and ecological clubs members, who were inspired by our example.

2. Materials and methods

Three groups of data were used to develop a sustainable assortment of trees and shrubs for the conditions of the North of Western Siberia:

1) the promising species assortment from donor regions (territories with similar climate) obtained by ecogeographical analysis;
2) the data on species list and stability of trees and shrubs in green spaces, usually planted spontaneously;
3) the test results from the experimental sites.

The first data group was the base for the development of species assortment. The second one and the third one were used to confirm the assumptions.

The 15 experimental sites are located in 8 geographical points:

- Sabetta village, arctic tundra, 1 site (at the Sports complex, N 71.2358, E 72.1244);
- the city of Labytnangi, forest-tundra, 2 sites (Arctic research station, N 66.6586, E 66.4062; the school № 1, N 66.6558, E 66.3891);
- the city of Salekhard, forest-tundra, 5 sites (the YNAD Government, N 66.5422, E 66.5422; the Park of Victory, N 66.5445, E 66.6069; the school №1, N 66.5269, E 66.6032; the school №2, N 66.5283, E 66.6336; the Country residence of the YNAD Governor, N 66.5474, E 66.7437);
- the city of Novy Urengoi, forest-tundra, 2 sites (the bank of Sede-Yakha river, N 66.0827, E 76.4529; Children's Ecological station, N 66.0749, E 76.655);
- the city of Nadym, northern taiga, 1 site (the Topchev street, SU-10 building, N 65.5440, E 72.7000);
- the city of Gubkinsky, northern taiga, 1 site (the office of forestry, N 64.4061, E 76.3986);
- the city of Noyabrsk, middle taiga, 1 site (the trees nursery of Noyabrsk forestry office, N 63.1833, E 75.4869);
- the city of Surgut, middle taiga, 2 sites (Botanical Garden, N 61.2347, E 73.4033; the Local History Museum, N 61.2347, E 73.4033).

The listed settlements are located in YNAD, except Surgut, which is located southwards in Khanty-Mansiysk Autonomous District (KhMAD). The location of these geographical points is shown on the map (figure 1).
Figure 1. The location of studied experimental sites in towns and settlements in the north of Western Siberia. Natural zones and subzones [5, with specification]: Tundra zone: NTu – northern tundra subzone; MTu – middle tundra subzone; STu – southern tundra subzone; FTu – forest-tundra zone; the Taiga zone: NTa – northern taiga subzone; MTa – middle taiga subzone.

The zones and subzones boundaries are drawn with the solid black lines.

District’s boundary between YNAD and KhMAD is marked by dotted line.

To manage the data a software complex for the selection of woody species, presumably stable in the Arctic and subarctic climatic zones of YNAD was developed [6].

Ecogeographical analysis was carried out as follows. Climate characteristics were obtained as a result of primary data processing of 234 weather stations. These characteristics were loaded into the database of our software complex. The combination of the species natural distribution map and weather stations data allowed to give the climatic characteristics of species. This makes it possible to select automatically species living in areas similar in climatic parameters to the conditions of different areas of the YNAD. So the program complex gave the opportunity to carry out primary selection of perspective species for different climatic conditions of investigated territory. Such work was conducted for forest-tundra and northern taiga of Western Siberia.

Planting material for experimental sites was imported from the nursery, located in the middle taiga (the Koloskovo village, Leningrad region, Russia, N 60.5886, E 30.1877) in more favourable environmental conditions than experimental sites. The plants usually transported within 3 days for autumn planting. Saplings with closed root system and lignified shoots were used. Only in the first time (2013) the most plants had open root system and transportation took up to 8 days in the hot summer period (July). The saplings were planted in prepared places. Then the caring for plants (watering) had been implemented, but not for all sites.

From 2013 to 2017, the experimental sites regularly assessed the survival rate (in %) and condition of plants. The condition was estimated by the resistance of plants to adverse effects of winter and dryness of the summer period, as well as the possibility of plants to bloom and bear fruit. Evaluation results were loaded into the software complex. The information about 6416 tested specimens of trees
and shrubs, which belong to 313 taxa (species, forms) and cultivars, and 28 families was loaded into the software complex. Based on the analysis of these data, a list of promising species for different climatic zones was compiled for YNAD.

3. Results

3.1. The survival rate of trees and shrubs in experimental plantings

According to the results of the field survey, the survival rate of trees and shrubs by 2017 was determined at 14 experimental sites (table 1). The one more planting (Children's Ecological station in Novy Urengoi) was accidentally destructed during building works.

Table 1 The survival rate (in %) of trees and shrubs of different years of planting at 14 experimental sites in the North of Western Siberia by 2017.

| Settlements | Experimental site name                  | Survival of plants of different planting years, % | Number of planted specimens |
|-------------|-----------------------------------------|---------------------------------------------------|------------------------------|
| Sabetta     | Sports complex                          | 86,7                                              | 143                          |
| Labytnangi  | Arctic research station school №1       | 99,2                                              | 1828                         |
|             |                                          | 89,2                                              | 65                           |
| Salekhard   | YNAD Government school №2               | 62,4                                              | 449                          |
|             |                                          | 58,7                                              | 75                           |
|             | Park of Victory                         | 74,3                                              | 35                           |
|             | Country residence of the YNAD Governor   | 74,3                                              | 591                          |
| Nadym       | SU-10 building                          | 17,5                                              | 252                          |
| Novy Urengoi| Sede-Yakha river bank                   | 14,9                                              | 118                          |
| Gubkinsky   | office of forestry                      | 17,4                                              | 126                          |
| Noyabrsk    | trees nursery of Noyabrsk forestry office| 42,4                                              | 318                          |
| Surgut      | Local History Museum                    | 73,2                                              | 119                          |
|             | Botanical Garden                        | 88,3                                              | 2061                         |

- no plantings;
* no watering at all;
** no watering in 2014.

The survival rate by 2017 varies depending on the geographical location, year of planting and plant care conditions (table 2). Low surviving was noted in the plantings made in 2013 because some specimens were planted with an open root system and some of them were transported for too long period (up to 8 days) in hot weather. In addition, most of these plantings were not cared for. In combination with unfavorable conditions in 2014, these factors led to a significant loss of plants, primarily in Nadym, Novy Urengoi and Gubkinsky. These experimental sites are located in forest-tundra and northern taiga. There is a fairly good preservation of plants (42,2%) in Noyabrsk despite the lack of watering. This is probably due to the fact that the city is in more favorable conditions of the middle taiga. Taking into account this experience in the future plants were imported within 3 days and with a closed root system.

The high survival rate by 2017 is observed for the plantings of 2016 regardless of geographical location. This can be explained by the fact that the trees and shrubs were planted in a favorable year
with wet summer and fairly mild winter. On the other hand, this is due to the short time elapsed since planting.

3.2. The sustainable assortment of trees and shrubs

Analysis of data on the condition of trees and shrubs in the experimental sites allowed to identify a group of promising taxa for different conditions of the YNAD. The period of observation was taken into account when developing a sustainable assortment. The first plantings in Sabetta were undertaken only in 2016. So the observation period is too short for even preliminary conclusions. But for the territory of the forest-tundra (Labytnangi, Salekhard, Novy Urengoy) there were 3244 specimens of trees and shrubs tested at experimental sites. So some recommendations can be done.

Taxa from different regions can be considered as suitable for sustainable assortment of trees and shrubs for landscaping settlements in the forest-tundra. They are Ribes aureum and Amelanchier spicata from North America, Salix schwerinii, Sorbaria sorbifolia, Spiraea salicifolia, S. betulifolia and S. betulifolia ‘Tor’ from Eastern Siberia and also cultivars and forms of native species – Ribes nigrum ‘Binar’, Padus avium f. Colorata. This species were not damaged or least damaged by adverse winter conditions (low temperatures) and summer conditions (prolonged drought). Some of these plants bloomed and bore fruit.

4. Discussion

Preliminary ecogeographical studies of 2011-2012 showed 52 taxa of trees suitable for the territory of YNAD, 33 of them are appropriate for the forest-tundra zone [4]. Similar work wasn't carried out on shrubs. The resulting number of suitable trees is quite large. According to the results of five years experience at the experimental sites, we can recommend only 9 taxa, and 3 of them are small trees or tall shrubs (Amelanchier spicata, Salix schwerinii, Padus avium f. Colorata). Y.F. Rozhdestvenskiy [2] recommended for landscape gardening of the forest-tundra settlements only 5 species of trees as a result of long-term investigations. All these species are indigenous. Of the 11 shrubs species he proposed, only 2 species are introduced (Spiraea salicifolia, S. betulifolia). Our data allowed to recommend two more species of introduced shrubs - Sorbaria sorbifolia and Ribes aureum.

Studies in green areas of settlements will complement the list of recommended species. So research from 2011 to 2017 in the forest-tundra settlements allows us to put forward the following additional species: Caragana arborescens, Dasiphora fruticosa, Cotoneaster lucidus.

All trees species recommended for planting in the forest-tundra cities of YNAD according to the results of tests on experimental sites and observations in green spaces originate from the donor regions of this territory (areas with similar climate).

5. Conclusion

The survival rate of plants varied at different experimental sites. The lowest survival rate is noticed in cases if there was no watering, open root system saplings were used and the transportation of specimens was too long. The list of 9 appropriate species and cultivars is composed as a result of this work.

Using only the experimental test data for the development of trees and shrubs sustainable assortment is not effective. The combination of ecogeographical analysis and observations gives good results. Testing plants on experimental sites is an important step to verify the results of the selection of trees and shrubs assortment for landscaping settlements. This work requires long-term testing and development of a system of care that provides better adaptation of plants, especially in the harsh conditions of Western Siberia. So the establishment and maintenance of experimental sites network is an important element of successful developing a sustainable assortment of woody plants for territories with harsh climate.

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