Ecological stability of wood species in conditions of root reclamation of salt flats

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Abstract. The state of artificial tree planting in 54 years after the meliorative effects on the solonetzic soils (land use, gypsum, manure application) and the transformation of annual soil treatments were studied. There was a general decrease in the forest stand and its quality on saline cells compared to common Chernozem. It is shown that the most salt-resistant tree crops are oak, ash and elm, whose safety is higher compared to other breeds tested in the experiment. Pears, apple trees, and poplars are now almost absent from the forest plantation. In the southern part of the saline section, by the age of 54, an ash-oak plantation with poplar and elm trees was formed (in the aggregate of the first two tiers), and in the Chernozem section, an oak-ash plantation with elm trees was formed. Plantings, according to forest management standards, have a significant difference in the composition of the first tier, in the completeness and totality of crowns and the stock of the stem tree. In the Northern part of the experimental site, the difference in the composition of the first two tiers is more significant, since the proportion of ash in the Chernozem section is 20% lower than in solonetzic soils, where the stand is less dense, full, stock and bonitet than the taxational indicators of the stand in Chernozem.

1. Introduction
In the structure of the soil cover of the steppe part of Russia, a significant place belongs to the solonetzic series of soils [1,2,3,4,5]. The productivity of such lands for agricultural use is at a fairly low level [6,7]. Solonetzic soils in different climatic zones and soil formation conditions differ in terms of forest vegetation. The growth of forest crops depends on many factors, among which the leading ones are the qualitative composition of the soil - absorbing complex of saline soils, salinity features and their water regime.

2. Materials and methods
Forest strip No. 147 (solonetzic cell) is the first experimental land plot, where since 1952 I. A. Yurin, I. F. Porotikov together with scientists of the V. V. Dokuchaev Soil Institute conducted experiments on the reclamation of old solonetzic soils by the forest reclamation method based on the application of Chernozem mass to solonetzic spots in combination with gypsum and manure [1].
In the field, a continuous cross-section of trees with a diameter of 1 cm at chest height was performed on each test area. At the same time, the height of trees was measured, at least 20-25 trees of each breed in three tiers. In some cases, measurements of fallen (windbreak) and dry trees (Tatar maple, ash and poplar) were used.

The diameter of the middle tier tree was calculated using the cross-section areas of each species involved in planting as the weighted average of these indicators. The average height of the tier was determined as a weighted average of the heights of each component of the rock. The average height of the latter was determined based on statistical processing materials and height graphs using the average diameter.

The stock of stem wood was determined by the diameter at a height of 1.3 m and the height of trees for each breed. The total stock is calculated for one hectare of plantings, through which, according to the age of the stand, the average annual increase in the stock was determined, which is a relative indicator of the energy of its growth. The bonitet of the stand was determined by the age and height of trees of the 1st tier.

3. Purpose of work
Based on the analysis of data obtained by researchers for the first time four years of crop growth on different variants of the experiment, to analyze the growth of tree species and the development of stands of plantings on reclaimed salt flats, by carrying out logging operations on variants of former salt flats 54 years after reclamation.

4. Research result
Sections of the studied stands grow on chernozems and solonetzic soils, which were reclaimed by land use with dewatering and gypsum. Based on the data obtained in 1959-1960, the safety of the main tree species (oak, ash and elm) depends on the location of the site in space, and within it on the soil conditions of growth. To date, the plantings belong to the sixth class of age (middle-aged age group) in which the process of forming a stand continues, which affects the preservation of tree species. Thus, in the southern section, the amount of oak in the Chernozem section is 67.2% more than in the solonetzic section, with almost equal density of ash and elm (table 1).

Table 1. Density and safety of wood species by area of experience

| Breed                      | Planted, PCs / ha | I plot (C°) | II plot (P°) | III plot (C) | IV plot (P) |
|----------------------------|------------------|-------------|--------------|--------------|-------------|
|                            | PCs ha %         |             | PCs ha %     | PCsha %      | PCsha %     |
| Quercus robur L.           | 1560 11.7%       | 306 19.6%   | 239 15.3%    | 284 18.2%    |
| Fraxinus pennsylvanica     | 1560 35.3%       | 523 33.5%   | 712 45.6%    | 467 29.9%    |
| Ulmus parvifolia           | 1040 5.3%        | 50 4.8%     | 61 5.9%      | 145 13.9%    |
| Populus balsamifera        | 1040 0.6%        | -           | -            | -            |
| Acer tataricum             | 3120 3.6%        | 150 4.8%    | 95 3.0%      | 56 1.8%      |
| Malus sylvestris, Pyrus communis subsp. pyraster | 520 1.2% | - | - | 12 2.3% |
| Subtotal                   | 9520 9.6%        | 1029 10.8%  | 1107 11.6%   | 981 10.3%    |
| Acer platanioides          | - 28%           | 139 28%     | 145 28%      |             |
| Cornus alba                | -                | -           | -            | 22 22%       |
| Fraxinus excelsior         | - 22%           | -           | -            | -            |
In the Northern part of the solonetzic section, the number of ash trees is 52.1% higher than in Chernozem, where there are more oak and elm trees. The preservation of poplar in the southern section is more related to the black earth section of the forest strip, while in the Northern part of the site it is preserved only in the black earth section. Tatar maple and fruit species were severely thinned during the felling of oak care in 1972. Most of the Tatar maple is dying, and, at present, it is preserved only in the form of dead wood. On both sites, the growth of self-seeding svidina (shrub) and Holly maple, which is part of the second tier of the stand, was noted. Its density in the Chernozem section is 4.4 times higher than the number of trees on solonetzic soils. The common ash we noted in the first section (unmeliorated saltbush) exceeds the growth parameters of downy ash trees, but it is a single tree.

Analysis of the density of preserved tree species shows that in the southern section of the experiment, the number of trees in the Chernozem section is 1.2% higher than in solonetzic soils.

Comparison of the growth parameters of the main tree species growing on the solonetzic soils and chernozems, respectively, sections I and II – III and IV shows that the first-tier oak in the southern half of the experimental site does not have a significant difference in growth, while in the Northern part of the oak on the Chernozem section significantly exceeds the growth rates of trees on the solonetzic soils (table 2).

### Table 2. Influence of soil conditions on growth parameters of tree species in the first tier of plantings

| Region | Number of trees, PCs / ha | The height of the tree (N), m M ± m | Trunk diameter (D ), cm M ± m | HCP<sub>05</sub> on height, m | diameter, cm |
|--------|--------------------------|-----------------------------------|-------------------------------|-----------------------------|--------------|
| I (C<sup>*</sup>) | 122 | 20.6 ± 0.25 | 23.9 ± 1.05 |
| II (З<sup>*</sup>) | 239 | 21.6 ± 0.22 | 22.4 ± 0.41 | 0.7 | 2.4 |
| III (C) | 172 | 18.0 ± 0.25 | 19.0 ± 0.66 |
| IV(3) | 239 | 21.8 ± 0.25 | 25.1 ± 0.80 | 0.8 | 2.2 |

**Quercus robur L.**

| Region | Number of trees, PCs / ha | The height of the tree (N), m M ± m | Trunk diameter (D ), cm M ± m | HCP<sub>05</sub> on height, m | diameter, cm |
|--------|--------------------------|-----------------------------------|-------------------------------|-----------------------------|--------------|
| I (C) | 195 | 19.1 ± 0.37 | 21.4 ± 0.74 |
| II (3) | 139 | 18.5 ± 0.19 | 21.3 ± 0.52 | 0.9 | 2.2 |
| III (C) | 178 | 16.9 ± 0.26 | 19.6 ± 0.76 |
| IV(3) | 133 | 19.5 ± 0.27 | 20.1 ± 0.90 | 0.8 | 2.5 |

**Fraxinus pennsylvanica + Fraxinus excelsior**

| Region | Number of trees, PCs / ha | The height of the tree (N), m M ± m | Trunk diameter (D ), cm M ± m | HCP<sub>05</sub> on height, m | diameter, cm |
|--------|--------------------------|-----------------------------------|-------------------------------|-----------------------------|--------------|
| I (C) | 22 | 17.6 ± 0.28 | 23.8 ± 0.95 |
| II (3) | 28 | 20.9 ± 0.26 | 26.4 ± 0.55 | 0.8 | 2.5 |
| III (C) | 11 | 16.5 ± 0.26 | 24.0 ± 0.72 |
| IV(3) | 39 | 17.7 ± 0.33 | 21.1 ± 0.39 | 0.9 | 1.7 |

Note:

*a Solonetzic soils not highlighted;*
land use in combination with manure and gypsum (Chernozem)

The growth of downy ash in the southern part of the experimental site does not depend on soil differences, and in the Northern part, trees growing on the Chernozem section (a variant of reclamation) significantly exceed the height of ash on the saline section. And if the number of oak on saline soils without reclamation is 67% less, then ash on these soils has a density 38% higher than on Chernozem sections.

For elm trees in the southern half of the site, the best conditions for growth have been created on land reclamation options, where the parameters of trees significantly exceed those on saline soils. In the Northern part, with a small difference in height, elm on solonetzic soils exceeds the diameter of trees growing on soils with root reclamation. For both sections of the experiment, it is characteristic that the number of trees on solonetzic soils is less than on the sites that include land use with the introduction of manure and gypsum.

Based on the data obtained for the first tier of the stand, which is the main canopy for further development of the plant, we can conclude that the best growth of oak and elm of the first tier on black earth sections and almost equal development of ash on saline differences.

For a more objective judgment about the influence of soil differences on the growth of different tree species, we conducted a comparative analysis of the first and second-tier trees growing on solonetzic and Chernozem sections (with root reclamation).

Summing up the results of research on the growth of tree species on soil differences, we can note a difference in the development of tree species of the first tier, while the indicators of average trees of the first two tiers of the stand are more smoothed.

The development of tree species on different soils had an impact on the taxation indicators of stands of the experimental site. In the southern part, on the solonetzic section by the age of 54, an ash-oak plantation with poplar and elm was formed (in the aggregate of the first two tiers), and on the Chernozem section (reclaimed solonetzic soils) an oak-ash plantation with elm. Plantings, according to forest management standards, have a significant difference in the composition of the first tier, in the completeness and totality of crowns and the stock of stem wood.

In the Northern part of the experimental site, the difference in the composition of the first two tiers is more significant, since the share of ash in the Chernozem section (with reclamation) is 20% lower than insolonetzic soils (without reclamation), where the stand is less dense, full, stock and bonitet than the taxation indicators of the stand on chernozems.

5. Conclusions
In General, according to the aggregate of the main taxation indicators of density, completeness and stock of stem wood, the average formula for solonetzic sections without reclamation (I, III sections) is 5Fraxinus pennsylvanica 4Quercus robur 1Ulmus parvifolia with a density of 654 trees with a fullness of 16.9 m²/ha, a wood reserve of 148 m³/ha and a crown density of 0.65. On the Chernozem sections (solonetzic soils with a limited reclamation), a stand with the composition of 5Quercus robur 2Fraxinus pennsylvanica 1Ulmus parvifolia 1Acer platanoides was formed with the number of trees 782 PCs. / ha, with a fullness of 23.6 m²/ha, and a wood reserve of 222 m³ / ha. And the closeness of the crowns is 0.90. On the salt-bearing sections, the average bonit is 7.5 with an annual growth of 2.8 m³/ha of wood, and on the black earth sections, respectively, 1 and 4.1 m³ / ha. According to the aggregate of the main taxation indicators of plantings, stands on Chernozem soils are 36.9% higher than those on solonetzic soils.

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