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ABOUT THE NATURAL SEED RESUMPTION AND TECHNOLOGY OF GROWING THE PLANTING STOCK IN PERMANENT FOREST SEED FIELDS AND NURSERY-GARDENS OF ANEMOCHOROUS TREE SPECIES IN KALMYKIA

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The paper shows and describes the carried out tests on the possibility to grow the planting stock of the anemochorous woody species (Siberian elm (Ulmus pumila L.), ash-leaved maple (Acer negundo L.)) by natural seeding of areas adjacent to the forest belts under the influence of wind conditions in Kalmykia. It allows combining the forestry seed farming and growing seedlings in one technological process by creating permanent belts of forest seed plots-nurseries (PPLSU nurseries) from the progeny of plus trees. This technology is patented and is an alternative to the existing nursery farming in Kalmykia.

Keywords. Anemochory, natural seed resumption, plus trees, permanent forest seed nurseries, growing seedlings.

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Anemochory is the ability of tree and shrub species to spread seeds with the wind. It manifests itself in the natural forests as a seed regeneration factor. Such tree species as birch, aspen and others (poplar, willow, alder, elm, maple, ash, pine, spruce, fir) spread in the area mainly using the anemochory mechanism. These species are able to regenerate naturally by seeds in large areas, when there are favorable conditions for germination of seeds and establishment of seedlings (warm, loose and long wet substrate, lack of competition of herbaceous vegetation). Cutover patches, waste areas and glades are mainly populated by the so-called tree species "pioneers" - birch, aspen and alder. The processes of natural regeneration of forests are especially intensive in recent decades on the abandoned croplands in temperate forests [4, 5]. This process significantly contributes to the digging activity of moles.

The abundant self-seeding of box elder, green ash (Pennsylvania) and Siberian elm occurs in the arid zone on the complexes of light-brown soils with different shares of participation of white alkali in wet years under the canopy of the artificial protective forest belts and next to them. This self-seeding is recommended to use as a planting stock [2, 3].

The anemochory property was used to produce planting stock of the anemochorous tree species in areas of permanent forest seed-nurseries as more accessible and cost-effective alternative to the existing nursery farming [1].

The most common anemochorous tree species for protective afforestation in steppe and semi-desert regions of Russia are Siberian elm (Ulmus pumila L.), Pennsylvania ash tree (Fracsinus pennsylvanica Marsh.), Ash-leaved maple (Acer negundo L.) and other types of maples. The artificial forest plantations in these regions are created in the form of stripes, oriented mostly in the meridional direction, i.e. perpendicular to the prevailing eastern and western winds. Wind speed is up to 10-15 m/s and gusts are up to 24 m/s. Wind Period with strong winds is long. Precipitation of the warm period in Kalmykia falls as cloudbursts.

The bulk of the mature winged seeds of these species is carried by wind over long distances from the forest belts. The seeds of the Siberian elm mature in the first half of May and fly away from the parent tree carried by wind up to 100 m and more. The maple and ash seeds mature in autumn, and the distribution takes place in autumn and in winter with the shorter distance from the seeding trees - up to 30-50 m. Germination of seeds of maple and ash during the autumn sowing is about 70-80%. Seeds, that didn't flow away from trees of these species in autumn and those kept on tree heads during the whole winter, show germination of 40-45% during the spring cropping.

The agricultural fields adjacent to the forest belt are constantly plowed and self-seeding is ruined. Massive self-seeding occurs inside the forest belts in wide row spacings of mature trees of the Siberian elm, box elder and Pennsylvania ash after the mechanical nursing is finished. The artificially structured forest belts in arid zones with a limited feed zone for 1 tree does not allow the natural seed regeneration of the forest due to the lack of moisture and defined boundaries of agricultural fields. But the use of this potential as a simple and cheap technology of producing seed with high hereditary properties is possible in each forest area of the State Forest Fund lands as an alternative for centralized and expensive basic seed farming.

The seedlings of tree species grown in the open ground of large basic nurseries from seeds collected in seed plantations, including the anemochorous volatile seeds easily carried by wind over long distances (e.g. maple, ash, elm etc.) are used in modern silvicultural production. The Bashantinsky basic irrigated nursery area of over 200 hectares has been operating until recently in Kalmykia. It provided planting materials not only for Kalmykia, but also for Astrakhan, Rostov and Stavropol region forestries. At this moment it became unprofitable and ceased production of planting materials.

Existing technology of growing seedlings in the open field nurseries includes harvesting seeds from growing trees, clearing them from the impurities, storage, seedbed preparation, sowing seeds in the seed furrows in the

ploughed and smoothed soil, weeding and loosening the soil, fertilizing and watering by spray irrigation, formation of fibrous root system of seedlings by trimming taproots with plane-cuts, mechanized digging. It is essential and justified for tree species the seeds of which cannot be spread by the wind due to their lack of adaptation to this. But in case of the anemochorous forest species the economically important and valuable biological property - fitness of their wind-carried flying seeds to natural colonization of the areas adjacent to forest seed-bearing plantations - is not used.

Centralized gathering of large quantities of seeds of the anemochorous forest species in scattered and separated by great distances (up to 500 km or more) small seed bases of consumers (forestries), mostly located in different soil and climatic conditions, and in conditions of shortage of seeds from random trees in the asphalted settlements, leads to the fact that forestries subsequently obtain ready planting materials with very diverse hereditary properties from nurseries, often little relevant to local forest growing conditions. This ultimately reduces the stability and durableness of the plantations created. The grown planting materials from the basic nursery farms is also transported over long distances by consumers thus affecting the quality, increasing the cargo and delaying the agronomic planting dates. In addition, the technology of growing seedlings in nurseries doesn't completely eliminate the manual labor and includes a number of time-consuming and expensive procedures namely harvesting seeds from growing trees, clearing them from the impurities, storing them in warehouses, seedbed preparation and sowing of seeds in the soil.

The proposed technology of growing seedlings of the anemochorous forest species can be used in forestry and agriculture for planting materials of local origin with improved hereditary properties. It is applied mainly to protective afforestation in open treeless areas with sustained regime of intensive winds with dominant direction.

The aim of this work is to expand the range of species and to increase the breeding, as well as biological and economic efficiency of growing the planting stock of the anemochorous forest plants using natural seeding in conditions of dry arid regions.

The goal is achieved by the fact that the process of planting stock growing is carried out directly in the forest seed plot spacings between few-rowed belts (no more than 3 rows) forming the blown design and put across the prevailing wind direction to ensure uniform filling of the previously prepared seed furrows by the emitted seeds (on the ploughed soil). The bands of seed plants are created from one species by planting young plants or renewing the existing grown-up multi-row plantings by cutting and uprooting inner rows in order to create the broad spacings between the belts. The fruiting of forest plants in the steppe and semi-desert areas occurs already at the age of 5-7 years.

The ploughing of soil by the plantation plough with the blade going 35-40 cm down into the soil while disking and harrowing is carried out in spacings between belts before the emission of seeds flying out from seed-carrying trees. Cutting the seed furrows is done by a cultivator implement using the scheme applied in nurseries for growing seedlings of the breed or other convenient scheme. For example, the distance between the centers of the furrows after the cultivation is 35-40 cm. This allows providing further mechanized nursing procedures in the space between furrows and mechanized digging of the prepared planting stock. The seeds fall to the ground after flying out, the wind moves them away from the ridges and they are accumulated in pockets. Seeds of forest species (e.g. maple, ash, etc.) maturing and flying away mostly in autumn and winter are covered with snow in the pockets of seed furrows. These are going through the stratification naturally. They are not subject to decay; they quickly germinate in the spring (after the snow melts and the effective temperatures rise) and give mass shoots using the most of the soil surface spring moisture and requiring no watering during the growing season. Seeds of forest species (e.g. elm) maturing in May after the seeding area need the spray irrigation for germination and seedling emergence in dry years. Precipitation of the warm period in Kalmykia falls as cloudbursts mainly in May or early June - this ensures simultaneous seed germination and subsequent growth of self-seeding.

Ordering the natural seeding in the open seed furrows creates the conditions for further mechanized nursing between the rows of seedlings, and manual weeding is carried out in rows during the growing season before the closure of the seedlings, i.e. according to the proposed method the technology of cultivation of planting stock is similar to the common in nurseries after the appearing of shoots. Furthermore, while using such technology of growing the planting stock the presence of forest seed belts helps to improve the microclimatic conditions of the growing process: in winter it helps to distribute snow in spaces between belts evenly, in the summer it helps to reduce the wind speed and the physical evaporation from the soil surface. But the planting stock is produced in standard volumes already in the first year exceeding the planned output for nursery growing by 1.5-2 times.

The spaces between rows are formed by cutting and uprooting inner rows while leaving rows of seed trees on the margins in order to use fruiting mature multi-row plantings as seed sites.

In addition, the seed plant bands are created by planting young seed plants or by vegetative progeny of plus trees to avoid cross-pollination with undesirable forms of breeding and for the mass reproduction of the promising sustainable forms. Also such plantings are put away from other plants of the breed or related species (for Siberian elm away from its sibbing smooth-leaved elm, hybrid forms of which are highly vulnerable to the Dutch disease). Thus, an analog of permanent seed area is obtained (PLSU), but the intermediate operations in gathering and sowing seeds in such "PPLSU - nurseries" are removed.

Plus trees of the Siberian elm were selected by the shape of the crown,

Fig. 1. Abundantly fruitful plus-tree of the Siberian elm at the age of 40 on the homestead of the Arshan' Zelmen science station of ILAN RAS. Left - in the leafy state; right - the trunk and branches after the leaf shedding

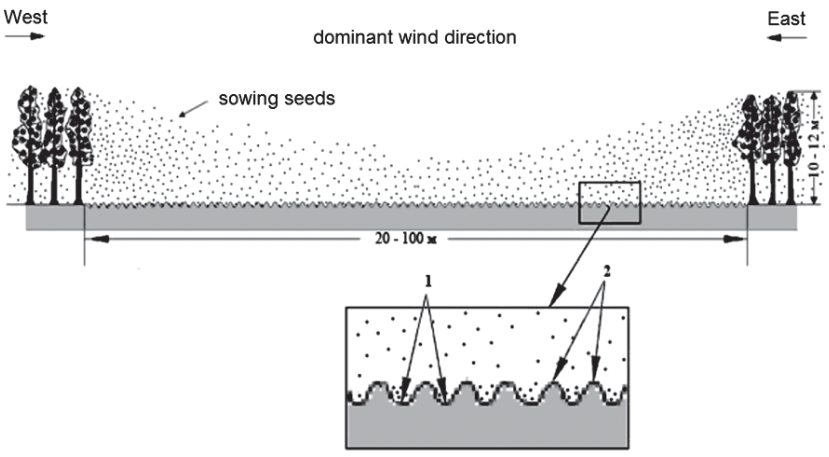

Fig. 2. Scheme of the belt of the permanent forest seeding in the field-nursery-garden during the sieving of seeds under the influence of wind in the space between bands 1 - seed furrow; 2 - ridges

shape of the trunk (habitus) and the type of lateral branches growing from the axial trunk. Usually Siberian elm is characterised by sympodial growth of the axial trunk with thick lateral branches at acute angle of divergence from the trunk. The large branches of the Siberian elm are often broken in winter during the glazed frost due to such type of branching. They accumulate large amounts of ice exceeding the weight of the branches themselves by 25-30 times. However, as in our case with the plus tree shown in Fig. 1, there are instances with monopodial-like shaft growing. Such trees have thin lateral branches with plagiotropic-like location in relation to the trunk and therefore the probability of ice-breaking is minimal.

The seed plantation bands of monoecious plants (e.g. elm) are formed by 1-2 rows and in dioecious (e.g. ash) - by 3 rows to ensure optimal conditions for wind blowing inside the bands and pollination of these plants. The ratio of male and female specimens in the forest belts made of ash-leaved maple and Pennsylvania ash varies roughly equally.

A system of seed plant bands, alternating with spaces between bands, is formed in order to organize the necessary crop rotation of the planting stock growing. The width of the spaces between bands is selected differently for each tree species, taking into account the area wind regime, the construction of seed plantation bands and their ventilation, as well as volatility and range expansion of winged seeds.

Fig. 2 schematically shows a cross-section through the 3-rowed seed planting bands of the box elder aged 17 and the space between bands with the width of 20m, obtained by reconstruction of the first part of the wide multi-row of the State Forest Belt Volgograd-Elista-Cherkessk at its 5-km stretch, which is located in the Sarpinsky district of the Republic of Kalmykia.

The inner rows of trees were cut down and uprooted and margin 3-rowed seed bands were leaved. The sick and defective trees were removed and the lower branches on the trunks of the left healthy trees were cleaned up to the height of 1.5 m in order to improve ventilation of the bands. We tried to uniform alternation in the ranks of female and male specimens while forming the seed plant bands. The reserve of seeds per fruit-bearing (1.000 pcs) trees of one kilometer three-row band was about 10.9 million pcs. The both marging seed plantation bands seeded the space between bands due to the periodic change of direction of the prevailing wind to the opposite, which is typical for dry steppe treeless areas of Kalmykia, therefore the area was seeded evenly. The bulk of the ash-leaved maple samaras seeds flied out in autumn during two months after their maturation at the wind speed of 10-15 m/s (wind gusts reached 24 m/s). The distance of the seed flow-out was 60-100 m with an average height of planting at 10-12 m and wind speed of 10 m/sec.

The extensive 15 cm deep sowing furrows were prepared with the cultivator CPN-2.8 in the unit with MTZ-50 in order to ensure the uniform distribution of seeds per square of space between bands and streamlining their sieving on ploughed soil to the depth of 40 cm, and

Fig. 3. A part of PLSU-nursery with a first year self-seeding of the Siberian elm in 2009. The furrows prepared by the cultivator can be seen; the wind brought the seeds into them from the forest wall.

aligned by harrowing soil. Fig. 2 shows a diagram of the cross-section of the seed furrow. The distance between the centers of the furrows (1) was 35-40 cm. Ridges (2) between the furrows are flat, that provided blowing the seeds with the wind to the seed furrow. After seeding the area each linear meter of the seed furrow in this scheme of furrow location had an average of 60-80 units of seeds or 150-200 pcs per 1 m2, and in terms of 1 ha - 1.5-2 million pcs of seeds, while in nurseries they spend more than 200 kg of seeds per 1 hectare or about 5 million pcs with a planned output of standard planting stock of 400 thousand seedlings.

Seeds in the furrows were left in winter without soil sealing, which increased their dirt germination to 80-85%, as they were not virtually compared in relation to rot with the soil sealing technique, where groundwater germination did not exceed 65% due to the rotting of the seeds in the soil. The seeds of ash-leaved maple, past stratification in natural conditions, sprout shoots together and gave mass young growth in an amount of 140-180 units per 1 m2 in early spring as soon as the snow melted and the surface of the soil warmed to 8-10°. Four manual nursing operations have been conducted in the space between rows with seedlings including the removal of weeds and loosening of the soil during the growing season. By autumn the output of standard planting stock of ash-leaved maple, grown by the described technique was 800 thousand units/hectare at a cost of one thousand pieces of seedlings equal to 315 rubles, or 2.5 times cheaper than the planting stock grown in nurseries in the usual way (calculated in prices of 2008).

Fig. 3 shows a fragment of an alternative PPLSU-nursery with an annual self-seeding of the Siberian elm. These grew from seeds brought by the wind, in the furrows prepared using the previously described techniques.

Conclusion. The use of the proposed technology of growing planting stock of the anemochorous forest species in the open soil by natural seeding from the growing trees provides the following advantages as compared to nurseries:

- possibility to get planting stock with high hereditary properties, the most adapted to local forest conditions;
- availability and simplicity of work (in practice it can be done in each forest region);
- significant reduction in the cost of cultivation of planting stock by eliminating some of the traditional processing methods used in nurseries (collecting seed from growing trees, clearing the impurities, warehousing, seedbed preparation and sowing of seeds in the soil);
- combination of seed production and cultivation of planting stock in a single process (creating seed plant bands from the offspring of plus trees as substitutes for forest seed plots);
- mass reproduction of promising sustainable forms;
- elimination of the capital and operating costs needed for the resettlement of large nurseries and their functioning;

This will significantly improve the quality of planting stock grown and created out of the forest crops and will reduce their cost by times.

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