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Identification of Wood-Seed Plantations of Scots Pine (*Pinus sylvestris L.*) on the Complex of Vegetative Signs in the Bashkir Predural

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Abstract: Reproduction of highly productive stands of Scots pine (*Pinus sylvestris* L.) will be successful through the creation of forest crops by planting material grown from improved seeds harvested from forest seed plantations for various purposes. An important role in this is given to the creation of new and effective use of existing forest seed plantations-family and clonal (vegetative) for harvesting high quality seeds for a long time with improved hereditary properties. The yield of Scots pine trees depends on their condition, growth and development of the reproductive organs. The selective approach to the objective evaluation of these qualitative characteristics is the goal of our study. The relevance of scientific research lies in the identification of forest seed plantations of various origins in a set of vegetative signs in order to establish their selection and compliance with the requirements of the standard.

Key words: Scots pine, forest seed plantations, clone, plus tree, the origin of plantations, establish

INTRODUCTION

The federal target program "Development of forest breeding seeds for the period 2009-2020" provides for a significant increase in harvesting of improved forest seeds for the reproduction of forests characterized by high productivity, sustainability and better quality of wood. Procurement of such seeds is carried out on seed-bearing plantations. In the Republic of Bashkortostan, mainly seed-bearing seed plantations have been established while clonal plantations, the most valuable in selection, occupy small areas. The available seed-bearing pine plantations of Scots pine need a detailed assessment of their selection efficiency. It is based on knowledge of the laws of growth, the state of life of trees and the development of their reproductive organs in conjunction with the origin of forest seed plantations.

The qualitative reproduction of pine forests is possible only if a selectively valuable seed-growing base of Scots pine and first of all forest seed plantations is created (Iozus and Makarov, 2009; Klushevskaia, 2016; Konovalov and Nasyrova, 2017; Tarakanov *et al*., 2014). A number of Russian scientists-forest breeders (Efimov, 2010; Fox *et al*., 2007; Iroshnikov, 2002; Nakvasina 2014; Tarakanov *et al*., 2001) in their studies paid special attention to the selection and genetic approach to the creation and evaluation of the effectiveness of forest seed species of forest-forming tree species, the use of seeds with improved hereditary properties in the reproduction of forests. These researchers are convinced that increasing the productivity and sustainability of forests is directly dependent on the quality of planting material grown in forest nurseries from improved seeds.

Currently, the share of valuable seeds harvested at the sites of forest seed production in the Republic of Bashkortostan is 3.9% (240 kg) of the total volume of seminal harvesting 61.300 kg. This circumstance causes an acute need for seeds with high seeding qualities and improved heredity, obtained mainly from forest seed plantations. In the Republic of Bashkortostan, the first stage of selection work with coniferous tree species has basically been completed.

As of 01.01.2013, plus plantations of various tree species were identified on an area of 1,209.5 ha, including 780 ha of Scots pine, 1.297 plus trees, including 741 pine trees. With the use of seed and vegetative material of plus trees, 216 ha have been created of which the common pine is 195 ha. Permanent forest seed plots were established on an area of 1,761.4 ha, including 952.9 ha of common pine.

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When creating and forming seed-bearing pine plantations with vegetative and seed material harvested from plus trees, it is necessary to evaluate them not only by radial and linear growth but also by reproductive capacity. In their studies, a number of researchers (Besschetnova and Besschetnov, 2017; Besschetnova, 2015) paid special attention to improving the efficiency of positive selection of tree species, selection and targeted use of plus trees and evaluation of their reproductive potential. They noted the importance of this problem in terms of qualitative selection of the initial selection material for planning and creating forest seed production facilities, including forest seed plantations.

The problems of fruiting the seed plantations of Scots pine, the variability of the generative sphere in correlation with climatic conditions were considered in the studies of Nakvasina (2014). An estimation of the reproductive capacity of this tree species in combination with various factors is given and a systematic approach to the successful solution of this issue has been developed (Nakvasina, 2014).

Also, according to Kroon (2011) when studying the nature of the Scots pine sowing, knowledge of the spatial-temporal patterns of the genetically determined variability in the growth and fecundity of this tree species is needed as well as an assessment of its genetic potential using the ISSR method (Kroon *et al*., 2009).

When creating pine plantations, it is necessary to approach systematically to the implementation of planned measures in accordance with the requirements of existing regulatory documents. Important attention, according to Alvarez *et al*. (2012) should be given to the analysis of environmental factors (water, light), actively influencing the growth and accumulation of wood volume. This will allow in a shorter time to receive wood stock with high quality of trunks and shorten the time of commissioning of stands.

In the reproduction of Scots pine, attention should be paid to the methods of preparing the forest area and the choice of the method of reforestation. This approach, according to Aleksandrowicz-Trzinska *et al*. (2017), promotes the stimulation of earlier growth and preservation of Scots pine when this species is introduced into the cultivation.

The selection and formation of an assortment of plus trees for the creation of forest seed plantations is a rather complex problem of forest selection science. First of all this is due to the danger of inbreeding depression in the seed progeny of plus trees which do not possess the expressed mechanisms of protection from self-pollination (Besschetnova and Besschetnova, 2016). In this case, it is important to develop optimal approaches and management solutions to minimize the risk of inbreeding depression in plants in the process of plantation of pine.

Adoption of optimal management decisions in the creation of plantations of Pinaceae conifer species in multifunctional forestry is important (Jin *et al*., 2017). When growing pines by seedlings and transplants, attention should be paid to stimulating the development of the root system using biologically active agents (Biodrugs).

The importance of this approach, according to the research of Feng-De *et al*. (2004) will ensure the future formation of artificial stands of Scots pine and a multifunctional approach to forest reproduction. Selection of wood species for the creation of forest seed plantations is carried out taking into account their biological features and ecological properties. A good development of their vegetative characteristics, including the size of the needles and its physiological characteristics (Alvarez *et al*., 2012; Besschetnova and Besschetnov, 2017; Feng-de *et al*., 2004) is a generator of the correspondence of forest and soil conditions to the needs of tree species. According to the research of Klushevskaya (2016), dimensional characteristics and physiological functions of needles can serve as diagnostic criteria in assessing the resistance of Scots pine to drought. When growing the planting material from the seeds of the pine trees in the forest selection nursery for use in plantation crops, it is necessary to carry out measures to combat diseases that ensure the quality and high yield of standard seedlings.

For these purposes, various drugs are used but the greatest effect is observed with chitosan (Aleksandrowicz-Trzcinska *et al*., 2015). For a qualitative assessment of the effectiveness of forest seed plantations of Scots pine clones on forest seed plantations, various methods for their identification are used (Fedorkov, 2004; Tarakanov *et al*., 2001). They are applicable when comparing forest seed plantations created by vegetative and seed materials. Therefore in our studies, the identification approach to the assessment of seed-bearing pine plantations of Scots pine was given considerable attention.

MATERIALS AND METHODS

Methods of research are based on the use of modern silvicultural and selection-genetic approaches in assessing the quality and efficiency of forest seed plantations. Experimental studies were carried out on 10 seed-bearing plantations of seed and vegetative origin,

established in the Dyurtyuli and Tuimazi forest districts of the Bashkir Preduralye. The research uses the identification approach which allows to approach more objectively the qualitative assessment of the seed-bearing pine plantations of the Scots pine according to the complex of features in correlation with their origin. On the seed-bearing plantations, trees were taken into account and the pine trees were measured according to the diameter, the height of the trunks and the width of the crown. From each tree cones were selected (50 pieces) and measured according to their length, diameter and mass. On the trees, the needles were selected to measure their width and length and the annual increment of the axial shoot was determined. The results of measurements of the traits studied were processed using modern mathematical methods and applied static programs.

RESULTS AND DISCUSSION

Identification of seed-bearing pine plantations of Scots pine of various origins was carried out according to a set of morphometric signs of the trunk, crown and cones.

Forest Seed Plantations (FSP) are laid in the Dyurtyuli Forestry of the Republic of Bashkortostan (Preduralye) in different years: No. 133-1990, No. 36-1993, No. 37-1995, No. 43-2000; clonal plantations No. 24 and No. 28 in 1985.

On these seed-bearing plantations at the age of 9-26, the tree counting of all trees was carried out and also measuring the height, the diameter of the trunks and the width of the crown and their condition was taken into account. Based on the counting and measurement of trees, the mean values of the traits studied were calculated (Table 1).

It is noted that the average diameter of the trunks of Scots pine within the limits of close age groups of trees varies insignificantly.

In trees on clonal plantations, its value is higher -24.5±1.26 to 24.8±1.31 cm, compared with trees of close age of seed origin -23.5±1.20 cm. A similar pattern is noted for the average height trunks of Scotch pine within their close ages. The state of the counted trees is generally good which indicates compliance with the requirements of OST 56-74-96 "Plantations of forest seed forests of the main forest-forming species. Rules of bookmarking" for the care of seed-bearing sites.

The variety of characteristics of pine needles is the subject of multi-purpose scientific research. According to Besschetnova and Besschetnov (2017), dimensions of needles are an indirect sign of the growth indicators of Scots pine.

Table 1: Average taxation indicators and condition of pine trees

Number of FSP	Age, (years)	Mean characteristic values: Diameter (cm)	Height (m)	Crown width (m)	State of trees
Family plantations					
43	9	5.6±0.20	2.9±0.15	1.7±0.07	Satisfactory
37	14	13.2±0.62	5.5±0.29	3.4±0.13	Good
36	16	16.5±0.73	6.5±0.25	4.8±0.21	Good
33	19	23.5±1.20	7.5±0.23	6.2±0.18	Good
Clonal plantations					
24	20	24.5±1.26	10.7±0.45	6.8±0.32	Good
28	22	24.8±1.31	11.2±0.54	7.2±0.34	Good

Table 2: Parameters of pine needles on annual shoots

Number of FSP	Width of needles (mm) $X\pm m_{\bar{x}}$	V (%)	Length of needles (mm) $X\pm m_{\bar{x}}$	V (%)	Growth of shoot (cm) $X\pm m_{\bar{x}}$	V (%)
Family plantations						
43	1.6±0.08	10.2	7.6±0.12	16.8	12.6±0.73	23.3
37	1.7±0.07	8.5	7.5±0.54	10.4	12.4±0.75	22.6
36	1.8±0.10	12.2	7.4±0.52	9.6	11.9±0.90	25.6
33	1.3±0.12	11.2	6.6±0.30	6.9	12.9±0.87	19.8
Clonal plantations						
24	1.9±0.09	10.8	8.2±0.52	10.2	13.5±1.12	20.5
28	2.1±0.14	11.6	8.5±0.49	12.3	14.2±0.98	23.2

Our studies were aimed at studying the size of needles in annual shoots of Scots pine in connection with the origin of forest seed plantations. The annual increment of annual shoots was fixed (Table 2). It was noted that the length of needles in homogeneous age groups of Scots pine trees is 6.6±0.30-8.5±0.49 cm with a coefficient of variability of the trait from 6.9-12.3%. According to the width of the needles, the trees of Scotch pine of a close age differ insignificantly. Their values vary from 1.3±0.12-2.1±0.14 mm.

The coefficient of variability of this feature is 11.2-11.6%. The best annual increment of shoots in pine trees of close age is noted on clonal forest seed plantations. Its value varies from 12.9±0.87-14.2±0.98 cm with coefficients of variability of the sign from 19.8-23.2%. In the northern part of the crown, the needles are smaller in size than in the southern part. In different years, a comparative analysis of the linear and radial growth of trees of the species was carried out on seed-bearing pine forests of the Tuymazi forest range (Table 3).

The location of pine trees on seed-bearing plantations is 7.0×5.0 and 8.0×7.0 m. These layouts, according to our observations, provide a good growth of trees for the diameter and height of the trunks and the development of the crown.

Identification of pine forest seeds of Scots pine according to different years of record indicates some of their differences in the main morphometric characteristics of the trunks.

Table 3: Regularities in the growth of Scots pine on forest seed plantations of various origins

Number of FSP	Age, (years)	Years of record: 1997 Average height (m) X±m$_X$	Z$_h$	1997 Average diameter (cm) Xm$_X$	Z$_d$	2013 Average height (m) X±m$_X$	Z$_h$	2013 Average diameter (cm) X±m	Z$_d$	2016 Average height (m) X±m$_X$	Z$_h$	2016 Average diameter (cm) Xm$_X$	Z$_d$
Clonal plantations													
13	36	8.9±0.49	0.24	13.5±1.56	0.38	15.6±0.34	0.43	23.7±1.05	0.68	16.1±0.42	0.41	25.3±1.12	0.64
22	37	8.5±0.50	0.23	13.3±1.62	0.36	16.2±0.32	0.44	25.4±0.93	0.69	17.8±0.46	0.46	26.4±1.02	0.66
Family plantations													
12	35	7.6±0.44	0.20	12.8±0.45	0.32	13.8±0.25	0.25	22.8±0.68	0.58	10.8±0.23	0.39	16.6±0.56	0.59
34	38	8.6±0.75	0.23	13.1±0.78	0.34	14.5±0.24	0.38	23.6±0.38	0.62	16.4±0.36	0.40	25.4±0.78	0.63

Table 4: Parameters of Scots pine cones on forest seed plantations

Number of FSP	Age (years)	Length of cone (cm) X±m$_X$	V (%)	Diameter of cone (cm) X±m$_X$	V (%)	Weight of one cone (g) X±m$_g$	V(%)
Clonal plantations							
22	37	5.4±0.05	7.2	5.0±0.03	6.9	12.9±0.15	20.3
Family plantations							
34	38	4.1±0.03	6.8	4.5±0.02	6.2	10.2±0.16	23.4

Table 5: Correlation connections of pine cone size

Forest seed plantation	Comparable signs of cones	Correlation coefficient	Regression equations	Coefficient of determination R^2
Clonal	Length and diameter (cm)	0.72	$y = 0.07X^2+0.13X+2.09$	0.53
Family	Length and diameter (cm)	0.65	$y = -0.08X^2+1,19X+1.07$	0.43
Clonal	Weight of cone (g) and diameter (cm)	0.82	$y = 0.09X^2+0.74X+17.73$	0.68
	Weight of cone (g) and diameter (cm)	0.84	$y = 0.08X^2-0.73X+16.89$	0.70
Family	Weight of cone (g) and diameter (cm)	0.83	$y = 0.04X^2-0.18X+16.30$	0.69
	Weight of cone (g) and diameter (cm)	0.81	$y = 0.04X^2-0,24X+16.55$	0.65

The information given in Table 3 on the size of Scotch pine trunks shows that in same-aged forest seed plantations the average diameter and height are higher, compared to the trees of family plantations.

Therefore, when creating pine-tree plantations of Scots pine, preference should be given to clonal plantations that ensure higher growth and development of trees in the future as well as their yield and seed productivity.

On clonal and family plantations, we studied the dimensional characteristics of pine cones-length, diameter and weight of one cone. The results of the measurements are given in Table 4.

On same-age plantations, differences in the parameters of pine cone pine cones are noted. Larger are cones on the clonal forest seed plantation, compared to the cones of trees of family plantations. The differences according to the analyzed signs of cones are reliable - $t_{\phi akT} = 2.1\text{-}9.2 > t_{0,05} = 1.96$.

The most variable characteristic is the mass of one cone with a coefficient of variability from 20.3-23.4%. According to the size of cones, the variability of symptoms varies from 6.2-7.2%.

On clonal and family plantations between the studied indicators of cones of Scots pine, a correlation analysis was performed to establish the tightness of their connection (Table 5). The data presented indicate the average (r = 0.65) and high (r = 0.72-0.84) levels of correlation between the comparative indicators of pine cones, approximated by the corresponding regression equations. The highest correlation links were found between the mass and the size of cones. This allows us to make an assumption about the high yield of seeds from cones and their fullness. On a clonal forest seed plantation between a mass of 1000 pcs. seeds and the length of the cones the correlation coefficient is 0.66, on the family -0.60.

Between a mass of 1.000 pcs. seeds and cone diameter, the value of the correlation coefficient on the clonal forest seed plantation increases to 0.82 on the family -0.68.

When harvesting cones on forest seed plantations, attention should be paid to the mass of cones, the yield of seeds and their fullness.

Kroon *et al.* (2009) studying the correlation between the productivity of cones in clones of pine of different ages, noted that genetic correlations proved to be higher than phenotypic ones. With the increase in the age of plantations of Scots pine on forest seed plantations, these connections intensified (Kroon *et al.*, 2009).

CONCLUSION

The carried out researches on identification of seed-bearing pine plantations of a pine of a various origin on a complex of vegetative signs of trees have allowed to draw a conclusion about advantage of clonal plantations before family. Clonal plantations are represented by a set of pine trees with more qualitative and fast growing trunks, developed crown and large cones. The analyzed forest seed plantations are characterized by insignificant variability in the characteristics of the reproductive sphere. Weight of cones and weight of 1.000 pcs. seeds are the best trees of Scots pine which grow on clonal plantations. The studied features can be used for an objective assessment of the combinational ability of clones of the plus trees of Scots pine and the subsequent genetic analysis of the created forest seed plantations. In the Bashkir pre-Urals clones of pine trees on the forest seed plantations are not covered by the genetic evaluation of the offspring.

The solution of this problem is an urgent task at the present stage of conducting forest seed selection of Scots pine in the region. Genetic selection approach to the assessment of the efficiency of seed-bearing pine forest plantations will allow solving the problem of their compliance with the requirements of OST 56 -74-96 standard and providing silvicultural production with high-quality seeds at a qualitatively new level.

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