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Bio-ecological Peculiarities of Genus *Pinus* L. Species Under Conditions of Eastern Georgia

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Abstract. The article discusses bio-ecological peculiarities of the following species of genus *Pinus* L. spread in eastern Georgia: ***Pinus eldarica* Medw., *P. griffithii* McClelland., *P. cembra* L., *P. pallasiana* Lamb., *P. pinea* L., *P. sabiniana* Dougl., *P. sylvestris* L., *P. sosnowskyi* Nakai, *P. strobus* L.**, the perspectives of their usage in Green Building and contemporary problems.

We have studied the periods of bud opening, vegetation ending, starting and finishing of cambium action, sprout woodening process, time and rate of growing in height, and regularities of accumulation-transformation of storage carbohydrates.

The studies revealed that the annual development cycle of all these species includes all morphological -physiological periods: sprout growth, latent growth, organic and forced rest. They are characterized by the good growth-development; almost all of them are perspective for eastern Georgia, particularly, for all regions of inner Kakheti.

However, in recent years, massive drying up of pine forests groves takes place in eastern Georgia. That is why it is necessary to conduct the fitopatologic research, identify the pest causing the damage and plan the measures against it.

Keywords: *Pinus*; spread; evergreen; coniferous; vegetation; cambium; life expanse; height growth period. accumulation- transformation of carbohydrates.

Introduction

From the gymnosperm of modern flora, coniferous plants are the richest in representatives. Genus *Pinus* L. involves approximately 100 species, naturally spread in the North Hemisphere. More than 40 species are introduced in Georgia.

We have studied the bio-ecological peculiarities of the following species of Genus ***Pinus*** spread in eastern Georgia ***Pinus eldarica***, ***P. Griffithii***, ***P. cembra***, ***P. Pallasian***, ***P. pinea***, ***P. sabiniana***, ***P. sylvestris***, ***P. sosnowskyi***, ***P. Strobus***.

Pinus eldarica is widely spread in local culture. It naturally spread in Eastern Caucasus, on the right bank of the River Iori, at an altitude of 450-600 m. It likes light and warmth. When cultivated at the height of 700-800m and higher, there is not enough heat and is damaged by the winter frosts. Frost resistance does not exceed $-20 - 22^{\circ}$ [1]. It is xerophytes species. In comparison to local pines growing in Georgia, ***Pinus eldarica*** is the most frost-resistant. This species is characterized with the slow growth and is widely used in the greenery of eastern Georgia.

Pinus griffithii is naturally spread in Himalayans, at an altitude of 1600-3000-4000 m. In the homeland it reaches 30-50 m in height, has a half-conical trunk, is slightly demanding to the soil and air moisture and is characterized with a good growth and development in arid as well as in humid regions [1]. It has been cultivated in Europe since 1823, and since the second half of the XIX century - in Georgia. Here it exists in western, as well as in eastern parts of the country. The best conditions for its growth and development are on the Black Sea coast, but it grows well in eastern Georgia as well, particularly, in Tbilisi, Telavi, Kvareli, and Lagodekhi.

From the ***Pinus griffithii*** specimen growing in Georgia, the best-developed individuals are in Kakheti, particularly, in Tsinandali Park. Here these trees, aged 100, reach 30 m in height and 80-85 cm in width [2]. In decorative gardening, ***Pinus griffithii*** is very popular with its conical trunk, long grizzled needles and cylindrical cones of 15-20 cm. Cultivation of this species is possible up to 1000-1200 m height. It is easily reproduced by the seed, provides self-crops and fruit-bears abundantly. ***Pinus griffithii*** is perfect for greenery of inner-Kakheti regions.

Pinus cembra is naturally spread throughout Siberia. In the homeland it grows up to 35 m in height and 1,8 m in width; has grey bark. It grows slowly, but lives up to 5000 years. In Tsinandali Park, there are three specimen of ***Pinus cembra***. One of them is 11-15 m in height and 45 cm in width.

Pinus pallasiana is naturally spread in: western part of Asia Minor, Balkans, Austria and western Caucasus. In the homeland, it reaches 30-40 m in height. It was introduced in Georgia in the 80s and 90s of the XIX century and widely spread in decorative gardening and forest cultures [1]. Adapts well to humid, as well as to arid climate, is frost and drought resistant, grows well on poor, rocky soils, loves the light, stands against the partially salted soils, smoke, etc.

In Tsinandali Park, ***Pinus pallasiana***, aged 100, has 23m height and 70-80cm width [2]. It is distinguished by the good growth-development here, as well as in Tbilisi and other regions of Kakheti: Telavi, kvareli, Lagodekhi. Therefore, it is widely cultivated all around Kakheti.

Pinus pinea is naturally spread in the coastal countries of Mediterranean - Italy, Portugal, Spain, Asia Minor, mainly in the coastal area, and rarely - in mountains, up to 1000m from the sea level. In the homeland, it grows up to 30m in height, is characterized by the roundish or umbrella-shaped trunk [1]. ***Pinus pinea*** is semi-xerophytes species, loves warmth and stands well against the limestone soils. It was introduced in Georgia after the second half of the XIX century; adapts well to humid and arid conditions; fruit-bears from the age of 20. The cone ripens in the third year after the pollination.

Pinus sabiniana is naturally spread in western California; is limited in its representatives in the mountains of the coastal area of the ocean and on the western slopes of Sierra-Nevada, at the height of 1500-1800 m from the sea level. In the homeland, it grows up to 30 m in height and 120 cm in width [1].

Pinus sylvestris is naturally spread in western Europe, from the Scandinavian peninsula to the Balkans; in Russia it is met in Siberia (to - N.L. 70°) and reaches the coats of the Sea of Okhotsk (N.L. 60°). It grows on various soils. In the homeland, it grows up to 30-40m in height. It has been cultivated in culture since the ancient times. ***Pinus sylvestris*** is frost and drought resistant.

Pinus sosnowskyi is a local pine, spread almost everywhere in the Caucasus and considered to be one of the main breeds of the forests. It loves the light and grows to 30-35m; has a

roundish or pyramid trunk; lives up to 400 years. The wood of **Pinus sosnowskyi** has valuable economic characteristics. Its health and sanitary-hygienic significance is particularly high.

Pinus strobus is naturally spread in North America and Canada. It exists in form of pure or mixed groves. It is characterized with the wide area of spreading. In the homeland, it grows to 40-50m in height and 100-180 cm in diameter. The branches are located circularly on the stem, forming the wide pyramid trunk. **Pinus strobus** is characterized with the fast growth, that contributes to its rapid spread outside the homeland. It grows on any kind of soil, is frost-resistant, and stands against -26-30°.

Pinus strobus is very often met in eastern Georgia. Here it was introduced in the 80s of the XIX century. It is widely used in Tbilisi greenery, Botanical Garden, Tsinandali Park, Telavi, Lagodekhi and in other regions of eastern Georgia.

Sources and methods

The aim of our research was the study of bio-ecological peculiarities of the listed species of genus *Pinus* L. introduced in Georgia; summarizing the issues of their introduction-acclimatization. For this reason, the observation has been conducted on the selected specimens since 2001. The phenology and phenometry has been conducted on the selected plants systematically, once or twice in the decade. We have observed the periods of bud opening, vegetation ending, starting and finishing of cambium action, sprout woodening process, the time and rate of the height growth.

Besides the apical growth, the cambial growth of the lateral branches has also been studied. For this purpose we took the patterns from the twigs once in every ten days from the early spring to the late autumn, then placed them in 60-70% alcohol [3], [4], [5], and observed the dividing of the cells of secondary meristem and development of annual cycle through a microscope. Transverse veneer was taken with safranin and the process of new wood cells development was determined; we conducted the research according to the methodical instructions by Yatsenko-Khmelevski, 1954, Lobzhanidze E., 1961, and Tsitsvidze A., 1973.

We have also studied the peculiarities of accumulation and transformation of storage carbohydrates in the lateral branches with regard to annual development rhythm and overcoming winter frosts. For this purpose in the third decade of each month, the analyzing samples were taken every morning. By the influence of chemicals on the diametrical slices, we studied carbohydrate content. Starch content was determined by the Potassium iodide (starch stained in blue), sugar – by alpha-naphthol, and concentrated sulfuric acid (stained in purple), and fats with the help of Sudan III (color - orange) [6]. We used a five-point system (1- very small, 2-small, 3-satisfactory, 4-much, 5 – too much).

Conclusions

The research revealed that under the conditions of eastern Georgian, the studied species begin growth in spring, when the average daily temperature is 5-10°, and end at different times, depending of the endogenic and exogenic factors, in May-June in lateral and in June-July - in top branches.

Besides, we have noticed that on **Pinus griffithii** and **Pinus strobus**, the growth is more intensive at night, than in the day. It mostly refers to the sprout lengthening. For example, for 10 days /from April 20th to April 30th/ the growth of **Pinus griffithii** and **Pinus strobus** during the night was 2,5cm and during the day -1,8cm. In addition, revealed that the sprout growth is not continuous, resting period 2-3 days, rarely – 4days, after about 8-15 days of growing.

Duration of the height growth of **Pinus griffithii** is 70-75 days, cambium activity lasts for 140-150 days; fruit-bears abundantly; seed fullness is 50-80%. Average starting date for cambial growth is April 30. Deviation from the average date is 7 days in both directions. The variation coefficient is 10%, so 15 years of observations are needed to determine relatively exact date.

In addition to the linear growth, we have studied the process of thickness growth /on the example of dried and fallen trees/ using the taxation method. **Pinus griffithii** finishes the radial growth approximately on October 10. Deviation from the average date is 10 days; growth duration - 147 days. The maximum starch amount in the branches of **Pinus griffithii** was observed in April-May and September-October. Besides, the maximal amount in spring exceeds the maximal amount in autumn. This suggests that this pine produces photosynthesis in winter as well. Fat content is

quite high in summer. Quantitatively it rises in autumn-winter and equals to 3 points, probably due to the fall of temperature. **Pinus griffithii** is a very interesting species for eastern Georgia, especially for Kakheti greenery-foresteing.

Pinus eldarica is very perspective for eastern Georgian conditions, so in this region, there are more than hundred hectares of cultivated forests with **Pinus eldarica**. Almost all forms are used in greenery of parks and gardens, street plantations, road greenery, alley formation, etc. **Pinus eldarica** forms a well-developed trunk, fruit-bears abundantly, and in most cases, reproduces by self-sowing. However, in recent years, trees in groups or individually are drying. In our opinion, this may be caused by the breach of water balance in soils or humidity, and pests. Therefore, we believe that it would be reasonable to cultivate it not in pure (only **Pinus eldarica**) but in forms of mixed plantation.

Seed fullness of **Pinus cembra** is 3-5%. Such a low quality is because the cold zone plants require long-term effect of low temperature for normal development of generative organs. That is why; lime content in soil, short days and relatively warm winter is restrictive for their growth-development here. Therefore, this species is almost useless for greenery and foresteing of eastern Georgian regions (in oak belt and lower).

Pinus pallasiana begins the bud opening in the first decade of April. The growth duration is 60-65 days; cambium activity period – 150-160 days, seed fullness – 60-80%. Two peaks of maximal starch content in the branches were observed in summer, and relatively lower- in August-September. Starch content decreased in January, when the air temperature equaled - 9,5°. At this time, fat content was maximal and equaled 5 points. Sugar content increased from autumn to January and in February, it decreased to 2 points from 3.

Pinus pallasiana is distinguished by the good growth and development in Tsinandali Park, as well as in other regions of Kakheti. Therefore, it is widely cultivated throughout Kakheti. In Telavi **Pinus pallasiana** culture is artificially cultivated on approximately 6 hectares.

At the age of 30-40 **Pinus sosnowskyi** is 15-18 m in height; stem diameter is 28-30 cm; fruit-bears regularly (seed fullness is 80-90%) and reproduces by self-sowing as well.

Well-developed specimens of *Pinus pinea* exist in Tbilisi, as well as in Tsinandali Park, where two of its centenarian trees are characterized with good growth-development (diameter – 75-88 cm, height – 18-20 m). **Pinus pinea** is perspective for eastern Georgian regions and from the decorative viewpoint, great attention should be paid to its widespread planting in greenery.

At the age of 70, **Pinus sabiniana** reaches 16m in height and 50cm in diameter in Tsinandali Park. It fruit-bears abundantly and hardly ever dies from droughts. This species loves light, does not stand against darkening, slightly demanding to the soils, adapts well to grey-brown soils of neutral and weak alkaline reactions; is not damaged by the frosts.

In Tsinandali Park, 59-60 years old **Pinus sylvestris** grows up to 20m and 30-32 cm diameter; pollinates in late April and mid-May. In eastern Georgia, it is hardly ever cultivated. It loves light, cannot stand darkening and saline soils.

Various forest cultures of **Pinus sosnowskyi** covers several hundred hectares in eastern Georgia and has been included in the artificial forest cultivation assortment for a long time. 30-40 years old specimens, existing in Telavi, are 15-18 m in height, 28-30 cm in stem diameter, fruit-bear regularly (seed fullness -80-90 %) and reproduce by self-sowing as well.

Pinus strobus is characterized with a good growth-development in Tbilisi, Telavi, Tsinandali Park. About 90-100 years old specimen reaches 20-21 m in height and 70-75 cm in width; fruit bears abundantly; seed fullness is 30-40 %; sometimes provides self-sowing as well. It begins growing in May. Growth duration is 40-45 days; duration of cambium activity – 145-150 days. It grows so well in Kakheti that may be widely cultivated in decorative gardening and forest cultures.

Thus:

The annual development cycle of the woody plants introduced in eastern Georgia involves all morphological - physiological periods (sprout growth, latent growth, organic and forced rest). At the beginning they grow, then pollinate and continue growing. Pollination of the studied plants, in spite of small changes, is almost the same as of those in natural spreading area.

The regularity of accumulation-transformation of carbohydrates correlates to the annual development cycle. Maximal starch content was revealed in autumn – September-October and in spring –April-May. Starch transformation into sugar begins in autumn, before the frosts.

Sugar and fat accumulation in winter is more active in temperate and cold zone plants. Frost-resistance is higher among the plants morphological-physiological process rhythm of which have synchronous connection to eastern Georgian climate seasons and fully transfer the starch into sugar and fat. This kind of rhythm ensures the plants dynamic unity with the surrounding environment. The vast majority of plants growing in eastern Georgia (Tbilisi, Telavi, Tsinandali, Kvareli, Lagodekhi) can be assigned to this group.

However, despite above mentioned, during the last 6 years reddening of needles, young sprout drying, stem damage by pests in artificial and natural groves of pine forests is observed in all regions of eastern Georgia. During the last 2 years, massive drying of pine groves takes place.

We suggest conducting fitopatologic research, identifying the pests causing the damage and planning the measures against them.

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