Effects of Climate Change on Seed Yield of Larch Forest

Institute of Geography and Geoecology, MAS

Abstract

The Ulaanbaatar green zone forest, where the research was conducted, is in charge of water regulation, which is the source of the capital's significant water supply, such as rivers and streams. The forest also provides soil protection, climate mitigation, and reduced air pollution, resulting in healthier and more comfortable living conditions for inhabitants. For Mongolia, over the past eighty years, the average annual temperature has increased by 2.2 degrees, and the amount of precipitation has decreased by 7-10 percent every year. The purpose of this study is to determine the indicators of flowering and seed yield of larch forests in the green zone of Ulaanbaatar and to study the effects of climate change on the conditions of the region. As a result, the trees in the sample area are in the age class IV-VII of the mixed taiga forest in mature states with larch, spruce, and cedar with a thickness of 0.6-0.7. The average diameter of the forest is 22.5–30.2 cm, the average height is 18.6–18.8 m, and according to the selection category, normal trees are prevalent. According to the flowering process, the trees began to bloom evenly in the second ten days of May, but due to sudden coldness in spring and continuous cold rain, the larch flowers dried up and could no longer produce seeds. Soil has the most important influence on the flowering, fruiting, seed yield, and seed maturation of trees, shrubs, and plants. According to the results of soil analysis, the content of humus contained in 100 g of soil is sufficient, the soil solution medium has an average pH of 5.8, or the reaction medium is generally neutral, carbonate content is not detected in all layers of the soil, electrical conductivity is low to moderate, mobile phosphorus and potassium supply thus mechanical components are good. The uppermost surface layers are sandy soil and below that are light clay and clay with particle composition.

Keywords: Larch, seed, crop, stand, green zone, climate change, flower

Introduction

Geographically, Mongolia is located in Northeast Asia, surrounded by dry land, with high mountain ranges in the north and steppe and deserts in the east.

The coniferous mountain forest spread in the northern part of the territory plays an important role in the vegetation cover of Mongolia, and it can be clearly seen from the negative effects directly caused by improper use of forests in some places and many research data that the protection role is more dominant than the importance of use (Udwal, 2014).

Forests in Mongolia grow in extreme continental climate conditions, so their productivity is low, and growth is slow. Natural factors such as drought, fire, harmful insects, diseases, and hostile human activities can easily lose their ecological balance, and the ability to regenerate and expand naturally is relatively weak (Gombosuren, 2000). For Mongolia, over the past 80 years, the average annual air temperature has increased by 2.2 degrees or 2.5 times the world average, and precipitation has decreased by 7-10 percent yearly. This climate change is increasing the number of atmospheric disasters. The number of weather disasters caused by climate change has doubled in the last 20 years compared to the previous decade. In accordance, Mongolia is becoming one of the most vulnerable countries to climate change (Climate Change Adaptation, 2013).

The negative human impact on the forest ecosystem intensifies with climate change and population growth. Deforestation, environmental degradation, and pressure on natural forests are increasing. Therefore, it is necessary to evaluate the yield of forest seeds to prepare seeds of improved quality, which are seeds of woody plants with adaptability, and then to create seed stock in seed years.

Research goals and objectives

The purpose of our research is to determine the flowering and seed yield of larch forests in the green zone of Ulaanbaatar and to study the effects of climate change on the conditions of the region. To achieve this goal, we have set the following goals. It includes:

1. To evaluate the flowering process of trees and determine the morphological parameters of flowers;
2. To detect the influence of climate in the region on flowering and seed yield, and seed ripening;
3. Determination of soil characteristics of the study area

4. Methodology

Isolation of study sample areas in green zone larch forests and basic parameters of tree mensuration were determined by NP. Anuchin (2004), tree selection was evaluated according to the method of Girgidov (1976) and Lyubavskaya (1982). When flowering was determined by the branch method, the length of several branches was measured in different parts of the crown from 10-15 trees during flowering, and the number of flowers per longitudinal meter was counted.

Flower biometry was measured using a caliper with an accuracy of 0.001 mm, flower length was measured from the lower base to the upper tip, and flower width was measured at the widest part.

The parameters of the soil characteristics were determined according to the methodology in the soil laboratory of the Institute of Geography and Geoecology of the MAS. Data processing was performed using JMP 5.1 and SPSS 17 statistical packages. Differences in tree flowering and soil chemical parameters of the sample areas were determined by one-way ANOVA.

Results

Without determining the main indicators of the structure of forest tree mensuration, it is impossible to detect and recognize the interrelationships and characteristics between them and to imagine what the forest will look like in the future (Tsogt, 1993). Therefore, we determined the leading indicators of forest mensuration in the green zone forests where the research was carried out and presented them in the following table (Table 1).

Table 1. Location of sample areas.

Sample area	Coordinates	MSL, m	Slope	Characteristics
Khandgait valley	N47°51′45.4″, E106°52′57.2″	1533	Facing northwest 4°	Green moss-alder taiga forests with cedar
Jigjid valley	N47°49′22.7″ E106°51′47.7″	1615	Facing north-east 6°	The cedar taiga forest is covered with cyperales grasses

Table 2. Main mensuration features

Sample area	Age class	Stocking level	Mean		Stock, m^3/ha	Bonitet
			D	H		
Khand gait valley	YII	0.7	30.2	18.6	216.9	YI
Jigjid valley	IY	0.6	22.5	18.8	235.0	IV

The forest of Khandgait valley has a slope of 4° facing the northwest, matured to be included in age class VII, 0.7 density, 5Ce3Sp2L composition, green moss-alder taiga cedar forest. The average diameter of the forest is 30.2 cm, the average height is 18.6 m, and according to the selection category, normal trees are prevalent.

Jigjid valley forest has a 6° slope facing northeast, 0.6 density, which can be included in the age class IY, 5L4Sp1Ce composition of cyperales grasses covered with cedar taiga forest. The average diameter of the forest is 22.5 cm, the average height is 18.86 m, and it is a mixed composition dominated by normal trees according to the selection category.

The seeding period of woody plants differs from other plants due to their late emergence, and the seeding age of trees and shrubs occurs at different times. Seeding will vary depending on the tree's age, and large quantities of good-quality seed can be harvested from middle-aged to mature forests. The seeding period of most trees occurs between 15-25 years of age, and the forest in our study area is in the age class IY-YII, reaching the age of producing a considerable amount of seeds.

The flowering of trees and shrubs is the primary indicator of the seed yield of the year. Spring is when most trees and shrubs flower, and their seed production can be predicted at this time, and the flowering duration varies with the year's weather. The trees in the study area have a flowering rating of 3 points or an average flowering rating, and the flowers of the trees are arranged in groups or evenly on the middle and apical branches of the crown on the sunside (Figure 1).

The ratio of male and female flowers was 40:60, or 40% of the total flowers were female, and about 60% were male. According to research materials, external environmental conditions, especially the formation of male and female buds on one tree, and the climatic conditions of that year have a particular influence on the size of the following seed harvest (Grigidov, 1976). In particular, air humidity has a major effect. In addition, air humidity has an intense impact on physiological functions, such as the accumulation of nutrients in the tree's respiration and the process of photosynthesis. Therefore, excessive reduction of air humidity has a negative effect on the formation of male and female buds.

Table 2. Flower biometric size, one-way ANOVA (n=30)

№	Flower biometric size	Degree of freedom	Fisher test
1	Flower length, mm	29	10.326**
2	Flower width, mm	29	3.897**

*P<0.001***, P<0.05** represents the level difference*

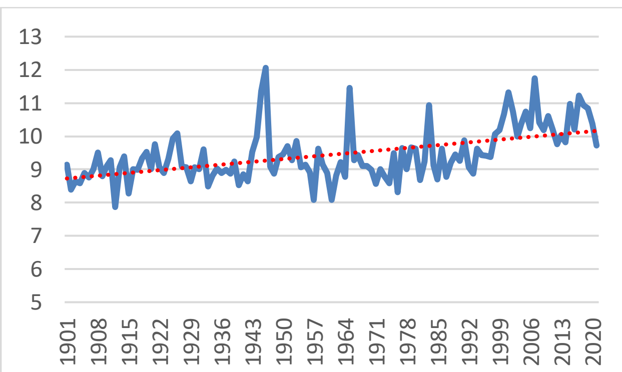
Siberian larch is a dioecious plant with male and female flowers located on the same branch and pollinated by the wind (Figure 1).

(Figure 1). Male and female flowers of Siberian larch

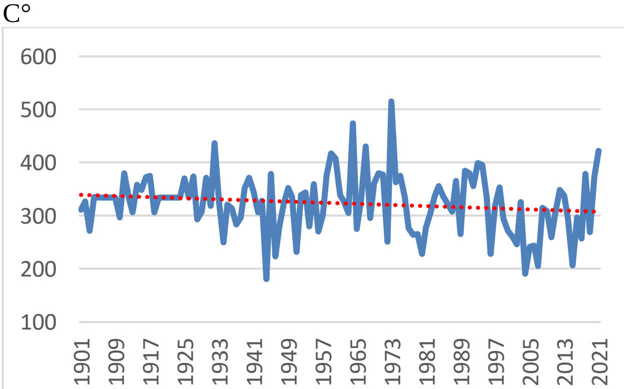
The male larch flowers are round or oblong in shape and light green in color. Female flowers are pinkish and oblong. The male flowers are located on shortened shoots and do not have sacs suitable for long flights of pollen. The female flowers are pale green and then turn brown to blue-pink. It is more sizeable compared to the male flower in shape and will develop into a cone. Larch female flowers are 8-12 mm long and 4-5 mm wide.

Although long-lived plant species such as trees survive the effects of climate change for many years in mature form, researchers have found that as the climate changes, their seed productivity decreases and eventually produces seeds that cannot grow (Udval &.Gerelbatar, 2021). Climate influence plays a significant role in the tree and shrub seed yield and ripening period. In addition, weather conditions will have a major effect on seed quality; the harsher the weather, the worse the seed quality.

In the research area, the average temperature during the growing season is 9.7°C, and the total rainfall during the growing season is 398 mm. Compared to a long-term average, it is warmer by 0.3 °C, and precipitation is 74.0 mm more (Graph 1, 2).



Graph 1. Average air temperature of the vegetation period, C°



Graph 2. Total rainfall during the vegetation period

Extreme heat, wet snow, continued strong winds, and cold shocks during flowering can somewhat reduce seed yield. As of the year 2023, when the research is being carried out, the trees began to flower evenly in May, but due to the sudden spring cold in the second ten days of May, they were injured by frost during the flowering period and dried up, resulting in a decrease in seed yield.

(Figure 2). Flower desiccation after cold shock

Even if the forest has the same type and age of trees, it varies according to the characteristics of the growing environment, such as soil, climate, and the range of forest vegetation. Forests and soils are in an essential interdependent relationship. In contrast, the forest cannot grow without the unique soil suitable for its conditions. The fertility of the soil improves under the influence of the forest. Earth has the most critical impact on the flowering, fruiting, seed yield, and seed maturation of trees, shrubs, and plants (Udwal, 2014). According to the research carried out in Russia, forests growing on fertile soils belonged to I-II bonity forests, while mature forests growing on marshy soils with low fertility belonged to IY class.

Under the conditions of sufficient soil fertility, trees will produce more seeds earlier, and with increasing fertility, the quality of the seeds improves, and the seed yield of trees in the I-III growth environment is 2-10 times higher than that of the IY-Y forests (Trakanov & Demidenko, 2001).

According to the results of the soil analysis of Khandgait valley and Jigjid valley forest, humus content in 100 g of soil in the study areas is sufficient, the average pH of the soil solution medium is 5.8, or the reaction medium is generally neutral, carbonate content is not detected in all layers of the soil, electrical conductivity is low to moderate, and mobile phosphorus, with good potassium supply, and in terms of mechanical composition, the uppermost surface layers are sand, and below that, the silt composition has changed to light clay and clay.

Table 3. Agrochemical properties of soil

Sampling depth	pHH_2O 1:5	$CaCO_3$ %	Humus %	$EC_{2.5}$ dS/m	Available, мг/100 г	
					P_2O_5	K_2O
Khandgait						
0-5	5.68	0.00	38.639	0.0625	13.685	49.7
5-20	5.88	0.00	7.785	0.081	1.828	30.7
20-40	5.60	0.00	0.550	0.050	1.146	6.1
40-65	6.60	0.00	1.476	0.043	1.686	6.5
65-100	6.74	0.00	0.961	0.054	2.997	7.5
Jigjid						

0-20	5.14	0.00	12.156	0.448	5.20	41.1
20-40	5.63	0.00	1.002	0.349	3.04	3.3
40-60	5.56	0.00	0.610	0.164	2.11	4.2

Humus content is one of the leading indicators of soil fertility (Baasandorj and Badrah, 2010). The level of native soil fertility in our country is low, and it has been determined that the amount of humus does not exceed 3.0 percent on average, and it is 1.5-2.0 percent in sandy soils (Dorzhgotov, 2002). According to the results of our research, the humus content of the soil in the sample areas is 9.9 in the Khandgait valley forest and 4.6 in the Jigjid valley forest, which indicates that the humus content is relatively good.

Table 4. The composition of soil particles

Study area	Depth, cm	Sand, %	Dust, %	Clay ,%	Mechanical composition
Khandgait	0-5	70.3	17.6	12.1	Sandy soil
	5-20	79.1	9.5	11.4	Sandy soil
	20-40	38.1	39.5	22.3	Light clay
	40-65	33.8	42.4	23.8	Хөнгөн шавранцар
	65-100	29.4	51.2	19.4	Clay
Jigjid	0-20	55.7	35.1	9.2	Sandy soil
	20-40	32.3	54.1	13.6	Clay

According to the univariate analysis of variance performed on soil chemistry and physical parameters, soil pH and dry matter residues of the research sites were statistically $P<0.1$ or no difference in each field, and $P<0.001$ or $P<0.001$ for soil mobile phosphorus and potassium (P_2O_5, K_2O), or statistically different. Also, for humus content and mechanical composition, $P<0.001$, or statistically, the sample plots differ in terms of soil fertility and characteristics.

According to the results of the research, there is no adverse effect from the soil on the flowering process of the forests of Khandgait and Jigjid valley, and it is shown that the climate of the year has a significant effect.

Result

1. The flowering of the studied forest has 3 points or an average rating, and it is distributed in groups or evenly on the branches of the middle and apical part of the crown on the sun side.
2. At the beginning of the vegetation period, the larch trees started to bloom evenly, but due to the cold shock in the second ten days of May, they were hit by frost and dried up, resulting in a seed yield decrease.
3. The humus content of the forest soil is sufficient, the average pH of the soil solution medium is 5.8, or the reaction medium is generally neutral, carbonate content is not detected in all layers of the soil, electrical conductivity is low to moderate, and it is good with mobile phosphorus and potassium supply. Regarding mechanical composition, the uppermost superficial layers are sandy soil, and the lower layers are light clay and clay, indicating that suitable conditions for tree growth, flowering, and seeding have been created.

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