DOI: https://doi.org/10.5564/mjas.v21i02.905

SOME RESULTS OF THE STUDY ON SIBERIAN FIR (ABIES SIBIRICA LEDEB) GROWN IN THE NURSERY OPEN FIELD AND GREENHOUSE

Ch.Oyun* and J.Bat-Erdene

School of Agroecology, Mongolian University of Life Sciences,
Ulaanbaatar, Mongolia

*Corressponding author: ehoz02@muls.edu.mn

ABSTRACT

The present study aims to investigate growth dynamics of Siberian fir (Abies sibirica Ledeb) saplings and determine their development stages. Siberian fir seeds were planted in the open field and in the greenhouse at narrow-row spacing (10x5x15x5x15x5x15x5x15x5x10) with 1200 saplings selected as random samples. Climate of a given region is mainly affected by interrelated factors such as geographic location, ray of sunlight, atmospheric cycle and ground surface. Therefore, the study determines air temperature, precipitation, humidity, air heat and dynamics of saplings. The study also suggests that there are seven stages of growth of saplings and starting from the eighth stage, saplings reach 2 years old. Because this is the first study on growing Siberian firs directly from seeds in forest-steppe zone in Mongolia, it determines growth dynamics and development stages of 1-3 years old saplings and would serve as the basis for further studies on Siberian firs.

KEYWORDS: *humidity, heat, sapling, growth*

INTRODUCTION

Siberian fir is a coniferous tree native to Siberian taiga in north-east part of Russia, Turkey, Mongolia and China. It is also spread in eastern and western parts of Europe, Far east, central and east Asia, north Africa, north America, western Alaska, as well as from the mount Skalisty to Guatemala, and from Labrador to mounts of north Carolina. Out of 56 species of firs, Siberian fir forests are found in Mongolia in the basins of Khuder and Bugat rivers in the north-west part of Khentii mountain range, in mountains north of Khamar pass, in the mouth of river Shishhed and in the basins of Jamts and Jolgo rivers in Khuvsgul aimag. No comprehensive studies have been conducted on planting Siberian fir so far, but there are some researches on forest management. The practical significance of this study is to identify seed quality and seed reserves of Siberian firs in Mongolia and increase standard sapling yield by preparing seeds from both elite and average trees at seed production fields. Another new scientific aspect of the study is determining pollen morphology and seed quality indicators of Siberian fir in taiga forests of Upper Yeruu-Minj river area in Western Khentii sub-zone, Inner-south natural forest-vegetation zone, and growing Siberian firs in the greenhouse and open field in Bayanchandmani soum of Tuv province in Western Khentii sub-zone, Inner natural forest-vegetation zone. Moreover, as aromatic essential oils extracted from Siberian firs are widely used worldwide in perfume, winery, chemical plants and medicine, it is suggested that processing of essential oils be significant in Mongolia. The following objectives have been set in transplanting Siberian fir seeds from taiga forest to forest steppe zone:

1. To study changes in air temperature, climate and precipitation;
2. To study humidity and heat indicators of plants at the pilot area during their growth;
3. To define changes in morphological characteristics of plants during ontogenesis;
4. To define growth dynamics of 1-year old and 2-year old saplings planted in greenhouses and open field.

Bayanchandmani soum of Tuv aimag is located in the south-west of Suuj mountain in the north-east part of the aimag in the longitude of E-48^{0} 13^{I} 30^{II} and latitude of N-$49^{o}17^{I}40^{II}$, and shares borders with Batsumber soum in the east, Bornuur soum in the north and Bayan Tsogt soum in the west and the south. Our stationary pilot field is situated in the north of Khar modot pass over in Bayanchandmani soum, Tuv aimag, 1524 m above sea-level within longitude of N-$48^{0}08^{I}21.6^{II}$ and latitude of E-$106^{0}23^{I}39.8^{II}$. This nursery belongs to steppe-forest zone where pine and birch trees predominate.

MATERIALS AND METHODS

Humidity and heat conditions for saplings involved in the research between 2010 and 2014 were studied according to the method of German scholar Gossen-Valter [8], whereas weather prognosis of warm seasons was determined based on long-term average, and changes in air temperature and precipitation – according to the interpolation method. The morphological variability values were defined by scale suggested by the method of S.A.Mamaev [6], and characteristics of coniferous trees – pursuant to the method of A.A.Molchanov and B.B.Smirnov [7].

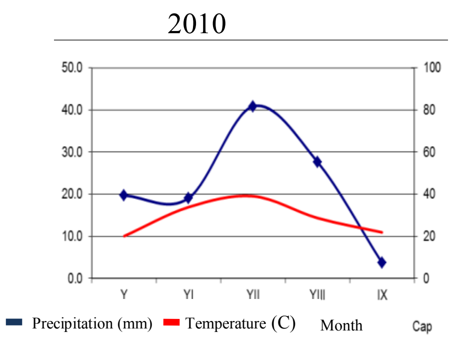
Statistical processing

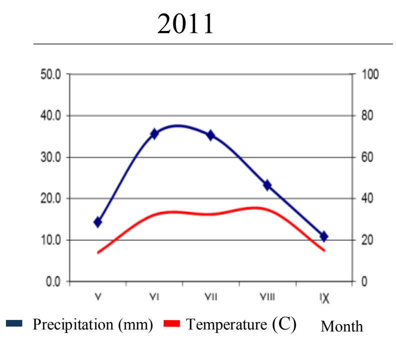
Methods for defining linear aggregation, mean deviation, frequency and error were used for statistical compilation. Applications ArcMAP, Spatial Analyst and Co-kriging were used for data processing, spatial analysis and drawing and comparing tables and graphs. ERDAS Imagine, an application that allows users to process satellite images for mapping use, and Excel spreadsheets were used as well.

RESULTS

A. Results of the study on air temperature, climate, precipitation, humidity and heat conditions during growing period of plants

The observation shows that climate condition was dry in Sept. 2010 and May 2012 and humid for the rest of the research period. It also indicated that humidity and precipitation was adequate during the research years.





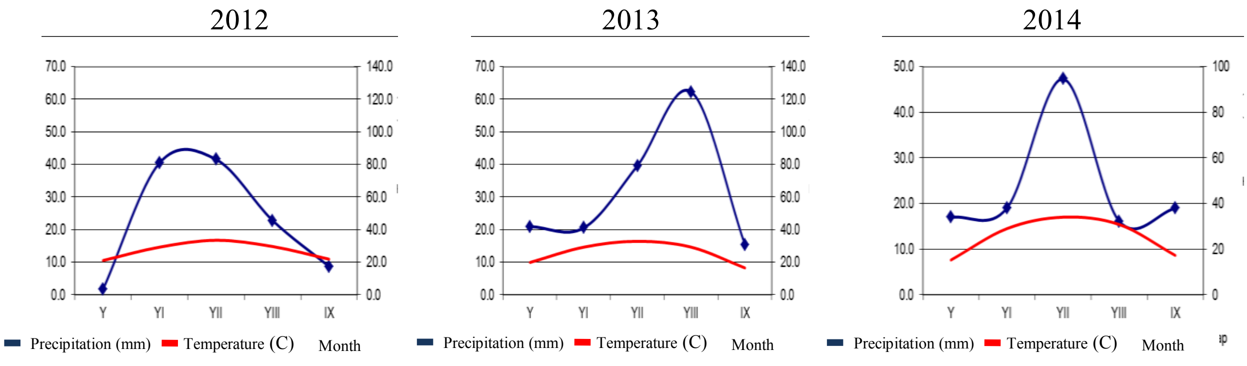


Figure1. Clima-diagrams between 2010 and 2014

The Table 1 below shows weather conditions during the research period from 2010 to 2014 in Bayanchandmani soum.

Table 1

Weather conditions during warm seasons of the research period (2010-2014)

Year	Months / Indicators	V	VI	VII	VIII	IX
2010	Air temperature (^{0}C), average	10.0	16.9	19.5	14.3	10.9
	Soil temperature (^{0}C), average	15.0	22.0	25.0	18.0	15.0
	Total precipitation (mm)	39.3	38.1	81.7	55.2	7.3
2011	Air temperature (^{0}C), average	7.0	16.1	16.2	17.3	7.5
	Soil temperature (^{0}C), average	9.0	21.0	22.0	22.0	10.0
	Total precipitation (mm)	28.6	71.2	70.4	46.3	21.7
2012	Air temperature (^{0}C), average	10.5	14.6	16.7	14.8	10.9
	Soil temperature (^{0}C), average	16.0	19.0	21.0	18.0	14.0
	Total precipitation (mm)	3.2	80.9	83.1	94.8	17.3
2013	Air temperature (^{0}C), average	9.9	14.6	16.4	14.6	8.2
	Soil temperature (^{0}C), average	13.0	20.0	22.0	18.0	11.0
	Total precipitation (mm)	41.9	41.0	79.3	142.5	30.5
2014	Air temperature (^{0}C), average	7.6	14.5	17	15.4	8.6
	Soil temperature (^{0}C), average	22	30	33.5	28	21
	Total precipitation (mm)	33.9	38.0	94.6	32.2	37.9
LTA*	Air temperature (^{0}C), average	9.6	16.3	18.5	16.3	10.0
	Soil temperature (^{0}C), average	22.3	30.5	31.7	29.3	19.5
	Total precipitation (mm)	32.6	52.3	62.2	71.5	20.4

LTA - Long-term average*

Maximum air temperature, minimum air temperature, maximum soil surface temperature, minimum soil surface temperature and wind speed values were used to calculate the average. Maximum air temperature was observed in May 2014 and June and July 2010 with 1.8-4.4^{0}C, 5.5-7.7^{0}C and 2.7-8.2^{0}C above the record of other years respectively (Figure 1). Minimum air temperature was recorded in May 2014, -4.4-6^{0}C lower than the record of other years. Air temperature in Sept. 2010, June 2014 and Sept. 2014 were -0.1^{0}C, -0.8^{0}C and -4.6-9.7^{0}C below the record of other years. Average air temperature in January in Bayanchandmani soum was -19.3^{0}C fluctuating between -14.0^{0}C and -24.2^{0}C. Based on data provided by 69 weather stations, changes in precipitation amount and spatial coverage over the years were outlined with Co-kriging interpolation method using ArcGIS tool (Source: Environmental Information Center). Accordingly, it shows that precipitation amount in Bayanchandmani area was decreased by 25.6 mm, and in Yeruu soum area – by 78.7 mm.

B. Results of the study on dynamics of growth, development, root length and root diameter of 1-year old and 2-year old Siberian firs

Table 2

Dynamics of root length and length diameter growth of 1-year old Siberian fir

Siberian fir	Root diameter, mm		Root length, cm	
	X±m	Cv,%	X±m	Cv,%
Lower belt	0.9±0.01	12.2	11±0.43	28.4
Middle belt	0.8±0.02	16.6	12.4±0.42	24.4
Upper belt	0.8±0.02	20	10.1±0.47	33.6

Note: X – mean value, Cv – coefficient of variation, %, m – acceptable error (5%)

Table 3

Dynamics of height growth of 1-year old Siberian fir

1-year old Siberian fir	Greenhouse				Open site		
	X±m	Cv,%	max	min	X±m	Cv,%	max
Lower belt	2.6±0.08	19.2	4	1.7	2.4±0.06	22.8	3.5
Middle belt	2.5±0.08	23.2	3.7	1.4	1.5±0.06	18.6	2.1
Upper belt	2.4±0.06	20	3.4	1.4	1.8±0.05	20.5	3.1

Note: X – mean value, Cv – coefficient of variation, %, m – acceptable error (5%)

The Table 3 above shows that Siberian fir saplings planted in the greenhouse belong to an average development level, whereas open field sapling growth and length root – to higher development level, and root diameter – to lower development level [5]. Ecological conditions vary in greenhouse and open site. Inside greenhouse, average air temperature was 25-27^{0}C and air humidity -5-80%. Due to unfavorable conditions (extreme cold, lighting etc.) carbon dioxide in the air has been increased. On the contrary, favourable greenhouse microclimate positively affects growth and development of saplings.

Table 4

Dynamics of height and diameter growth of 2-year old saplings
(Experimental and training center in Bayanchandmani soum, Tuv aimag)

2-year old Siberian fir	Height, cm				Diameter, mm			
Forest belt	X±m	Cv,%	max	min	X±m	Cv,%	max	min
Lower belt	3.1±0.09	22.2	4.5	5.4	1.2±0.02	15.8	1.9	0.9
Middle belt	2.9±0.12	26.2	4.5	1.5	1.3±0.06	23.8	1.9	0.6
Upper belt	2.9±0.11	23.8	4.5	0.8	1.1±0.05	20	1.9	0.8

Note: X – mean value, Cv – coefficient of variation, %, m – acceptable error (5%)

Table 5

Dynamics of height and diameter growth of 3-year old saplings
(Experimental and training center in Bayanchandmani soum, Tuv aimag)

3-year old Siberian fir	Height, cm				Diameter, mm			
Forest belt	X±m	Cv,%	max	min	X±m	Cv,%	max	min
Lower belt	7.4±0.17	16.2	10.4	5.4	2±0.05	19	3	1.2
Middle belt	5.7±0.16	20.7	8	3.5	1.7±0.06	27	2.6	0.8
Upper belt	5.1±0.17	23.1	7.5	2.9	1.5±0.05	27.3	2.3	0.8

Note: X – mean value, Cv – coefficient of variation, %, m – acceptable error (5%)

Tables 4 and 5 above indicate that saplings in lower belt out of 3 forest belts involved in the research has better growth. That is our research proves study methods, results and conclusion of Russian and other scholars.

C. Results of the study to determine development stages in sapling growth

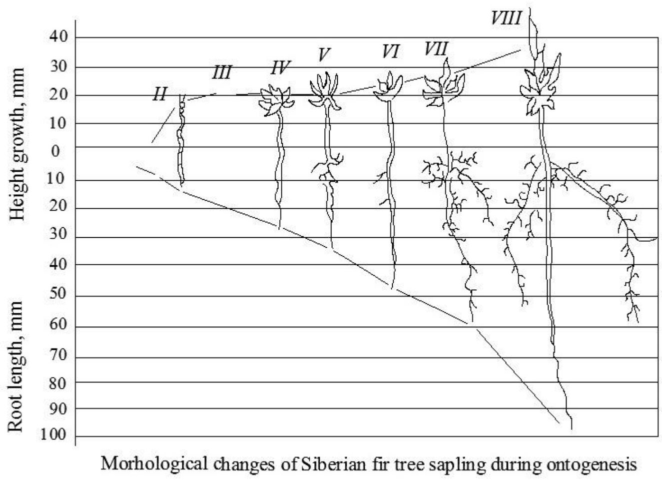


Figure 2. Growth stages I-VII. Stage VIII - saplings in the 2nd year.

The Figure 2 above shows growth stages of saplings: seed planting, seed germination, seed unfolding, bud formation, needle unfolding, main stem growth and shoot formation (I-VII). From the stage VIII, sapliing reaches 2 years old. From the Figure 2 above, it is clear that when seed is planted deeper, the sprout is heavier and the root is smaller. It is considered that the depth the seed is planted depends on seed size, forest vegetation condition, mechanical characteristics of soil and agro-technical elements for planting trees.

DISCUSSION

Siberian fir and Siberian spruce are both evergreen coniferous trees that prefer shadow and have seeds attached to wings. The studies of our researchers on planting Siberian spruce saplings in 2004 and 2005 indicate that 3-year old saplings belong to classification II in terms of length, the height of 4-year old sapling reached 11.38cm and the mean stem girth is 2.32 mm [4]. The results of these studies as compared to ours are approximate in terms of methodology, findings and conclusion. Seed viability is lower at higher altitude [1]. Further, it is suggested to carry out comprehensive study on population of Siberian firs and to facilitate growth of this species.

CONCLUSION

1. It needs to perform a detailed research on seed reserve of Siberian fir and work out further measures to be taken. As seeds of Siberian firs have not been stocked up, it is necessary to allocate a separate site for permanent forest seed reserve.
2. It was determined that diameter of 2-3-year old Siberian fir sapling is 15-20 mm and height is 5.1-7.4 cm. That indicates quite sufficient growth which belongs to standard sapling classification II.
3. It was defined that Siberian fir involved in our study has 4 needles.
4. Saplings planted in open site were tolerant to external factors.
5. Growth period of 1-2 years old saplings continued 113-116 days a year.

ACKNOWLEDGMENTS

We would like to express our appreciation to the Mongolian Journal of Agricultural Sciences for their invaluable comments and assistance on earlier versions of our manuscript and for accepting our article for publication.
We are also thankful for all those who supported and shared their expertise and time for us.

REFERENCES

1. Belova N.V., Bajina E.V (2007). Viability of Siberain fir seeds in forest ecosystem of western Sayan. Volume: XXIV, № 4-5. *Journal. Coniferous trees in boreal forest zone.* 474-477. (in Russian)
2. Beideman I.K. (1974). The methodology of studying the phenology of plants and plant communities *In Beideman I.K. Novosibirsk: «Science»*. 156. (Russian).
3. Bulygin N.E. (1979). Phenological observations of woody plants. *L.LTA, 96. Buokatti: Scientific center of agriculture.* (in Russian)
4. Dashzeveg Ts. (2014). Scientific background for reclamation of coniferous forests. UB. 154-158. (in Mongolian)
5. Dashzeveg Ts., Enkhsaikhan D. (1996). Review of the Siberian cedar growth study. *In "Recommendations on cultivation and forestation of major tree saplings that comprise Mongolian forests" booklet. UB*. 45-49. (in Mongolian)
6. Mamayev.S.A. (1972) Forms of intraspecific variability of arboreal plants. *M.Science.* 283. (in Russian)
7. Molchanov A.A., Smirnov.V.V. (1967). Methods of studying arboreal plants. M. 95. (in Russian)
8. Terbish.Kh., Adya.Ya. (2009). Ecology. UB. 46-46. (in Mongolian)
9. Tsedendash G. Northern Mongolian forests – vegetation zones. *Scientific works of the Forest and vegetation research institute №2*. (1996). 24-29. (in Mongolian)