Variation in Seed Quality, Seedling Growth and Biomass Allocation of One-year-old Siberian Larch (*Larix sibirica* Ledeb.) Seedlings Grown in Different Conditions from Diverse Seed Sources of Mongolia

Nyam-Osor Batkhuu[1], Don Koo Lee[1], Jamsran Tsogtbaatar[2], Park Yeong Dae[1], Ravdanlkhumbuu Bat-Amgalan[2] and Park Go Eun[1]

[1]*Silviculture and Restoration Ecology Laboratory, Department of Forest Sciences, Seoul National University, Seoul, 151-921, Korea*
[2]*Institute of Geoecology, Mongolian Academy of Sciences, Ulaanbaatar, 211238, Mongolia*

Abstract

The rehabilitation of degraded forests in Mongolia showed very low success and the total area reforested successfully represents only 5% of the total forest lost. One of the reasons for such poor results may be low quality of planting stock due to the poor quality of seeds. The objectives of this study were to determine seed source variation in seed quality, to examine their growth and biomass allocation in one-year-old seedlings of Siberian larch from diverse seed sources, and to select the most promising seed sources for reforestation of degraded forest lands in Mongolia. Siberian larch seedlings from eight geographically different seed sources were grown at an open nursery and in greenhouse nursery conditions, and seedlings were subjected to growth and biomass allocation measurements at the end of the first growing season. It was found that there were significant differences in seed quality, growth and biomass allocation among the seed sources in both growth conditions. Overall, Sources No.3 (Tuul river) and No.4 (Mungun) showed the best growth performances and biomass accumulation at open nursery and greenhouse nursery conditions, respectively. Source No.1 (Ovorkhangai) had the lowest performances in both growth conditions for all measured variables. On the other hand, seedlings grown in the greenhouse nursery conditions had more intensive growth and accumulated more biomass compared to seedlings grown in open nursery conditions. However, the proportion of biomass of the roots at open nursery grown seedlings was higher than that of greenhouse grown seedlings, which may indicate a more promising survival rate after field transplanting.

Key words: Seed quality, seed source, growth, biomass allocation, *Larix sibirica* Mongolia

Introduction

Mongolia is a land-locked country located in the heart of Central Asia between N41°35′ and N52°06′, E87°47′ to E119°57′, in it and borders with Russia and China. The total land area of Mongolia is 1,566,000 km^2 consisting of 76.2% steppe and pasture land, 11.4% forest land area and less than 0.5% is currently cultivated.

The forests in Mongolia occur mainly in the northern part of the country, forming a transitional zone between the Siberian taiga forest and Central Asian steppe (World Bank, 2002). The species composition of Mongolian forests (Table 1) is simple, as in other temperate forests, composed mostly of Siberian larch (*Larix sibirica* Ledeb.) which covers almost 60% of the total closed forest area. The growth rate of Mongolian forests is slow because of the relatively harsh Central Asian climate with its dry and windy characteristics and short growing season. As a result, they are easily influenced by fire, pests, disease and human activities. Forest resources in Mongolia have been continuously degraded over the past few years due to improper exploitation and inadequate management, which are negatively affected by environmental conditions causing severe deforestation, desertification and ecological stress in some regions.

During the last decades, Mongolia lost approximately 4 million ha of forests, averaging 40,000 ha annually. Between 1990 and 2000, the rate of deforestation increased up to 60,000 ha per year. As a result of ongoing loss and degradation, only 13 million ha of forests are relatively remote and closed canopy forests. Much of the other 5.3 million ha of forests are fragmented and degraded (World Bank, 2002). According to another report

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on the forest status of Mongolia, some 1.6 million ha of forest area has been completely destroyed between 1974 and 2000 due to fire, improper and illegal logging, overgrazing, mining activities and also due to pests and diseases (UNEP, 2002). Reforestation activity in Mongolia started in the 1970's. During the period of 1980-2000, reforestation was carried out in 72,132 ha, 50 percent of which was replanted by seedlings. Although positive results were shown, fires, disease infection and livestock grazing have damaged some of these planted forests. Up to 2002, an area of about 98.000 ha has been reforested (MNE of Mongolia, 1999).

The Siberian larch is a tree species that appears in the most favorable habitats, both in steppe and mountain tundra (Savin *et al*., 1978). Hence, it has been widely used for reforestation and afforestation activities in Mongolia. However, reforestation success was very low and the survival rate of planted seedlings varied between 30% and 60%, seldom reaching 50%. Consequently, the total area that had been successfully replanted represents only 5% of the total forest lost (World Bank, 2002). Approximately 150,000 ha of forest needs to be rehabilitated, but an average of only 5,000 ha are being planted each year (Tsogtbaatar, 2004). The main reasons for such poor results of the plantations are the lack of compatibility between sites and species, poorly equipped nursery systems with outdated techniques, poor site preparation, poor quality of planting stock due to poor seed and nursery techniques, seed orchard unavailability and forest plantations on grazing land often resented by herders (JICA, FMC and MNE, 1998).

The objective of this study was to investigate the seed source differences in seed quality, seedling growth, and biomass allocation in one-year-old Siberian larch seedlings from diverse seed sources in Mongolia. The results of this study may be useful in understanding geographical variations of studied characteristics among seed sources and in selecting the most promising seed sources for reforestation of degraded forest lands in Mongolia.

MATERIALS AND METHODS

1. Seed and seedling materials

Seeds of Siberian larch (*Larix sibirica* Ldb.) were collected from the stands of eight different geographical locations in Mongolia between 2002 and 2004 (Figure 1; Table 2). Laboratory tests of seed quality were conducted by the International Rules for Seed Testing (ISTA, 1999). Seeds were examined for their qualities by purity, weight of 1,000 seeds, germination test, seed viability by soft X-ray photography, and tetrazolium test. Seeds of different sources were sown in open and greenhouse nursery beds at the Dambadarjaa Nursery (N47°59'15", E106°57'31") belonging to the Forest Experimental Station of the Institute of Geoecology, Mongolian Academy of Sciences in May 2005.

2. Measurement of growth and biomass allocation

Seedling emergence was monitored and 50

Table 1. Main forest tree species distribution in Mongolia

Species	Area		Growing stock	
	ha	%	m^3	%
Larix sibirica (Siberian larch)	7,526,900	58.8	1,017,149,000	74.6
Pinus sylvestris (Scots pine)	662,100	5.2	92,107,000	6.7
Pinus sibirica (Siberian pine)	984,700	7.7	161,855,000	12.0
Picea obovata (Siberian spruce)	27,900	0.2	3,633,200	0.3
Abies sibirica (Siberian fir)	2,300	0.02	375,500	0.03
Betula spp. (Birch)	1,134,300	8.8	82,539,800	6.0
Populus spp. (Aspen)	26,300	0.2	1,997,400	0.1
Populus tremula	17,700	0.1	1,351,800	0.1
Salix spp.	19,600	0.1	428,000	0.03
Ulmus spp.	800		37,700	
Shrubs	376,500	2.9		
All except saxaul	10,779,100	84.0	1,361,474,300	99.9
Haloxylon ammodendron (Saxaul)	2,028,800	16.0	1,400,100	0.1
Total	12,807,900	100.0	1,362,874,400	100.0

* Source: Ministry of Nature and Environment (MNE) of Mongolia (2002).

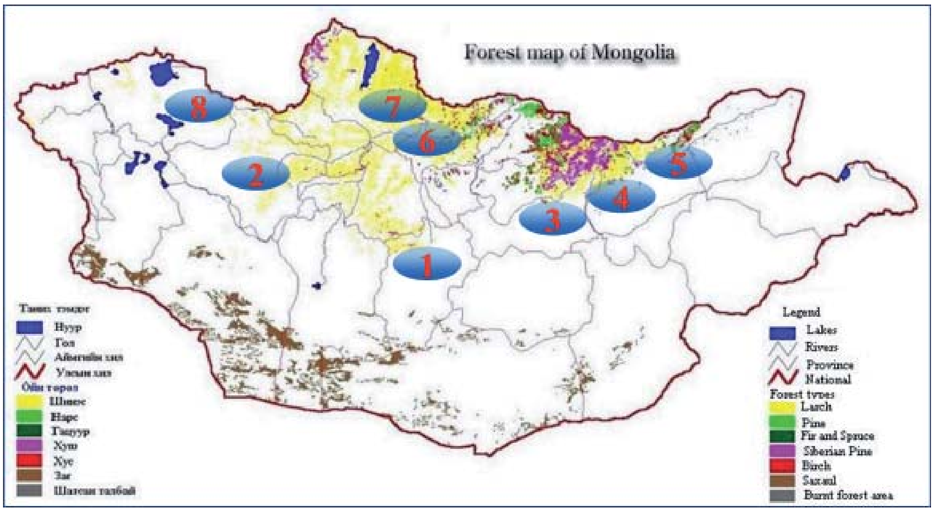

Figure 1. Location of seed sources of *L. sibirica* Ldb.

Table 2. Description of seed sources used for this study.

No	Seed source	Collection date	Species	Lat. (N)	Long. (E)	Alt. (m)	Temp. (^{0}C)*	Prec.(mm)*
1.	Ővőrkhangai	2003, Sept	*L. sibirica*	46.49	102.15	1700	-1.8	296.2
2.	Zavkhan	2003, Aug	*L. sibirica*	47.38	96.32	1658	-6.3	225.7
3.	Tuul river	2003, Sept	*L. sibirica*	47.59	108.00	1843	-3.3	250.7
4.	Mőngőn	2003, Sept	*L. sibirica*	48.12	108.30	1450	-2.73	281.5
5.	Binder	2004, Sept	*L. sibirica*	48.37	110.34	1100	-1.26	327.1
6.	Hővsgől	2002, Sept	*L. sibirica*	49.38	100.1	1275	-1.3	235.5
7.	Uvs	2003, Sept	*L. sibirica*	49.39	94.24	1200	-3.36	146.5
8.	Turag	2003, Sept	*L. sibirica*	51.17	100.49	1700	-1.3	231.5

*Long-term mean annual temperature and precipitation data obtained from the Institute of Meteorology, Ministry of Nature and Environment of Mongolia

seedlings from each of the seed sources were subjected to measurement of growth parameters and biomass allocation. Height and root collar diameter measures were taken between July and September. Total shoot length of each seedling was measured in millimeters from the root collar to the tip of the young shoot. Biomass allocation was assessed at the end of growing season. The root, shoot and leaf samples were oven dried at 80°C for 48 hours, until constant weight after getting the fresh weight. The biomass of each shoot and root parts weighed separately, and biomass allocation of roots, was expressed as the root to shoot ratio (RS=root biomass/shoot biomass) and Root Weight Ratio (RWR = root dry weight/total seedling dry weight) (Cregg, 1993). Relative growth rate was calculated using the formula given below (Tjoelker *et al*. 1993):

$$RGR = \frac{(\log H_2 - \log H_1)}{(T_2 - T_1)}$$

where H_1 and H_2 are heights at the beginning and end of sampling period; T_1 and T_2 are the dates of sampling.

Data analysis

All statistical tests were computed using the SAS statistical software package (SAS Institute Inc., NC, USA, 2000). The differences in seed quality traits, growth, and biomass allocation between growth conditions and among seed sources were determined by analysis of variance (ANOVA). Duncan's multiple range test (DMRT) was used for multiple comparisons.

Results

1) Seed quality

Seed quality traits of *Larix sibirica* Ldb. seed sources like germination capacity, germination energy, weight of 1,000 seeds, viability, and seedling emergence varied significantly among seed sources (Tables 3 and 4). Overall mean germination capacity and germination energy were 51% (2.6 to 83) and 3 % (1.6 to 59), respectively. The highest GC (83.3±7.02) and GE (2.66±0.56) was found in Source No.5 (Binder) whereas lowest values were found in Source No.3 (Tuul) (Table 3 and Figure 2 a, b). The mean viability was 59%, and it varied from 15% for Source No.3 (Tuul) to 77% for Source No.5 (Binder). The mean weight of 1,000 seeds was 6.65g. The heaviest seed (7.2±0.02g) was recorded for Source No.3 (Tuul) and the lightest (5.96±0.11g) was from Source No.8 (Turag). Seedlings emerged 22-45 days after sowing and varied from 26% and 33% for greenhouse and open nursery grown seedlings, respectively (Figure 2 d).

2) Growth performance

All measured growth parameters (shoot length, root collar diameter, relative growth rate) were significantly different among seed sources in both growth conditions (Tables 5 and 7). Mean shoot length was an average of 20.51 mm and 37.09 mm at open nursery and greenhouse nursery, respectively. Source No.4 (Mőngőn) showed the best shoot growth (29.51±1.5mm

Table 3. Seed test results of Siberian larch seed sources used in this study (*n*=400)

No	Seed sources	Germination capacity (%)	Germination energy (%)	1000 seed weight, g	Viability (%)	Seedling emergence (%)	
						Open nursery	Greenhouse
1	Ővőrkhangai	38.66±10.2d	27.33±14.2c	6.61±0.09c	51.33±9.2b	20.8	16.6
2	Zavkhan	47.00±10.2cd	24.0±4.35c	6.73±0.04bc	65.33±6.11ab	33.2	-
3	Tuul	2.66±0.56e	1.66±1.15d	7.18±0.06a	15.33±3.05c	2.99	2.16
4	Mőngőn	46.66±11.1cd	26.33±1.15c	6.96±0.16ab	68.0±17.3a	44.4	19.2
5	Binder	83.33±7.02a	59.0±7.81a	6.96±0.12ab	77.33±3.36a	54.2	37.5
6	Hővsgől	62.66±14.4bcd	51.33±12.7ab	6.51±0.08c	72.0±3.46a	55.5	43.9
7	Uvs	64.00±7.2bc	44.33±4.93b	6.18±0.06d	66.0±9.16ab	27.7	36.7
8	Turag	66.20±2.45b	41.83±2.02b	5.96±0.11d	63.3±3.23ab	27.5	20.3
	Mean	51.40	34.8	6.65	59.83	33.28	25.18

*Note: Different letters indicate significant difference at 1% error level (Duncan test).

Table 4. ANOVA for seed testing result for *L. sibirica* Ldb. seed sources (*n*=400).

Source	DF	MS	*F* value	*P* value
Weight of 1000 seeds	7	0.52	29.95	<.0001
Seed viability	7	1137.32	15.57	<.0001
Germination capacity	7	1758.56	20.47	<.0001
Germination energy	7	1003.03	16.25	<.0001

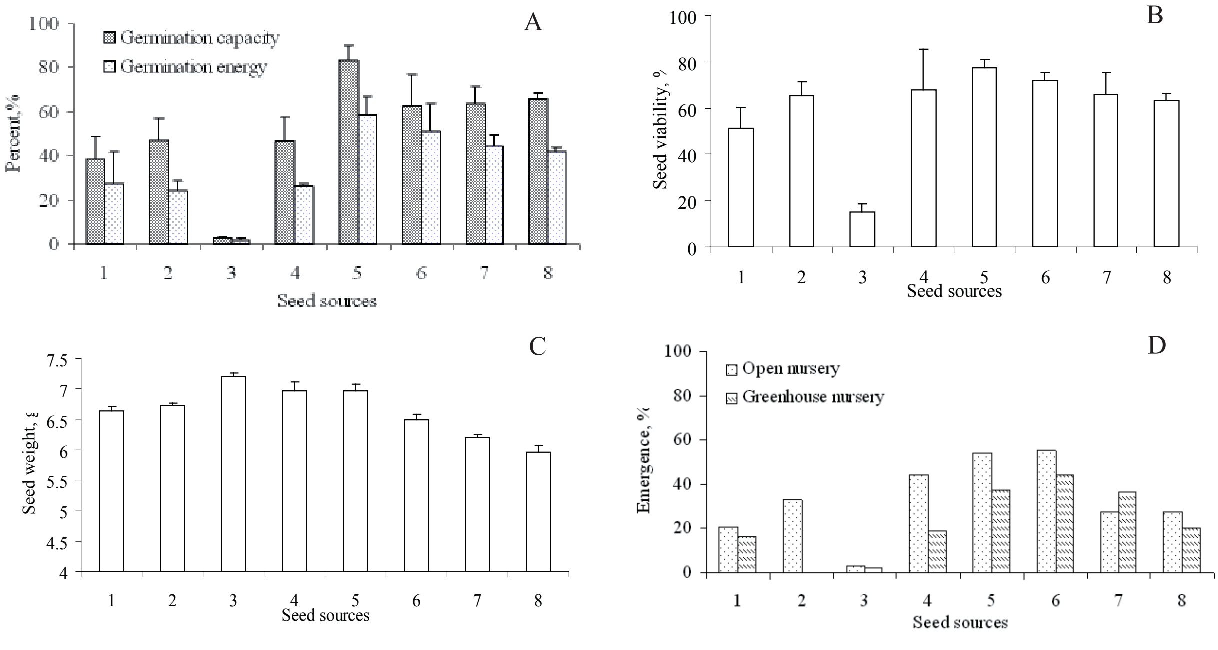

Figure 2. Seed quality traits of *L. sibirica* studied seed sources

and 63.63±3.28mm) at both conditions whereas Sources No.1 (Ővőrkhangai) and No.7 (Uvs) had the lowest performance (12.81mm and 17.86mm). Mean root collar diameter was 1.45 mm and 1.99 mm at open nursery and greenhouse nursery grown seedlings, respectively. Sources No.6 (Hővsgől) and No.4 (Mőngőn) had the best growth in diameter (1.81±0.05mm and 2.51±0.07mm) whereas Source No.7 (Uvs) and No.1 (Ovorkhangai) had the worst performance (Table 7 and Figure 3).

Mean relative growth was 0.81mm/day and 0.96mm/day at open nursery and greenhouse grown seedlings, respectively. Sources No.3 (Tuul river) and No.4 (Mőngőn) had intensive growth rate in both open nursery and greenhouse nursery conditions whereas Sources No.1 (Ővőrkhangai) and No.7 (Uvs) had the lowest growth rate in open and greenhouse nurseries, respectively (Figure 4).

3) **Biomass allocation**

Biomass allocation differed significantly among seed sources ($P<0.0001$) at both growth conditions except root to shoot ratio and root weight ratio at the greenhouse nursery (Table 6). Source No.3 (Tuul) accumulated high total biomass (0.116±0.006g and 0.319±0.037g) at both nursery conditions, whereas Source No.1 (Ővőrkhangai) had the lowest total biomass accumulation (0.029±0.009g and 0.07±0.01g; Fig 5). Proportional allocation expressed as RWR and RS differed significantly among seed sources at both growth conditions. Sources No.4 (Mőngőn) and No.1 (Ővőrkhangai) allocated more biomass to roots, while Sources No.5 (Binder) and No.4 (Mőngőn) allocated less biomass to roots at both open nursery and greenhouse nursery conditions. Seed sources that had intensive height growth accumulated less root biomass compared to the slow growing seed sources.

Table 5. ANOVA for growth traits of the Siberian larch seed sources used in this study.

Source	Open nursery			Green house nursery		
	DF	MS	F value	DF	MS	F value
Shoot length	7	1323.68	28.97***	6	12184.06	41.40***
Root collar diameter	7	1.89	10.28***	6	8.87	39.00***
Relative growth rate	7	2.37	2.59*	6	2.43	17.02***

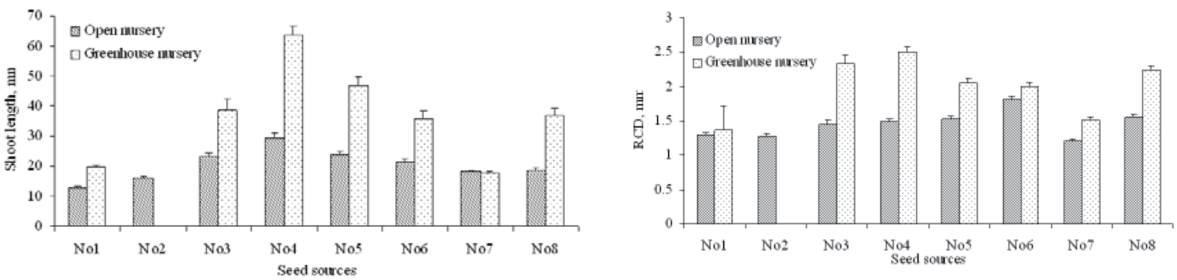

Figure 3. Shoot length and root collar diameter of one-year-old Siberian larch seedlings grown at different growing condition.

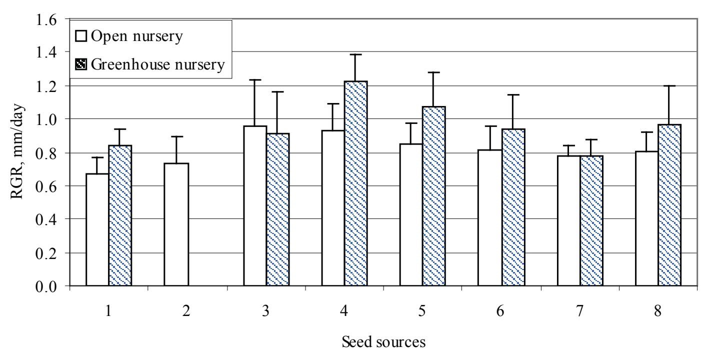

Figure 4. Relative growth rate one-year-old seedlings grown from different seed sources.

Table 6. ANOVA for biomass allocation of Siberian larch seed sources used in this study.

Source	Open nursery			Green house nursery		
	DF	MS	F value	DF	MS	F value
Shoot biomass	7	0.001	17.01***	6	0.01	8.46***
Root biomass	7	0.001	35.33***	6	0.009	52.64***
Total biomass	7	0.004	34.86***	6	0.035	53.37***
Root to shoot ratio	7	1.207	8.06***	6	6.577	1.06ns
Root weight ratio	7	0.024	7.90***	6	0.025	2.37ns

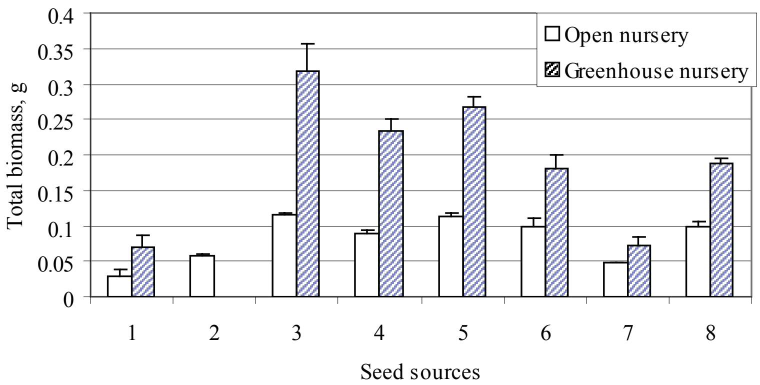

Figure 5. Total dry biomass of diverse seed sources at different growth conditions.

Table 7. Results of growth and biomass allocation of one-year-old Siberian larch seedlings grown from diverse seed origins. (*n*=50, mean±standard error).

No	Seed origins	Height, mm	RCD, mm	Shoot biomass, g	Root biomass, g	Total biomass, g	RS, %	RWR, %	RGR, mm/day
Open nursery									
1	Ővőrkhangai	12.81±0.39e	1.30±0.03cd	0.016±0.005c	0.013±0.005c	0.029±0.009d	0.813b	0.448c	0.672e
2	Zavkhan	16.17±0.56d	1.27±0.04d	0.024±0.002c	0.034±0.001b	0.058±0.002c	1.417b	0.586b	0.730ed
3	Tuul	23.38±1.20b	1.45±0.06bc	0.054±0.002ab	0.062±0.004a	0.116±0.006a	1.148b	0.534bc	0.958a
4	Mőngőn	29.51±1.50a	1.49±0.04b	0.025±0.002c	0.064±0.002a	0.089±0.001b	2.560a	0.719a	0.934a
5	Binder	23.74±1.23b	1.53±0.04b	0.056±0.003a	0.057±0.003a	0.113±0.005a	1.018b	0.504bc	0.851b
6	Hővsgől	21.34±1.16bc	1.81±0.05a	0.046±0.007ab	0.054±0.005a	0.1±0.011ab	1.174b	0.540b	0.812bc
7	Uvs	18.48±0.32d	1.20±0.03d	0.019±0.002c	0.028±0.003b	0.047±0.001c	1.474b	0.595b	0.779cd
8	Turag	18.70±0.74cd	1.56±0.03b	0.043±0.005b	0.056±0.005a	0.099±0.006ab	1.302b	0.566b	0.806bc
	Mean	**20.51**	**1.45**	**0.035**	**0.046**	**0.081**	**1.392**	**0.561**	**0.813**
Green house nursery									
1	Ővőrkhangai	19.79±0.51d	1.36±0.35e	0.030±0.009b	0.04±0.007d	0.070±0.016d	1.333a	0.588ab	0.838de
3	Tuul	38.85±3.27c	2.33±0.13ab	0.138±0.04a	0.181±0.02a	0.319±0.037a	1.312a	0.601a	0.908cd
4	Mőngőn	63.63±3.28a	2.51±0.07a	0.137±0.01a	0.096±0.007bc	0.234±0.017b	0.701a	0.411c	1.227a
5	Binder	46.90±2.9b	2.05±0.06cd	0.154±0.011a	0.113±0.005b	0.267±0.014b	0.872a	0.424bc	1.075b
6	Hővsgől	35.91±2.58c	1.99±0.07d	0.102±0.02a	0.078±0.005c	0.180±0.021c	0.765a	0.448abc	0.941c
7	Uvs	17.86±0.5d	1.52±0.04e	0.033±0.005b	0.040±0.007d	0.073±0.012d	1.212a	0.541abc	0.776e
8	Turag	36.73±2.76c	2.23±0.08bc	0.106±0.006a	0.083±0.003c	0.189±0.006c	0.783a	0.439abc	0.967c
	Mean	**37.09**	**1.99**	**0.1**	**0.09**	**0.191**	**0.994**	**0.493**	**0.965**

*Note: Different letters indicate significant difference at 1% error level (Duncan test)

Discussion

Success of restoration and reforestation depends on many factors, including seed and seedling quality, matching species to the appropriate site, and the silvicultural practices employed. Given the tremendous genetic variation in forest tree species, the origin of plant material is one of the most important factors in successfully establishing plantations and reforestation. Use of seeds geographically adapted to a specific region can increase resistance to pest and pathogen damage, unfavorable growth conditions, and yield higher seedling survival and better performance. Extensive guidelines for transferring conifer seeds and seedlings exist worldwide, and were developed based on climatic data, as well as geographic and genetic information. Although, there has been a little research conducted in Mongolia (Bat-Erdene & Dashzeveg, 1995; Jamiyansuren, 1989), information on seed source control, regulation, seed transfer and seed zoning is lacking.

The Siberian larch is the most important and widely distributed timber tree species in Mongolia. This can be explained by its broad tolerance to moisture, temperature and soil requirements. Pure natural stands and open woodlands of *L. sibirica* Ldb. occupy almost 60% of the total closed forest area in Mongolia. It is a single tree species that appears in most favorable habitats both in steppe and mountain tundra (Savin *et al.*, 1978; Milyutin and Vushnevetskaja, 1995). In the present study, a considerable variation in seed quality, seedling growth and biomass allocation was observed among seed sources (Tables 4, 5 and 6).

The production of high quality plants is the fundamental objective of nurseries, from which success of a plantation depends and one in which seed quality plays a key role. Many factors as both biological and environmental, influence the quality of seed produced by a given tree in natural conditions (Harper, 1977). Seed quality traits like germination capacity, germination energy, seed weight and size may vary due to both internal (maternal and heredity) and external (environmental) conditions operating at the time of seed development (Harper *et al.*, 1970). Physiologically, seeds with greater mass have a more developed embryo and greater energy reserves, which produce plants with greater vigor and capacity to grow. Some studies have found a correlation between seed size and germination and initial growth of plants (Wrzesniewski, 1982a-c; Howe and Richter, 1982; Bonner, 1987; Righter 1945; Dunlap and Barnett, 1983). Generally, large seeds produce large and vigorous plants, except in a few cases where this effect has not been significant (Kuser and Ching, 1981; Wrzesniewski, 1982a-c; Gailis 1973; Mann 1979; Dormling & Johnsen, 1992; Bonner, 1987). In the present study, no particular correlation was found between seed weight and seed germination parameters among studied seed sources. However, seedling emergence at the nursery conditions were strongly correlated with seed germination and viability of seeds (data were not shown).

Rapid growth of shoots and roots is important for successful establishment of planted tree seedlings. Rapid shoot growth allows seedlings to compete with surrounding vegetation and rapid root growth is crucial for efficient water uptake by newly planted seedlings (Burdett, 1990). In this study we found that seedlings grown at greenhouse nursery conditions had more intensive growth than that of open nursery grown seedlings (Table 7 and Figures 3 and 4). Selection on the development of deep roots, relative to aboveground biomass, is likely to be stronger in water-limiting environments and, indeed, plants are often reported to exhibit a higher root to shoot ratio at drier sites (Chapin *et.al*., 1993; Schenk & Jackson, 2002). We found that seedlings grown at open nursery conditions allocated more to roots than greenhouse nursery conditions (Table 7), and it may be explained that the greenhouse nursery conditions are more favorable than those of open nursery conditions for shoot growth and elongation. Higher proportional allocation of biomass to roots may be suggestive of a more promising survival rate after transplanting to the field.

Conclusion

This study reveals the existence of considerable variation in seed quality traits, growth and biomass allocation characteristics in Siberian larch. During bulk seed collection, either for *ex situ* conservation in seed banks or seedling production for plantation establishment or reforestation, collection should be made from several sources to ensure sufficient genetic variability in future plants and to obtain good germination performances.

As this study is the first attempt in the country, further study is recommended to quantify seed source or population variations and to conduct progeny trials in order to select genotypes suitable for different geographical conditions. Consideration of ecologically important genetic variation within species is important and this information should be integrated into seed collection and seed certification strategies for successful ecological restoration. Increased attention on incorporating tree improvement into operational seedling production is needed as present levels of nursery improvement appear insufficient to meet future demands for vigorous seedlings for reforestation of degraded forests in Mongolia.

However, the results were only obtained within a short period of time (one growing season); these responses in growth and biomass allocation characteristics may change after prolonged period of growth. Therefore continuous investigations on growth and biomass allocation characteristics including physiological traits are needed for future.

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Хураангуй

Монгол орны доройтсон ойг нөхөн сэргээх ажлын үр дүн маш ядмаг байгаа бөгөөд амжилттай нөхөн сэргээсэн ойн талбай хэмжээ нийт доройтсон ойн талбайн дөнгөж 5%- ийг л эзэлдэг. Ойжуулалтын ажлын үр дүн муутай байгаагийн нэг шалтгаан нь тарьж буй үрийн чанар муу, түүнээс ургуулсан тарьц, суулгацын чанар муу байдагтай холбоотой байж болох юм. Энэхүү судалгаагаар бид Сибир шинэсний тархалтын бүс нутгуудаас цуглуулсан үрийн дээжинд үрийн чанарын ялгааг олж илрүүлэх, газарзүйн ялгаатай үрээр ургуулсан нэг настай тарьцын өсөлт, биомассын хуваарилалтын онцлогийг тодорхойлох, үүний үндсэн дээр Монгол орны доройтсон ойг нөхөн сэргээхэд хамгийн тохиромжтой үрийн гарал үүслийг тогтоох зорилт тавьсан юм. Бид газарзүйн хувьд ялгаатай найман газраас Сибирь шинэсний үр цуглуулж, хүлэмж болон ил мод үржүүлгийн газар ургуулан тарьцын өсөлт, биомассын хуваарилалтын хэмжилтүүдийг хийсэн. Судалгаагаар газарзүйн ялгаатай үрийн дээжүүд нь үрийн чанарын болон тарьцын өсөлт, биомассын хуваарилалтын хувьд туршилтын аль ч нөхцөлд ялгаатай байгааг тогтоолоо. Туул гол (No.3), Мөнгөн (No.4) зэрэг нутгийн үрнээс ургуулсан тарьцын өсөлт, биомассын хуримтлал ил талбай болон хүлэмжийн аль ч нөхцөлд хамгийн өндөр үзүүлэлттэй байхад Өвөрхангай (No.1)-н тарьц туршилтын хоёр нөхцөлд хэмжсэн бүх үзүүлэлтийн хувьд хамгийн бага үзүүлэлттэй байв. Түүнээс гадна хүлэмжинд ургуулсан тарьц нь ил талбайтай харьцуулахад илүү хурдан өсөлттэй, илүү биомасс хуримтлуулж байгаа нь тодорхой байна. Гэхдээ ил талбайд ургуулсан тарьцын үндэсний биомассын хэмжээ хүлэмжинд ургуулсантай харьцуулахад илүү өндөр байгаа нь тарьцыг ойжуулалтанд шилжүүлсний дараах амьдралт өндөр байх боломжтойг харуулж байна.

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