Journal for Research in Applied Sciences and Biotechnology

www.jrasb.com

ISSN: 2583-4053

Volume-3 Issue-1 || February 2024 || PP. 82-86

https://doi.org/10.55544/jrasb.3.1.14

Growth and Survival of Chilgoza Seedlings as Influenced by Different Types and Size of Sowing Media

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www.jrasb.com || Vol. 3 No. 1 (2024): February Issue

Received: 21-01-2024	**Revised:** 22-01-2024	**Accepted:** 29-01-2024

ABSTRACT

Chilgoza pine (*Pinus gerardiana* Wall.) is an important but endangered tree species in Afghanistan. Due to poor natural regeneration, seed-related dormancy and anthropogenic factors, the IUCN put this species on the red list. Therefore, this study was undertaken to investigate the effect of growing medium and polybag sizes on seedling growth and survivability. In this study, four growing media of soil (So), compost (Co), forest soil (Fs) and sand (Sa), *viz*., M_1 (So + Co + Fs); M_2 (Fs + Co + Sa); M_3 (So + Fs + Sa); and M_4 (Sa + Co + Fs) and three polybag sizes including P_1 (16 cm×16 cm), P_2 (18 cm×18 cm), and P_3 (21 cm×26 cm) were used and arranged in the frame of 4×3 factorial design to assess their effects on seedling growth and survivability. The results revealed that among different growing media treatments, higher seedling growth parameters and survival rate percentage were observed on treatment M_4 (Sand + Compost + Forest Soil). Seedling growth parameters and survivability were significantly affected by polybag size, and the highest seedling growth parameters and survival rate were obtained for Large Polybag size (P3).

Keywords- sowing media, polybag, survivability, seedling growth, chilghoza.

I. INTRODUCTION

Pinus gerardiana is the most economically and ecologically important tree species in Afghanistan, commonly known as Chilgoza, chalghoza, pine nuts, and Himalayan pine nuts [5]. Chilgoza is one of the 110 pine species of the Pinus genus, found at 1800 to 3350 m elevation in the temperate forests of the Himalayan region [7]. It produces edible kernels that are rich in many essential nutrients such as proteins, carbohydrates, fats, minerals, and fibers [20]. Fresh kernels contain sugars (4.07%), proteins (13.03%), oils (52.15%) and moisture (25.36%) [13].

Furthermore, Chilgoza plays an important role in the socio-economic development of the local communities and the national economy of Afghanistan; the livelihood of approximately 120,600 households directly depends on the Chilgoza forest. Each family obtains 444-555 USD income per year from this species [18]. Poor natural regeneration, seed-related dormancy, and other anthropogenic factors cause the degradation of the species ([17,8,9,19,3]. On the other hand, seedling growth and its survivability in ex-situ are too low even uneconomical. Usually, most soils, especially the soil of pine forests, have mycorrhizae and colonize the roots of many plants. Mycorrhizae are structures resulting from the symbiosis between these fungi and plant roots and directly contribute to the mineral nutrition of plants. The symbiotic relationship between root and fungus increases the absorption of essential nutrients [16] Mycorrhiza helps pine seedlings to survive [12]. Different factors affect seed seedling growth [10]. Therefore, it is important to improve the seedling growth and survivability of this species. The type and size of the growth medium are important factors for seedling growth and survivability. seedling growth are greatly affected by the sowing medium and GA_3 [3]. Also Soil media has important effects on plant growth and survival [11].

Journal for Research in Applied Sciences and Biotechnology
www.jrasb.com
ISSN: 2583-4053
Volume-3 Issue-1 || February 2024 || PP. 82-86
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Chilgoza pine seedlings require adequate drainage in nurseries [9]. Based on the latest research, soil media, and growth-promoting chemicals can improve however, the size of the media is also important to investigate and define the proper type and size of the growing media.

II. MATERIALS AND METHOD

2.1 *Study area*:

The study was conducted during 2021–2022, in the research farm of the agriculture faculty of Paktia University, Gardez City, Paktia, Afghanistan, which is located at 33º 38 48 N, 69 13 56 E, and 2390m altitude. This area is far from the natural chigoza forests and is also lower than it in terms of height, in this study, we used a completely randomized design (CRD) with three replications.

2.1.1 Treatment properties:

Two factors were included in this experiment. The first factor was sowing medium, with four combinations: ground soil: compost: forest soil (M_1), ground soil: compost: sand (M_2), ground soil: forest soil: sand (M_3), and sand: compost: forest soil (M_4). Second factor was polybag size: P_1(16×16), P_2(18×18), and P_3(21×21).

Forest soil: Forest soil was collected from Satto Kondow forest from a depth of 0-30 cm.

Seeds: Seeds were collected from the forest area of the province. Seeds were sorted and graded based on their healthiness, size and physical properties, respectively. Healthy seeds were sown in polybags filled with the prepared sowing media. Irrigation was performed using a hand sprinkler.

2.1.1.1 Studied parameters and data collection:

In this study seed seedling growth parameters and seedling survivability were measured, Seedling growth parameters and their survivability were measured at the end of the growing season in the ninth month after sowing, more details regarding growth parameters are presented in Table 1.

Table 1: Survivability and seedling growth parameters, formulas, and units

Studied parameters	Calculation formula	Unit of Measurement	Used References
survivability	$\text{Survival rate\%} = \frac{number\ of\ survived\ seedling}{number\ of\ germinated\ seeds} \times 100$	%	[15]
Collar diameter	Digital clipper	mm	[4]
Shoot Length	Ruler	cm	[4]
Shoot fresh Weight	Precision scale	gr	[4]
Root fresh weight	Precision scale	gr	[4]
Shoot dry weight	Precision scale	gr	[4]
Root dry weight	Precision scale	gr	[4]

The first germination of seeds was observed and recorded 21 days after seed sowing and continued up to the 48th day, after 9 months of sowing, survival rate was calculated from completing date of germination and seedlings were removed from polybags in order to measurement of some growth parameters. Root and shoot dry weights were assessed after oven drying at 68 °C for 48 h.

III. RESULTS AND DISCUSSION

Analysis of variance tables showed that survival rate was affected by growing media and ploy bag size (Tables 3). and seedling growth was significantly affected by both growing media and ploy bag size (Tables 2). Highest survivability was observed in M4(sand: compost: forest soil) media, and large polybag size P3 (26 cm × 21 cm). However, survival rate decreased in M1 (soil: compost: forest soil) medium and small poly bag size P1 (26 cm × 21 cm), (Table 5). Seedling growth parameters were significantly affected by media and polybag size and were higher in M4 (sand: compost: forest soil) and P3 (26 cm × 21 cm) polybag sizes (Table 4).

Table 2: Analysis of variance (ANOVA) for growing media (M), polybag size (P), and their interaction (M×P) for seedling growth parameters.

SOV	DF	MS								
		Diameter	Seedling Height	Seedling Fresh Weight	Root Fresh Weight	Seedling Dry Weight	Root Dry Weight	Root : Shoot ratio	Sturdiness Quotient	Seedling Quality Index
M	3	0.3188**	0.4016*	0.0098 ^{ns}	0.0087*	0.0119*	0.0022*	0.0043 ^{ns}	0.1159 ^{ns}	0.0011**
P	2	0.5**	0.61*	0.02 ^{ns}	0.02**	0.02**	0.0025*	0.01 ^{ns}	0.44 ^{ns}	0.002**

ISSN: 2583-4053
Volume-3 Issue-1 || February 2024 || PP. 82-86
https://doi.org/10.55544/jrasb.3.1.14

M×P	6	0.2916**	0.3414*	0.056**	0.002 ns	0.003 ns	0.0005 ns	0.0054 ns	1.2524*	0.0005
Error	24	0.0611	0.1224	0.0134	0.0024	0.0030	0.0007	0.0067	0.4518	0.0002

*, **, and ns show significant differences at 5% and 1% levels of probability and non-significance, respectively.

Table 3: Analysis of variance (ANOVA) for growing media (M), polybag size (P), and their interaction (M×P) for seed survivability.

SOV	DF	Mean Squares (MS)
		Survival rate (%)
M	3	267**
P	2	149.1**
M×P	6	127.6ns
Error	24	289.3

, **, and ns show **significant differences at 5% and 1% levels of probability and non-significance, respectively.*

3.1 Effect of Growing Medium

Collar diameter, root dry weight, and seedling quality index in M4 (sand: compost: forest soil) growing medium were significantly higher than those in other growing media. Shoot length, root fresh weight, and shoot dry weight were statistically similar in M4 (sand: compost: forest soil) and M3 (soil: forest soil: sand). Shoot fresh weight, Root: Shoot ratio and sturdiness quotient were not significantly different in the different growing media (Table 4).

Table 4. Effect of growing medium and polybag size on seedling growth of *Pinus gerardiana*

Growing media and polybag size	Diameter	Seedling height	Shoot fresh weight	Root fresh weight	Shoot dry weight	Root dry weight	Root: shoot ratio	Sturdiness quotient	Seedling quality index
Soil: compost: forest soil	1.62 b	5.11 b	0.69 a	0.44 b	0.48 b	0.30 b	0.62 a	3.29 a	0.10 b
Soil: compost: sand	1.62 b	5.22 b	0.66 a	0.47 ab	0.51 b	0.31 b	0.61 a	3.27 a	0.10 b
Soil: forest soil: sand	1.67 b	5.33 ab	0.71 a	0.47 ab	0.53 ab	0.30 b	0.58 a	3.22 a	0.11 b
Sand: compost: forest soil	2.01 a	5.60 a	0.64 a	0.51 a	0.57 a	0.33 a	0.58 a	3.04 a	0.13 a
P1(16cm*16cm)	1.53 b	5.08 b	0.65 a	0.44 b	0.49 b	0.30 b	0.62 a	3.41 a	0.10 b
P2(18cm*18cm)	1.72 b	5.33 ab	0.65 a	0.45 b	0.51 b	0.31 ab	0.61 a	3.16 a	0.11 b
P3(21cm*26cm)	1.94 a	5.53 a	0.73 a	0.52 a	0.57 a	0.32 a	0.56 a	3.03 a	0.12

In M_4 (sand: compost: forest soil) growing media, had the highest survival rate of 55.78% than the other treatments of sowing medium, M_1 (sand: compost: forest soil) had the lowest survival rate of 48.22% (Table 5).

Table 5. Effect of growing medium and polybag size on seedling survivability of *Pinus gerardiana*

p	Survival rate (%) media				P Mean
	M1	M2	M3	M4	
p1	44.67d	52.33bc	49.67cd	50.33cd	49.25b
p2	48.33cd	47.67cd	50.33cd	57.67ab	51.00b
p3	51.67c	53.00bc	52.67bc	59.33a	54.1a
media mean	48.22 b	51.00 b	50.89 b	55.78 a	
Total mean	51.47222%				
CV	6.75%				

3.1.1 Effect of Polybag Size

The growth parameters were significantly affected by the polybag size. Collar diameter, root fresh weight, shoot dry weight, and seedling quality index were significantly affected by P3 (26 cm × 21 cm). Seedling height and root dry weight were measured and parred in P2 and P3 polybags. Shoot fresh weight, Root: Shoot ratio and sturdiness quotient were not significant for any polybag size (Table 4).

ISSN: 2583-4053
Volume-3 Issue-1 || February 2024 || PP. 82-86
https://doi.org/10.55544/jrasb.3.1.14

Seedling survivability significantly affected by Polybag sizes highest survival rate obtained from large polybag size P3 (26 cm × 21 cm), (Table 5).

3.1.1.1 Interaction Effect

The collar diameter and seedling height were greater in M4 (sand: compost: forest soil) for P3 (26 cm × 21 cm) polybag size. Shoot fresh weight interaction was better in M3 (soil: forest soil: sand) for P1 (16 × 16 cm) polybag size. The sturdiness quotient was greater in M3 (soil: forest soil: sand) for P3 (26 × 21 cm) polybag size (Table 6).

The effects of the growing media and polybag size on seedling growth and seedling survivability are shown in Tables 4 and 5, respectively. Seedling survivability were observed to be greater in M4 (forest soil: compost: sand) for P3 (26 cm × 21 cm), (Table 5). However, there was no significantly (P>0.05) difference on the survival rate of interaction sowing medium and poly bag sizes.

Table 6: Interaction effect of growing medium and seed size on seedling growth of *Pinus gerardiana*

Soil media	Poly bag size	Diameter	Seedling height	Shoot fresh weight	Root fresh weight	Shoot dry weight	Root dry weight	Root: shoot ratio	Sturdiness quotient	Seedling quality index
Soil: compost: forest soil	P1(16cm*16cm)	1.50 cd	4.33 c	0.80 ab	0.40 d	0.40 d	0.27 c	0.69 a	2.94 bc	0.09 d
	P2(18cm*18cm)	1.57 bcd	5.33 ab	0.54 ef	0.45 bcd	0.49 cd	0.30 bc	0.63 ab	3.41 ab	0.10 cd
	P3(21cm*26cm)	1.53 bcd	5.25 b	0.60 cdef	0.43 cd	0.49 bc	0.30 bc	0.61 ab	3.43 ab	0.10 cd
Soil: compost: sand	P1(16cm*16cm)	1.53 bcd	5.40 ab	0.66 bcdef	0.49 bc	0.58 abc	0.31 bc	0.54 b	3.86 ab	0.11 bcd
	P2(18cm*18cm)	1.93 b	5.40 ab	0.56 def	0.44 cd	0.50 bc	0.31 bc	0.62 ab	2.80 bc	0.11 bcd
	P3(21cm*26cm)	1.47 cd	5.17 b	0.65 bcdef	0.45 bcd	0.49 bc	0.31 bc	0.64 ab	3.56 ab	0.10 cd
Soil: forest soil: sand	P1(16cm*16cm)	1.60 bcd	5.23 b	0.87 a	0.45 bcd	0.51 bc	0.28 bc	0.56 ab	3.28 abc	0.10 bcd
	P2(18cm*18cm)	1.87 bc	5.53 ab	0.52 f	0.46 bcd	0.53 abc	0.32 ab	0.61 ab	3.02 abc	0.12 bc
	P3(21cm*26cm)	1.43 d	5.58 ab	0.71 abcde	0.47 bcd	0.55 abc	0.31 bc	0.56 ab	4.12 a	0.10 cd
Sand: compost: forest soil	P1(16cm*16cm)	1.83 bcd	5.17 b	0.78 abc	0.49 bc	0.56 abc	0.31 bc	0.55 ab	2.83 bc	0.12 b
	P2(18cm*18cm)	1.87 bc	5.50 ab	0.67 bcdef	0.53 ab	0.58 ab	0.32 ab	0.55 ab	2.95 bc	0.12 b
	P3(21cm*26cm)	2.63 a	5.87 a	0.75 abcd	0.59 a	0.60 a	0.36 a	0.59 ab	2.23 c	0.15 a

IV. DISCUSSION

4.1 Effect of Growing Medium

Our findings showed that the seedling survival rage percentage was higher in those media treatments which had sand and forest soil as a combinational portion like M_4 (sand + compost + forest soil). In media treatments with no sand and forest soil portion, seedling survivability percentage was better in forest soil-containing treatments. This betterment in survival rate might be attributed to forest soil forest soil with mycorrhiza can be effective in absorbing nutrients and sand that in turn prepare *in situ* conditions and good aeration for seedling roots. These results are in harmony with those of [14] and [4].

Our results also showed that sand-containing treatments (M_4) resulted in higher growth parameters and seedling quality index as compared with treatments not contained sand portions. Media with sand (M_4) causes aeration leading to longer primary root and good respirational activity. Similar results have been reported by [1] in *Azadirachta indica* Nemm.

4.1.1 Effect of polybag size

Our findings regarding seedling survivability showed that polybag size had significant effects on seedling survival rate, the highest survival rate percentage obtained from large poly bag size P_3 (26 cm × 21 cm). whilst polybag size significantly influenced seedling growth. The highest growth parameters were obtained by treatment P_3 (26 cm × 21 cm). The larger the polybag size, the higher the seedling growth. This assumed to be due to adequate space for the growth of both (above and below ground) portions. These findings are parallel with the results of [2].

4.1.1.1 Effect of interaction of container size and potting media on growth and development of seedlings

Results of this study showed that the interaction of growing media and polybag size was significantly effective on diameter and height. $P_3 \times M_4$ interaction resulted in the highest diameter and height. Large polybag size with good growing media, paves the way for good water-holding capacity, porosity, and root growth as reported by [6]. Although various interactions had different effects so the results made inconclusive. For precise estimation of interaction effects, additional studies are needed to be run in the future.

V. CONCLUSION

The results of the study conclude that seedling growth and seedling survivbility of *P. gerardiana* seeds depend on growing medium and polybag size. The application of different growing mediums and the use of different polybag sizes significantly affected the seedling growth

ISSN: 2583-4053

Volume-3 Issue-1 || February 2024 || PP. 82-86

https://doi.org/10.55544/jrasb.3.1.14

and survivability of the chilgoza. In general, in the present study, M4 (sand: compost: forest soil) is recommended for seedling growth and seedling survival, also P3 (26 cm x 21cm) polybag size is recommended for enhancing seedling growth parameters and seedling survival percentage. So, polybag size should be selected according to the nursery space and economic prospects of the grower. For accurate estimation of the survivability of seedlings of Chilgoza, further research is needed to be done by using mycorrhiza in the growing medium.

ACKNOWLEDGEMENT

Authors extend the sincerest words of thanks to Associate Professor Salari for critical reviewing the manuscript. Also authors are thankful to senior students of the department of Forestry and Natural Resources Management of Paktia University for their invaluable contribution in the silvicutural practices of the project.

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