ANNUAL PROGRESS REPORT

(2023-24)

PAKISTAN FOREST INSTITUTE

PESHAWAR

2024

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SUMMARY

From July, 2023 to June, 2024, the Pakistan Forest Institute continued to advance its mandate of conducting research and providing training in the fields of forestry and allied disciplines. During this period, the Institute undertook a range of research activities, including the development of volume and yield tables, formulation of growth models for coniferous forests, and surveys of flora and fauna in the merged areas of Khyber Pakhtunkhwa. Additional studies focused on evaluating various grass species for fodder production under irrigated conditions, compiling comprehensive forestry statistics, analyzing the anatomical properties of wood species, and conducting research on medicinal plants.

Moreover, the report includes details of various studies conducted under the developmental projects: (i) Mapping, Digitizing, Value Addition, and Marketing of Non-Timber Forest Products (NTFPs) in collaboration with the NTFP Directorate, Forest Department, Khyber Pakhtunkhwa (ii) Biodiversity Research Initiatives in the Merged Areas of Khyber Pakhtunkhwa (iii) Survey of Wild Bee Pollinators in the Coniferous Forests of Khyber Pakhtunkhwa and (iv) Improving the Efficiency of Forest Management through the Development of Volume Tables, Yield Tables, and Growth Models for Coniferous Forests of Khyber Pakhtunkhwa.

Furthermore, the Institute extended advisory services on technical aspects of forestry and allied disciplines to forest departments, farmers, and other stakeholders through training programs conducted at the Institute and via correspondence. In addition, expert guidance was provided on the properties, applications, and processing of local timber, as well as on its efficient utilization, to various governmental and non-governmental organizations and private-sector users.

Recognizing the importance of human resource development for the sustainable management of the forestry sector in Pakistan, the Institute continues to implement comprehensive education and training programs in forestry and allied disciplines, leading to the award of a four-year BS Forestry degree. In addition, the Institute conducted various short courses for nominees from the Forest and Wildlife Departments. Research findings were disseminated to end users across the country through publications and research articles published in scientific journals.

Khalid Ilyas
Director General,
Pakistan Forest Institute, Peshawar

1. FORESTRY RESEARCH DIVISION

1.1 SILVICULTURE

1.1.1 Study on the growth performance of different poplar clones at nursery stage

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Source of Funding:	ADP Project "Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa"
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry) Saif Ullah Khan, Research Officer (Farm Forestry)
Design:	Randomized Complete Block
Total area:	0.5 acres
Spacing:	2′ X 1′
No. of clones:	17
No. of replications:	02

Hybrid poplar (*Populus* spp.) is integral to Pakistan's agroforestry and economy due to its fast growth, adaptability, and diverse uses. With a short rotation cycle of just 6–8 years, it provides farmers with quick financial returns while supplying raw materials to industries for furniture, plywood, and sports equipment manufacturing. Its cultivation supports local economies, meets international demand, and contributes to environmental sustainability by sequestering carbon, improving soil health, and preventing erosion. Resilient to climatic variations, it thrives in agroforestry systems, optimizing land use alongside crops like wheat and sugarcane. As Pakistan expands poplar-based industries, ongoing research, such as studies at PFI Silva Research Garden, aims to identify superior clones for growth and biomass production, underscoring its role in sustainable land use and economic growth. The study aims to examine and compare the growth rates of different hybrid poplar clones under similar nursery conditions.

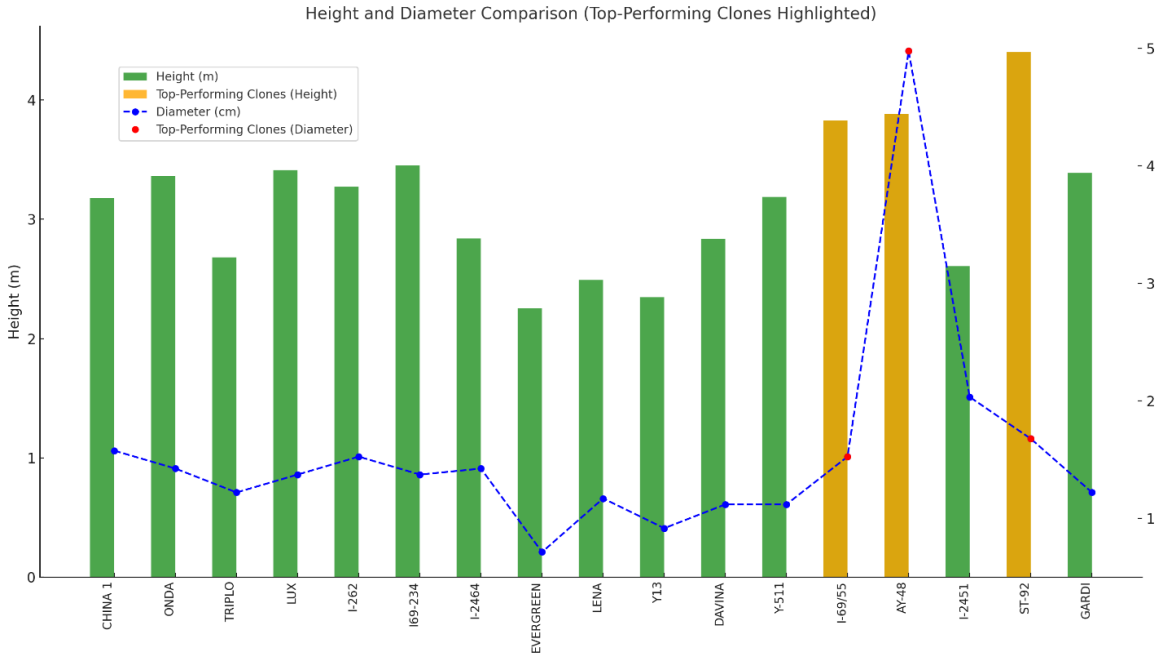


Figure.1: Comparison of height and diameter among different Poplar clones

The figure-1 displays the height (green bars) and diameter (blue dashed lines) of poplar clones. The top-performing clones, highlighted with orange bars for height and red dots for diameter, are I-69/55 (height: 3.83 m, diameter: 1.52 cm), AY-48 (height: 3.88 m, diameter: 4.98 cm), and ST-92 (height: 4.40 m, diameter: 1.68 cm).

1.1.2 Study on the suitability of different species and soil treatments for raising Miyawaki Plantations

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2022
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry) Saif Ullah Khan, Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva)
Design:	Randomized Complete Block
Total area:	10 Kanals
Spacing:	2′x2′, 3′x3′, 3′x4′, 4′x4′
No. of replications:	02

The Miyawaki is a proven technique for rapidly creating dense forests in urban areas. It involves meticulous land preparation, the use of tree species, and close planting distances. This method accelerates plant growth by a factor of ten compared to traditional forestry practices.

In 2022, the PFI Research Garden started a study examining how different soil treatments and planting densities affect plant growth. The experiment used the spacing of 4′x4′, 3′x4′, 2′x3′, and 2′x2′ feet, with the soil treated using leaf manure, farmyard manure, husk, and poultry waste. Twenty-one plant species, including Bakain, Shisham, and Albizia, were part of the study.

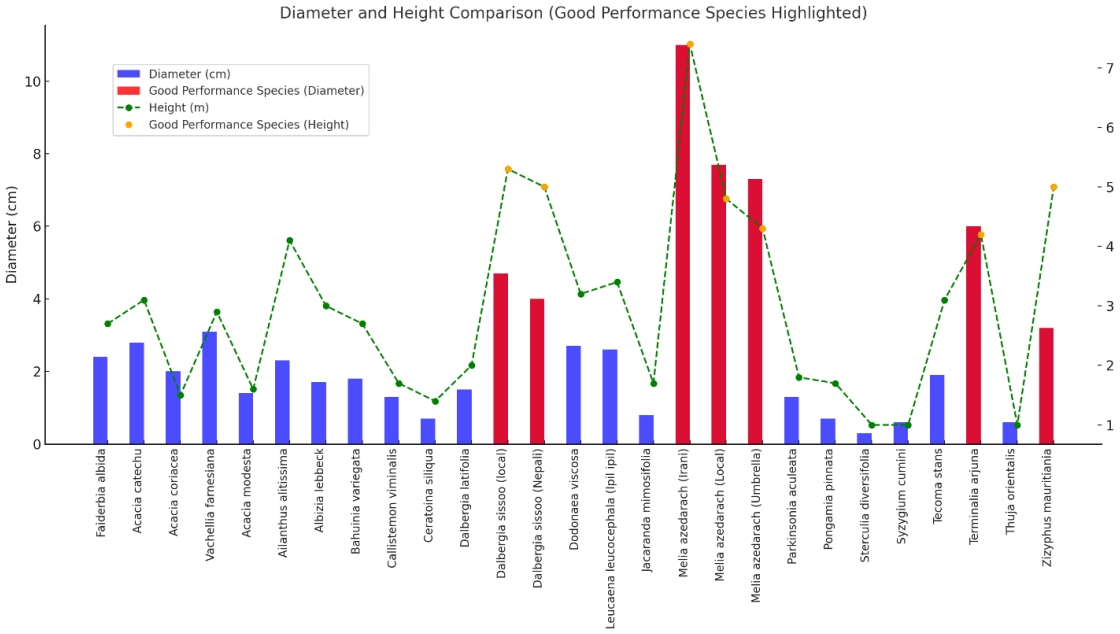


Figure.2: Growth performance (height and diameter) of different species in Miyawaki plantation

After 2.5 years, the data revealed that *Melia azedarach* (Irani) exhibits excellent growth with the highest diameter (11.0 cm) and tallest height (7.4 m), making it an ideal candidate for projects requiring fast and substantial growth in both trunk size and height. *Melia azedarach* (Local), with a height of 4.8 m and a diameter of 7.7 cm, performs strongly as a versatile choice for plantations focused on robust structural growth. Similarly, *Melia azedarach* (Umbrella), with a diameter of 7.3 cm and a height of 4.3 m, offers a good balance of growth metrics suitable for multi-purpose forestry. *Dalbergia sissoo* (Local) reaches a height of 5.3 m and a diameter of 4.7 cm, making it a strong candidate for structural and ecological purposes, particularly in reforestation projects, while *Dalbergia sissoo* (Nepali), slightly smaller than its local counterpart, and reaches a height of 5.0 m and a diameter of 4.0 cm, making it a

reliable option for plantation programs. *Faiderbia albida* shows moderate growth with a height of 2.7 m and a diameter of 2.4 cm, potentially requiring specific conditions to achieve optimal growth. *Acacia catechu*, with a height of 3.1 m and a diameter of 2.8 cm, displays balanced growth but falls slightly short of the performance criteria. *Acacia coriacea* exhibits modest growth with a height of 1.5 m and a diameter of 2.0 cm, suitable for areas with limited resources. *Vachellia farnesiana* performs well with a height of 2.9 m and a diameter of 3.1 cm, making it a potential candidate for semi-arid regions. *Ailanthus altissima* achieves a height of 4.1 m but has a thinner trunk with a diameter of only 2.3 cm, potentially limiting its application in structural forestry. *Albizia lebbeck* reaches a height of 3.0 m and a diameter of 1.7 cm, indicating moderate growth, often used for shade and ornamental purposes. *Bauhinia variegata*, with a height of 2.7 m and a diameter of 1.8 cm, is valued for its ornamental properties but may not be ideal for large-scale forestry. *Callistemon viminalis*, at 1.7 m in height and 1.3 cm in diameter, is better suited for decorative urban landscaping. *Ceratonia siliqua* shows minimal growth with a height of 1.4 m and a diameter of 0.7 cm, likely requiring specialized environments. *Tecoma stans*, at 3.1 m in height and 1.9 cm in diameter, is visually appealing but lacks the substantial growth of top performers. *Terminalia arjuna* stands out as a strong contender with a height of 4.2 m and a diameter of 6.0 cm, making it suitable for ecological restoration projects. *Zizyphus mauritiania*, with a height of 5.0 m and a diameter of 3.2 cm, proves resilient in arid and semi-arid conditions. *Syzygium cumini* and *Thuja orientalis* exhibit minimal growth with a height and diameter of ~1.0 m and ≤0.6 cm, respectively, likely requiring niche environments for optimal performance.

1.1.3 Comparative assessment of growth performance of different tree species in under-storey, i.e., partially or fully shaded areas.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2022
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry) Saif Ullah Khan, Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva)
Spacing:	$10' \times 6'$

A study was conducted to assess the growth of various tree species in under storey environments where sunlight is partially blocked. The research aimed to understand how different species respond to reduced sunlight, a vital factor for photosynthesis and overall plant health. Key growth indicators were evaluated under varying shade levels, including height and overall vitality. The goal was to identify species that exhibit resilience and robust growth in shaded conditions, which is crucial for effective forest management, particularly in dense forests or urban areas with limited light availability. The results of this study are expected to provide valuable information for ecological conservation, landscaping, and urban forestry, where selecting suitable species for shaded areas is essential.

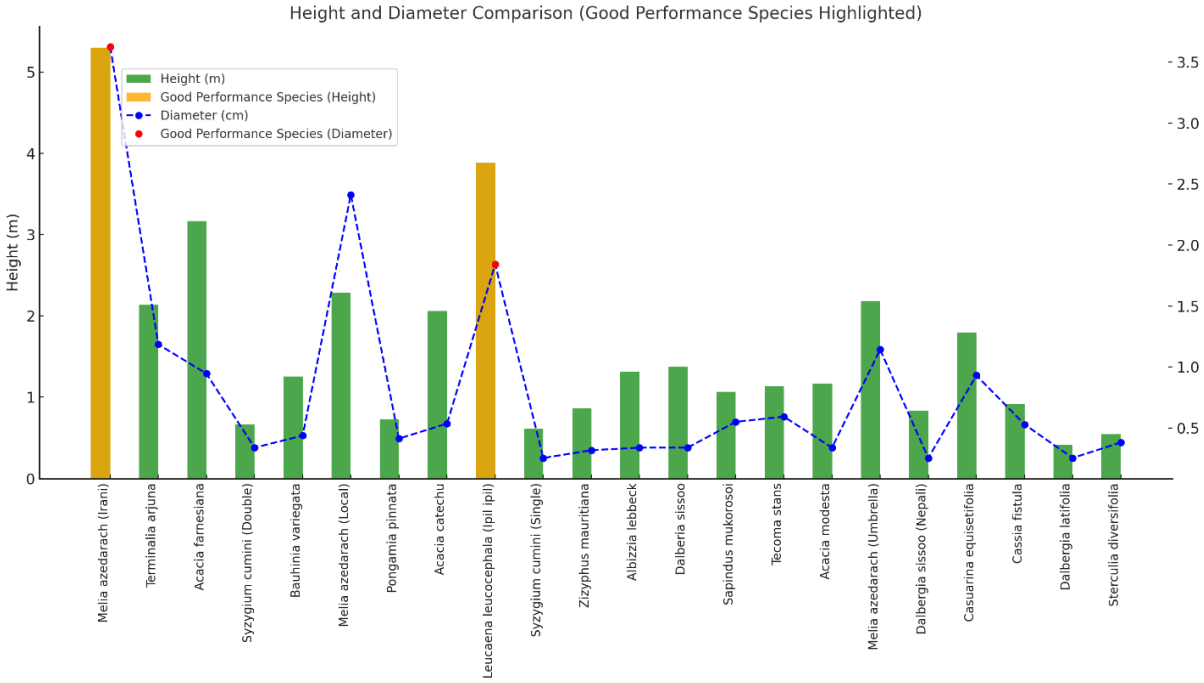


Figure.3: Height and diameter comparison of various tree species in under- storey

Melia azedarach (Irani) demonstrates exceptional growth with a height of 5.30 m and a diameter of 3.63 cm, making it a top performer, particularly in areas where sunlight is partially blocked. *Leucaena leucocephala* (Ipil ipil) also stands out with a height of 3.89 m and a diameter of 1.84 cm, indicating strong growth potential under similar conditions. While showing varied growth patterns, other species fall short of the height and diameter thresholds. This visualization highlights the balance between vertical and structural growth across all species, emphasizing the adaptability of top performers to less direct sunlight.

1.1.4 Comparative assessment of growth performance of local and Nepali Shisham; local and Irani Bakain and other species.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Source of Funding:	ADP Project "Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa"
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry) Saif Ullah Khan, Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva)
Design:	Randomized Complete Block
Total area:	1 acre
Spacing:	$10' \times 6'$
No. of replications:	02

In light of the increasing demand for trees suitable for medium-density fiber production, a comparative study was undertaken to assess the growth performance of local and Nepali Shisham, local and Iranian Bakain, and other species regarding their potential biomass. This comprehensive evaluation focused on various growth parameters such as height, diameter, and overall health, with a special emphasis on estimating the biomass yield of each species. Considering the current market demands, the study aimed to determine which species can provide the most efficient and sustainable raw material source for medium-density fiber. By analyzing the biomass potential alongside the traditional growth metrics, this research seeks to inform forestry management and commercial planting decisions, ensuring that the selected species effectively meet both ecological and industrial needs.

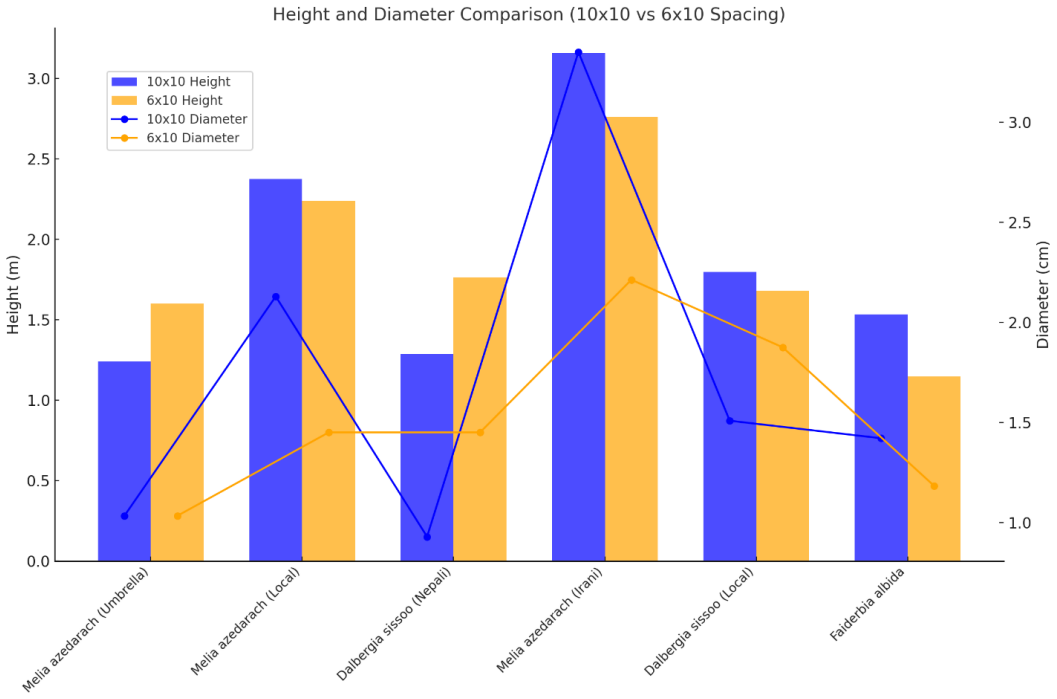


Figure.4: Growth response of different tree species raised under different spacing

The observations highlight the impact of spacing on tree growth and species performance. On average, height growth is slightly higher in the 10x10 feet spacing, although some species perform better in the 6x10 feet spacing. Diameter growth, however, tends to be better in the 10x10 spacing for most species. Among the species, *Melia Azedarach* (Irani) stands out with the highest height and diameter in both spacing, showing even better growth in the wider 10x10 spacing. In contrast, *Faidherbia Albida* exhibits reduced growth in the narrower 6x10 spacing for both height and diameter, highlighting the influence of spacing on its performance.

1.1.5 Comparative Assessment of Biomass Yield in Different Hybrid Olive Varieties at Agroforestry Models.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Source of Funding:	ADP Project “Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa”
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry)

	Saif Ullah Khan, Research Officer (Farm Forestry)
	Mr. Qayyum Khattak, FR (Silva)
Design:	Randomized Complete Block
Total area:	0.79 acres
Spacing:	18′ X 18′
No. of replications:	02

The exploration into biomass yield of various hybrid olive varieties has unveiled groundbreaking insights into agricultural practices. This comprehensive analysis contrasts the productivity of different hybrids, considering factors such as growth rate, fruit yield, and overall biomass generation. Key findings suggest that genetic diversity among these hybrids significantly influences their performance. Factors like climate adaptability, disease resistance, and nutrient absorption efficiency are pivotal in determining the biomass output. Such research is crucial for the agricultural sector, offering data-driven guidance for selecting the most efficient olive varieties. This not only aids in maximizing yield but also ensures sustainable and economically viable farming practices.

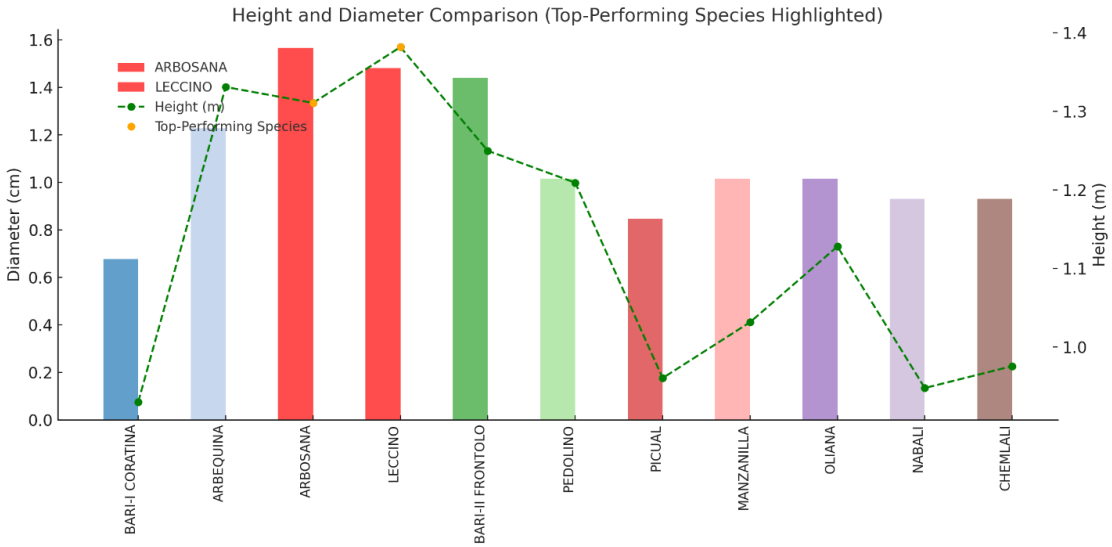


Figure 5: Height and diameter comparison for Biomass Yield in Different Hybrid Olive Varieties at Agroforestry models.

The top-performing species in the dataset are Arbosana, with a height of 1.31 m and a diameter of 1.57 cm, and Leccino, with a height of 1.38 m and a diameter of 1.48 cm. Whereas, Bari-I Coratina and Picual are among the shortest species.

1.1.6 Assessment of different agroforestry models using different tree species and agricultural crops.

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Source of Funding:	ADP Project “Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa”
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry) Saif Ullah Khan, Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva)
Design:	Randomized Complete Block
Total area:	1.3 acres
Spacing:	18′ X 18′
No. of replications:	02

This study delves into how varying tree species contribute to biomass production, a vital component in maximizing land use efficiency and environmental stewardship. Emphasizing the farmers' intention to utilize every inch of their land, the research explores these species' growth dynamics, leaf litter contribution, and overall biomass accumulation in practical agroforestry settings. This approach aligns with the dual objectives of environmental sustainability and maximizing agricultural output, which is crucial for farmers looking to make the most of their land resources.

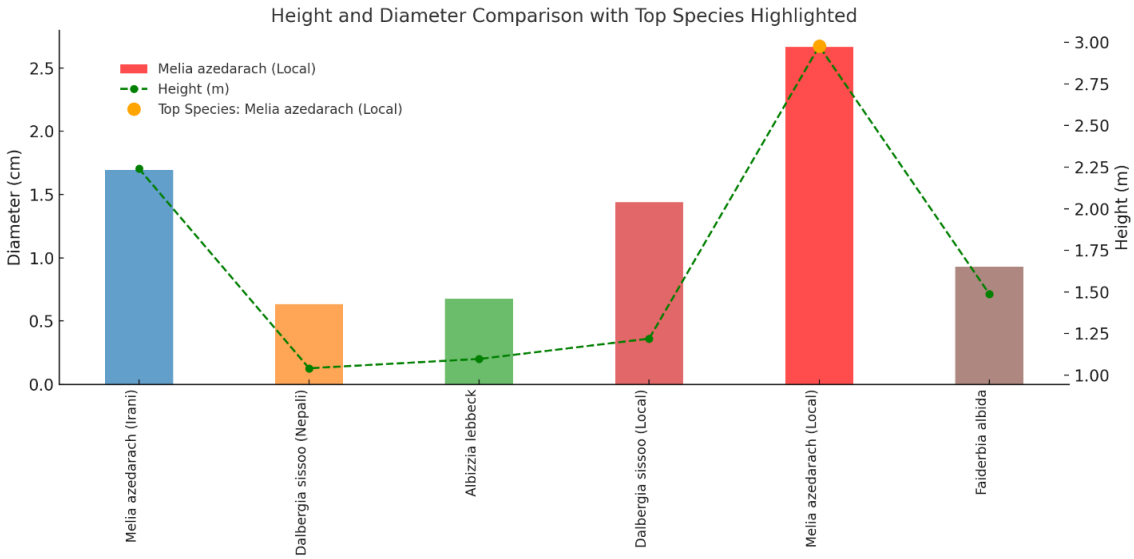


Figure.6: Growth Performance of Various Tree Species in Different Agroforestry Models

The species like *Melia azedarach* (Local) is highlighted as the top performer, marked with red bars and orange markers, due to its exceptional height of 2.98 m and the largest diameter of 2.67 cm. This visualization effectively highlights the variability in growth among species and identifies those with superior growth characteristics, making them suitable candidates for agroforestry projects focused on high productivity.

1.1.7 Comparative assessment of growth performance of different species of Acacia, Ipil Ipil, Siris and Shisham using Super Absorbent Polymers (SAP)

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Source of Funding:	ADP Project “Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa”
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry) Saif Ullah Khan, Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva)
Design:	Randomized Complete Block

Total area:	0.79 acres
Spacing:	10′ X 6′
No. of replications:	02

The study examined the growth performance of distinct species such as Acacia, Ipil-Ipil, Siris, and Shisham, all in the presence of Super Absorbent Polymers (SAP). This investigation aims to understand how SAP, known for its water-retaining properties, impacts the growth dynamics of these diverse tree species. Each species, with its unique physiological characteristics and growth requirements, responds differently to the presence of SAP in its soil environment. The study meticulously tracks parameters such as growth rate and overall health and vigour of the plants. This research is pivotal in identifying which tree species benefit most from SAP use, thereby providing valuable insights for forestry management and sustainable agricultural practices. The findings can potentially revolutionize planting strategies in arid and semi-arid regions, where water conservation is crucial, and could significantly affect the success of reforestation and afforestation efforts.

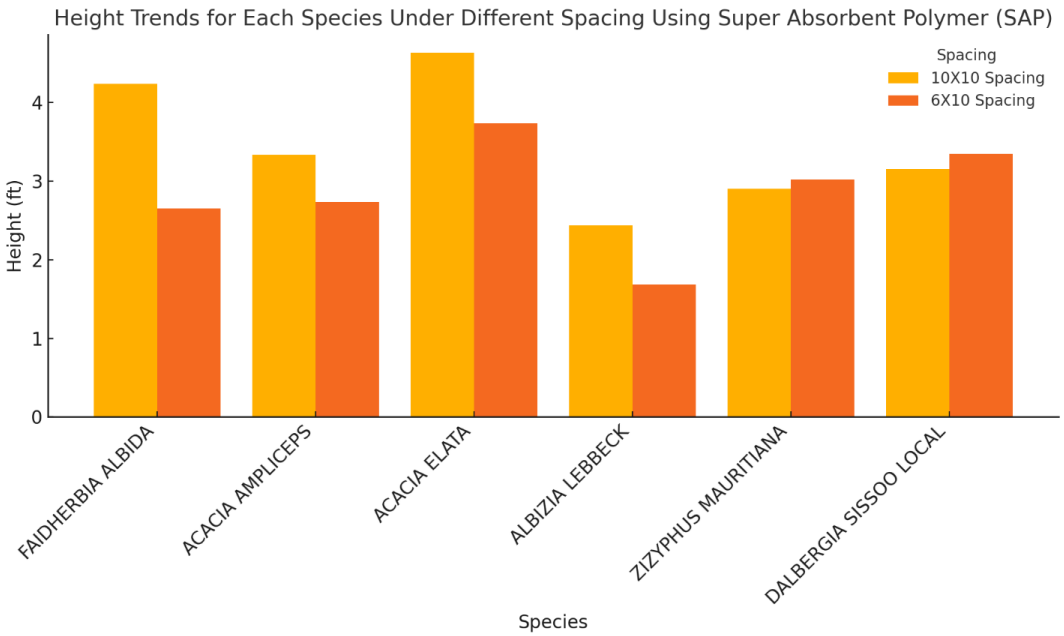


Figure.7: Height trends of each species under different spacing conditions with super absorbent polymer (SAP)

From the results it is evident that the height trends for each species under two spacing conditions (10′X10′ and 6′X10′) by using super absorbent polymer (SAP). *Faidherbia albida, Acacia ampliceps*, and *Acacia elata* grow taller under the 10X10

spacing, with *Acacia elata* showing the highest growth in both spacing. *Albizia lebbeck* exhibits the lowest growth overall, but performs much better under the 10′X10′ spacing. *Zizyphus mauritiana* and *Dalbergia sissoo* (Local) show slightly better growth in the 6′X10′ spacing compared to the 10′X10′. This trend suggests that most species benefit from the wider spacing (10′X10′), likely due to reduced competition for resources, while a few species perform better in closer spacing.

1.1.8 Comparative Assessment of Different Trees Species of Eucalyptus

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Source of Funding:	ADP Project "Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa"
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry) Salman Ahmad, Research Officer (Farm Forestry) Saif Ullah Khan, Research Officer (Farm Forestry) Mr. Qayyum Khattak, FR (Silva)
Design:	Randomized Complete Block
Total area:	2.49 acres
Spacing:	
No. of replications:	02

This study investigates the growth and adaptability of seven different eucalyptus species planted with 10′x10′ spacing at the Research Garden PFI in Peshawar. Eucalyptus species are widely recognized for their economic and ecological benefits, including rapid growth, high biomass production, and significant potential for carbon sequestration, making them a popular choice for reforestation, afforestation, and agroforestry practices worldwide. By utilizing controlled 10′x10′ spacing, this research aims to provide detailed insights into each species' growth performance, canopy development, and overall health, enabling a direct comparison of their adaptability to local conditions. The outcomes of this study could provide valuable data to policymakers, forestry managers, and landowners, supporting decision-making processes for large-scale planting projects aimed at combating deforestation, improving land productivity, and enhancing rural livelihoods. Ultimately,

the research seeks to contribute to the broader understanding of eucalyptus species' roles in diverse ecosystems, fostering a more resilient and sustainable approach to forestry management in Peshawar and similar regions.

1.1.9 Establishment of an arboretum of drought-resistant species

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2015
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry)
	Salman Ahmad, Research Officer (Farm Forestry)
	Saif Ullah Khan, Research Officer (Farm Forestry)
	Mr. Qayyum Khattak, FR (Silva)

In Pakistan, the per capita forest area is merely 0.033 ha compared with the world average of one hectare. The primary reason for the meager forest area is that most of the land area (70-80%) of Pakistan falls in arid or semi-arid zones where precipitation is too low to support tree growth. Moreover, the ever-increasing demand for timber, fuel wood and other goods and services has degraded the existing forest resource. Afforestation of arid and semi-arid areas has become the need of the hour to meet the social, ecological and economic needs of the people dwelling in the rural areas. Due to harsh climatic conditions, likewise low and erratic rainfall and high temperature, the drought resistance species are amongst valuable options. PFI has tested and successfully demonstrated exotic Acacias in different parts of the country. The establishment of an arboretum of drought-resistant species aims to serve the purpose of demonstration and also provide a seed source for the future replenishment needs of the drought-resistant species.

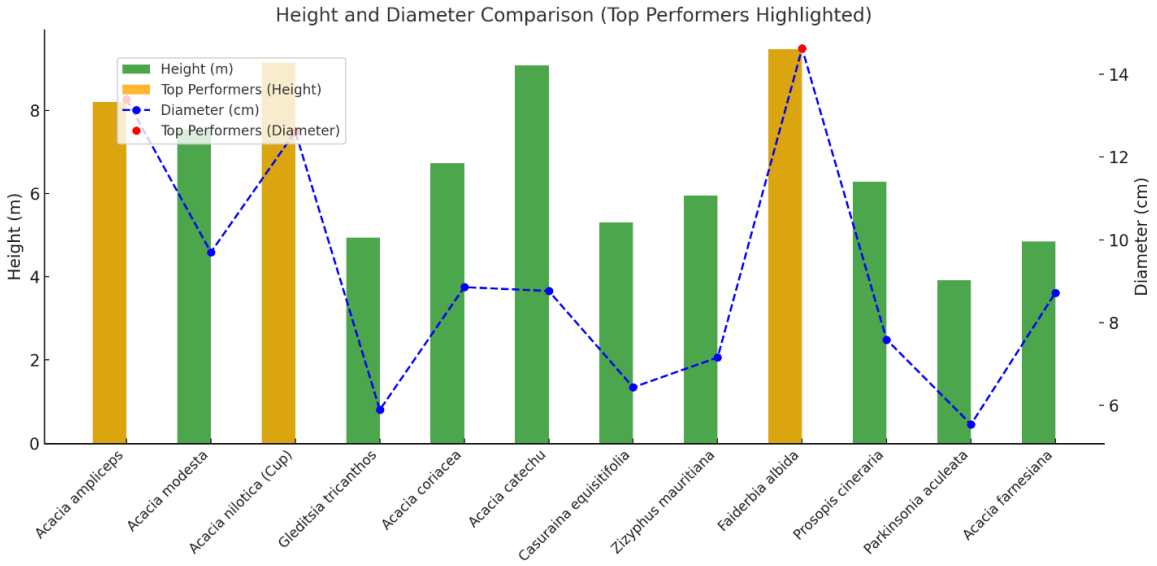


Figure.8: Height and diameter of each species in the arboretum of drought-resistant tree species.

The results showed that species like *Faiderbia albida*, *Acacia nilotica* (Cup), *Acacia ampliceps* showed significant growth with height of 9.48m, 9.16m and 8.2m, and diameters of 14.63 cm, 12.62cm, and 13.4cm respectively. However, other species exhibit moderate growth patterns, with height and diameter.

1.1.9.1 Establishment of arboretum of drought resistant species at Ratta Kulachi

Location:	PFI, Field Station Ratta Kulachi, D.I.Khan
Year of commencement:	2016
Principal Investigator:	Dr. Nowsherwan Zarif (Central Silviculturist)
Co-Principal Investigators:	Basheer Ahmad, Research Officer (Farm Forestry)
	Salman Ahmad, Research Officer (Farm Forestry)
	Saif Ullah Khan, Research Officer (Farm Forestry)
	Mr. Qayyum Khattak, FR (Silva)

Arid and semi-arid land reforestation is urgently needed to address the sociological, environmental, and socioeconomic demands of rural residents. Drought-resistant species are useful because of the harsh climate, which includes little, and irregular rainfall as well as high temperatures. The establishment of an arboretum of drought-resistant plants serves as a demonstration and seed source for the future replenishment requirements of the drought-resistant species.

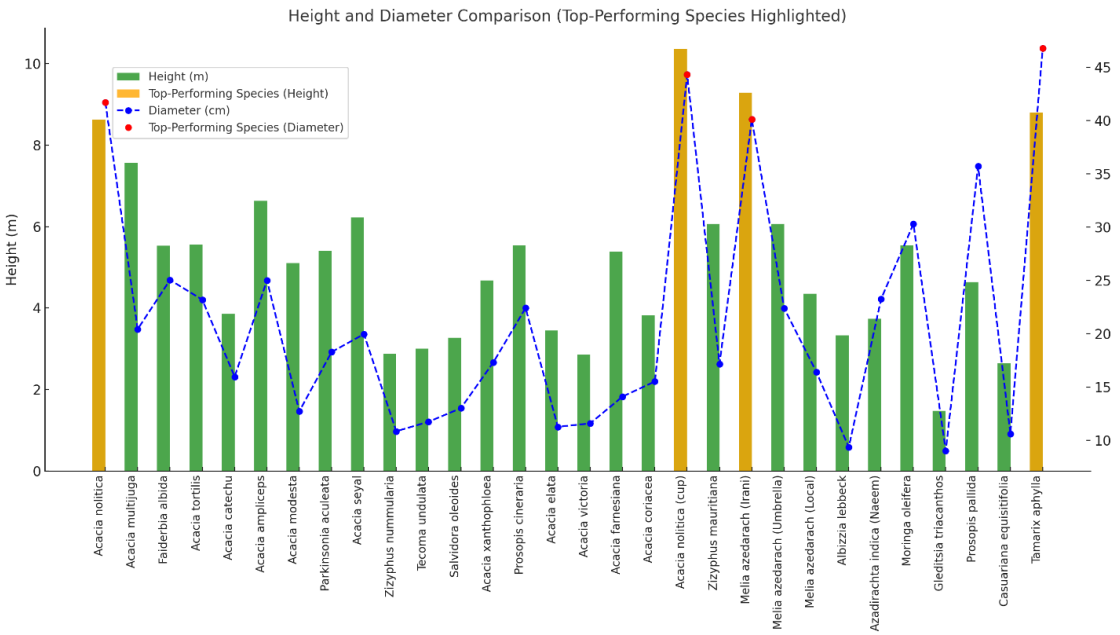


Figure. 9: Height and diameter of each species in the arboretum of drought-resistant tree species.

Top performing species, such as *Acacia nilotica* (8.62m, 41.69cm), *Acacia nilotica* (cup) (10.36m, 44. 31cm), *Melia azedarach* (Irani) (9.29m, 40.09cm), and *Tamarix aphylla* (8.80m, 46.80cm), are marked with orange bars and red dots. These species meet or exceed the height threshold of 8 meters and the diameter threshold of 30 cm, showcasing exceptional growth characteristics suitable for forestry or plantation projects.

1.1.9.2 Maintenance of Nursery

Maintenance of a Bed and Tube Nursery is a regular activity of the Silviculture Branch where thousands of plants are raised from quality seed. These plants are used in different research trials of PFI and also provided to local farmers, educational institutions, NGOs and forest department on subsidized rates. The objective is to promote tree plantation culture in the society and propagate rare and endangered plant species of high quality in the country. The nursery also serves as a learning site for PFI students where they are practically involved in tube filling, punching, sowing, root pruning, shifting and other nursery activities.

40,000 tube plants and 10,000 Poplar cuttings were raised under the project titled" Improving the efficiency of forest management through the development of volume table, Yield tables and growth models for the coniferous forest of Khyber Pakhtunkhwa".

1.2 FOREST MENSURATION

1.2.1 Collection of data for updating Volume tables of Coniferous Species

Location:	Malakand and Hazara Forest Regions
Year of commencement:	2023
Source of Funding:	ADP Project “Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa”
Principal Investigator:	Dr. Anwar Ali , Director Forestry Research Division
Co-Principal Investigators:	Sajid Ali, Assistant Silviculturist (Mensuration) Basheer Ahmad, Research Officer (Farm Forestry)

Saifullah, Research Officer (Farm Forestry)
Faizan Ahmad, Research Officer (Watershed)

Pakistan Forest Institute has prepared volume Tables in 1970s, however, it has been reported by the KP Forest Department that some of the available volume tables either over-estimate or under estimate the actual volume of the standing trees especially for coniferous species in some areas. This variation may be due to changes in growth pattern of trees due to climate change and other biotic and abiotic factors. It is, therefore, essential to examine the out turns of timber and small wood from these tables and revise and update these tables where variations are significant.

So, data was collected for updating and revision of volume tables of Chirpine, Kail, Deodar and Fir/Spruce under the project titled “Improving the Efficiency of Forest Management through Development of Volume Tables, Yield Tables, and Growth Models for Coniferous Forests of Khyber Pakhtunkhwa”.

Table.1: Sites for data collection for revision of volume tables

S. No.	Species	Forest Division
1	*Pinus roxburghii*	Abbottabad, Agror & Tanawal, Battagram, Dir Lower, Haripur, Siran, Swat,
2	*Cedrus deodara*	Kaghan, Kalam, Kohistan
3	*Pinus wallichiana*	Battagram, Kaghan, Kalam,
4	*Abies pindrow & Picea smithiana*	Battagram, Kaghan, Kalam, Kohistan,

The revised Volume Tables of chir pine are given below.

1.2.1.1 Revised Volume Table for Chir Pine of Buner

Volume: Over bark

Dia (inch)	Height (ft)	Timber (cft)	Small Wood (cft)	Total Vol (cft)
4	10	0	1	1
5	12	0	1	2
6	21	0	2	3
7	28	0	4	4
8	35	3	3	6
9	41	6	3	9
10	46	9	2	12
11	50	13	2	15
12	55	17	2	19
13	59	21	2	23
14	62	26	2	28
15	66	31	3	33
16	69	36	3	39
17	72	41	4	46
18	75	47	5	52
19	77	53	7	60
20	80	60	8	68
21	82	67	10	76
22	84	74	11	85
23	87	81	13	95
24	89	89	16	105
25	91	98	18	116
26	93	106	21	127
27	94	115	23	139
28	96	125	26	151
29	98	135	29	164
30	100	145	33	178

31	101	155	36	192
32	103	166	40	206
33	104	178	44	222
34	106	190	48	238
35	107	202	52	254
36	108	215	57	271
37	110	228	62	289
38	111	241	67	308
39	112	255	72	327
40	114	269	77	346

Derived from Equations

Height (m) = 14.9451n(D) - 34.174

Timber (m^3) = $-0.42398+0.02162*D+0.000017*D^2*H$

Total Volume (m^3) = $EXP(-9.31377+0.63482*LN(H)+2.02949*LN(D))$

Small Wood (m^3) = Total Volume — Timber

Where:

D is Diameter at Breast Height in cm

H is tree height in meters

LN is natural log

For conversion from metric units to British units:

1 m = 3.28 feet 1 (m^3) = 35.314 cft

1 inch = 2.54 cm

1.2.1.2 Revised Volume Table of Chirpine for Abbottabad

Volume: Over bark

Dia (inch)	Height (ft)	Timber (cft)	Small Wood (cft)	Total Vol (cft)
4	25	0	1	1
5	31	0	2	2
6	35	0	4	4
7	38	1	4	5
8	42	4	3	8
9	45	7	3	10
10	49	11	2	13
11	51	14	2	16
12	54	18	2	20
13	57	23	2	25
14	58	26	2	28
15	60	32	3	34
16	62	35	3	38
17	63	41	4	45
18	64	45	5	50
19	65	51	6	57
20	65	55	7	62
21	66	61	9	70
22	66	66	10	76
23	66	72	12	84
24	65	76	13	89
25	65	82	16	98

26	64	88	18	106
27	63	92	19	112

Derived from Equations

Height (m) = $-0.003*D^2+0.6499*D-1.1861$

Timber (m^3) = $-0.42398+0.02162*D+0.000017*D^2*H$

Total Volume (m^3) = $EXP(-9.31377+0.63482*LN(H)+2.02949*LN(D))$

Small Wood (m^3) = Total Volume — Timber

D is Diameter at Breast Height in cm

H is tree height in meters

LN is natural log

For conversion from metric units to British units:

1 m = 3.28 feet 1 (m^3) = 35.314 cft

1 inch = 2.54 cm

1.2.1.3 Revised Volume Table of Chirpine for Agror Tanawal

Volume: Over bark

Dia (inch)	Height (ft)	Timber (cft)	Small Wood (cft)	Total Vol (cft)
2	12	0	0	0
3	16	0	1	1
4	22	0	1	1
5	26	0	2	2
6	32	0	4	4
7	36	0	5	5
8	41	4	3	8
9	44	7	3	10
10	49	11	2	13
11	52	14	2	16
12	57	19	2	21
13	61	24	2	26
14	64	28	3	30
15	67	34	3	37
16	70	38	4	42
17	73	45	5	50
18	75	49	6	55
19	78	57	7	64
20	80	62	9	71
21	83	71	11	81
22	85	76	12	89
23	87	85	15	100

24	88	92	16	108
25	90	101	19	121
26	92	112	23	134
27	93	119	25	143
28	94	129	28	158
29	95	136	31	167
30	96	148	35	182
31	96	155	38	193
32	96	166	42	209
33	97	174	45	219
34	97	185	50	236
35	97	193	54	247
36	96	204	59	263
37	96	212	62	274

Derived from Equations

Height (m) = $-0.004*D^2+0.6901*D-0.2909$

Timber (m^3) = $-0.42398+0.02162*D+0.000017*D^2*H$

Total Volume (m^3) = $EXP(-9.31377+0.63482*LN(H)+2.02949*LN(D))$

Small Wood (m^3) = Total Volume — Timber

Where:

D is Diameter at Breast Height in cm

H is tree height in meters

LN is natural log

For conversion from metric units to British units:

1 m = 3.28 feet 1 (m^3) = 35.314 cft

1 inch = 2.54 cm

1.2.1.4 Revised Volume Table of Chirpine for Siran

Volume: Over bark

Dia (inch)	Height (ft)	Timber (cft)	Small Wood (cft)	Total Vol (cft)
2	9	0	0	0
3	13	0	0	0
4	18	0	1	1
5	22	0	2	2
6	28	0	3	3
7	31	0	5	5
8	37	4	3	7
9	40	6	3	9
10	45	10	2	12
11	48	13	2	15
12	53	18	2	20
13	57	23	2	25
14	60	27	2	29
15	64	33	3	36
16	67	37	4	41
17	71	44	5	48
18	73	49	6	54
19	77	56	7	64
20	79	62	9	70
21	83	70	11	81

22	85	76	12	89
23	88	86	15	101
24	90	93	17	109
25	92	103	20	123
26	95	114	23	137
27	96	122	25	147
28	99	134	29	162
29	100	142	32	173
30	102	154	36	190
31	103	163	39	202
32	105	177	43	220
33	106	186	46	232
34	107	200	52	251
35	108	209	55	264
36	109	224	61	285
37	110	234	64	298
38	110	249	70	319
39	111	264	77	341
40	111	275	81	355
41	111	290	88	378
42	112	300	92	393
43	112	316	99	415
44	111	326	104	430
45	111	342	112	453
46	111	352	117	469

47	110	367	125	492
48	110	377	130	507
49	109	392	138	530
50	108	401	144	545
51	107	415	152	567
52	106	428	161	589
53	105	437	167	604

Derived from Equations

Height (m) = $-0.003*D^2+0.6499*D-1.1861$

Timber (m^3) = $-0.42398+0.02162*D+0.000017*D^2*H$

Total Volume (m^3) = $EXP(-9.31377+0.63482*LN(H)+2.02949*LN(D))$

Small Wood (m^3) = Total Volume — Timber

Where:

D is Diameter at Breast Height in cm

H is tree height in meters

LN is natural log

For conversion from metric units to British units:

1 m = 3.28 feet 1 (m^3) = 35.314 cft

1 inch = 2.54 cm

1.2.2 Collection of data for development of Volume tables of Selected Broad-Leaved Species

Location:	Malakand and Hazara Forest Regions
Year of commencement:	2023
Source of Funding:	ADP Project “Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa”
Principal Investigator:	Dr. Anwar Ali , Director Forestry Research Division
Co-Principal Investigators:	Sajid Ali, Assistant Silviculturist (Mensuration) Basheer Ahmad, Research Officer (Farm Forestry) Saifullah, Research Officer (Farm Forestry) Faizan Ahmad, Research Officer (Watershed)

Broad-leaved tree species in Khyber Pakhtunkhwa play a vital role in the region’s ecology and economy, yet their volume tables are not available. To address this gap, surveys were conducted for the first time to collect data for developing volume tables for key species such as *Alnus nitida, Diospyros lotus, Quercus* spp., and *Taxus baccata.* This fieldwork encompassed extensive measurements and analysis, forming a foundation for improving forest resource assessments and sustainable management."

Table.2: Broad-leaved species and data collection sites

S. No.	Forest Division	Species
1	Dir (Lower)	*Alnus nitida, Diospyros lotus, Quercus spp.*
2	Swat	*Taxus baccata, Quercus dilatata, Quercus ilex,*
3	Battagram	*Alnus nitida, Diospyros lotus, Quercus spp.*

1.2.3 Collection of data for development of yield table of Deodar, Fir, Spruce and Mixed coniferous.

Location:	Malakand and Hazara Division, KPK
Year of commencement:	May, 2023
Source of Funding:	ADP Project "Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa"
Principal Investigator:	Dr. Anwar Ali , Director Forestry Research Division
Co-Principal Investigators:	Sajid Ali, Assistant Silviculturist (Mensuration) Basheer Ahmad, Research Officer (Farm Forestry) Saifullah, Research Officer (Farm Forestry) Faizan Ahmad, Research Officer (Watershed)

Yield Tables are only available for Kail and Chirpine prepared by PFI in 1990 and 1992. However, no yield table is available for deodar which is the most valuable timber species of KP and national tree of Pakistan. The Working Plans for Deodar Forests prepared by KP Forest Department are based on Yield Table of 1940 prepared for Temperate Forests of India. Similarly, no yield tables are available for fir and spruce which are important species of temperate forests of KP. There is also a limitation of the existing yield table of kail which is meant for even-aged and pure forests of Kail, whereas currently most of the kail forests are mixed and uneven aged

that requires different yield tables. The project will develop yield tables for deodar, fir/spruce and mixed coniferous forests.

The sample plots were established across various forest divisions to analyze yield and develop yield tables for major tree species under the project titled “Improving the Efficiency of Forest Management through Development of Volume Tables, Yield Tables, and Growth Models for Coniferous Forests of Khyber Pakhtunkhwa”. The selected sites included Kalam, Kaghan, Battagram, and Kohistan, where plots were laid for Deodar, Fir/Spruce, and mixed coniferous forests. This effort aims to provide accurate data for sustainable forest management and resource planning.

Table.3: Species, number and sites of sample plot for yield analysis.

S.No.	Forest division	Deodar	Fir/Spruce	Mixed Coniferous stands	Total
1	Kalam	20	7	1	28
2	Kaghan	20	20	20	60
3	Battagram	---	20	19	39
4	Kohistan	25	31	26	82
Total		65	78	66	209

1.2.4 Standardization of forest inventory techniques

Location: Shinkiari, Mansehra

Year of commencement: 2023

Source of Funding: ADP Project “Improving the efficiency of Forest Management through the development of Volume tables, yield tables and growth models for coniferous forest of Khyber Pakhtunkhwa”

Principal Investigator: Dr. Anwar Ali , Director Forestry Research Division

Co-Principal Investigators: Sajid Ali, Assistant Silviculturist (Mensuration)
Basheer Ahmad, Research Officer (Farm Forestry)
Saifullah, Research Officer (Farm Forestry)
Faizan Ahmad, Research Officer (Watershed)

The forest management plans are prepared on the basis of data collected through forest inventory in the field. Currently Khyber Pakhtunkhwa Forest Department uses different techniques in different areas such as relaskope sampling,

prism sampling and fixed area sampling without knowing the sampling errors of these techniques. It is essential to select proper bands of prism and relaskope for measurement of sample trees. Standardization of forest inventory techniques involves the development of standardized sampling design, measurement methods, and data analysis procedures. The sampling design specifies the sampling unit, plot size, and sampling intensity, while the measurement methods specify the type of measurements to be taken and the instruments to be used.

The data analysis procedures involve statistical methods for estimating forest parameter and assessing the precision and accuracy of the estimates obtained through different forest inventory techniques. It is essential for several reasons. Firstly, it ensures that data collected from different surveys are comparable, enabling reliable estimates of forest resources and changes over time. Secondly, it facilitates international cooperation in forest management, conservation, and planning by providing a common framework for data collection and analysis. Finally, it promotes transparency and accountability in forest management by providing a standard set of procedures that can be audited and verified.

1.2.4.1 Analysis of the full enumeration of compartment-8.

The team had collected data of approximately 50 thousand trees in Masar forest compartment-8 and that data was processed and analyzed to get cubic meter volume per hectare as a standard for comparison which is shown in the table below.

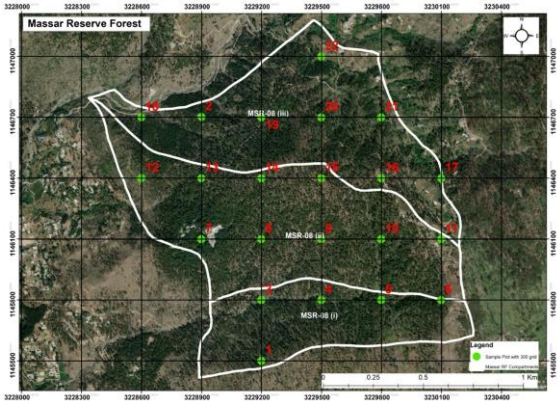
Table.4: Details of Masar compartment-8.

Dia. Class (cm)	Number of trees	Tree average Height (m)	Vol/Ha
6 -15	15219	6.56	Volume = Total Volume Total Area=204.74 m^3/ha
16 – 25	11957	9.11	
26 -35	4826	12.85	
36 – 45	5915	23.12	
46 -55	5856	26.01	
56 – 65	3216	27.78	
66 – 75	1102	28.62	
76 – 85	337	29.47	

86 – 95	96	34.15	
96 – 105	22	30.4	
106 – 115	16	31.5	
Number of Total Trees: 48562			Total Area:200 Ha

1.2.4.2 Analysis of Partial Enumeration and Sample Plots

According to GIS grids300 map, 21 sample plots were considered for data collection and each sample plot data was taken by following three different methods



1.2.4.2.1. Fixed Area Method

In fixed area method, hypsometer along with transponder was used for data collection, and the plot was fully enumerated for basal area and height.

1.2.4.2.2. Prism Method

Prisms of different basal area factors (M2, M4, M6, and M10) were centered number by number and data of “In-Trees” were taken separately for each prism, height of those trees was taken by hypsometer.

1.2.4.2.3. Relaskope Method

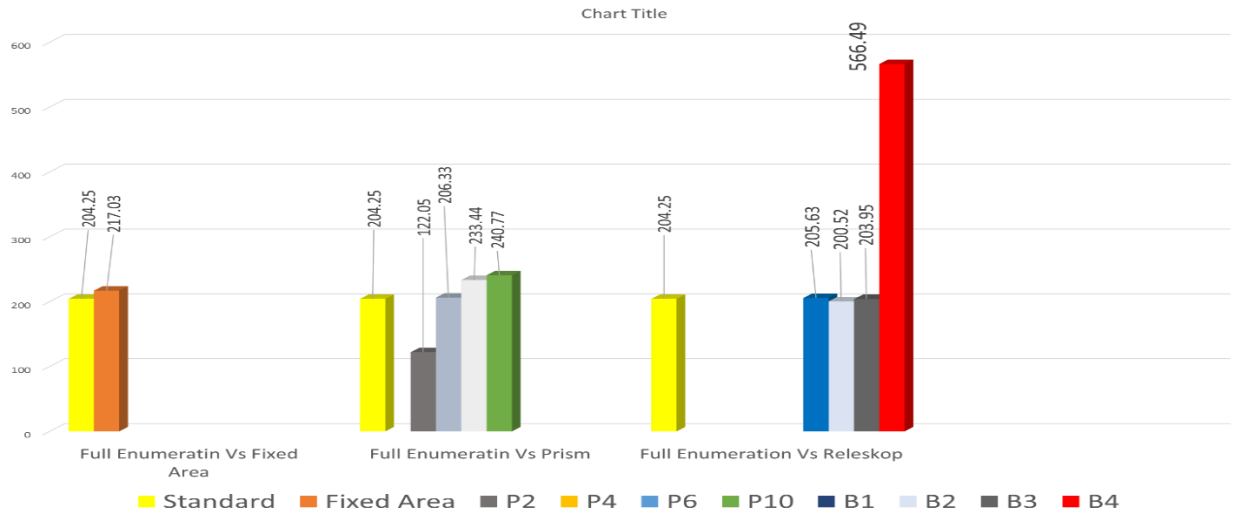
GPS was used for finding sample plot location on ground and “IN-trees” data were collected by using all four bands (Band-1,Band-2,Band-3,Band-4) of Relaskope separately while trees height were taken by hypsometer.

1.2.5 Data Analysis

The preliminary results obtained through different method shows that full enumeration and fixed area method have no significant difference statistically, there is great precision of relaskope Band-1, Band-2, Band-3 to one another, and statistically shows no significant difference to the standard, while prism M4 have great precision to the result obtained from full enumeration.

Table.5: Average volume per hectare obtained from different methods.

Method used		Volume(m^3)/Hectare
Full Enumeration		204.25
Partial Enumeration		
Fixed Area		217.03
Relaskope	Band 1	205.63
	Band 2	200.52
	Band 3	203.95
	Band 4	566.49
Prism	M 2	122.05
	M 4	206.33
	M 6	233.44
	M 10	240.77



1.3 Watershed Management Branch

1.3.1 Compilation of meteorological data recorded at watershed observatory Pakistan Forest Institute, Peshawar

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	July 2023- June 2024
Principal Investigator:	Bilal Ahmad, Watershed Management Specialist
	Asim Kareem, Forest Ranger
	Muhammad Kabeer, Forester

Daily recording of meteorological data, including maximum and minimum temperatures, daily temperature variations, relative humidity, evaporation, sunshine duration, and rainfall, was conducted at the PFI observatory from July 2023 to June 2024. The data was systematically compiled and analyzed over the same period.

3.1 Summary of meteorological data 2023-24

Months	Maximum Temperature (C^O)	Minimum Temperature (C^O)	Daily Temperature (C^O)	Relative Humidity (%)	Evaporation (mm)	Sun-shine (Hrs.)	Rainfall (mm)
July	38.84	25.42	28.68	65.78	56.48	2.4	20
August	38.27	26.38	28.11	67.11	78.37	6.73	00
September	39	25.10	28.73	72.52	61.9	2.8	15.5
October	30.90	16.13	19.90	67.54	31.4	4.89	00
November	26.23	13.80	17.61	62.61	35.89	4.52	5
December	21.6	7	10.3	64.1	75.17	4.88	0.5
January	15.82	1.73	5.30	78.34	46.83	4.31	9.5
February	18.31	6.68	9.52	66.73	55.98	6.56	19
March	26.52	12.38	15.61	62.90	63.53	5.77	17.3
April	30.44	14.66	22.61	62	68.95	6.15	23.46
May	39.38	20.42	30.66	60.04	58.35	8.73	00
June	41.6	23.06	32.73	53.26	62.21	7.33	0.5
Average for the whole year	**30.58**	**16.06**	**20.81**	**65.24**	**57.92**	**5.42**	**9.23**

1.4 GIS BRANCH

1.4.1 Mapping, Digitization, value addition and marketing of NTFP in collaboration with NTFP Directorate Forest Department

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2019
Principal Investigator:	Aamir Shakeel (GIS Specialist)
Co-Principal Investigator	Tahir Iqbal (Technical Assistant)
	Ziad Raza (Technical Assistant)

Activities

Revised PC-1 has already been submitted to the Government with new objectives and scope of the project. Meanwhile work is in progress on Field Data Compilation and Uploading to website under the project “Mapping Digitization, Value Addition and marketing of NTFP in Collaboration with NTFP Directorate Forest Department”

1.4.2 Mobile App-Based bamboo resource assessment in Punjab, Pakistan

Location:	Pakistan Forest Institute, Peshawar
Year of commencement:	2023
Principal Investigator:	Aamir Shakeel (GIS Specialist)
Co-Principal Investigator	Tahir Iqbal (Technical Assistant)
	Ziad Raza (Technical Assistant)

Activities

District wise Mapping of Bamboo Plantation in different Districts of Punjab under the Study” *Mobile App-Based Bamboo Resource Assessment in Punjab, Pakistan”.*

1.4.3 Deployment of Google workspace for PFI under MoU signed with M/s Tech Valley, Pakistan under Google for education programme.

- Official Domain (www.pfi.edu.pk) acquisition for PFI from Google Tech Valley.
- Created official email addresses of all PFI Officers under official domain www.pfi.edu.pk.

1.4.4 Installation of high-speed internet facility in main campus of Pakistan Forest Institute

Technical and official support was provided by the GIS branch to install the high-speed internet facility into the main Campus building of PFI.

Publication of research and review papers in academic journals:

- The Western Himalayan Fir tree ring record of soil Moisture in Pakistan Since, 1855 (Published)
- Farmer’s attitude towards agroforestry in Tehsil Razzar, Swabi, Khyber Pakhtunkhwa. (Published)

- Socio-economic Impacts of Billion Tree Afforestation Project in District Buner, Khyber Pakhtunkhwa, Pakistan. (Published)
- Impact of Agroforestry on the livelihoods of Farmers in District Bannu, Khyber Pakhtunkhwa. (Published)
- The impacts of Agroforestry Practices on Farmers in Tehsil Thana, District Malakand, Khyber Pakhtunkhwa. (Published)
- Survival Rate, Regeneration Status and Growth Performance of plantations raised under Billion Trees Afforestation Project in District Karak (Published) "Trend Analysis of Climate Variables in Urban Microclimate of Peshawar District" (Published).
- "Causes of Deforestation in Gilgit-Baltistan" (Published)
- "Applying a Random Encounter Model to Estimate the Asiatic Black Bear (*Ursus thibetanus*) Density from Camera Traps in the Hindu Raj Mountains, Pakistan'' (Published)
- Leopard Intrusion into human settlements (A study of Conflict in Margalla hills National Park) (Published)
- "Assessing Asiatic black bear (*Ursus thibetanus*) temporal overlap and co-occurrence with sympatric species in the temperate zone of the Hindu Raj Mountain range" (Published).
- "Application of species distribution models to estimate and manage the Asiatic black bear (*Ursus thibetanus*) habitat" (Published)
- "Phyto-sociology of subtropical Chir pine forest of Matta Forest subdivision" (Published)
- Land Use Land Cover Change Detection of District Lahore Using GIS and Remote Sensing (1993-2023)" (Published).
- Impacts of Agroforestry systems in Pakistan- A Review (Published).
- "Trend Analysis of Climate Variables in Urban Microclimate of Peshawar District" (Published).
- "Applying a Random Encounter Model to Estimate the Asiatic Black Bear (*Ursus thibetanus*) Density from Camera Traps in the Hindu Raj Mountains, Pakistan'' (Published).
- "Phyto-sociology analysis of moist temperate forest in Shahpur, district Shangla" (Published).
- "Species Richness and Diversity in sub- tropical Chir pine Forest in Abbottabad city" (Published)

- “Agroforestry; Available alternative for social and economic sustainability” (in process).
- A review paper on “Dry land afforestation in Pakistan” (Published).
- A review article on “Significance of cultivating genus Paulownia and its utilization in different sectors” (Published).
- A review article on “Potential of Poplar (*Populus deltoides*) based agroforestry for economic benefits and climate change mitigation” (Published).
- Ecological-Economic Assessment of Forest Land degradation neutrality in the Indus River Basin of Pakistan. (Published)
- Effects of Low light, inter-specific competition and their combination on flavonoid exudation patterns and rhizo-sphere fungal community in *Juglans mandshurica* and *Fraxinus mandshurica* roots. (Published)

2. FOREST PRODUCTS RESEARCH DIVISION

2.1 LOGGING

2.1.1 Wood Anatomy Lab:

2.1.1.1 A study on comparative wood anatomy of Shisham (*Dalbergia sissoo*) growing under climate conditions of District Nowshera

Year of commencement:	2023-24
Principal Investigator:	Dr. Tanvir Hussain, Logging Officer
Co-Principal Investigator	Said Akhtar, Assistant Wood Technologist

Background

Dalbergia sissoo, commonly known as Shisham is a high valued timber species in view of its durability, strength, and resistance to termites. The wood is preferred for making of furniture, flooring, and other wood products. However, the growth, health, and quality of *Dalbergia sissoo* wood are significantly influenced by climatic conditions**.** *Dalbergia sissoo* flourishes in tropical to subtropical climates, with optimal growth occurring at temperatures ranging from 10°C to 40°C. Extremely high temperatures, especially those exceeding 45°C, can stress the trees, leading to reduced growth rates and potentially affecting wood quality. Conversely, low temperatures and frost can damage young seedlings and impede their development**.**

District Nowshera experiences a semi-arid climate with distinct seasonal variations in temperature and precipitation, influencing the growth patterns and wood structure of *Dalbergia sissoo*. Similarly, the soil type and nutrient availability in Nowshera also affect the wood anatomy, particularly the size and distribution of vessels and the thickness of fibres.

Keeping in view the above information, the present study was conducted to compare the growth and wood anatomical characteristics of Shisham growing under different climatic condition of Distract Nowshera, Khyber Pakhtunkhwa.

Methodology

Wood samples in the form of logs were collected from different locations of Nowshera District i.e. from Taru Jabba (TJ), Azakhil Payan (AK), and Jahangira (JAN) and brought to Pakistan Forest Institute, Peshawar for research work at Wood Anatomy Lab. of Forest Products Research Division. Discs of about two inches in thickness were cut and standard blocks of 1x1x2 cm were prepared from each log. Permanent slides of cross, radial and tangential sections of all the wood samples were prepared by standard laboratory procedures and observed under microscope for various structural features. To measure the fiber length, a small portion of wood from each sample was macerated in Schulze's mixture (20% Nitric acid and Potassium chlorate) to separate the fibers. Data were collected for the frequency and dimensional measurements of different wood elements/ structures in each wood sample by the process of micrometry and analyzed for statistical variables for each feature in each sample.

Results and Discussion

a) Growth rate comparison of Shisham

The growth rate of a tree refers to how quickly it increases in size i.e. height, diameter or volume. This rate can significantly impact the tree's physical properties and the characteristics of its wood. Factors such as climate, soil quality, water availability, and genetic factors influence the growth rate, and these, in turn, affect the wood's characteristics. Trees that grow quickly typically produce wood with lower density. Fast growth results in wider growth rings and larger cells, which increases the spacing between fibers, reducing the compactness of the wood. Figure 1 shows the comparison of *Dalbergia sissoo* growth rate growing under different location of district Nowshera. It is obvious from the figure that growth rate of *Dalbergia sissoo* at TJ occupied the highest value (3.277) followed by JAN (3.062) while the lowest of growth rate was observed in AK (2.81).

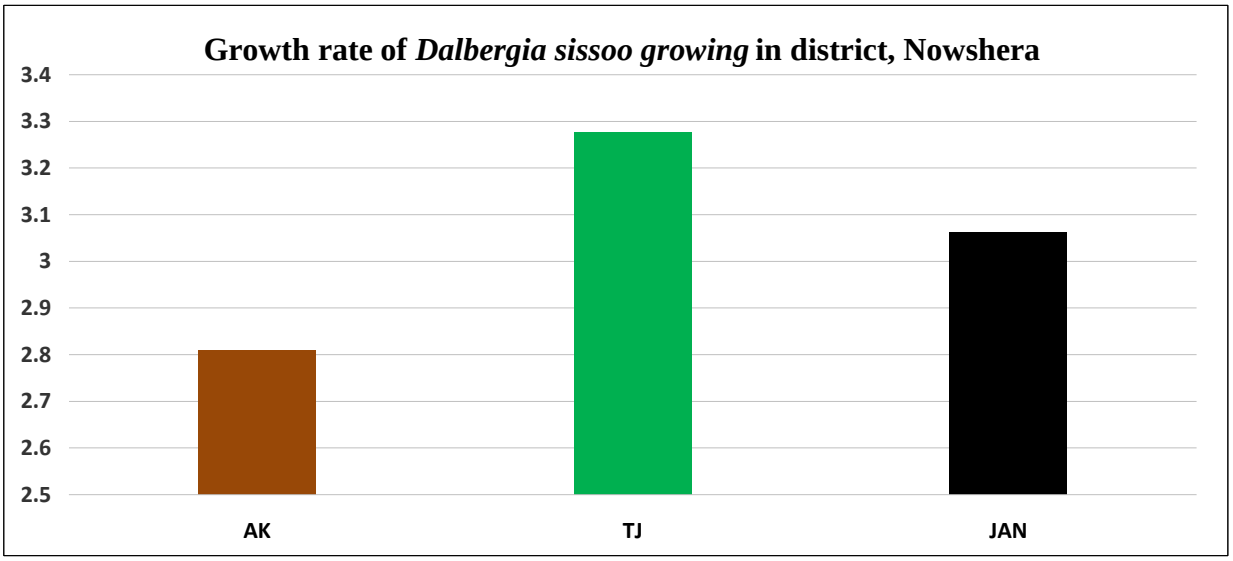


Figure 10: Comparison of Growth rate of *Dalbergia sissoo* growing in district Nowshera

b) Anatomical Features Comparison of Shisham

The fiber length and diameter of wood plays a critical role in determining its physical and mechanical properties, especially for applications like paper production, composite materials, and structural uses. Longer fibers tend to enhance tensile strength and toughness. They provide better interlocking and resistance to mechanical stress. Similarly, fiber wall thickness is a key indicator of the wood's suitability for specific applications. Thicker cell walls increase the density of wood. This results in heavier wood with greater strength and durability, suitable for structural applications. The fiber morphological characteristics i.e. fiber length and fiber wall-thickness revealed that shisham wood growing in the climatic conditions of AK (0.70mm; 3.51µ) is better in position than others (table 1). However, TJ scored the highest value of fiber diameter (21.52) (table 1). The Runkel ratio of wood fibers is a key parameter used to evaluate the suitability of wood for certain applications, particularly in pulp and paper production. Low Runkel ration (<1) indicates thick fiber walls relative to the lumen diameter, fibers are less collapsible and stiffer and suitable for packaging materials, such as kraft paper, which require higher bulk and tear resistance. In this regard JAN scored the highest Runkel ratio value i.e. 0.56 (table 1).The features of vessels, is a key determinant of a wood's porosity, strength, stability, and usability. It helps in selecting the appropriate wood species for specific applications, balancing factors like strength, workability, and resistance to environmental stresses. Higher vessel frequency results in greater porosity, which often corresponds to lower wood density. Such wood tends to be lighter and easier to

work with but less durable and strong. Longer vessels allow for more efficient water transport because water travels through fewer pit membranes between vessel elements. This is advantageous for fast-growing trees in moist environments. Similarly vessel's diameter allows for more efficient water transport because they can move larger volumes of water. Regarding the seasoning as well as preservation behavior of the wood, it was assessed that there is no prominent difference among anatomical features such as Frequency of vessels (No of vessels/mm^2), Vessel Length (µ), Vessel diameter (µm) in three woods (table 1). As far as durability characteristic is concerned, it was found that Shisham wood growing in Taru Jabba and Jahangira are in better position than the shisham wood growing in Azakhil Payan regarding the anatomical features of ray parenchyma (table 1).

Conclusion

From this comparative wood anatomical study of *Dalbergia sissoo*, it was concluded that both edaphic and climatic conditions of District Nowshera are favourable for the growth of this species but with a bit variation. The anatomical features of this wood growing in these regions represented ideal for sawing, planning, sanding, finishing and other wood working properties. The durability of this species growing in these regions also expected satisfactory against the wood deteriorating agents. As regarding the seasoning behaviour of this wood among the three regions, Jehangira scored the maximum values and as for as pulping properties of wood is concerned, Shisham wood growing at Taru Jabba found better in position. It is recommended that to get more in-depth picture of variation in wood properties of Shisham growing in three regions of Districts Nowshera, determination of physico-mechanical and pulping propertied are recommended.

Table 1: Statistical Summary of Anatomical Features of Shisham Wood Growing in Districts Nowshera

Anatomical Parameters	Units	Azakhil Payan			Taru Jaba			Jahangira		
		Average value	Standard deviation (±)	Co-efficient of variation (%)	Average value	Standard deviation (±)	Co-efficient of variation (%)	Average value	Standard deviation (±)	Co-efficient of variation (%)
Fiber Length	(mm)	0.70	0.18	0.25	0.69	0.14	0.21	0.66	0.12	0.18
Fiber diameter	(µ)	19.36	4.63	0.23	21.52	3.17	0.14	20.96	4.61	0.22
Fiber wall thickness	(µ)	3.51	1.66	0.3	3.03	0.55	0.18	2.91	0.54	0.18
Runkel ratio	-	0.47	-	-	0.39	-	-	0.56	-	-
Frequency of vessels	No of vessels/mm²	399.76	51.11	0.12	401.22	49.08	0.12	408	29.96	0.07
Vessel Length	(µ)	92.43	17.15	0.18	90.59	21.72	0.23	82.11	17.70	0.21
Vessel diameter	(µ)	134.18	20.17	0.15	109.36	22.82	0.28	105.15	21.47	0.20
Rays' frequency	No of rays/mm²	94.96	1.25	6.80	88.78	6.02	0.06	83.8	5.67	0.06
Diameter of ray	(µ)	2.32	0.61	7.77	2.26	0.62	0.27	30.29	3.67	0.12
Height of ray	(µ)	8.52	1.25	6.80	7.5	1.45	0.19	89.90	9.00	0.10

2.1.2 Development of Tree Rings Chronology of Juniper *(Juniperus excelsa)* growing in Gilgit-Baltistan

Year of commencement:	2023-24
Principal Investigator:	Dr. Tanvir Hussain, Logging Officer
Co-Principal Investigator	Dr. Zahid Rauf, Director Forest Products Research Division

Introduction

The study of tree rings (dendrochronology) has significantly advanced throughout the globe over the past few decades. Due to these developments, a large number of tree species that are appropriate for dendrochronology have been identified based on the presence of annual tree rings. In temperate and high latitude regions, winter cambial dormancy caused by lower temperatures typically promotes the creation of clearly defined tree-ring borders, but this is not the case in much of the tropics where similar temperatures typically predominate throughout the year. On the other hand, unfavorable environmental conditions at specific times of the year, typically more associated with the hydrological cycle (for example, wet/dry seasons), can result in cambial dormancy or a slowdown in development, leading to the establishment of yearly growth layers. The inter-annual variation of tree ring patterns is crucial in dendrochronology as it allows the identification of possible limiting factors on growth. Tree-ring width is a frequent indication of climate changes at the tree level because it incorporates the majority of physiological processes associated with resource acquisition and use. Because ring widths give a record of radial growth of trees during previous shocks, this is an effective indication of ecological resilience.

Junipers are called ancient trees with long evolutionary history. They are drought-tolerant and can survive in harsh environments. They are considered excellent subjects for dendrochronology in view of their distinct annual growth rings. Therefore, the present study has been designed with the objective to assess the potential of this species for dendroclimatic studies in these areas.

Methodology

For research work, 20-30 cores were extracted from the trees of study site. The core samples were air dried, mounted on wooden core holders and then sanded for smooth

surfacing. Each core was examined under the variable power microscope and their visual cross-matching among the cores were established. This procedure allows false or double and missing rings to be detected from ring-width series. Ten (10) cores were rejected at this stage. Cores showing good cross-matching were measured to the nearest 0.001mm using the most advance WinDendro System. The measurement series from each core was then cross-checked for possible dating errors using the software Cofecha. The cross dated series were then compiled into site chronology using the program dplR of R package. The age related growth effects were removed by single detrending using the Negative exponential Curve options in the program. For similar reason, the “Standard” chronologies from the output were selected for subsequent modeling. To find growth trend Mann-Kendle growth analysis was carried out using Minitab-18 software.

Results

Using computer-based quality control programs Cofecha and dplR from the R package, the site tree ring width (TRW) of *Juniperus excelsa* was generated. The chronology, which covered the years 1822 to 2023, was collected in the Gilgit Forest region of Gapa Valley, Nagar and Morkhun Valley, Hunza at an altitude of (8808 feet–13504 feet) and on slopes (25–62%) that faced north-west to north-east.

Table 1: Statistics of Quality control Program Cofecha for *Juniperus excelsa* from Gilgit-Baltistan, Pakistan.

PART 7: DESCRIPTIVE STATISTICS: 16:24 Sun 03 Se

						Corr	//-------- Unfiltered --------\\				//---- Filtered -----\\			
Seq	Series	Interval	No. Years	No. Segmt	No. Flags	with Master	Mean msmt	Max msmt	Std dev	Auto corr	Mean sens	Max value	Std dev	Auto corr	AR ()
1	GT4JAA	1914 2023	110	4	3	.379	8.08	16.00	2.638	.670	.152	3.08	.446	.022	1
2	GT7JAA	1887 2023	137	5	0	.542	5.85	10.10	1.652	.749	.143	2.62	.439	.044	1
3	GT9JAA	1918 2023	106	4	0	.544	6.23	10.10	1.525	.713	.118	2.51	.411	-.062	2
4	GT11JA	1822 2023	202	8	2	.619	6.80	14.79	3.447	.908	.203	2.75	.447	-.020	1
5	GT14JA	1954 2023	70	2	1	.424	9.22	14.00	2.269	.728	.134	2.71	.464	-.086	1
6	GT15JA	1943 2023	81	3	1	.429	9.26	17.20	2.972	.830	.142	2.72	.491	-.051	2
7	GT17JA	1981 2023	43	1	0	.340	11.59	16.00	1.903	.381	.133	2.58	.509	-.005	1
8	GT18JA	1822 2023	202	8	3	.620	6.58	16.20	3.508	.792	.223	2.83	.417	-.001	1
9	GT20JA	1969 2023	55	2	0	.588	9.99	15.08	1.695	.372	.141	2.69	.518	-.068	1
10	GT22JA	1947 2023	77	3	1	.507	9.07	14.40	2.202	.728	.134	2.74	.450	-.069	1
11	GT24JA	1854 2023	170	6	0	.386	5.56	10.18	1.730	.776	.152	2.46	.364	-.012	1
12	GT25JA	1950 2023	74	2	1	.356	6.43	10.80	2.160	.849	.141	2.72	.558	.035	1
13	GT26JA	1923 2023	101	4	0	.503	6.09	9.20	1.405	.790	.115	2.45	.381	.040	1
14	GT28JA	1930 2023	94	3	3	.256	6.01	10.90	2.102	.855	.147	2.65	.498	.003	1
15	MT1JAA	1900 2023	124	4	3	.142	6.13	13.98	2.669	.851	.220	2.69	.531	.014	1
16	MT4JAA	1962 2023	62	2	1	.350	8.42	13.90	1.454	.549	.125	2.70	.638	-.058	1
17	MT6JAA	1964 2023	60	2	1	.287	8.49	13.90	1.434	.598	.114	2.71	.591	-.107	1
18	MT8JAA	1960 2023	64	2	2	.148	7.65	15.08	1.900	.700	.144	2.65	.417	-.019	1
19	MT15JA	1929 2023	95	3	3	.157	6.37	15.00	2.427	.790	.198	2.72	.499	-.009	1
20	MT16JA	1938 2023	86	3	3	.193	6.96	15.00	1.868	.744	.134	2.58	.385	-.024	1
Total or mean:			2013	71	28	.417	7.09	17.20	2.305	.755	.160	3.08	.458	-.015	

The developed tree ring chronology of *Juniperus excelsa* demonstrated a sophisticated inter-series value of all cores with master chronology, and the total value also came within an acceptable range (0.417), according to statistical analysis of cofecha. The average width of all tree rings, which was 7.09, indicated that this species was growing moderately in the area. Regarding the sensitivity of the study site, the value of mean sensitivity (0.160) constituted an acceptable level for the regions of Pakistan and was also sufficient to study the relationship between climate and growth. The value of auto-correlations (0.755) indicated good range with regard to the earlier effects of climatic conditions on the growth of *Juniperus excelsa*. The growth pattern of this species showed significant variability at the magnitude of the standard deviation (2.30).

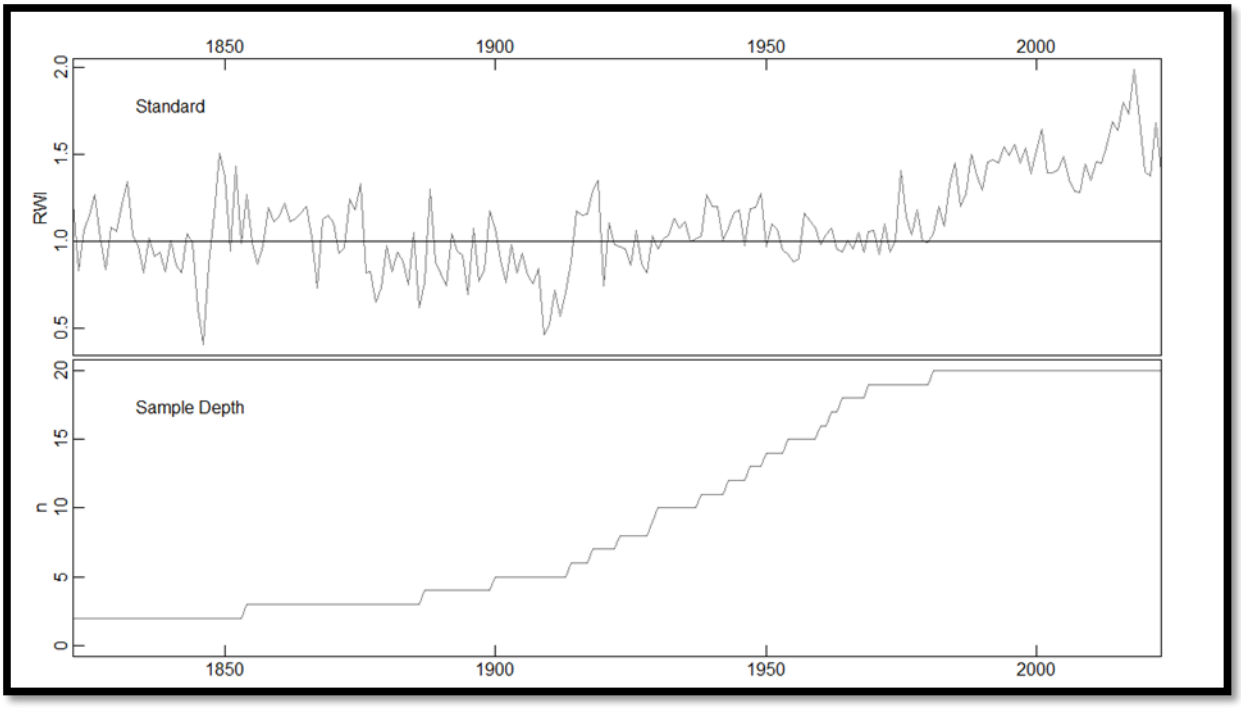


Figure 11: Tree Ring Width (Standard) chronology of *Juniperus excelsa* from Gilgit-Baltistan Forest Areas.

Figure 12 served as the pointer and event years. Event years show a noticeable rise or fall in growth, while pointer years showed a noticeable response to growth.

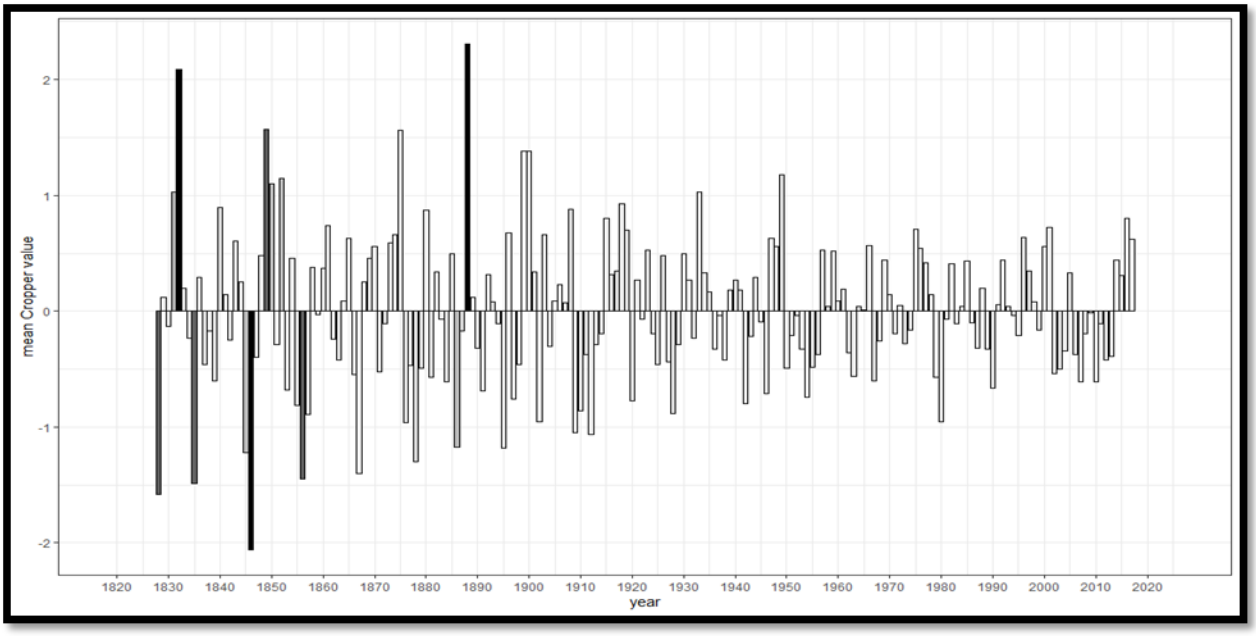


Figure 12: Positive and negative pointer years during growth period 1822-2023.

Figure 13 indicated event year classes of individual trees under extreme, strong, weak and non positive or negative events.

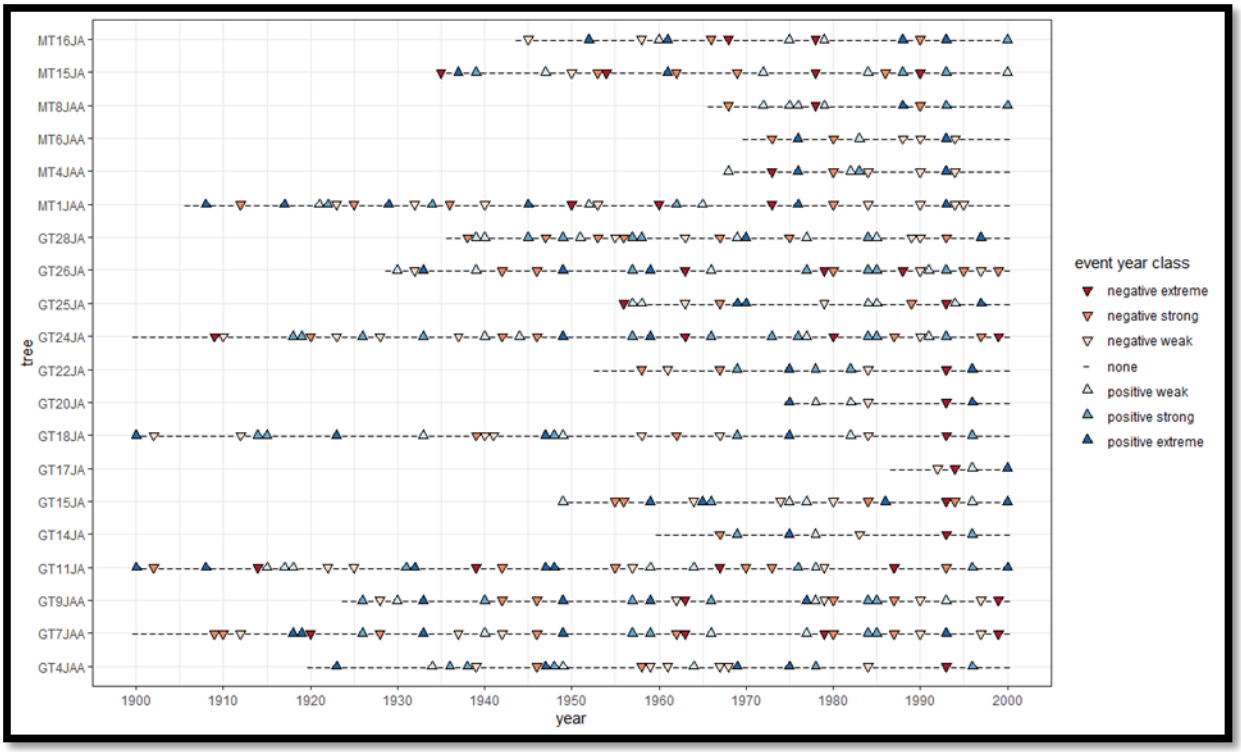


Figure 13: Event Year Classes of individual Tree sampled from Gilgit Forest Division.

Growth trend Analysis

Mann-Kendle test was used to determine the growth trend of *Juniperus excelsa* for the years 1822 to 2023. It was discovered that this species experienced upward growth during the study period (Table 2), indicating that the climatic change that had occurred in this location had favored its growth.

Table 2: Trend Analysis of Tree Growth of Juniper growing in Gilgit Forest Division (1822-2023)

Tree ring Feature	Z-value	p-value upward	p-value downward	Trend
TRW	4.906	0.000	1.000	UWT

TRW: Tree Ring width, UWT= Upward Trend

Conclusion

Based on the results of this study it was concluded that *Juniperus excelsa* growing under the dry temperate conditions of Gilgit Forest Division has great potential for dendroclimatic study for assessing the impact of climate change on the growth of this species. Further, growth trend analysis of this species showed an upward trend for the studied period.

2.2 WOOD SEASONING AND PRESERVATION

2.2.1 WOOD SEASONING AND PRESERVATION

2.2.1.1 Testing & Evaluation of Local & Imported Wood Species of Diverse Regions

Year of commencement: 2023-24

Principal Investigator: Mr. Mansoor Ali Khan, Assistant Wood Seasoning Officer

Background

Wood has been a primary construction and manufacturing material for centuries, valued for its versatility, aesthetic appeal, and natural abundance. With increasing global demand for wood-based products, there is a growing need to evaluate the mechanical, physical, and aesthetic properties of both local and imported wood species. Diverse regions, each with unique environmental and climatic conditions, produce wood with distinct characteristics. Understanding these variations is critical to optimizing wood selection for specific applications, such as furniture making, construction, or decorative uses.

S.No.	Wood property	Specimen size
1	Density	6 cm x 2 cm x 2 cm
2	MoR	30 cm x 2 cm x 2 cm
3	MoE	30 cm x 2 cm x 2 cm
4	Compression parallel to grain	6 cm x 2 cm x 2 cm

5	Compression perpendicular to grain	6 cm x 2 cm x 2 cm
6	Tensile	5 cm x 2 cm x 2 cm
7	Cleavage	5.5 cm x 2 cm x 2 cm

Local wood species often offer economic and ecological advantages due to reduced transportation costs and support for regional industries. However, the durability, strength, and workability of local wood may not always meet the desired standards for specialized applications. Conversely, imported wood species, while often meeting high-performance criteria, may face issues like sustainability concerns, higher costs, and environmental impact associated with long-distance transport.

A comprehensive comparison of local and imported wood is vital for developing sustainable practices in the wood industry. By testing and evaluating various wood species, this study aims to identify materials that balance performance, cost, and sustainability. Such research can help industries make informed choices, promote the use of locally available resources, and reduce dependency on imports. Furthermore, understanding the behaviour of different wood species under diverse environmental conditions can inform better utilization practices, improve product lifespan, and encourage innovation in material engineering.

This study, therefore, addresses the need to bridge the gap between traditional wood usage practices and the growing emphasis on sustainability, quality, and economic efficiency. By doing so, it aims to contribute to the advancement of both local and global wood industries.

Objectives

1. To evaluate physical and mechanical properties of different species of wood.
2. To recommend best practices for selection and use for wood based industries.
3. To contribute to knowledge on wood use in regional contexts.

Methodology:

The study was conducted to evaluate the physical and mechanical properties of local and imported wood species using a moisture meter and a Universal Amsler Wood Testing Machine. The following steps were followed to complete the project:

Sample Collection

Representative samples of local and imported wood species commonly used in construction and furniture industries were identified and procured. The samples were prepared to have uniform dimensions and were inspected to ensure they were free from visible defects, minimizing variability.

Moisture Content Measurement

A digital moisture meter was used to measure the moisture content (MC) of each wood sample. Measurements were taken at room temperature, and multiple readings were recorded from different points on each sample to ensure accuracy. The wood species were categorized based on their moisture levels to assess the impact of MC on their mechanical properties.

Preparation of Test Specimens for Mechanical Properties

The wood samples were cut into standard dimensions suitable for mechanical testing, in accordance with international standards such as ASTM D143 or ISO 3129.Each sample was labeled with a unique identification number indicating its origin, species, and moisture content.

Mechanical Testing Using Universal Amsler Wood Testing Machine

Mechanical tests were conducted to determine the following properties:

- **Compressive Strength**: Samples were subjected to axial loads to evaluate their resistance to crushing forces.
- **Flexural Strength (Modulus of Rupture)**: Bending tests were performed to measure the wood's resistance to deformation.

- **Tensile Strength**: Tests assessed the maximum tensile load each sample could withstand before failure.
- **Elastic Modulus**: The stiffness of the samples under applied load was determined.

Standardized procedures were strictly followed to ensure consistency and reliability of the test results.

Data Recording and Analysis

All test results, including load, deformation, and failure modes, were recorded for each sample. The data were analyzed to compare the performance of local and imported wood species in terms of strength, durability, and workability. Correlations between mechanical properties and moisture content were examined to assess the influence of MC on wood performance.

This methodology provided a systematic and comprehensive approach to evaluating the physical and mechanical properties of wood species, ensuring accurate and meaningful results.

Results & Discussions

The results of the study table 1, reveal significant variations in moisture content and density among the tested wood species, highlighting the diverse characteristics of local and imported wood. Deodar (*Cedrus deodara*) samples, predominantly sourced locally, exhibited moisture content ranging from 9.7% to 19.23%, with an average density of approximately 0.49 g/cm³ to 0.54 g/cm³. This variation indicates that local environmental conditions and treatment processes influence the physical properties of wood.

Shisham (*Dalbergia sissoo*), another prominent local wood species, demonstrated consistent moisture content values around 10%–12% and relatively high density, with a maximum recorded value of 0.88 g/cm³, making it suitable for high-strength applications. Imported woods such as Oak (*Quercus)* and Ekki (*Lophira alata*) presented contrasting characteristics. Oak displayed low moisture content (10.6%), while Ekki had a higher average moisture content of 29.6%, indicating a need for drying treatments to enhance its usability.

The differences in moisture content directly affected the mechanical performance, with higher density and lower moisture woods showing greater durability and strength. The results emphasize the importance of considering both origin and specific properties when selecting wood for construction and manufacturing. This evaluation provides practical insights for industries, supporting the efficient and sustainable use of both local and imported wood species.

Table 2 compares the mechanical properties of Sherawa and Ziar Largai wood species. Sherawa demonstrated a higher Modulus of Rupture (MoR) at 1851.85 Kg/cm² (181.48 N/mm²) compared to Ziar Largai's 1547.62 Kg/cm² (151.66 N/mm²). However, Ziar Largai exhibited a superior Modulus of Elasticity (MoE) at 108171.08 Kg/cm² (10600 N/mm²), suggesting higher stiffness compared to Sherawa, which recorded 95281.12 Kg/cm² (9337.54 N/mm²).

Table 03 provides the mechanical properties of Yellow Pine wood. Its bending strength (MoR) was moderate at 93.24 N/mm². The tension perpendicular to the grain was minimal (0.58 N/mm²), indicating low resistance to splitting forces. Compression perpendicular and parallel to the grain were recorded at 3.78 N/mm² and 38.48 N/mm², respectively, reflecting its suitability for compression-dominant applications. The shear modulus was low (0.49 KN/mm²), suggesting limited performance in resisting shear forces.

These findings indicate that Sherawa and ZiarLargai woods are better suited for high-strength applications, while Yellow Pine, with its moderate properties, may serve well in lightweight or non-structural uses.

Table 1: Physical Properties of Different Wood Species

S. No.	Wood Species	Source	Average Moisture Contents %	Average Density g/cm^3
1	Deodar (*Cedrus deodara*)	Local	19.23	
2	Oak *(Quercus)*	Imported	10.6	
3	Deodar (*Cedrus deodara*)	Local	11.10	0.49

4	Shisham (*Dalbergia sissoo*)	Local	11.97	
5	Deodar (*Cedrus deodara*)	Local	9.8	
6	Shisham (*Dalbergia sissoo*)	Local	10.2	0.88
7	Ekki (*Lophira alata*) Wood	Imported	29.6	
8	Shisham (*Dalbergia sissoo*)	Local	10.9	
9	Deodar (*Cedrus deodara*)	Local	9.7	
10	Ekki (*Lophira alata*) Wood	Imported	13.03	
11	Ash (*Fraxinus excelsior*) Wood	Local	9.9	
12	Shisham (*Dalbergia sissoo*)	Local	11.6	
13	Keekar (*Acacia nilotica*) wood	Local	18.16	
14	Deodar (*Cedrus deodara*)	Local	9.95	0.54
15	Chipboard sample (Keekar)	Local	7.95	0.64

Table 2: Mechanical Properties

S.No.	Sample of Wood	Average MoR Value	Average MoE Value
16	Sherawa (*Coprosma dumosa*)	1851.85 Kg/Cm^2OR 181.48N/mm^2	95281.12 Kg/Cm^2OR 9337.54N/mm^2
17	Ziar Largai (Elum Tree, *Almus varitiana*)	1547.62Kg/Cm^2OR 151.66N/mm^2	108171.08 Kg/Cm^2OR 10600N/mm^2

Table 3: Mechanical Properties

S. No.	Test Name	Results
1	Bending (MoR)	93.24 N/mm^2
2	Tension Perpendicular	0.58 N/mm^2
3	Compression perpendicular	3.78 N/mm^2
4	Mean Shear Modulus	0.49 KN/mm^2
5	Compression Parallel	38.48 N/mm^2

Conclusion

The study successfully tested and evaluated the physical and mechanical properties of local and imported wood species from diverse regions. The results highlighted significant differences in moisture content, density, and strength parameters among the wood types. Local species such as Deodar and Shisham exhibited consistent properties, with high density and moderate moisture levels, making them suitable for structural applications. Imported woods, including Oak and Ekki, demonstrated contrasting characteristics, with some requiring additional treatment to optimize their performance. Mechanical testing revealed that species like Sherawa and Ziar Largai offered superior strength and stiffness compared to others. The findings emphasized the importance of selecting wood species based on specific applications and environmental considerations. This evaluation provided valuable insights for industries to make informed, sustainable material choices.

2.2.2 COMPOSITE WOOD

2.2.2.1 Comparative evaluation of Particleboard prepared from *Tamarix aphylla* and *Morus alba* locally grown in Khyber Pakhtunkhwa

Year of commencement: 2023-24

Principal Investigator: Abdur Rehman Khan, Assistant Composite Wood Officer

Background

One of the ways to combat with deforestation is to reduce the consumption of wood. The wood finds its common application in home fixtures, furniture and fuel; therefore investigating the wood substitutes in these cases would be most advantageous. One of the most important wood-based composites is particleboard, which was made from wood or lingo-cellulose material particles glued with binder (adhesive) under pressure and temperature. Urea- formaldehyde is the most economic and useful adhesive because of its low cost and easy production. Historically, the products from the light wood technology were very expensive and exclusive. They were used in the aeronautic field or in the automotive field. Over the time, the light wood products could be produced cheap, but with a better quality through increased efficiency in production processes, research, and development. This trend is very strong in the furniture industry. Particleboard is cheaper, denser and more uniform than conventional wood and plywood and is substituted for them when appearance and strength are less important than cost. However, particleboard can be made more attractive by painting or the use of wood veneers that are glued onto surfaces that will be visible. There are over a hundred particleboard plants in operation today worldwide and particleboard is one of the strongest reconstituted panel products and is considered as an ideal substitute to wood and plywood.

Growing social demands for various wood-based panel products leads to the continuous efforts to find new wood resources as an alternative to solid wood from natural forests. The use of non-timber resources wood wastes and agricultural residues are a way of saving wood.

This research work, therefore, aims to evaluate locally grown non-timber wood species Ghaz (*Tamarix aphylla*) and Toot (*Morus alba)* for particle board manufacturing

Objectives:

1. To analyze and compare the physical and chemical properties of ***Tamarix aphylla*** and ***Morus alba*** wood, including density, moisture content, and lingo-cellulosic composition, for their suitability in particleboard manufacturing.
2. To fabricate particleboards using wood particles derived from ***Tamarix aphylla*** and ***Morus alba****,* employing standardized production techniques, adhesives, and pressing conditions
3. To evaluate and compare the mechanical properties (e.g., modulus of rupture, modulus of elasticity) and physical properties (e.g., water absorption, thickness swelling) of particleboards made from the two wood species.

Material

Tamarix aphylla and *Morus alba* wood species, Urea Formaldehyde, chipper, Mixer, and compressor machine were used in this research work.

Methods

1. Collection of Wood Species

   Tamarix aphylla and *Morus alba* logs were collected from local area of the Peshawar KPK, Pakistan. Total number of logs acquired is four (04) of each species.
2. Processing of Wood Species

   The *Tamarix aphylla* and *Morus alba* logs are processed, debarked and then convert to chips of size with the help of chipper installed in the composite wood labs of Pakistan Forest Institute, Peshawar
3. Mixing with synthetic adhesive

   The chips of were mixed with a fixed ratio to Urea Formaldehyde with the help of electrical mixer installed in composite wood plant so that equal distribution of the adhesive to each particle of the wood.
4. Hot pressing

   After thoroughly mixing the mixture were transfer to the specific pot made for desired thickness of particle board sheet, and then put in Hot presser at temp about 150

degree celcius and time 10 min and pressure 200 kg per cm^2 After that the sheet is cooled and dried.

Physical tests

- **Density Test**

Density of the each board was determined to find the mean density of each board following the British code of standards BS EN 323.

$$\sigma = \frac{m}{v}$$

σ Represents the density, m represents mass of each test piece in kg, and v is the volume of test piece.

- **Water Absorption test**

Water absorption test was carried for the particle board that how much water absorbed by the particle board in a given time

$$WA = \frac{wf - wi}{Wi} \times 100$$

Wf represents final weight, *Wi* represents initial weight and *WA* is the water absorbed by sample in %.

- **Thickness swelling test**

The thickness swelling test is dimensional analysis test used for determination in the thickness of the board sample after being immersed in the water in a given time frame. This test is used to find the effect of water on the board sample. It was carried by following the British code of standards BS EN 317.

$$Ts = \frac{T2 - T1}{T1} \times 100$$

t1 is initial thickness while t2 is final thickness and Ts is thickness swelling

Mechanical Tests

- **Static Bending tests**

The Modulus of rupture (MOR) and Modulus of Elasticity (MOE) was determined using universal testing machine following the central concentration loading method. MOR and MOE are measured in N/mm^3. This was carried following British code of standards BS EN 310.

$$\text{MOE} = \frac{(F2 - F1)l1^3}{4bt^3\,(a2 - a1)}$$

$$MOR = \frac{3Fmaxl1}{2bt^2}$$

- F_2-F_1 is the gradual increase of load on the straight-line portion of the load deflection curve ad is measured in Newton, N. F1 is approximately 10 % of the maximum load while F2 is approximately 40 %.
- Fmax is the maximum load measured in Newton.
- b is the breadth of the specimen, measured in millimeters, mm.
- t is the thickness of the specimen, measured in mm.
- l_1 is the distance between the centers of the support which is also measured in mm.

a_2-a_1 is the deflection of the specimen at mid span, corresponding to F2 – F1 and is also measured in mm.

Results and Discussions

Ghaz (*Tamarix aphylla)* Data

Properties	x1	x2	x3	x4	Average value	Standard deviation
Board density (kgm-3)	822	818	824	815	820	4.031128874
Water Absorption 2 hr	16.8	15.53	14.7	15.8	15.708	0.749779134
Water Absorption 24 hr	28.34	29	29.43	28.5	28.8175	0.429323596
Thickness Swelling 2 hr	5.6	4.9	6	6.5	5.75	0.585234996
Thickness Swelling 24 hr	17	14.3	15.5	17.5	16.075	1.261695288
Modulus of rupture (MOR) Kg/ cm^2	395	398.5	398	396	396.875	1.430690393
Modulus of Elasticity (MOE) Kg/ cm^2	38365	38370	38367	38369	38367.75	1.920286437
Face Nail with drawl Kg	114	112	128	123	119.25	6.533567173
Face Screw with drawl Kg	238	240	210	220	227	12.52996409

Toot (*Morus alba)* Data

PROPERTIES	X1	x2	x3	x4	Average value	Standard deviation
Board density (kgm-3)	897	885	860	854	874	17.69746
Water Absorption 2 hr	17.59	19.78	13.93	14.78	16.52	2.187706
Water Absorption 24 hr	23.94	22.32	30.91	29.35	26.63	3.389623
Thickness Swelling 2 hr	8.21	7.93	2.81	3.33	5.57	2.416132
Thickness Swelling 24 hr	13.2	12.5	17.5	19.2	15.6	2.908883
Modulus of rupture (MOR) Kg/ cm^2	588	593	555	600	584	16.72603
Modulus of Elasticity (MOE) Kg/ cm^2	64228	62000	62500	63000	62932	740.7006
Face Nail with drawl Kg	154	141	185	200	170	24.25696
Face Screw with drawl Kg	180	280	200	300	240	51.53639

A representative trend showing the Density of Board samples is shown in Fig 1.

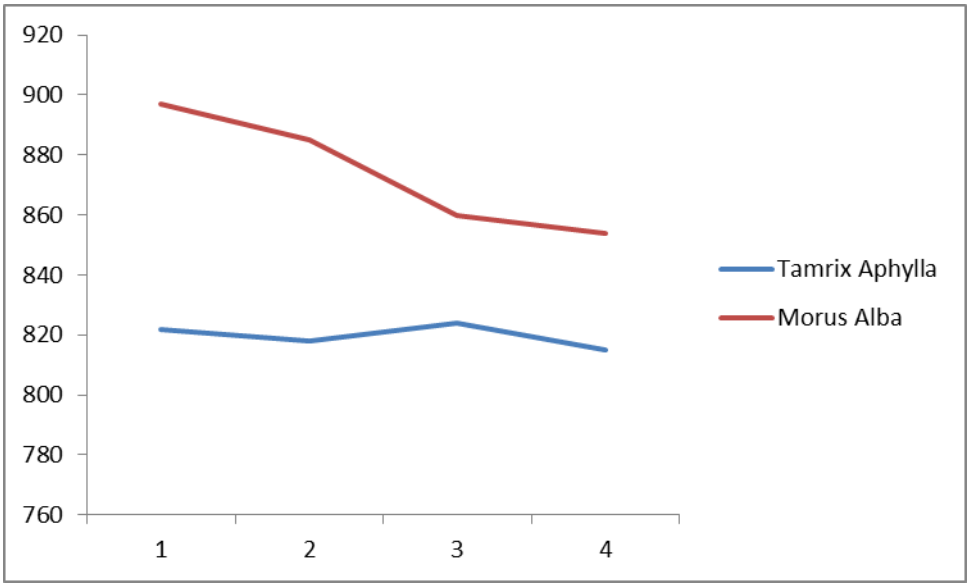


Figure 1: Variation in Density of Board Samples of *Tamarix aphylla* and *Morus alba*

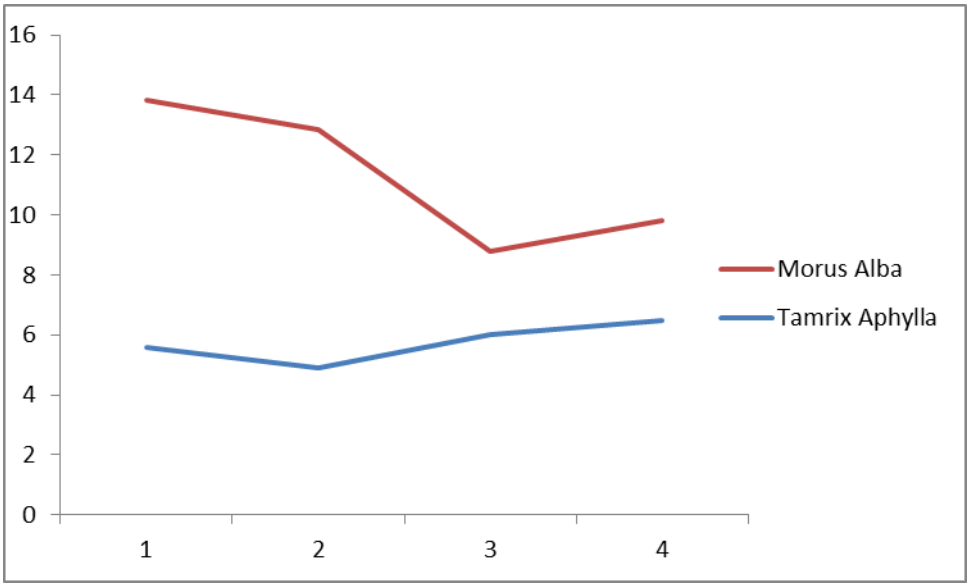


Figure 2: Variation of thickness swelling after 2 hrs.

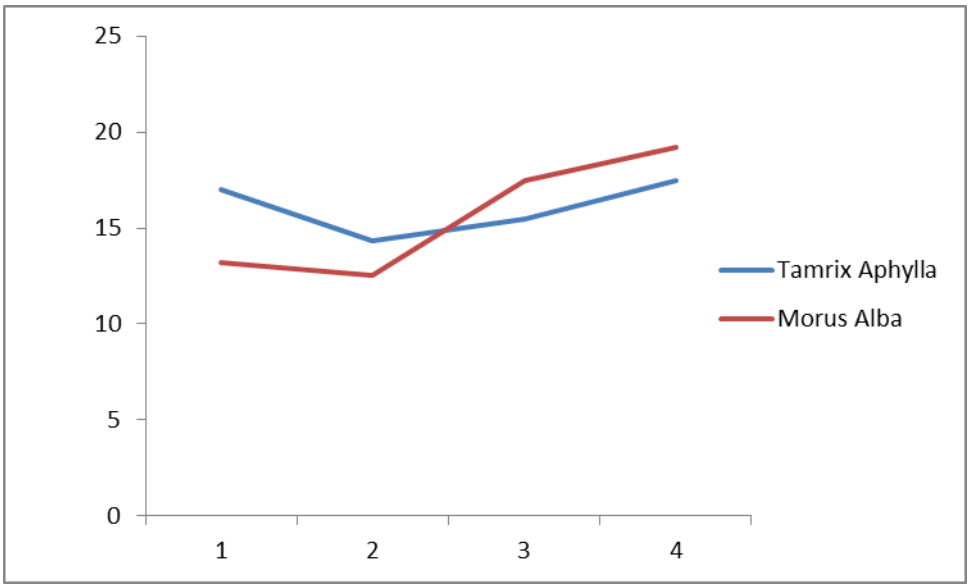


Figure 3: Variation of thickness swelling after 24 hrs

The density value of composite wood material is an important property which determines its performance in service environment. As shown in Fig 1 the density of different samples of *Tamarix aphylla* and *Morus alba* all of them are medium density particle boards. According to ANSI 280 standards all these are medium density particle boards as above than 600 Kg/m^3.

The water absorption of particle boards at temperature (20^oC) after 2hr and 24hr soaking in water. This is due to hydrophilic nature of wood which contains the organic polymers like cellulose and lignin etc. which are rich in hydroxyl which readily interacts with water molecule. The similar trend is notice in thickness swelling test also.

Mechanical properties: The result of MOE and MOR value are presented in figure 4 and 5 From the above two figures of MOR and MOE it shows that *Morus alba* showed high mechanical strength than that of *Tamarix aphylla.* This is because the hardness with in the species of *Morus alba*

Conclusion

The particle board industry is flourishing very abruptly, so it is the need of the day to find new sources which is economic and easily available. From the above study we concluded that *Morus alba* is better for the particle board production.

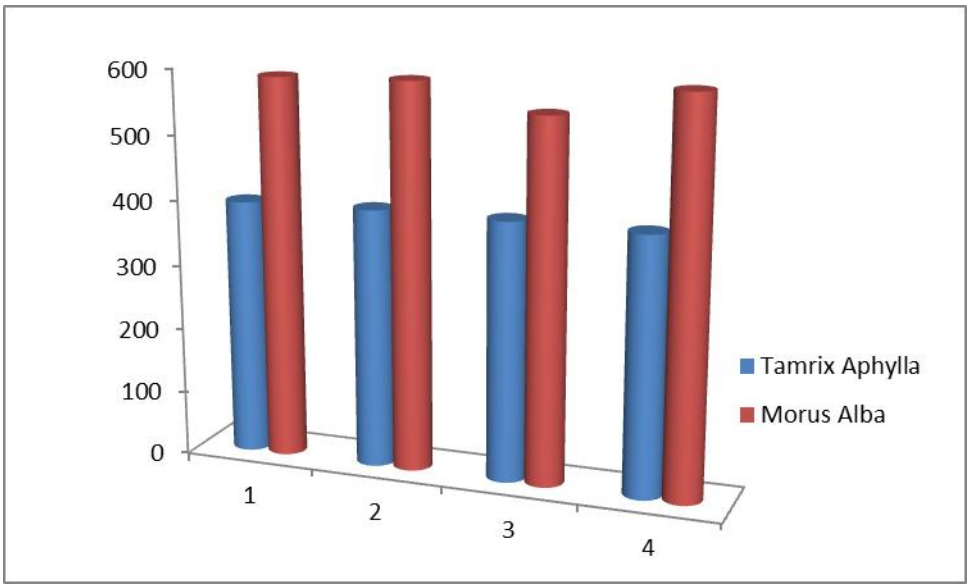


Figure 4: Variation in Modulus of Rupture of Board Samples

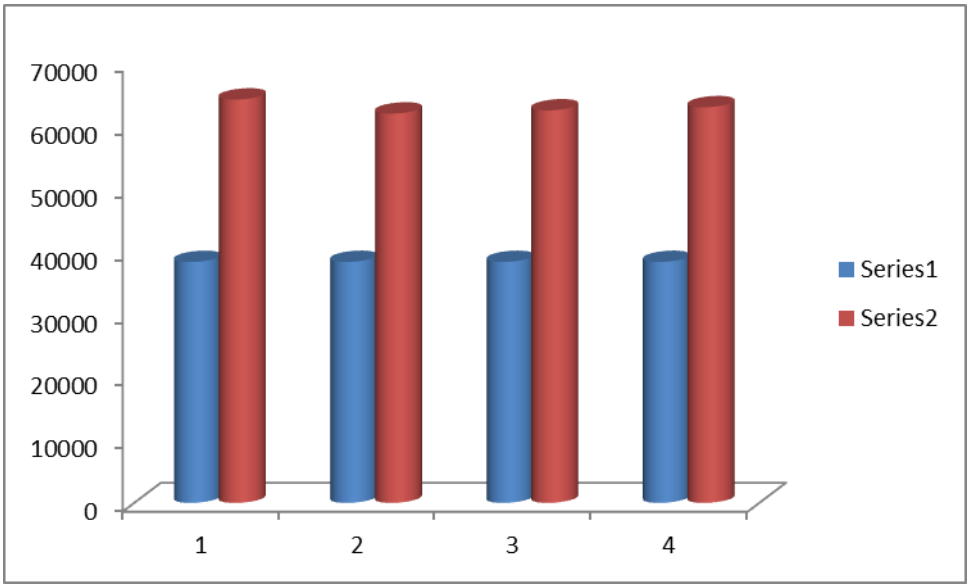


Figure 5: Variation in Modulus of Elasticity of Board Samples

2.3 PULP AND PAPER

2.3.1 Utilization of Non-Wood Fibers as Raw Materials for Pulp and Paper Production in Pakistan: A Review

Year of commencement:	2023-24
Principal Investigator:	Engr.M. Umair Khan, Pulp and Paper Officer (Chemistry)
Co-Principal Investigator	Engr. Abdur Rehman, Pulp and Paper Officer (Technology)

Background

The global as well as Pakistan's pulp and paper industries have been experiencing rapid growth, leading to a substantial surge in demand for raw materials used in their production. Paper and pulp mills provide a wide range of goods for different uses, making them essential to both the national and international economies. Pakistan is poor in forest cover. Most of the raw material is imported to meet the demand. However, Pakistan is an agriculture country which produces a large amount of fruits, vegetables, cereals and agriculture residues. These residues can be utilized as a source of fibers in the production of pulp, paper and paperboards.

In countries like China, India, and Egypt where there are little forest resources, a wide variety of non-wood plant fibers are vital as fiber supplies and are gradually becoming more significant in these locations. The utilization of forest resources in a variety of businesses, including the production of paper, building and furniture, has significantly increased in recent years. Due to this increasing global demand for wood, the shortage of plants in numerous countries and the increasing awareness of sustainability, agricultural crop residues (Non-wood) have emerged as one of the great significant alternative resources.

Objectives

The study aims to evaluate the potential of non-wood fibers as sustainable raw materials for pulp and paper production in Pakistan. It seeks to identify and discuss the

availability, types, and properties of non-wood fibers in the country, assessing their suitability for pulping through a review of existing processing techniques and technologies.

Methodology

The review study presents a comprehensive analysis of various non-wood raw materials used in pulp and paper production, utilizing data from multiple sources. The study references a variety of research articles, reviews and reports that provide empirical data on the properties of different agricultural residues and non-wood fibers. It compiles data from various studies to compare the properties of different non-wood fibers, such as rice straw, wheat straw, and sugarcane bagasse. This comparative approach allows for a broader understanding of the potential of these materials in pulp production. The review effectively synthesizes data from multiple sources, employing tables and potentially graphs to present a clear and comparative analysis of non-wood raw materials for pulp and paper production in Pakistan.

Reasons for utilization fibers of non-wood in pulp and paper sector of Pakistan

1. Quickly Expanding Paper Sector

The population and economic growth of Pakistan have led to an increase in need for paper and paperboard products. With a total installed capacity of 1,050,499 metric tons annually, the paper industry of Pakistan is made up of more than 57 pulp and paper factories. Most of the raw material for the production is imported from different countries. This import can be reduced by utilizing the agriculture residue which is abundantly found in Pakistan.

2. Shortage of Wood Fiber

In Pakistan, using non-wood plant fibers to produce pulp and paper is not an option, it is a need because this country is not rich in forest resources. Only 4.8% of Pakistan's total land area is covered by forest which indicates a lack of forest resources appropriate for pulp manufacturing. Because of the growing need for wood fibers in the pulp and wood industries, this shortage becomes even more

severe. So, the virgin wood has an important role in fulfilling the demand of forest products. However, several parts of Pakistan have limited forested areas, making the availability of non-wood fibers for the production of pulp and paper necessary rather than optional.

3. Special papermaking properties of selected non-wood fibers

Certain non-wood plant fibers are in demand due to their unique properties which make them superior to wood fibers, especially for specialty paper production. The applications of Bagasse pulp are found in a wide array of paper types such as bag, wrapping, printing, writing, toilet tissue, toweling, glassine, corrugating medium, liner board, bleached boards and coating base stocks. Wheat straw has shown a good indication in the proper supply for writing and printing paper.

Over View of Agriculture Sector of Pakistan

The agricultural sector of Pakistan plays a vital role in its economy. Its contribution to the total GDP is 22% and the total workforce absorbed is 42%. Year-wise Agriculture Contribution and Labor Employed in Agriculture Sector of Pakistan are illustrated.

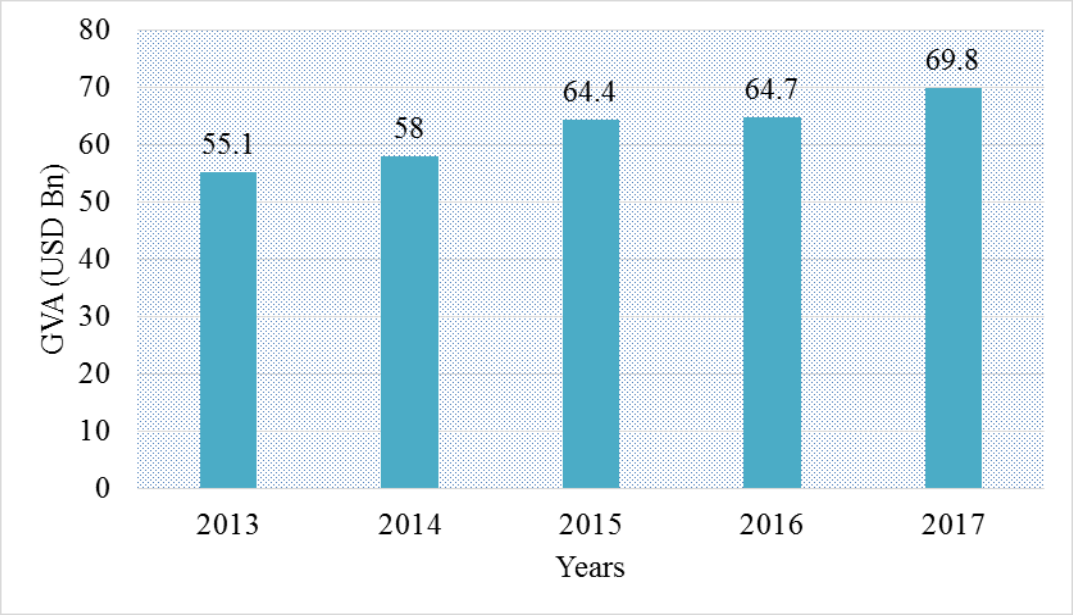


Figure 1: Pakistan Year Wise Agriculture Gross Value Added in USD Billion (SAARC Energy Centre)

Pakistan accounts 40.2 % Agriculture land of its total land. The agriculture land distribution by crops illustrated in Figure 2, shows that sugarcane is the highest crop produced as compare to other crops in Pakistan which is 63% of the total crop production.

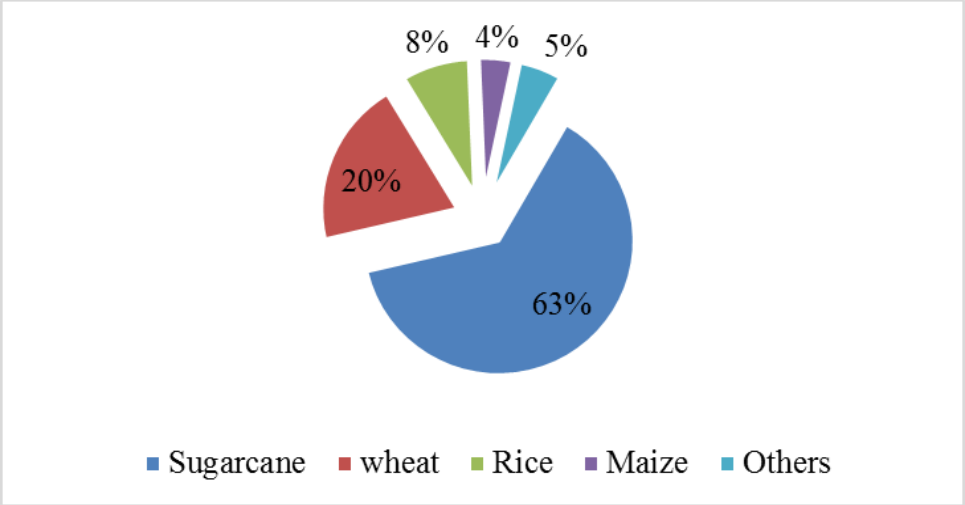


Figure 2: Total Crop Production (Total: 129 million Tons) in Pakistan (SAARC Energy Centre)

Pakistan has a potential of cultivation of major crops including wheat, maize, rice, sugarcane and cotton etc. The annual production of major crops of Pakistan and their generated residues are presented in the following Table and Figures.

Table 1: Crop Residue Potential in 2017-18 in Pakistan (SAARC Energy Centre)

Crop	Annual Production (000 Tons)	Gross Residue generated (000 Tons)	Surplus Residue potential (000 Tons)
Wheat	25,490	45,882	10,294
Rice	10,320	17,544	4,912
Maize	5,700	13,110	3,278
Coarse cereals	504	907	200
Cotton	1,935	7,353	4,559
Sugarcane	81,102	32,441	12,652
Pulses	125	250	95
Oilseeds	3,555	5,333	1,600
Total	128,731	122,820	37,389

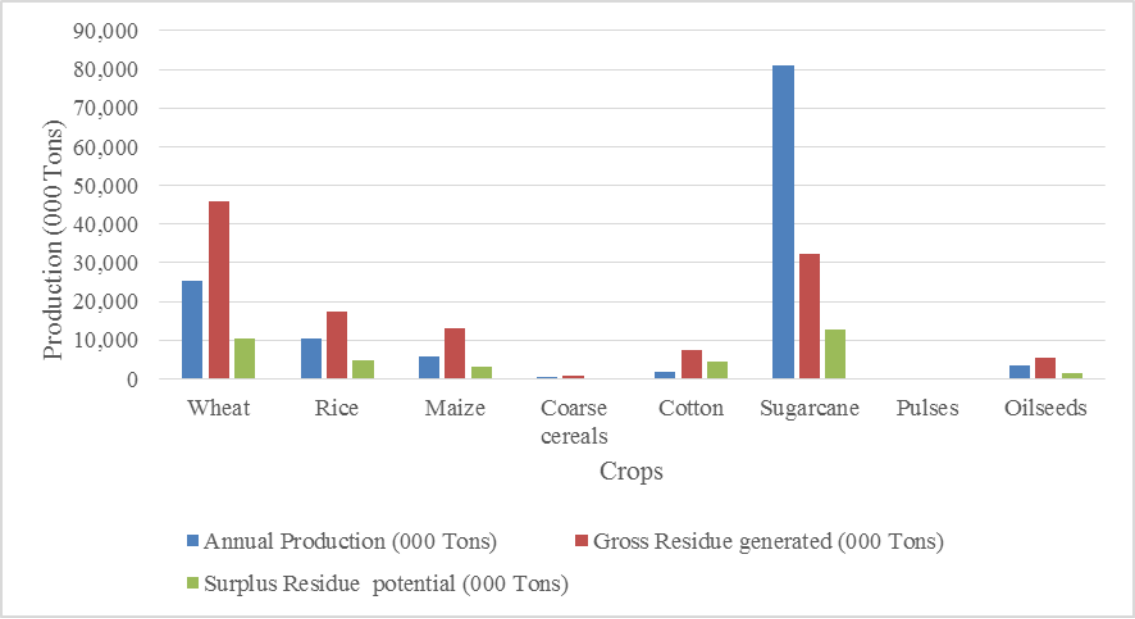


Figure 3: Crop Residue Potential in 2017-18 in Pakistan (SAARC Energy Centre)

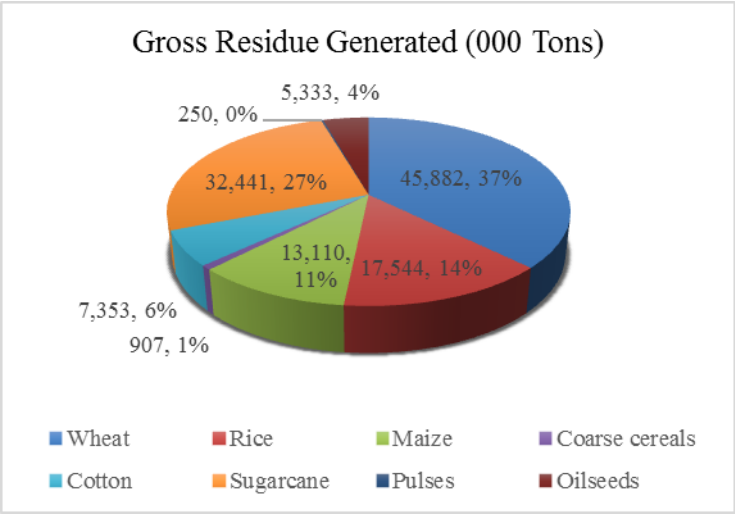


Figure 4: Crop Residue Potential in 2017-18 in Pakistan (SAARC Energy Centre)

The Crop Residue Potential in 2017-18 in Pakistan indicates a substantial amount of crop residue available, which can be utilized for various purposes including pulping and paper production. Wheat is the largest contributor, generating 45,882,000 tons, which accounts for 37% of the total crop residue. Rice follows with 17,544,000 tons (14%). Maize contributes 13,110,000 tons (11%). Other crops like coarse cereals, cotton, sugarcane, pulses, and oilseeds also contribute, but to a lesser extent.

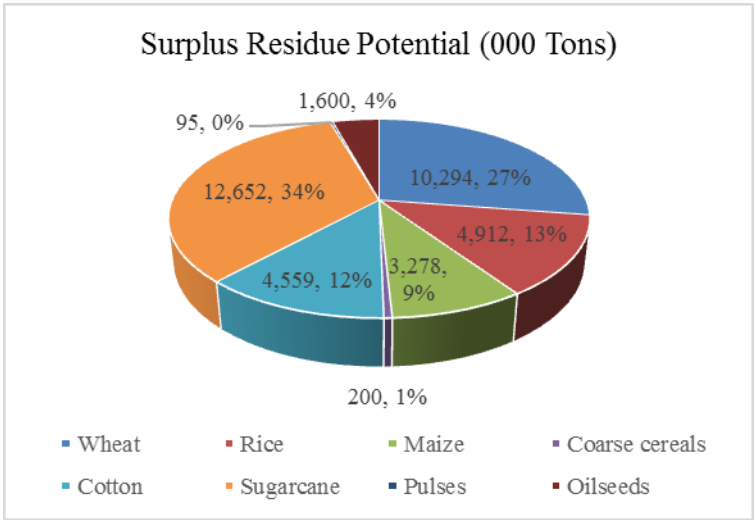


Figure 5: Surplus Residue Potential in 2017-18 in Pakistan (SAARC Energy Centre

Surplus Residue Potential in 2017-18 in Pakistan highlights the amount of crop residue that remains after accounting for the needs of the crops, indicating the potential for utilization beyond what is necessary for agricultural practices. Wheat again stands out as the largest source of surplus residue, with 10,294,000 tons, which constitutes 27% of the total surplus. Rice contributes 4,912,000 tons (13%), while maize accounts for 3,278,000 tons (9%). Other crops such as coarse cereals, cotton, sugarcane, pulses, and oilseeds also contribute to the surplus, but in smaller quantities. The substantial surplus from wheat and rice suggests that these crops could play a crucial role in developing sustainable practices and reducing waste.

Conclusion

Non-wood pulp technology and raw materials may soon gain prominence in the paper manufacturing sector because of the imported pulp huge cost and wood resources scarcity in emerging nations like Pakistan. Pakistan has an abundance of agricultural residue, with wheat accounting for the most (45.88 MT), followed annually by sugarcane bagasse (32.44 MT), rice (17.54 MT) and maize (13.11 MT). As a result, Pakistan has access to enough high-quality non-wood raw materials for pulping. Furthermore, the widespread availability of straws makes it a cheap and appealing raw material for papermaking in Pakistan. Combining non-wood materials with other wood pulps has the potential to produce pulp of a higher quality while also protecting Pakistan forests and financial resources.

MISCELLANEOUS

Training Workshop on "Application of Molecular Techniques in Forest Management and Conservation" 20-22 February, 2024

by

Dr. Tanvir Hussain, Logging Officer, Forest Products Research Division
Mr. Bilal Zia, Forest Geneticist, Biodiversity Research Division.

A three (03) days training workshop on "Application of Molecular Techniques in Forest Management and Conservation" was arranged from 20-22 February, 2024 at Pakistan Forest Institute, Peshawar, under the ADP-Project titled" DNA Fingerprinting of Important Pakistani Timbers for their Identification and Illegal Trafficking Control".

The primary objectives of the workshop were 1) To familiarize participants with modern molecular techniques applicable in forest management and conservation 2) To explore the potential of molecular tools in Molecular Identification of Forest Trees, illegal logging and trafficking control, 3) To facilitate networking and knowledge exchange among professionals working in the field of forestry and conservation.

The participants from Forest Department, Khyber Pakhtunkhwa (KPK); R&D Department-KPK; Centre of Biotechnology& Microbiology (COBAM), University of Peshawar; Botany Department, Islamia University of Peshawar; PBG-Department, University of Agriculture, Peshawar; Botany Department, University of Peshawar and Pakistan Forest Institute (PFI), Peshawar attended the workshop. Presentations were given on the Challenges and Possible Solutions of Forest Management and conservation through Molecular techniques for Pakistani tree Species, DNA Technologies and applications in Forest Tree improvement and Conservation, Techniques for DNA Collection and handling in Forest Tree Species, DNA sequencing/NGS, Development of DNA barcode database etc. Practical demonstration of DNA extraction, purification, Gel electrophoresis, reading of binary data was also given to the participants of the training course at Biotechnology Labs. of the Division.

At the end of training workshop, the Additional Director General (Research) and Additional Director General (Education), Pakistan Forest Institute, Peshawar awarded certificates to the participants.

Group Photo of Training Course Participants with ADG (Res.), ADG (Edu.)

3. BIOLOGICAL SCIENCES RESEARCH DIVISION

3.1 FOREST BOTANY

3.1.1 Maintenance and Improvement of Botanical Garden

Location	Pakistan Forest Institute, Peshawar
Year of commencement:	2023-24
Principal Investigator:	Forest Botanist

Cleanness:

- Weeds were uprooted from wild tress, paper mulberry, grasses etc. from all plots of botanical garden throughout the year.
- Provided river water to all plots of Botanical garden weekly throughout the year. Cleaning of trenches in Botanical Garden.
- Water supply to newly planted plants as well as to small plant with fountain and plastic pipe on alternate days.
- Pruning of different tree species and cut off the hedges from colony side and girls hostel.

Plantations:

The following plant species are planted in different plots of Botanical Garden:

- *Poncerus trifolita, Terminalia belarica, Acer oblongum, Oroxylem indicum, Gladetia tricanthose*
- Seedlings of *Terminalia arjuna, Pinus roxburghi, Eucalyptus torreliana, Terminalia belarica, Bauhenia variegata* planted in nursery of Botanical garden, PFI.
- Sowing of 20 seeds of *Magnolia grandiflora* was planted as research to see germination.

Bamboo Plot:

Observation of Bamboo plots on daily basis.

Seedling Provision:

- Seedlings of *Seritinia seliqua* (50 No.) were provided to Silviculture branch PFI, Peshawar.
- Cuttings of *Ficus variegate* were provided to Siliviculture branch, PFI Peshawar.
- Seedlings of *Bauhenia variegate*, common asperagus, *Oroxylem indicum*, *Bombax cieba* were provided to Pathology branch.

Lectures delivered:

- Lectures were delivered on 09-10-2024 to officers of MCMC about Botanical garden.

Field studies conducted/participated:

Team member of ongoing task assigned by worthy Director General, PFI:

- Entitled as: “Thorough inventory and mapping of tree species on the PFI campus and colony, taking into account the attributes such as age, diameter, height, species name, and their respective coordinates.”

Conducted Study on: Tree diversity of Torghar district.

Name Plates Installation: 25 new name plates have been installed on different plants.

Maintenance of Herbarium:

- Maintaining Herbarium with proper preservative measures
- Lectures delivered to Forestry students on herbarium and its importance in plant sciences enlisting of all herbarium specimens is under process.
- Lectures to BS Forestry 7th, 3rd Semester and 1st Semester are in progress

Research Papers for PJF:

- One review paper has been published in PJF entitled as:
- Invasive species and its Management

- One review article under production in PJF, entitled as: Significance of cultivating genus *Paulownia* and its utilization in different sectors: A review
- Three research papers have been in progress in PJF:
- Ethno-Botanical study of some important wild plants in tehsil Ykka Ghund, District Mohmand, Merged Areas, Pakistan.
- Floristic Composition and biological spectrum of plant resources of Village Palangzai, North Waziristan, KP, Pakistan.

3.2 FOREST CHEMISTRY

3.2.1 A Depth-Wise and Species-Wise Comparative Analysis of Soil Physical Chemical and Biological Properties in the Botanical Garden of Pakistan Forest Institute, Peshawar.

Year of commencement:	2023-24
Principal Investigator:	Dr. Sanam Zarif, Director , Biological Sciences Research Division

Objectives:

- To investigate the variation in soil properties versus depth, examining how physical, chemical and biological properties change with depth.
- To examine the relationship between soil properties and tree species, determining whether specific species are associated with distinct soil characteristics.
- To know the correlation between soil properties at different depths and tree growth parameters, identifying potential interactions that influence tree growth and development.

Methodology:

Soil samples were collected from the Botanical Garden of the Pakistan Forest Institute, Peshawar from January to March 2024. Sampling was carried out at varying depths (e.g., 0–15 cm and 15–30 cm) under different tree species. Composite samples

were prepared by mixing subsamples collected randomly from each depth and tree species. The samples were carefully labelled and transported to the laboratory for analysis of their physical and chemical properties. A total of 96 Soil samples were completed.

Glimpses captured during the field work of sample collection:

Results:

The following laboratory analyses were conducted from April to December 2024.

Table 1. Shows the analysis of soil bulk density, pH, Moisture and Ash content of the Botanical Garden of the Pakistan Forest Institute, Peshawar.

S#	Specie Name	Depth (cm)	Rep	Density (g/cm^3)	Moist (%)	Ash (%)	pH
1	Chirpine-M	0-15	1	0.398	16.64	2.21	8.3
2	-	15-30	1	0.644	8.93	0.92	8.4
3	-	0-15	2	0.543	28.18	1.61	8.7
4	-	15-30	2	0.638	7.31	0.91	8.3
5	Chirpine-I	0-15	1	0.262	14.12	1.32	8.1
6	-	15-30	1	0.720	9.64	1.04	8.2
7	-	0-15	2	0.676	4.56	0.75	8.1
8	-	15-30	2	0.587	16.60	1.22	8.2
9	Chirpine-Y	0-15	1	0.563	5.69	1.14	8.1
10	-	15-30	1	0.537	15.94	0.86	8.0
11	-	0-15	2	0.612	18,96	1.42	8.1
12	-	15-30	2	0.427	16.18	0.73	7.9
13	Sterculia-M	0-15	1	0.513	19.89	1.75	8.3
14	-	15-30	1	0.901	17.82	1.00	8.3
15	-	0-15	2	0.448	19.82	2.12	8.3
16	-	15-30	2	0.784	17.27	1.31	8.1
17	Sterculia-I	0-15	1	0.521	17.61	1.81	8.2
18	-	15-30	1	0.587	16.69	1.37	8.2

19	-	0-15	2	0.311	21.27	2.24	8.4
20	-	15-30	2	0.781	16.47	1.24	8.3
21	Sterculia-Y	0-15	1	0.544	24.78	2.20	8.3
22	-	15-30	1	0.503	20.50	1.42	8.3
23	-	0-15	2	0.577	21.07	2.16	8.2
24	-	15-30	2	0.701	18.18	1.59	8.0
25	Shisham-M	0-15	1	0.561	20.84	1.56	8.5
26	-	15-30	1	0.780	18.42	1.04	8.4
27	-	0-15	2	0.591	26.37	0.98	8.4
28	-	15-30	2	0.567	16.61	0.29	8.2
29	Shisham-I	0-15	1	0.508	21.83	2.42	8.3
30	-	15-30	1	0.672	19.12	1.24	8.2
31	-	0-15	2	0.709	19.11	1.42	8.2
32	-	15-30	2	0.793	19.19	0.65	8.2
33	Shisham-Y	0-15	1	0.640	15.24	2.07	8.1
34	-	15-30	1	0.611	14.44	1.39	8.4
35	-	0-15	2	0.540	15.77	4.49	8.2
36	-	15-30	2	0.839	15,02	1.09	8.2
37	Peepal-M	0-15	1	0.640	24.48	0.03	8.1
38	-	15-30	1	0.410	25.29	2.29	8.2
39	-	0-15	2	0.565	21.26	1.07	8.2
40	-	15-30	2	0.554	21.53	0.66	8.2
41	Peepal-I	0-15	1	0.432	24.90	3.05	8.2

42	-	15-30	1	1.029	21.72	1.09	8.2
43	-	0-15	2	0.582	24.84	2.15	8.2
44	-	15-30	2	0.886	19.88	1.16	8.2
45	Peepal-Y	0-15	1	0.718	21.42	1.06	8.3
46	-	15-30	1	0.709	21.80	0.72	8.3
47	-	0-15	2	0.703	12.84	1.02	8.2
48	-	15-30	2	0.645	46.05	1.82	8.2

Table 2. Shows the analysis of soil bulk density, pH, Moisture and Ash content of Botanical Garden of Pakistan Forest Institute, Peshawar.

S#	**Specie Name**	**Depth (cm)**	**Rep**	**Density (g/cm^3)**	**Moist (%)**	**Ash (%)**	**pH**
49	Pterospermium-M	0-15	1	1.160	2.41	3.37	8.2
50	-	15-30	1	1.349	2.98	1.12	7.9
51	-	0-15	2	0.731	0.40	1.18	7.9
52	-	15-30	2	1.370	0.58	1.11	8.0
53	Pterospermium-I	0-15	1	1.112	0.27	2.11	8.1
54	-	15-30	1	1.516	0.09	1.20	8.0
55	-	0-15	2	1.319	0.08	2.05	7.8
56	-	15-30	2	1.798	0.18	1.25	8.0
57	Pterospermium-Y	0-15	1	1.308	0.01	1.15	7.9
58	-	15-30	1	1.293	0.04	0.66	8.1
59	-	0-15	2	1.162	0.27	1.12	7.9
60	-	15-30	2	1.453	0.06	0.91	7.8
61	Chukrasia-M	0-15	1	1.499	0.89	1.37	8.0
62	-	15-30	1	1.562	0.53	1.42	8.0
63	-	0-15	2	1.809	1.18	1.95	7.8
64	-	15-30	2	1.975	2.57	1.58	7.9

65	Chukrasia-I	0-15	1	1.578	0.46	1.62	7.8
66	-	15-30	1	1.565	1.57	1.81	7.8
67	-	0-15	2	1.367	0.82	1.37	7.9
68	-	15-30	2	1.555	2.65	1.54	8.0
69	Chukrasia-Y	0-15	1	1.193	4.12	1.58	8.0
70	-	15-30	1	1.421	2.40	1.30	8.1
71	-	0-15	2	1.296	1.12	1.53	7.8
72	-	15-30	2	1.332	1.47	1.26	8.0
73	Putranjiva-M	0-15	1	1.055	1.18	1.95	8.1
74	-	15-30	1	1.552	1.16	0.93	7.9
75	-	0-15	2	1.528	0.73	1.89	7.8
76	-	15-30	2	1.316	1.57	1.30	7.9
77	Putranjiva-I	0-15	1	1.153	1.56	1.71	7.9
78	-	15-30	1	1.492	1.13	1.58	8.0
79	-	0-15	2	1.550	2.62	1.57	7.9
80	-	15-30	2	1.548	1.54	1.33	8.0
81	Putranjiva-Y	0-15	1	1.553	2.31	1.23	7.9
82	-	15-30	1	1.547	16.02	1.10	8.0
83	-	0-15	2	1.478	3.20	1.50	7.9
84	-	15-30	2	1.465	2.69	1.08	8.2
85	Lagerstroemia-M	0-15	1	1.535	3.60	0.66	8.2
86	-	15-30	1	1.554	2.19	0.44	8.6
87	-	0-15	2	1.567	12.72	0.48	8.2
88	-	15-30	2	1.443	3.46	0.36	8.8
89	Lagerstroemia-I	0-15	1	1.569	2.74	0.80	8.2
90	-	15-30	1	1.524	3.37	0.42	8.3
91	-	0-15	2	1.510	3.72	0.55	8.3
92	-	15-30	2	1.383	2.55	0.10	8.3
93	Lagerstroemia-Y	0-15	1	1.530	0.92	0.38	8.2
94	-	15-30	1	1.538	0.51	0.60	8.2
95	-	0-15	2	1.538	0.92	0.16	8.3
96	-	15-30	2	1.490	0.00	0.32	8.4

Laboratory analyses for soil bulk density, pH, moisture, electrical conductivity (EC), and ash content have been successfully completed. Currently, the analyses for potassium and phosphorus are in progress.

Photographs captured during the laboratory analysis:

Trainings and Teaching Activities

- Attended three-day training on "Forest Carbon Accounting" at the Pakistan Forest Institute, Peshawar on February 19-21, 2024.
- Thought Soil Sciences to BS-Forestry students (2023-27) at PFI, along with practical.
- Attended three-day training on "Forest Inventory Techniques" at the Pakistan Forest Institute, Peshawar and Field Station Shinkyari on December 26-28, 2024.

Research Activities

- Published one research paper in Pakistan journal of forestry with the title of *"Isolation of Nepetin (6-Methoxyluteolin) from Artemisia vulgaris and Spectroscopic Characterization: A Bioactive Flavonoid"*
- Reviewed one paper for PJF titled *"Socio economic impacts of agroforestry practices in District Charsadda".*
- Submitted one research paper to PJF titled *"Assessment of Soil Physico-Chemical Characteristics in Response to Biochar and Inorganic Fertilizers in Maize Field"*
- Successfully completed the assigned task by the Honorable Secretary, CCFEWD, *on "Tree Diversity Study in Torgarh District"*

Research and Internship Students Currently Enrolled:

- **Mr. Asfandiyar**

- Degree: MSc (Hons) in Horticulture
- Institution: The University of Agriculture, Peshawar
- Role: Conducting experiments at the PFI research garden under the supervision of Mr. Muhammad Ilyas, Research Officer (Soil).

- **Mr. Shoukat Ullah**
  - Degree: BS (Hons) in Soil Science
  - Institution: The University of Agriculture, Peshawar
  - Role: Completing his final-year internship under the supervision of Mr. Muhammad Ilyas, Research Officer (Soil).
- **Miss Nafila**
  - Degree: PhD Scholar
  - Institution: The University of Peshawar
  - Role: Conducting laboratory analyses in the Chemistry Lab under the supervision of Dr. Salim Saifullah, Assistant Forest Chemist.

Research Projects and Grant Applications

- **TIKA-** Turkish Cooperation and Coordination Agency

  "Conservation of Endangered and Critically Endangered Tree species through Nursery raising".

- **Pakistan Forest Institute**

  "Understanding the Role of Soil Physiochemical Properties and Microbial Diversity in the Incidence of Shisham Die-back in Khyber Pakhtunkhwa".

- **Agreement on Technical Cooperation Between Pakistan and Brazil**

  "Impact of climate change on heavy metals accumulation in soil and some important medicinal plants in different ecological zones of KP".

Challenges

- The available scientific equipment in the lab is out of odor, and there is no budget for scientific equipment repair.
- Chemical and reagents are expired and their use in experiment results in non-reliable data.
- Internet connectivity is not available for searching the latest literature.
- No institutional level subscription to international scientific journals.
- No proper guidance for research project formulation.

3.3 FOREST PATHOLOGY BRANCH

3.3.1 Maintenance and improvement of pathology garden:

Following practices were carried out at pathology garden:

- Weeds were uprooted from tress of pathology garden and pruning of trees throughout the year.
- Construction of trenches and irrigation channels for smooth water supply.
- Following plant species were added to the garden:
  Moringa oliefera, Murraya koenigii, Oroxylum indicum, Bauhinia variegata, Asparagus spp.
- Watering to all plots of the garden throughout the year.
- Monthly basis cleaning of irrigation channels and trenches.

- Collection of Shisham seeds from the trees at the pathology garden.
- Already existing die-back resistant Shisham trees were propagated through root suckers.
- Pruning of trees

3.3.2 Maintenance of Herbarium

- Samples were cleaned, labeled and placed in new paper bags
- Spirit was filled in bottle samples and naphthalene balls were placed in cupboards.
- Lectures were delivered to Forestry and Agriculture university students on herbarium and its importance in plant sciences
- Computerization of herbarium data is already in progress
- Lectures delivered to Forestry students on herbarium and its importance in the study and identification of forest tree diseases

3.3.3 Research Study:

Greenhouse experiment was conducted at the Bhurban Field Station of the Pakistan Forest Institute, Peshawar to check the pathogenicity of two-year-old *Pinus wallichiana* and *Pinus roxburghii* seedlings against *Fusarium circinatum* (Pine pitch canker disease pathogen). Seedlings were artificially inoculated with lab grown culture of *F circinatum* fungi. The surfaces of seedlings were disinfected with 85% ethanol, and bark was removed with the help of a sterile, sharp blade to expose the cambium. A 4-mm plug was taken from the margins of *Fusarium circinatum* mycelium growing on PDA media and inoculated into each seedling. The mycelium was covered with cotton soaked in sterile distilled water and sealed with the parafilm. *Pinus wallichiana* seedlings inoculated with sterile PDA plugs were used as controls. The length of lesions produced by fungi was measured every two weeks to assess the pathogenicity of the isolated fungi on each *Pinus* seedling. Re-isolation of the disease-causing fungi was performed to satisfy Koch's postulates.

Both *Pinus* species, i.e., *Pinus wallichiana* and *Pinus roxburghii*, exhibited cankers and branch wilt. Upon removal of bark from the cankered areas, brown discoloration and lesions corresponding to external injuries were observed. Symptoms were more severe on

P wallichiana, with a high lesion length of 40 mm on the 48th day post-inoculation (Table 1). There was no significant difference in mean lesion lengths between the post-inoculation days. The control seedlings, which were mock-inoculated, showed minor injuries that healed completely over the time. *Fusarium circinatum* was isolated and identified from both *Pinus* seedlings through culturing on PDA media and microscopic examination.

Table 1: Mean lesion length on two *Pinus* species artificially inoculated with *Fusarium circinatum*

***Pinus* specie**	**Mean lesion length (mm)**		
	14 DPI*	28 DPI	48 DPI
Pinus wallichiana	35	38	40
Pinus roxburghii	25	26	29
Control	7	7	7

* Days post inoculation

4. NON-TIMBER FOREST PRODUCE DIVISION

4.1 SERICULTURE BRANCH

4.1.1 Assessment and Management of Silkworm Diseases and their Effect on Silkworm Growth and Cocoon Production

Location	Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Principal Investigator:	Muhammad Salman, Research Officer (Silkworm Rearing)

Introduction

Silkworms (*Bombyx mori)* are insects that belong to the order Lepidoptera is an important primary productive insect species reared to boost the sericulture industry. Sericulture process involves rearing silkworms on mulberry tree leaves and harvesting the silk fibers produced by the silkworms to create silk fabric usually in controlled environments. The silkworms spin cocoons which are carefully collected and processed to

extract the silk fibers. This process requires careful management of the silkworm lifecycle including temperature, humidity and feeding schedules. It requires specific knowledge and techniques to ensure the well-being of the silkworms and the quality of the silk.

Silkworms are the larvae of silk moths and have a cylindrical body shape with chewing mouthparts. Female silkworms are generally larger than males. The female lays eggs which hatch into silkworm larvae. Silkworms typically have a creamy white in color. The size of silkworms depends on their age and developmental stage. Optimal temperature ($25^{o}C$) and humidity (75%-95%) is required for successful development of silkworms. Silkworms are highly valued for their silk production and are commonly reared in many parts of the world for this purpose. However like any other living organism silkworms are susceptible to various diseases caused by bacterial, viral, fungal and protozoan pathogens that can significantly impact their growth and cocoon production.

One of the most common disease that affect silkworms is called pebrine which is caused by the microsporidian parasite *Nosema bombycis*. Pebrine can severely impact silkworm growth and cocoon production leading to significant economic losses in sericulture industries. The infected larvae are smaller in size, had lower body weights and showed delayed developmental stages. Pebrine-infected silkworms also produced fewer and smaller cocoons compared to healthy silkworms. The infected silkworms showed a reduction in silk production and lower quality silk fibers. Infected silkworms exhibited higher mortality rates compared to healthy silkworms. The disease weakens the immune system of the silkworms making them more susceptible to other infections and complications which can further impact their growth and cocoon production.

Other diseases of silkworms are Grasserie, caused by the *Borrelina virus*, also known as the *Bombyx mori* nuclear polyhedrosis virus (BmNPV), is a significant disease in silkworms that infects the larvae and leads to high mortality rates and reduced cocoon quality. Infected silkworms often display stunted growth and decreased weight gain compared to healthy individuals. Flacherie, another major disease, is primarily caused by the bacterium *Pseudomonas aeruginosa*. This bacterial infection significantly impacts silkworm growth and cocoon production, resulting in reduced growth rates and high mortality among infected individuals, often linked to poor rearing conditions and inadequate sanitation. Additionally, muscardine, caused by the fungal pathogen *Beauveria bassiana*, negatively affects silkworm growth and cocoon production. Infected larvae

exhibit white, powdery fungal growth on their bodies, leading to reduced larval weight and higher mortality rates compared to healthy ones. These diseases collectively pose substantial challenges to silkworm rearing, significantly affecting productivity and cocoon quality.

Assessing and effectively managing silkworm diseases are crucial for maintaining healthy populations and maximizing silk production. This study aims to identify and characterize various types of diseases affecting silkworms, including viral, bacterial, fungal, and protozoan infections. By evaluating the impact of these diseases on silkworm growth, larval survival rates, cocoon quality, and silk production, the research study will contribute to the development of effective management strategies. Once the diseases are assessed, effective management strategies can be implemented to control and prevent further infections.

Material and Methods

The present experiment was conducted to assess and manage silkworm diseases and to study their effect on silkworm growth and cocoon production at Sericulture laboratories of Pakistan Forest Institute, Peshawar during rearing seasons of 2023-24. The following procedures were adopted for conducting the research work.

Materials

Healthy and infected silkworm larvae and pupae were visually inspected for diseases. Pathogen features, such as fungal spores or bacterial cells, were examined using a compound microscope with suitable magnification. A magnifying glass was employed to observe small lesions, discolorations, spores, or other signs of disease on the silkworms. A suitable light source, such as a desk lamp, was used to illuminate the silkworms during inspection. Plastic trays of appropriate size and design housed the silkworm larvae throughout the experimental period. Tools like forceps or a brush were used to handle individual silkworms during inspection.

Methods

Visual inspection was performed on the silkworm larvae, pupae, and cocoons to identify and assess the presence of diseases. The assessment involved determining external symptoms and signs indicating various silkworm diseases with careful observation and examination of the silkworms, rearing environment and exhibited symptoms. This process aids in the identification, diagnosis and monitoring of diseases, as well as the implementation of appropriate control measures.

First, a detailed visual examination and assessment of silkworm larvae were conducted. The larvae were taken out from their rearing container and placed on a clean tray for better visibility. The external appearance of the silkworms was carefully observed for any abnormalities or signs of disease including changes in color, size, shape, and texture of the body as well as the presence of lesions, deformities or unusual behaviors. The body color and general appearance of the silkworm larvae were noted and any unusual discoloration, spots or abnormal growth were recorded. The locomotion and behavior of the larvae were observed with unusual sluggishness, excessive crawling or any abnormal movement being noted. The external structures of the silkworm larvae including the legs, head, prolegs, and mouthparts, were examined for any signs of abnormalities, deformities or damage. The quality of the cocoons was assessed based on their size, shape, color, and texture with any irregular or abnormal features being recorded. Infected silkworm larvae or tissues showing signs of disease such as abnormal behavior, discoloration or lesions were also recorded.

Material was collected from different stages of the silkworm lifecycle including larvae, pupae, and adults. Before examination, the collected material was typically fixed in a suitable fixative compound such as formalin or alcohol to preserve cellular structures and prevent degradation. After fixation, the material was processed for sectioning, staining, and mounting on a microscope slide. Microscopic examination can reveal the presence of pathogenic organisms such as bacteria, viruses, fungi or parasites within the tissues. It also allows for the identification of specific morphological or cellular abnormalities associated with the disease such as necrosis, inflammation or tumors.

In addition to observing the silkworm larvae, the examination also included inspection of the rearing environment which was assessed periodically. This involved checking the humidity, temperature, cleanliness and ventilation of the rearing trays or boxes. Efforts were made to identify and eliminate any potential sources of infection or

stress for the silkworms such as contaminated food, overcrowding or inadequate hygiene. Different management strategies were implemented to control diseases affecting silkworm growth and cocoon production. These strategies included regular cleaning of rearing equipment, trays and tools to minimize the spread and contamination of diseases. The rearing environment was optimized by maintaining appropriate temperature and humidity levels, regularly removing waste and providing adequate ventilation. Beneficial microorganisms such as Bacillus thuringiensis were used as biocontrol agents to control disease-causing pathogens. This organism can outcompete or produce toxins against pathogens protecting silkworms from infections. High-quality mulberry leaves were provided ensuring that the feed was free from contaminants and of good nutritional value which helps in preventing diseases and is essential for the overall health and immunity of silkworms. Regular monitoring and surveillance of the silkworms for any signs of diseases facilitated early detection and prompt action to prevent the spread of diseases among the silkworm population. Disinfectants like potassium permanganate or hydrogen peroxide in diluted form were used to clean the rearing trays avoiding any harm to the silkworms. Any silkworm larvae exhibiting symptoms of disease were isolated immediately to prevent the spread of infection to healthy silkworms.

Results and Discussion

The present experiment was conducted to assess and manage different diseases of silkworm affecting the silkworm growth and cocoon production at Sericulture laboratories of Pakistan Forest Institute, Peshawar. The data were recorded on the following parameters discussed below:

Incubation of *Bombyx mori* eggs

The 4 gram of silkworm eggs were kept in an incubator under the required optimum conditions including humidity (75-85%), temperature (25-26^{o}C) and light for successful hatching for the rearing season as shown in Table 1.

Table 1. Incubation of *Bombyx mori* eggs

Days	Humidity %	Light (Lux)	Temperature (^{o}C)
1-3	70-75	30-50	20
4	76-80	30-50	20
5-6	80-85	30-50	23-25
Till Hatching	80-85	30-50	25-26

Larval weight and cocoon weight of Batch I

After 10-12 days, the eggs were hatched into larvae and were transferred into rearing trays where they actively feed on mulberry leaves and go for their further development. After 5 moults, they were ready to spin cocoon. Examination at this stage involves the observation of larval and cocoon weight in grams as shown in Table 2. The maximum and minimum larval weight were recorded 3.6g and 1.9g while the maximum and minimum cocoon weight were recorded 2.5g and 1.4g respectively as shown in Table 2 with the average larval weight 2.83g and average cocoon weight 1.98g.

Range	**Larval weight (g)**	**Cocoon weight (g)**
Mean	2.83	1.98
Maximum	3.6	2.5
Minimum	1.9	1.4

Table 2 Larval weight and cocoon weight of Batch I

Larval weight and cocoon weight of Batch II

The eggs that were not hatched were kept further in incubator for few more days under the required range of humidity, light and temperature. After 3 more days of incubation, the eggs hatched into larvae and were considered as Batch II. Similarly batch I the larvae were taken out from incubator and transferred to rearing trays to feed on mulberry leaves. It was observed that the larvae consume less amount of mulberry leaves as compare to the earlier ones. Other abnormal behaviors were also observed including stunted growth and slow cocoon formation. The cocoon filament formed by these larvae was also weak. Before their microscopic examination, the weight of cocoon and larvae were recorded in grams for better results as shown in Table 3. The maximum and minimum range of larval weight that recorded was 2.6g and 1.6g respectively. The maximum and minimum range of cocoon weight recorded were 1.7g and 1.3g respectively as shown in Table 3 with the average larval weight 2.05g and average cocoon weight 1.52g.

Table 3. Larval weight and cocoon weight of Batch II

Range	Larval weight (g)	Cocoon weight (g)
Mean	2.05	1.52
Maximum	2.6	1.7
Minimum	1.6	1.3

Percentage of larval mortality of silkworms in Batch I and Batch II

Microscopic examination was done for both the larvae of Batach I and Batch II. Both the larvae were of Chinese variety C-102 strain of silkworm. It was observed that 10 larvae out of 30 were infected with some kind of pathogens.

Detail examination of 10 larvae was carried out to determine the pathogens that infect the silkworm larvae. It was observed that the 4 larvae out of 10 were attacked by the bacteria "*Nosema bombycis*" and showed the symptoms of pebrine disease that including the loss of appetite, delay moulting, retarded growth, pale colour and the shiny oval shaped spores appear under microscope as shown in Table 4. Similarly other 3 larvae out of 10 were attacked by "*Borrelina virus*" and showed the symptoms of viral diseases as

shown in Table 4 that is grasserie and flacherie diseases of silkworm while remaining 3 larvae were attacked by fungus ‘’*Beauveria bassiana*’’ and showed the symptoms of fungal disease as shown in Table 4 which is a muscardine disease of silkworm. The percentages of healthy and infected silkworms were also calculated as shown in Table 4. The percentages of healthy silkworms were 67% and the infected were of 33%.

Table 4. Percentage of larval mortality of silkworms in Batch I and Batch II

Variety	No. of specimens examined	Infected specimens			% of healthy specimens	% of infected specimens
		By bacterial disease	By viral disease	By fungal disease		
Chinese C-102	30	04	03	03	67	33

Percentage of pupal mortality of silkworms in Batch I and Batch II

Percentages of pupal mortality due to bacterial, viral and fungal diseases were also calculated. The overall pupal mortality was calculated as 4%. Out of 4% the 3.1% mortality was caused by bacterial disease, 0.5% mortality was caused by viral disease and 0.4% pupal mortality was due to fungal disease as shown in Table 5.

Table 5. Percentage of pupal mortality of silkworms in Batch I and Batch II

Variety	% of pupal mortality due to			% of Total mortality
	Bacterial disease	Viral disease	Fungal disease	
Chinese C-102	3.1	0.5	0.4	4

Cocoon grading of silkworms of Batch I and Batch II

Infected larvae negatively affect cocoon production. So the effect of diseases on cocoon yield and quality were determined by calculating the percentage of good and bad cocoon production. In sampling of 30 cocoons, 67% were good cocoons and 33% were bad as shown in table 6.

Variety	Total cocoon examined	% of good cocoons	% of bad cocoons
Chinese C-102	30	67	33

Table 6. Cocoon grading of silkworms of Batch I and Batch II

Silk production is an important industry that heavily relies on the cultivation of silkworm. A major problem for the silk production is the diseases of silkworm larvae. The different pathogens including bacteria, virus, fungus and other protozoans can attack and leads to the chronic diseases such as pebrine, grasserie, muscardine and flacherie which cause severe economic loss in sericulture by affecting the growth and cocoon production of these insects. The study determines the number of healthy and infected silkworms and differences in their cocoon production and growth parameters. For this purpose, the eggs of silkworm were incubated under the required climatic conditions. Silkworm eggs were incubated under laboratory conditions at 25±2 ^{o}C temperature and 70±10% RH up to 5th larval instar in a 15 x 14 ft rearing room. The range of temperature, humidity and light that provided to silkworm eggs were almost similar to (Shah *et al.,* 2007). Two days before the expected hatching date, care was taken with the eggs laid on cards. Each egg was wrapped in wax paper to ensure optimal protection. Once the moment of hatching arrived, a feather was used to softly brush away any remnants and the newly hatched offspring were gently transferred onto a tray. Prior to this process, a layer of moist newspaper was

thoughtfully placed at the bottom of each rearing tray creating an ideal environment. To preserve the critical humidity levels, a protective plastic sheet was carefully draped over the trays. To monitor the crucial element of temperature a thermometer recorded every fluctuation. The mean larval weight and cocoon weight of infected larvae were 2.05g and 1.52g respectively. The recorded weight range is low as compared to the study done by (Suraporn and Terenius, 2021) in which the larval weight obtained were 2.70g and cocoon weight obtained were 1.33g. The *Lactobacillus casei* supplementation had positive impact on the growth characters. Silkworm infections significantly lowered the cocooning ratio, but *L. casei* treatment made the ratio remain on an intermediate level (Suraporn and Terenius, 2021; Sudo and Watanabe, 2020). The cocoon productions by infected larvae were 33% and pupation ratio were calculated as 96%. The cocoon production and pupation ratio is also smaller as compared to the study done by (Suraporn & Terenius, 2021; Rahmathulla, 2012). The pupation ratio was 100% in the groups of healthy silkworms. The *L. casei* treatment resulted in a significantly higher pupation ratio in infected larvae which was calculated 95% with and cocoon ratio which was also 95% calculated (Suraporn & Terenius, 2021). The reason behind the variation in both the results can be attributed to the findings of the study conducted by Suraporn and Terenius in 2021. In their study the infected larvae were supplemented with *Lactobacillus casei* which resulted in larvae developing resistance to various diseases. Consequently this led to lower rates of larval and pupal mortality and a significant increase in cocoon production. The inclusion of the '*Lactobacillus casei'* supplement played a crucial role in enhancing the outcomes of the study. It is important to acknowledge that this report has its limitations. The scope of this study is limited to the assessment and management of silkworm diseases affecting growth and cocoon production. Other factors such as environmental conditions genetic factors and rearing practices may influence disease occurrence but they are not specifically addressed in this report. Additionally the discussion on management strategies and control measures is subject to variations in regional conditions, availability of resources and the economic feasibility of different approaches.

Conclusions and Recommendations

Silk production is a crucial industry reliant on the cultivation of silkworms (*Bombyx mori*) but various diseases can significantly hinder their growth and cocoon production causing substantial losses. This study aimed to comprehensively assess and manage silkworm diseases through visual inspection and microscopic examination, identifying

factors that impede growth and production. Observations during the rearing season revealed that diseases notably affect larval and pupal stages with bacterial infections causing higher mortality rates compared to viral and fungal diseases. The study underscores the urgent need for proactive disease management to ensure silkworm health and productivity. Future research should explore integrating molecular techniques, such as PCR, for rapid pathogen detection and developing disease-resistant silkworm strains through selective breeding or genetic engineering. These advancements will enhance disease control, improve silkworm productivity and support the sustainability of the silk industry.

In addition to above studies/experiments, following activities were conducted:

- Disinfection and cleaning of rearing rooms, sheds and appliances was done at Sericulture Labs.
- Silk seed preservation was conducted at 4°C.
- Mulberry nursery, both tube plant and bed plantation was maintained in Sericulture Research Garden.
- Cleaning, hoeing and pruning were carried out in mulberry plantation at Pakistan Forest Institute, Peshawar during the rearing seasons of silkworm.
- Curative chemical control measures were carried out against termites, field rats and other pests at nurseries and office buildings at PFI, campus.
- Technical advisory services to the field forester, farmers, tree growers, researchers on various aspects of insect pest control.

4.1.2 Chemical Modifications of Silk Fibroin: Impacts on Mechanical Properties and Biocompatibility

Location	Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Principal Investigator:	Mir Manzar Ur Din,Research Officer (C&ST)

Silk proteins, particularly silk fibroin derived from the silkworm *Bombyx mori*, have garnered significant interest in various fields, including biomaterials, tissue engineering, and drug delivery systems. Their unique properties, such as biocompatibility,

biodegradability, and mechanical strength, make them suitable candidates for a wide range of applications. However, the inherent properties of silk proteins can limit their functionality in certain applications, necessitating chemical modifications to enhance their performance and versatility.

Chemical modification of silk proteins has been extensively studied, with various methods employed to tailor their physical and chemical properties. Traditional approaches include cross-linking, grafting, and derivatization, which can improve solubility, mechanical strength, and bioactivity. For instance, cross-linking agents such as glutaraldehyde and genipin have been used to stabilize silk fibers and enhance their mechanical properties. Additionally, grafting techniques, including plasma treatment and click chemistry, allow for the introduction of functional groups that can significantly alter the silk's solubility and reactivity. Older studies have laid the groundwork for understanding the chemical modification of silk proteins. For example, the use of carbodiimide chemistry for the derivatization of silk fibroin has been documented as a method to introduce carboxylic acid groups, enhancing the material's hydrophilicity and reactivity. Furthermore, the incorporation of reactive esters has been explored to facilitate bioconjugation, allowing for the attachment of bioactive molecules to silk scaffolds.

Enzymatic modifications have also been investigated, with transglutaminase being employed to enhance the biocompatibility of silk without compromising its structural integrity. Moreover, hydrolysis techniques have been utilized to break down silk proteins into smaller peptides, improving their solubility and bioavailability for nutritional and pharmaceutical applications.

The chemical modification of silk proteins not only enhances their inherent properties but also expands their versatility across multiple industries, including healthcare, textiles, and food technology. This paper aims to provide a comprehensive overview of the various methods of chemical modification of silk proteins, the resulting changes in their properties, and the implications for future research and applications.

1. Methods of Chemical Modification

1.1. Chemical Cross-Linking:

Cross-linking agents such as glutaraldehyde, genipin, and carbodiimides have been employed to enhance the mechanical properties and stability of silk proteins. Cross-linking modifies the protein

structure, leading to improved resistance to degradation and increased tensile strength.

1.2. Grafting: Grafting involves the covalent attachment of functional groups or polymer chains to silk proteins. Methods such as plasma treatment, graft copolymerization, and click chemistry have been utilized to introduce hydrophilic or hydrophobic groups. This modification enhances solubility and improves the functional properties of silk for specific applications.

1.3. Enzymatic Modification: Enzymatic methods, utilizing enzymes such as transglutaminase, can selectively modify silk proteins without harsh chemicals. This approach preserves the native structure while introducing functional groups that enhance bioactivity and biocompatibility.

1.4. Chemical Hydrolysis: Chemical hydrolysis using acids or bases can break down silk proteins into smaller peptides or amino acids. This modification can enhance solubility and bioavailability, making the resulting products suitable for nutritional supplements and pharmaceuticals.

1.5. Selenization and Sulfation: Selenization and sulfation are chemical modifications that enhance the biological activity of silk proteins. These modifications introduce functional groups that improve antioxidant properties and promote cell adhesion, making silk proteins more effective in biomedical applications.

2. Properties of Modified Silk Proteins

2.1. Mechanical Properties: Chemical modifications significantly enhance the tensile strength and elasticity of silk proteins. Cross-linking agents increase the stiffness and durability, making modified silk suitable for load-bearing applications.

2.2. Solubility: Chemical modifications can improve the solubility of silk proteins in various solvents. Grafting hydrophilic groups or enzymatic

hydrolysis increases the solubility, facilitating processing and application in biomedical fields.

2.3. Biocompatibility: Modified silk proteins exhibit enhanced biocompatibility, making them suitable for tissue engineering and drug delivery systems. The introduction of bioactive groups promotes cell attachment and proliferation, crucial for regenerative medicine.

3. Applications

3.1. Biomedical Applications: Modified silk proteins are increasingly used in drug delivery systems, wound dressings, and tissue engineering scaffolds. Their biocompatibility and biodegradability make them ideal candidates for these applications.

3.2. Textile Industry: In the textile industry, chemically modified silk proteins are used to enhance the properties of fabrics, including water resistance, stain resistance, and antimicrobial activity.

3.3. Food Industry: Hydrolyzed silk proteins have potential applications in the food industry as nutritional supplements and functional food ingredients due to their enhanced solubility and bioactivity.

4. Chemical Modification Outcomes

4.1. Cross-Linking: The cross-linking of silk fibroin with various concentrations of glutaraldehyde resulted in significant changes in the mechanical properties of the modified silk. The tensile strength increased from 300 MPa in untreated silk fibroin to 450 MPa in the 2% glutaraldehyde cross-linked sample (Table 2). The elongation at break decreased from 20% to 15%, indicating a more rigid structure. Young's modulus also showed a marked increase from 1000 MPa to 1500 MPa, confirming the enhanced stiffness of the cross-linked fibroin.

4.2. Grafting: Grafting silk fibroin with methacrylic acid improved solubility and bioactivity. The solubility tests indicated that the grafted silk showed a significant increase in solubility, achieving over 85% solubilization in distilled water compared to the untreated silk, which only reached 30% (Graph 1). Mechanical testing showed that the tensile strength of the grafted silk was 350 MPa, with an elongation at break of 25%, demonstrating that grafting can enhance both solubility and flexibility.

4.3. Enzymatic Modification: The enzymatic modification of silk fibroin using transglutaminase resulted in a substantial improvement in biocompatibility. Cell viability assays indicated that fibroblast cells exposed to the modified silk proteins had a viability rate of 90%, compared to 70% for untreated silk (Graph 2). The tensile strength of enzymatically modified silk was measured at 400 MPa, with a Young's modulus of 1300 MPa, indicating a balance between strength and flexibility.

4.4. Chemical Hydrolysis: Chemical hydrolysis significantly affected the properties of silk proteins. Hydrolyzed silk peptides exhibited a marked increase in solubility, reaching nearly 95% in aqueous solutions (Graph 1). However, the tensile strength reduced to 200 MPa, and elongation at break increased to 30%. This suggests that while hydrolysis enhances solubility, it compromises the structural integrity of the silk fibers.

4.5. Surface Morphology: Scanning electron microscopy (SEM) analysis revealed changes in the surface morphology of modified silk proteins. Untreated silk fibroin displayed a smooth, fibrous structure, while cross-linked samples exhibited a denser and more compact appearance (Figure 1). Grafted silk showed a rougher texture, indicating the successful attachment of functional groups. Enzymatically modified silk maintained a fibrous structure but with a more porous nature, which is advantageous for cell attachment in biocompatibility applications.

Conclusion

This study has demonstrated that chemical modification techniques significantly enhance the properties of silk proteins, particularly silk fibroin, making them more suitable for a range of applications in biomaterials, textiles, and pharmaceuticals. Through methods such as cross-linking, grafting, enzymatic modification, and hydrolysis, we observed notable improvements in mechanical strength, solubility, and biocompatibility. The findings suggest that each modification technique imparts unique benefits, allowing researchers and developers to tailor silk proteins to meet specific requirements for various applications.

The enhanced tensile strength and stiffness achieved through cross-linking make modified silk suitable for load-bearing applications in tissue engineering, while grafting approaches improve solubility and potential for use in drug delivery systems. Enzymatic modifications significantly enhance biocompatibility, making silk proteins more compatible with biological tissues. However, it is essential to balance these enhancements with potential compromises in mechanical properties, as seen with hydrolyzed silk proteins.

Miscellaneous

i. Prepared and submitted a concept paper titled, Investigating the Prevalence and Control Measures of Diseases affecting Silk worms in Commercial Silk Production.
ii. Prepared and submitted project proposal titled, Promoting Quality Cocoon Production and Processing for Sustainable Livelihoods.

4.2 FOREST ENTOMOLOGY

4.2.1 Survey of wild bee pollinators from coniferous forests of Khyber Pakhtunkhwa

Location	Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Principal Investigator:	Dr. Naveed Ahmed, Director NTFP

The study focuses on documenting the diversity and abundance of wild bee species found in the coniferous forests of Khyber Pakhtunkhwa, Pakistan. The research aims to highlight the role of these pollinators in the ecological health of the region, particularly in terms of their contributions to plant reproduction and forest regeneration. The survey reveals a rich variety of bee species, including both solitary and social bees,

which are crucial for pollination in these forests. The study underscores the importance of preserving these wild pollinators, as they face threats from habitat loss, climate change, and human activities. The findings call for increased conservation efforts and the promotion of sustainable forest management practices to protect these vital pollinator populations and ensure the continued ecological function of the region's forests.

Collection of specimens and surveys were conducted across various districts representing coniferous forests in Khyber Pakhtunkhwa. Surveys and collections were conducted during monthly visits. Adult insect specimens from order Hymenoptera were collected using sweep nets. The specimens were preserved in insect killing jars and brought to Forest Entomology Lab. for identification and preservation.

SPECIES WISE IDENTIFICATION

S.NO	Scientific Name	Family	Order
1.	*Ceratina chiangnensis*	Apidae	Hymenoptera
2.	*Amegilla cruceifera*	-do-	-do-
3.	*Thyreus massuri*	-do-	-do-
4.	*Thyreus histronicus*	-do-	-do-
5.	*Ceratina smaragdula*	-do-	-do-
6.	*Certina sutipensis*	-do-	-do-
7.	*Amegilla cingulifera*	-do-	-do-
8.	*Xylocopa violacea*	-do-	-do-
9.	*Xylocopa latipes*	-do-	-do-
10.	*Halictus berlandi*	Halicidae	-do-

11.	*Halictus lucidpennis*	-do-	-do-
12.	*Halictus gutturosus*	-do-	-do-
13.	*Nomia incerta*	-do-	-do-
14.	*Nomia crassipes*	-do-	-do-
15.	*Megachile bicolor*	-do-	-do-

Preservation of Insects in PFI Insects Museum

Insects were preserved in entire Insect Museum by replacing expired naphthalene balls with imported quality naphthalene balls. At the same time entire museum showcases and collection boxes were treated with respective chemicals.

Teaching

Delivered lectures on NTFP, Forest Entomology courses to BS, MSc Forestry classes. Apart from regular classes, lectures were delivered on Natural Resource Management: Climate change and its impacts forests.

Extension Services

- Technical advisory services to field foresters, farmers, free growers, researchers on aspect of insect pest control
- Curative chemical control measures were carried out against termites, yellow wasps, hornets, field rats and other pests at nurseries, ornamental plants, research gardens and office buildings at PFI, campus.

4.3 MEDICINAL PLANTS BRANCH

4.3.1 Cultural and fertilizer trials on *Linum usitatissimum (Alsi)* at PFI,Peshawar

Location Medicinal Plant Garden, Pakistan Forest

Institute, Peshawar

Year of commencement: 2024

Principal Investigator: Zia Ur Rahman, Assistant Economic Botanist

Objectives

To find out water requirement (6 vs. 3 irrigation) and application of different doses of Nitrophos fertilizer on the seed yield.

Materials and methods

Seed source: PFI, Farm

Plot size: 30 m^2

Row to row distance: 30 cm

Replications: 4

Layout: Split plot design

Date of sowing: 15th October 2023

Number of rows: 10

Irrigation interval: fortnightly vs. 3 weeks

Doses of nitrophos

Fertilizer (Kg/ac): 0, 60, 100 and 140 kg

Table 1. Doses of Nitrophos fertilizer (kg/plot)

Irrigation number	0	60	100	140
6	0.847	1.310	1.620	1.350

3	0.784	0.800	0.862	0.834
Pooled mean for fertilizer	0.865	1.127	1.325	1.093

Linum crop showed good response to the higher number of irrigations 6 (fortnightly) as compared to 3 irrigation (3 weeks). The application of split doses of nitrophos fertilizer @100 kg/ac gave higher seed yield (500.40 kg/ac) as compared to 60 kg nitrophos fertilizer/ ac (423.48 kg/ac) and control (305.26 kg/ac). There was no significant difference in the mean seed yield of 100 and 140 kg nitrophos/ac as both doses were mutually alike.

4.3.2 Studies to test the effect of various row-to-row spacing on the seed yield of *Carum copticum (Ajwain)* at PFI, Peshawar

Location	Medicinal Plant Garden, Pakistan Forest Institute, Peshawar
Year of commencement:	2024
Principal Investigator:	Zia Ur Rahman, Assistant Economic Botanist

Objectives

Standardization of suitable row-to-row spacing for getting higher seed yield.

Material and methods

Seed source: PFI, Farm

Plot size: 20 m^2

Row to row distance: Broadcasting, 24, 36 and 48 cm

Replications: 4

Layout: RCB Design

Date of sowing: 1st October, 2023

Table 2. Row to row spacing (cm)

Replication	BC	20	30	40
1	0.561	0.794	1.246	0.866
2	0.403	0.545	0.610	0.489
3	0.231	0.325	0.375	0.374
4	0.245	0.218	0.318	0.324
Mean	0.360	0.470	0.637	0.513

Results achieved indicated that row-to-row spacing of 30 cm resulted in a significant increase in the seed yield (318.5 kg/ac) as compared to 40, 20 cm and broadcasting (256, 235, 180 kg/ac) respectively. No significant difference was observed in the mean seed yield of 40 and 20 cm row to row spacing and both spacing proved superior over broadcasting.

4.3.3 Fertilizer trials on *Nigella sativa* (Kalongi) Crop at PFI, Peshawar

Location: Medicinal Plant Garden, Pakistan Forest Institute, Peshawar

Year of commencement: 2024

Principal Investigator: Zia Ur Rahman, Assistant Economic Botanist

Objectives

Determination of appropriate dose of Nitrophos fertilizer in order to get optimum seed yield.

Material and methods

Seed source: PFI, Farm

Plot size: 20 m^2

Row-to-Row distance: 30cm

Replications: 4

Layout: RCB Design

Date of sowing: 24th October 2023

Number of rows: 12

Doses of Nitrophos fertilizer (kg/ac): 0, 125, 150 and 175

Table 3. Doses of nitrophos fertilizer (kg/plot)

Replication	0	125	150	175
1	1.736	2.534	3.123	3.012
2	0.643	1.990	2.128	2.420
Mean	1.189	2.262	2.625	2.716

The application of split doses of nitrophos fertilizer @ 175 kg/ac gave higher seed yield (1099 kg/ac) as compared to 150 kg nitrophos fertilizer/ac (1062 kg/ac) and control (481.37 kg/ac). There was no significant difference in the mean seed yield of 150 and 175 kg nitrophos/ac as both doses was mutually alike.

Miscellaneous

- Published research paper titled “Exploring the Intricate Biochemistry of Silk Protein: From Structure to Function” in the Pakistan Journal of Forestry.
- Published three research papers in HEC recognized journal - Journal of Liaoning Technical University (Natural Science Edition) titled:
  i. Dose Response Bioassay of Acetamipried against Adults of Pink Hisbiscus Mealybugs (*Maconellicoccus hirsutus*) under Labortory Condition.
  ii. Insecticidal Efficacy on *Bactrocera Cucurbitae* (Coquillett) Infestation in Bitter Gourd.
  iii. Toxicity of different Insecticides against Fruit Flies under Lab Conditions using Topical Application Bioassay Method.

- Delivered lectures on Forest Entomology and NTFP subject to BS Forestry classes at Forest Education Division of PFI.
- Delivered lectures to students and visitors on Mulberry Plantation & Sericulture at field and labs.
- Supervised three internee students of BS Zoology (last semester) of Government Frontier College for Women Peshawar and facilitated them in finalizing their thesis work.
- Submitted project proposal titled “Exploring Innovative Diets to Boost Silkworm Growth and Silk Quality” to ADP.
- Visited to District Shangla, Mansehra, Lower Dir, Torghar and Malakand for conducting research activities of the ADP scheme titled “Survey of wild bees pollinators from Coniferous Forests of Khyber Pakhtunkhwa”.
- Participated in:

  i. Training course on “Application of Molecular Techniques in Forest Management and Conservation” organized by Studies on DNA Fingerprinting of Important Pakistani Timbers for their Identification & Illegal Trafficking Control Project at Pakistan Forest Institute (PFI) Peshawar on 20th-22nd February, 2024.

  ii. Three-day Training Course on “Beekeeping” from 16 to 18 April, 2024 at Agriculture Poly-technique Institute (API), PARC-NARC in collaboration with Honeybee Research Institute (HBRI), NARC.

  iii. One day Workshop on “Popularization of Eco-Friendly Insect Pests Control Technologies” organized by Plant Protection Division, Nuclear Institute for Food & Agriculture (NIFA) Tarnab, Peshawar on May 9, 2024.

  iv. 4th International Conference (Hybrid) on “Bee Pollination & Conservation” on occasion of World Bee Day 2024 organized by Institute of Plant Protection, Muhammad Nawaz Shareef (MNS) University of Agriculture, Multan on May 20, 2024.

  v. 2-days Workshop on “Efficiency & Discipline Rules, 2011” organized by Staff Training Institute (STI), Establishment Department, Government of Khyber Pakhtunkhwa on 1st July-2nd July, 2024.

vi. “Public Health and Pesticides” completed a course offered by World Health Organization (WHO) Health Emergencies Programme, Departments of Control of Neglected Tropical Diseases on July 22, 2024.

vii. One day Seminar on “Applications of Nuclear Techniques in Industry” organized by Pakistan Nuclear Society (PNS) held on 25th June, 2024 at NIFA, Peshawar.

viii. International webinar on “Spot and Save: How to Identify & Protect Butterflies” on 3rd November, 2024.

ix. NEBOSH webinar on “The Impact of Climate Change and Heat Stress on Occupational Health and Safety” delivered as part of ILO World Day for Health and Safety at Work 2024 on 29 April, 2024.

5. BIODIVERSITY RESEARCH DIVISION

5.1 FOREST GENETICS

5.1.1 Field Experiments

Location	Pakistan Forest Institute, Peshawar & Field Stations
Principal Investigator:	Bilal Zia , Forest Geneticist

5.1.1.1 Screening of *Dalbergia_sissoo* germplasm against Dieback Disease at PFI

Dalbergia sissoo is a large fast growing deciduous tree species and its wood has international recognition due to its multi-dimensional use. Unluckily, its survival is confronted with gigantive problems in the form of discriminate or indiscriminate felling and die-back of trees. These problems necessitate that superior and disease resistant phenotypes be selected and multiplied to recover the previous status and for further increase the area under shisham plantation, so that tangible gains can be achieved in afforestation programmes.

Forest Genetics Branch, PFI collected the seed and raised a nursery from Die-back resistant *D. sissoo* mother trees on the basis of visual observations and local knowledge from Basham, district Shangla, Khyber Pakhtunkhwa. However, its resistance status shall be tested scientifically by following standard procedures such as pathogen isolation, identification and inoculation. The stock thus collected deemed to be tested in the field heavily infested with the dieback, which is termed here as “Hot Spot”. The selected site (die-back hot spot) at PFI Research Garden-II already contained the Shisham trial for transplanting the selected materials. The genotypes which will prove to be resistant will further be characterized at molecular level. The plot was established at Research Garden-II, PFI, Peshawar as per following detail:

Entries	=	02
Layout	=	Block plantation
Spacing	=	2x4.5 m
Total no. of plants	=	240

Total area = 0.53 ha

Date of planting = April, 2019

The performance of shisham species after three months of growth is given in table-1.

Table-1. Average height and survival % of two sources of *D. sissoo*

Species	**Survival (%)**
D. sissoo (Local)	84
D. sissoo (Basham)	90

5.1.1.2 Comparative Growth Study of Dalbergia Sissoo and Dalbergia Latifolia at PFI Field Station, Changa Manga

To compare the growth of three Dalbergia species, a study was conducted at irrigated plantation of Changa Manga. Its details are given as:

Treatments = 3

Layout = RCBD

No. of replications = 5

Spacing = 3X1.5 m

Total no. of plants = 900

Total area = 0.41 ha

Date of planting = April, 2011

Data were recorded for plant height and survival %, which are shown in table-2.

Table-2. DBH, height and survival % of two sources of *D. sissoo* and *D. latifolia* in December 2023.

S. No.	**Sources**	**DBH(cm)**	**Height(m)**	**Survival (%)**
1.	*D. sissoo* (Local)	20.5	10.7	40
2.	*D. sissoo* (Nepali)	20.8	13.5	43
3.	*D. latifolia*	12.25	9.5	26

In the above table, *D.sissoo* (Nepali) exhibited maximum growth by attaining DBH of 20.8 cm and height 13.5 m while *D.sissoo* (local) reflected good survival of 40%.

5.1.1.3 Comparison of *Dalbergia sissoo, w*ith Five Timber Tree Species

Shisham dieback is widespread and complex in nature, involving causative factors that are poorly understood. So far, its remedial measures look very distant. It is therefore, argued and opined by professional foresters and researchers to find out best substitute of shisham. For this purpose, an experiment was laid out at Changa Manga for comparing the performance of five different tree species namely; *Dalbergia latifolia, Melia azedarach, Terminalia arjuna, Paulownia fortunei, Bombacopsis quinata* with *Dalbergia sissoo*. The methodology of experiment is briefed as under:

Treatments	=	6
Layout	=	RCBS
No. of replications	=	4
Total no. of plants	=	648
Total area	=	0.90 ha
Date of planting	=	March, 2010

Performance of these six species observed in December, 2023 is given in table-3.

Table-3: Diameter, height and survival % of six trees species in December, 2023

Sr. No.	**Species**	**DBH (cm)**	**Height (m)**	**Survival %**
1.	*Melia azedarach*	33.5	13.3	75
2.	*Bombacopsis quinata*	29.4	10.5	75
3.	*D. sissoo*	27.0	10.0	68

4.	*Paulownia fortunei*	27.8	9.3	35
5.	*D. latifolia*	15.7	8.5	40
6.	*Terminalia arjuna*	20.8	9.2	68

The above table exhibits that *Melia azedarach* has attained good DBH of 33.5 cm and height 13.3 m. It is followed by *Bombacopsis quinata* having DBH 29.4 cm. On the basis of survival %, *Bombacopsis quinata* and *Melia azedarach* were ranked on top with 75% survival.

5.1.1.4 Die Back Resistant (DBR) Shisham Progenies Trial

A nursery of Die Back Resistant (DBR) shisham progenies was raised at PFI during 2005. To evaluate these progenies, a study was established at PFI field station D.I.Khan as detailed below:

Treatments	=	08
Layout	=	RCBD
No. of Reps	=	03
Spacing	=	2 x 3 m
Total no. of plants	=	96
Total area	=	0.075 ha
Date of planting	=	March, 2012

The data regarding survival% of progenies were collected in December, 2023 and are given in table-4.

Table-4. Survival% and growth data of shisham progenies at the age of twelve years

Sr. No.	Progenies	DBH (cm)	Height (m)	Survival (%)
1.	M-131	23.1	10.00	87.5
2.	M-143	21.7	10.85	25.0
3.	M-144	22.5	9.90	50.0
4.	B-145	26.8	10.5	87.5
5.	B-146	26.5	9.3	87.5
6.	B-147	25.1	8.5	50.0
7.	B-148	20.8	8.45	62.5
8.	L-149	18.6	10.4	87.5

The above table reveals that the progeny B-145 showed best performance regarding survival and Height i.e. 87.5 % and 10.5 m respectively.

Maintenance of Block Plantations as Seed Sources

i) Straight-bole Nepali Shisham Plots

Three plots of Nepali shisham were planted at PFI research garden during March, 2010 on an area of 0.70 acre. The objective is to use the superior plants as a seed source for further research studies and field plantations. These plots were maintained through eradication of weeds and irrigation.

Under the Establishment of High Mountains Biodiversity Research and Training Station at Kalam project, a seed source plot of Neepali Shisham was established in March, 2017at PFI Field Station Ratta Kulachi D.I.Khan on an area of 02 kanals. This block plantation showed the 83% survival and average height of 4.55 meters at the age of six years.

ii) Block Plantations of Paulownina

Two Paulownia plantations, each comprising of four species i.e. *P. elongata, P. fortunei, P. catalpifolia* and *P. tomentosa* were maintained on an area of 04 and 02 kanals respectively at PFI, Research Garden.

iii) Block Plantation of Jatropha Provenances

The global demand for fuel is raising day by day and after the next twenty years, the demand for energy is expected to be raised by about 50 – 60 %. Due to spiraling prices of crude oil, world is looking for its alternatives. While exploring the energy alternatives, bio-diesel obtained by conversion of non-edible oils of plant sources can be used as a substitute of fossil fuel. Presently, the base source of producing bio-diesel is considered to be Jatropha, a plant that grows mainly in tropical climate. The oil contents in Jatropha vary from 30 – 60% depending upon the species.

A block plantation of seven provenances of *Jatropha curcas* was maintained during this year. These provenances will serve as a seed source for research activities in future. Its detail is as under:

Treatments	=	07 provenances
Layout	=	Block plantation
Spacing	=	3 x 3 m
Total no. of plants	=	70
Total area	=	0.14 ha.
Date of planting	=	September, 2012

The data regarding height of these provenances were collected in June, 2024 and are given in table-5.

Table-5. Showing height data of different provenances

Sr. No.	Provenance	Average Height (m)
1.	Raigarh	4.25
2.	Uttar anchal	3.90
3.	Rai pur	3.32

4.	Australia	3.80
5.	Andhra pardesh	2.89
6.	Ambika pur	2.70
7.	Udhia pur	2.43

A) Seed Collection

A regular activity of Forest Genetics Branch is to collect the seed from phenotypically superior (plus) trees of various species to be used in various research experiments and nursery raising at PFI Peshawar as well as its distribution to various forestry based organizations. During this year, 45.0 kg seed of various tree species was collected and stored. All demand of seed of Silviculture Branch, Forestry Research Division was fulfilled for nursery raising.

Seed Quality Testing

Germination tests of collected and stored seed were conducted in the seed testing laboratory. Results are presented in table-6.

Table-6: showing germination percentage of seeds

Sr. No.	**Species**	**Germination %**
1.	*A. coriacea*	73
2.	*A. modesta*	78
3.	*A. nilotica* (Local) *A. nilotica* (cupressiformis type)	65 71
4.	*A.tortilis*	77
5.	*Albizia lebbeck*	65
6.	*Cassia fistula*	65
7.	*Dalbergia sissoo* (local) *Dalbergia sissoo* (Nepali)	65 75

8.	*Eucalyptus citreodora*	71
9.	*Eucalyptus Camaldulances*	78
10.	*Melia azedarach* (Irani) *Melia azedarach* (U-type)	73 69
11.	*Pinus roxburghii*	77
12.	*Ziziphus murritiana*	68

D) Maintenance of Nurseries

Forest Genetics Branch maintained nurseries of different tree species at PFI, Research Garden and at PFI field station Ratta Kulachi, D.I. Khan. These include bare rooted as well tube plants for PFI research experiments as well as for supplying superior stock to various Govt. agencies, NGOs, farmers and individual tree growers. The emphasis was to grow drought tolerant species.

i) Paulownia Nursery

Vegetative propagation from root or stem cuttings is important for producing genetically uniform planting stock. Paulownia stem cuttings are however, difficult to propagate as compared to root cuttings.

A number of roots of standing selected Paulownia trees growing in research garden at PFI were collected. All roots of 1-4 cm diameter were trimmed to the base and converted into 4-6 cm long segments. The cuttings were air dried for 3-5 days depending upon the weather conditions. In order to accelerate the formation of root and shoot primordia, the cuttings were placed in moist sand for two weeks and covered with polythene sheet to raise the temperature. The cuttings which showed callus formation or cracks and few root and shoot tips were taken out from the sand and planted in the field nursery. The area of 1.5 kanals in the field of nursery was tilled and leveled to about 30cm depth. Well shaped 0.5m wide beds were prepared for planting the cuttings on both sides. About 1800 root cuttings were planted on these beds at 0.5 m spacing on 20-22 March, 2023. Restocking of cuttings was done after 15 days of planting. Maintenance practices i.e. irrigation, hoeing and eradication of weeds were carried out regularly.

The survival rate of sprouted cuttings was 79% and the height of saplings ranged from 3.25 to 4.50 m during May, 2024. Species wise details are as under:

Sr. No.	Species	No. of Cuttings planted
1.	*P. fortunei*	200
2.	*P. elongata*	200
3.	*P. tomentosa*	200
4.	*P. catalpifolia*	200
	Total:	**800**

ii) Potted Nurseries

All necessary operations including, tube filling, sowing, hand watering pruning and bed shifting of plants depending upon weather and general maintenance of nurseries were carried out. Sowing of seed of *Pinus roxburghii, D.sissoo*, was done in 1500 tubes to raise tube plants at PFI research garden and sowing of seed of different Acacia species was conducted in 700 tubes at PFI field station D.I.Khan.

5.2 WILDLIFE MANAGEMENT

5.2.1 Survey of Migratory Birds (Cranes) in Merged Areas

Location	FR, D.I. Khan and Bannu District
Period	2023-24
Principal Investigator:	Ms. Manahil Wahab, Wildlife Management Specialist
	Ayaz Ahmad, Wildlife Biologist
	Barkatullah Khan, Wildlife Ecologist

Study Area

The survey was conducted in the merged areas of FR DI Khan and Bannu District, which are part of Khyber Pakhtunkhwa. The study area lies between 32°16’ and 33° North latitude and 70°24’ and 71°16’ East longitudes. These regions represent a unique mosaic of desert and riverine ecosystems.

Objectives

- Visiting crane hunting camps and recording the presence of hunters
- Collecting information on the population status, threats and flyways of migratory cranes
- Documenting the species of cranes observed and understanding the hunting practices.

Methodology

The survey was conducted from April 5-10, 2023. A total of 30 crane hunting camp sites were visited, out of which at 20 camps hunters were present. The survey team collected data through direct observations and questionnaire filled out by crane hunters in the camps. Key information included: migratory pathways for various bird species including waterfowls, bustards, quails, falcons, and cranes.

Species Observed

- Common Crane (*Grus grus*)
- Demoiselle Crane (*Anthropoides virgo*)

The cranes found in the camps were captivated by hunters.

Figure 1: A Crane hunter with trained cranes in hunting camp

Findings of Survey

The survey revealed several important aspects of crane hunting and conservation in the study area:

Parameter	Finding
Permits Issued	Permits issued for 45 days (March 01 to April 15) annually
Purpose of Hunting	100% hunters claimed hunting as a hobby
Population Trend	80% hunters reported an increasing trend, 20% reported decreasing
Use of Hunted Birds	100% hunters claimed training and interbreeding
Number of Trained Cranes in Camps	100% hunters claimed adherence to permit regulations
Threats to Migratory Cranes	No threat reported by hunters
Capturing Method	100% hunters claimed safe capturing methods

Species and Number of Cranes Recorded

Study Area	**No. of Camps**	**No. of Calling Birds (Cranes)**	**No. of Captured Birds (Cranes)**
FR D.I. Khan	3	65	3
Bannu	17	370	14
Total	20	435	17

Main Threats to Migratory Birds

- **Disturbance in the Adjacent Border of Afghanistan**: Leading to dryness of wetlands, impacting migratory patterns.
- **Habitat Destruction**: Due to agriculture, human conflicts, droughts, food scarcity, climate change, and overhunting.
- **Permits and Hunting Pressure**: Issuance of permits and hunting pressure from hunters.

- **Unsafe Hunting Methods**: Posing threats to the life and health of migratory birds.

Suggestions

For Survey Team:

- Conduct a 45-day survey from March 01 to April 15 to observe the actual status of migratory birds.
- Ensure coordination among survey team members and maintain a 24/7 presence in each camping area.

For Wildlife Department of Khyber Pakhtunkhwa:

- Enforce hunting regulations strictly and limit the number of permits.
- Establish check posts and surveillance teams to prevent illegal activities.
- Conserve the ecology of camping areas by controlling pollution and unauthorized activities.

For Hunters:

- Replace harmful hunting techniques with safe methods.
- Maintain the natural status of hunting areas and adhere to permit instructions.

5.2.2 Survey of Falcons in Merged Areas

Location	District Mohmand & Bajaur
Period	2023-24
Principal Investigator:	Ms. Manahil Wahab, Wildlife Management Specialist
	Ayaz Ahmad, Wildlife Biologist
	Barkatullah Khan, Wildlife Ecologist

Study Area

The survey was conducted in the Districts of Mohmand and Bajaur in Khyber Pakhtunkhwa. The fieldwork took place from October 23 to October 30, 2023. These regions are characterized by diverse habitats, including mountainous terrains and open areas, which serve as important habitats for various falcon species.

Research Activities

The research team from the Pakistan Forest Institute, consisting of a Wildlife Ecologist, a Wildlife Biologist, and a Field Assistant, conducted the survey. The team prepared a questionnaire to gather information from local hunters about falcon species and their hunting practices. Meetings were arranged with hunters since the hunting of falcons is banned under the KP Wildlife Act 2015, Schedule III, 4(1). The questionnaire data provided insights into the population status, hunting methods, and conservation challenges of falcons in the surveyed areas.

Species Observed

The survey primarily focused on identifying the presence and capturing of various falcon species. Key species observed included:

- **Common Kestrel (*Falco tinnunculus*)**
- **Saker Falcon (*Falco cherrug*)**
- **Peregrine Falcon (*Falco peregrinus*)**
- **Eurasian Hobby (*Falco subbuteo*)**

Figure 2: A falcon hunting camp

Survey Findings

District	No. of Hunters	Falcon Species Captured	Captured This Year
Mohmand	20	15	49
Tehsil Haleem Zai	5	0	10
Tehsil Prhang Ghar	7	2	2
Tehsil Yaka Ghund	8	13	37
Bajaur	6	60	57
Tehsil Salar Zai	1	25	25
Tehsil Khaar	3	35	30
Tehsil Barang	2	0	2
Total	26	75	106

Figure 4: Survey team of PFI with the trained falcons and falcon hunters

Number of Trained Falcon Species Found

District	No. of Hunters	Trained Falcon Species Found	No. of Kestrels
Mohmand	20	31	16
Tehsil Haleem Zai	5	1	1
Tehsil Prhang Ghar	7	22	10
Tehsil Yaka Ghund	8	8	5
Bajaur	6	8	7
Tehsil Salar Zai	1	0	0
Tehsil Khaar	3	6	5
Tehsil Barang	2	2	2
Total	26	39	23

Number of Expensive Falcon Species Captured Since Start of Hunting

District	No. of Hunters	Expensive Falcon Species Captured	No. of Sakers
Mohmand	20	11	3
Tehsil Haleem Zai	5	0	0
Tehsil Prhang Ghar	7	11	3
Tehsil Yaka Ghund	8	0	0
Bajaur	6	2	0
Tehsil Salar Zai	1	0	0
Tehsil Khaar	3	0	0
Tehsil Barang	2	2	0
Total	26	13	3

Common Findings

- Hunters capture falcons due to poor economic conditions.
- Saker and Peregrine falcons are targeted, with Kestrels and Hobbies used as decoys.
- Kestrels and Hobbies are either captured or purchased locally and released after the hunting season.
- The hunting season runs from mid-August to mid-November.
- Migratory falcons do not nest in the area but come from Central Asia due to cold weather.
- Hunters cannot freely hunt falcons and thus cannot predict population trends accurately.
- Captive falcons are sold immediately after capture.
- Captive falcons are fed meat-based diets, including pigeons, finches, doves, and chicken.
- Sunny and clean environments are preferred for hunting.

- Falcons do not have any superstitions, social or cultural customs associated with them in this area.
- Falcon prices depend on species, gender, age, size, color, beauty, health, and behavior, with female Saker and Peregrine falcons being the most valuable, potentially reaching prices over 10 million. Kestrels and Hobbies range from a few hundred to a thousand in value.

5.2.3 Survey of Waterfowls in District Bajaur, Kurram, North and South Waziristan

Location	District Bajaur, Kurram , South Waziristan and North Waziristan
Period	2023-24
Principal Investigator:	Ms. Manahil Wahab, Wildlife Management Specialist Ayaz Ahmad, Wildlife Biologist Barkatullah Khan, Wildlife Ecologist

Study Area

The survey was conducted in the merged areas of District Bajaur, Kurram, North Waziristan, and South Waziristan, Khyber Pakhtunkhwa. These regions are critical habitats for migratory waterfowls and offer diverse ecosystems ranging from wetlands to grasslands. The survey was part of the "Biodiversity Research Initiatives in Merged Areas of Khyber Pakhtunkhwa" project and aimed to document the diversity, population, and distribution of waterfowl species in these areas.

Research Activities

The survey was conducted from March 11 to March 20, 2024, by the Pakistan Forest Institute. The research team utilized two primary methods: hunting interviews and direct sightings.

Hunting Interviews:

- Engaged with local waterfowl hunters to gather information about species observed during their hunting activities.
- Collected details such as species names, abundance, and locations.
- Conducted interviews to explore migration patterns and potential threats to waterfowl, including habitat loss, pollution, and hunting pressure.

Figure 5: Waterfowl (ducks) hunted

Direct Sightings:

- Conducted field observations to directly record waterfowl species.
- Noted the species, precise coordinates, time of sighting, behavior, group size, and habitat type.
- Documented any co-occurring wildlife species during sightings.

Species Observed

The survey focused on various waterfowl species, including:

- Common Teal (*Anas crecca*)
- Shoveller (*Anas clypeata*)
- Mallard (*Anas platyrhynchos*)
- Gadwall (*Anas strepera*)
- Pintail (*Anas acuta*)
- Wigeon (*Anas penelope*)
- Pochard (*Aythya ferina*)
- Garganey (*Anas querquedula*)
- Tufted Duck (*Aythya fuligula*)
- Ruddy Shelduck (*Tadorna ferruginea*)

Figure 6: Waterfowl (ducks) hunting site

Survey Findings

Survey of Migratory Birds (Waterfowls) in Merged Areas

District	Recorded Species
Bajaur	Common teal, Shoveller, mallard, gadwall, pintail, Wigeon, Pochard, Garganey, tufted duck, ruddy shelduck
Kurram	Common teal, Shoveller, common shelduck, ruddy shelduck, mallard, gadwall, Wigeon, pintail, Pochard, cormorant, whooper swan, Garganey, tufted duck
North Waziristan	Egrets, cormorants, various unidentified ducks at Baran Dam
South Waziristan	Egrets, herons, unidentified ducks at Gomal Zam Dam

Figure 7: The survey team at waterfowl hunting site alongside the Kurram River

Detailed Observations

District Bajaur:

- **Qamar Daag:**
    i. Common teal: 16 observed flying above a small river.
    ii. Common teal: 1 observed flying above a pond.
- **Yusufabad/Kalacha:**
    i. Common teal: 2 observed flying above a small pond.
    ii. Shoveller Duck: 2 observed flying above a larger pond.
- **Raghagan Dam:**
    i. Common teal: 2 observed flying above the dam.
    ii. Moorhen: 10 observed swimming in a pond.
    iii. Common Pochard: 7 observed swimming in the dam.
    iv. Cormorants: 5 observed swimming in the dam.
    v. Egrets: 6 observed flying above the dam.
    vi. Gull: 1 observed sitting on the brink of the dam.
    vii. Moorhens: 6 observed swimming in the dam.
    viii. Coot: 2 observed swimming in the dam.

District Kurram:

- **Kotragha Dam:**
    i. Common teal: 3 observed swimming in the dam.
    ii. Unidentified Ducks: Over 200 observed flying above the dam.
- **Aagra (Parachinar):**
    i. Egret: 2 observed sitting on the river bank.
    ii. Common teal: 1 observed flying above a pond.
    iii. Moorhen: 1 observed swimming in a pond.
    iv. Pintail: 1 observed flying above a small river.
    v. Unidentified Ducks: 5 observed flying above the river.
    vi. Grey Heron: 3 observed sitting on the side of a pond.
- **Manda Dam:**
    i. Pintail: 3 observed swimming in the dam.
    ii. Gadwall: 1 observed swimming in the dam.
    iii. Cormorant: 1 observed swimming in the dam.

District North Waziristan:

- **Baran Dam:**
    i. Egret: 1 observed flying above the dam.
    ii. Cormorant: 6 observed swimming in the dam.
    iii. Unidentified Ducks: 28 observed swimming in the dam.
    iv. Coot: 3 observed swimming in the dam.
    v. Heron: 15 observed sitting on the bank of the dam.
    vi. Gull: 1 observed flying above the dam.

Figure 8: A hunter along with hunted ducks

District South Waziristan:

- **Gomal Zam Dam:**
    i. Egret: 2 observed sitting on the bank of the dam.
    ii. Heron: 1 observed flying near the dam.
    iii. Unidentified Duck: Over 300 observed swimming in the dam.
    iv. Great Crested Grebe: 2 observed swimming in the dam.

5.2.4 Miscellaneous

1. Taught Wildlife Management Course to BS 6th Semester Forestry Students (2024-24).
2. Prepared Concept Paper for KOICA (RFP) on “Executing Sustainable Development Goal Fifteen (SDG-15) For Wildlife Conservation and its Role in other SDGs Achievement in Merged Areas (FATA)
3. Prepared Project Concept Paper for Agricultural Linkages Program (ALP) [RFP] on “Conservation of Pangolin in Khyber Pakhtunkhwa, Pakistan”.
4. Prepared Project Concept Note for Green Climate Fund (GCF) on “Developing and Implementing Community-based Adaptation Strategies for Conserving Endangered Species Habitats in Pakistan”.
5. Attended Four-Day Online Training Course on Natural Resource Management arranged by PARD, Peshawar.
6. Prepared Policy Brief on Crane Hunting Status in Pakistan.
7. Prepared Catalogue of Literature from 1951 to 2021 (Prior to 1972: Library Record, after 1972: Online Record) on Wildlife Research Conducted in PFI/PJF
8. Did literature review of 26 Wildlife Species (in PJF) for Review Paper.
9. Attended One Week Physical Training Course on MS Project Management Arranged by Staff Training Institute, Peshawar.

5.3 RANGE MANAGEMENT

5.3.1 Germplasm Multiplication of different Forage and Fodder Species

Location	Pakistan Forest Institute, Peshawar
Period	2023-24
Principal Investigator:	Assistant Silviculturist (Range)

The PFI Range Research Nursery is very important for cultivating diverse forage species in the country. Seeds that are produced here are being used in research trials at the Range Management Branch of PFI nationwide. The nursery also provides seeds to Forest Departments, NGOs and farmers for viewing and analysis purposes. It is distributed according to the particular needs and the regional demand. It

supports both scientific research and development of practical rangeland development efforts.

Table 1: Seed Collection of forage grasses from Range Research Garden, PFI during 2023-24.

Sr. No.	**Name of Species**	**Quantity (Kg)**
1	*Cenchrus ciliaris*	0.9
2	*Amorpha fruticosa*	1.2
3	*Panicum antidotale*	1.8
4	*Setaria anceps*	0.8
5	*Pennisetum orientale*	2.2
Total		**6.9**

Table 2: Seed collection of fodder trees from Range Research Garden, PFI

Sr. No.	**Name of Species**	**Quantity (Kg)**
1	*Grewia optiva*	2.1
2	*Robinia pseudocacia*	1.5
3	*Sesbania sesban*	2.3
4	*Acacia* spp.	1.5
Total		**7.4**

5.3.2 Determination of forage yield of forage grasses grown at Range Research Garden, PFI, Peshawar

Location Pakistan Forest Institute, Peshawar

Period 2023-24

Principal Investigator: Assistant Silviculturist (Range)

At PFI Range Research Garden, we evaluate the forage production of different grass species cultivated in plots. A clipping is made from five randomly placed quadrats per plot for each species and measurement of forage yield is made. Immediately after harvesting, fresh weights are recorded and the samples are air dried

to obtain dry matter yield. Every weight is documented with extreme care for exactness. With this method, we have a reliable comparison between forage productions of different species. The collected data aids in identification of high yielding grasses for use in rangeland improvement. The results of forage production of studied species are given as follows:

Table-3: Air-dried forage production (Kg/ha) during August, 2024

Sr. No.	**Forage Species**	**Forage Production (kg/ha)**
1	*Panicum maximum*	3853
2	*Pennisetum orientale*	7651
3	*Cenchrus ciliaris*	6904
4	*Chloris gayana*	5452
5	*Panicum antidotale*	4701
6	*Setaria anceps*	5530
7	*Panicum coloratum*	15685
8	Hybrid bajra	13547
9	*Pennisetum purpureum* (mott grass)	17468

The table shows that the highest air dried forage yield was for *Pennisetum purpureum* (17468 kg/ha), *Panicum coloratum* (15685 kg/ha) and Hybrid Bajra (13547 kg/ha). In this, these three species surpassed others in total forage production. High yields make them a potential improvement in fodder availability. All these are cultivated under irrigated conditions. Therefore, they are suggested for increasing productive forage in such regions.

Data collection from sample plots in Range Research Garden, PFI, Peshawar

5.3.3 Rangeland assessment in merged areas of Khyber Pakhtunkhwa

Location	Bajaur and Mohmand districts
Period	2023-24
Principal Investigator:	Assistant Silviculturist (Range)

This study evaluates the range assessment in Bajaur and Mohmand districts of Khyber Pakhtunkhwa under the project titled “Biodiversity research initiatives in merged areas of Khyber Pakhtunkhwa”. In this study, 1x1 m^2 quadrat was used for grasses. Plot size of 4x4 m^2 was used for shrubs and 10x10 m^2 for tree assessment. In each plot, frequency and cover were noted in the field book before the species clipping. After clipping, fresh weight (gm/m^2) of the species was recorded and samples were placed in polythene bags separately.

- **Frequency:** The ratio between the number of sample units that contain a species and the total number of sample units. It is calculated with this formula:

$$\frac{\text{Number of plots in which species occurs}}{\text{Total number of plots}} \times 100$$

- **Cover:** It is the surface area occupied by each species or vertical projection of the crown or stem of a plant onto the ground surface and expressed in percentage of area.

$$\frac{\text{Total area covered by a species}}{\text{Total area sampled}} \times 100$$

- **Species Composition**

  With the help of cover data, species composition is calculated as follows: -

$$\frac{\text{Average cover of species}}{\text{Total cover of all species}} \times 100$$

Data collection from sample plots for rangeland assessment

Table-4: Forage productivity and carrying capacity in different tehsils of Bajaur district

Region	**Species composition**	**Cover %**		**Productivity (Kg/ha)**		**Carrying Capacity AU/ha/M**
	No. of species recorded	Foliar	Bare ground	Fresh Forage Productivity	Dry Forage Productivity	
Utman Khel	06	90	10	8410	3840	7.1
Barang Khel	11	72	28	8600	4130	7.6
Salarzai	06	95	05	5330	2380	4.4

Table-5: Forage productivity and carrying capacity in different tehsils of Mohmand district

Tehsil	**Species composition**	**Cover %**		**Productivity (Kg/ha)**		**Carrying Capacity AU/ha/M**
	No. of species recorded	Foliar	Bare ground	Fresh Forage Productivity	Dry Yield Productivity	
Ghalanai	02	20	80	00	00	00
Safi	05	75	25	2840	1460	2.7
Baizai	02	30	70	750	400	0.7
Pindiali	06	65	35	5610	2020	3.7
Yaka Ghund	04	70	30	2350	990	1.8
Parang Ghar	03	60	40	3970	1820	3.3

5.3.4 Forage Production of some Tropical Grasses at different stages of their Phonological Development

The study was conducted at Range Research Garden, Pakistan Forest Institute Peshawar. The soils of the area are alluvial, local outwash or loess in origin. These are moderately calcareous and their lime content is uniformly distributed throughout the soil profile. The soils of the area are non-saline and non-sodic, have a slightly alkaline pH and are low in organic matter. Five grasses i.e., Blue panic grass (*Panicum antidotale*), Buffel grass (*Cenchrus ciliaris*), Elephant grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*) and Setaria grass (*Setaria anceps*), were selected for the research. The experiment was conducted in three replicates using Randomized Complete Block Design. Three samples of each species were collected at three different stages of their phenological development i.e. vegetative, flowering and maturity. For this purpose, three quadrats from each plot were taken at random following standard procedure with the help of 1mx1m quadrat for fresh yield determination. Each sample at each growth stage was placed in a paper bag and dried at 70^{o}C for 48 hours to obtain dried samples with minimum chemical changes and was weighed again. The initial weight of the sample before drying and the final weight of the sample after drying were noted. Data were statistically analyzed using Analysis of variance (ANOVA). Differences in means were evaluated by Least Significant Difference (LSD) test.

RESULTS

Changes in Fresh Yield of Grasses at different stages

In Rhodes and Setaria grasses, fresh yield increased significantly at full flowering stage and remained same at maturity stage while in Blue panic and Buffel grasses. In Elephant grass, fresh yield decreased significantly at full flowering stage while increased significantly at maturity stage.

Table-6: Fresh yield of grasses (t/ha) at three stages of their phenological development

Name of Grass	**Pre-flowering stage**	**Full flowering stage**	**Maturity stage**	**LSD**
Blue panic grass	4.46[a]	12.00[b]	6.78[a]	2.84
Buffel grass	3.80[a]	6.93[b]	4.92[a]	1.15
Elephant grass	11.70[b]	9.85[a]	11.71[b]	1.56
Rhodes grass	2.72[a]	6.00[b]	5.66[c]	1.14
Setaria grass	4.61[a]	8.00[b]	9.46[b]	3.21

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

Changes in Dry Matter Yield of grasses at different stages

In Buffel, Rhodes and Setaria grasses, dry matter yield increased significantly at each growth stage until the last harvest stage. In Blue panic, dry matter yield increased significantly at full flowering stage while remained same at maturity stage. In Elephant grass, dry matter yield increased significantly at full flowering stage while decreased significantly at maturity stage.

Table-7: Dry matter yield of grasses (t/ha) at three stages of their phenological development

Name of grass	Pre-flowering stage	Full flowering stage	Maturity stage	LSD
Blue panic grass	1.81[a]	4.85[b]	4.89[b]	1.04
Buffel grass	1.84[a]	3.30[b]	4.56[c]	1.09
Elephant grass	2.72[a]	5.90[b]	6.09[b]	1.14
Rhodes grass	0.76[a]	3.41[b]	3.90[c]	0.46
Setaria grass	1.00[a]	2.73[b]	5.13[c]	0.70

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

YIELD PERFORMANCE OF GRASSES AT PRE-FLOWERING STAGE OF GROWTH

Yield performance of grasses at pre flowering stage of growth

The highest fresh yield was shown by Elephant grass (11.70 t/ha) while the lowest fresh yield was shown by Rhodes grass (2.72 t/ha). The highest dry matter yield was shown by Elephant grass (2.79 t/ha) while the lowest dry matter yield was shown by Rhodes grass (0.76 t/ha) at first stage of growth.

Table-8: Yield performance of grasses (t/ha) at pre-flowering stage of growth

Name of Grass	Fresh yield	Dry matter yield
Blue panic grass	4.46[b]	1.81[b]
Buffel grass	3.80[a]	1.84[b]
Elephant grass	11.70[b]	2.79[c]
Rhodes grass	2.72[a]	0.76[a]
Setaria grass	4.61[a]	1.00[a]
LSD	4.28	0.51

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

Yield performance of grasses at full flowering stage of growth

At full flowering stage of growth, the highest fresh yield was shown by Blue panic grass (12.00 t/ha) while the lowest fresh was shown by Rhodes grass (6.00 t/ha). The highest dry matter yield was shown by Elephant grass (5.90 t/ha) while the lowest dry matter yield was shown by Setaria grass (2.73 t/ha).

Table-9: Yield performance of grasses (t/ha) at Full flowering stage of growth

Name of Grass	**Fresh yield**	**Dry matter yield**
Blue panic grass	12.00^{c}	4.85^{b}
Buffel grass	6.93^{ab}	3.30^{a}
Elephant grass	9.85^{bc}	5.90^{c}
Rhodes grass	6.00^{a}	3.41^{a}
Setaria grass	8.00^{ab}	2.73^{a}
LSD	2.80	0.91

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

Yield performance of grasses at Maturity stage of growth

At maturity stage of development, the highest fresh yield was shown by Elephant grass (11.70 t/ha) while the lowest fresh yield was shown by Buffel grass (4.92 t/ha). The highest dry matter yield was shown by Setaria grass (5.13 t/ha) while the lowest dried yield was shown by Rhodes grass (3.90 t/ha).

Table-10: Yield performance of grasses (t/ha) at maturity stage of growth

Name of Grass	**Fresh yield**	**Dry matter yield**
Blue panic grass	6.78[a]	4.89[ab]
Buffel grass	4.92[a]	4.56[ab]
Elephant grass	11.70[c]	4.09[ab]
Rhodes grass	5.66[a]	3.90[a]
Setaria grass	9.46[b]	5.13[b]
LSD	2.18	1.20

Note. Values followed by the same letter(s) are statistically similar at P=0.05 level of significance.

As it is clear from the results that grasses exhibited significant differences in fresh and dry matter yield which ranged from 2.72 to 11.70 t/ha fresh matter yield in pre flowering stage, 6.00 to 12.00 t/ha in full flowering and 4.92 to 11.70 t/ha in maturity stage while 0.76 to 2.80 t/ah dry in full flowering and 4.92 to 11.70 t/ha in maturity stage while 0.76 to 2.80 t/ha dry matter yield in pre flowering stage, 2.73 to 5.90 t/ha in full flowering and 3.90 to 5.13 t/ha in maturity stage. This could be attributed to their genetic inheritance potential. Climatic and soil conditions also play a major role in determining yield and yield parameters. Significant differences were obtained among grasses in forage yield. The highest dry matter yield of 2.80 and 2.79 ton ha^{-1} was attained by elephant grass during pre-flowering stage respectively. The top dry matter yielding grasses during full flowering stage were elephant and blue panic grass that yielded 5.90 and 4.85 ton ha^{-1} respectively.

It was observed that yield and composition of grasses changed as they reached maturity. In Buffel, Rhodes, Setaria dry matter yield increased significantly at each growth stage until maturity stage. In Blue panic, dry matter yield increased significantly at full flowering stage while remained same at maturity stage. In Elephant grass, dry matter yield increased significantly at full flowering stage while decreased significantly at maturity stge.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded from the study that forage yield at pre flowering stage is low. Full flowering stage is the best stage for harvesting these grasses as we take into consideration forage yield. Maturity stage has adequate yield. Elephant and Blue panic grasses are high yielding grasses with 5.90 and 4.85 tons/ha dry matter yield respectively. Taking into consideration forage yield and quality, Elephant and Blue panic grasses are recommended for large scale seeding/planting in Pothwar area. Studies on mixing of low palatable grasses with fodder, tree leaves and palatable grasses may be done so that low palatable grasses may be included in the existing feedlot. Value added of low palatable grass hay may also be studied to improve forage quality.

6. FOREST EDUCATION DIVISION

Admissions:

During the year 2023-24, 40 self-finance & departmental students were admitted from all the federating units of the country.

Passed Out:

During the year 2023-24 the following Classes of M.Sc. & BS Forestry were passed out.

S.No	Classes	Strength
1.	M.Sc. Forestry (2021-23)	24
2.	BS Forestry (2019-23)	22
Total Strength		46

Lecture Schedule

BS Forestry (2020-24), BS Forestry (2021-25), BS Forestry (2022-26) and BS Forestry (2023-26) courses were continued as per their study program & according to the lecture schedules.

Examinations& Results

All examinations of M.Sc. and BS Forestry courses were conducted by the University of Peshawar according to schedule. The detail of results announced and examinations held during the year is tabulated below;

Results

CLASSES	Results Declared On
BS Forestry (2022-26) 2nd Semester	29-08-2023
BS Forestry (2020-24) 4th Semester	29-08-2023
BS Forestry (2019-23) 6th Semester	29-08-2023
BS Forestry (2018-22) 8th Semester	29-08-2023
M.Sc. Forestry (2021-23) 2nd Term	17-08-2023

Annual Term/Semester Examinations

CLASSES	FROM	TO
BS Forestry (2022-26) 2nd Semester	19-10-2023	26-10-2023
BS Forestry (2021-25) 4th Semester	19-10-2023	26-10-2023
BS Forestry (2020-24) 6th Semester	19-10-2023	26-10-2023
BS Forestry (2019-23) 8th Semester	19-10-2023	26-10-2023
M.Sc. Forestry (2021-23) 4th Term	19-10-2023	31-10-2023

Results

CLASSES	Results Declared On
BS Forestry (2022-26) 2nd Semester	15-02-2024
BS Forestry (2021-25) 4th Semester	15-02-2024
BS Forestry (2020-24) 6th Semester	15-02-2024
BS Forestry (2019-23) 8th Semester	29-01-2024
M.Sc. Forestry (2021-23) 4th Term	23-01-2024

Annual Term/Semester Examinations

CLASSES	FROM	TO

BS Forestry (2023-24) 1st Semester	23-04-2024	30-04-2024
BS Forestry (2022-26) 3rd Semester	23-04-2024	30-04-2024
BS Forestry (2021-25) 5th Semester	23-04-2024	30-04-2024
BS Forestry (2020-24) 7th Semester	23-04-2024	30-04-2024

Thesis:

Thesis of M.Sc. Forestry 2021-23 and BS Forestry (2019-23) were completed.

Tours:

1. Forest Road Survey, Participatory Forestry, EIA and Biodiversity Conservation Tour of BS Forestry (2021-25) was conducted from 14-07-2023 to 23-07-2023. .
2. Excursion to study the management of Moist Temperate Forests and Plantation Tour of BS Forestry (2020-24) was conducted from 24-07-2024 to 26-07-2023.
3. Study the Environmental impact assessment & effect environmental degradation tour of BS Forestry (2022-26) was conducted from 26-08-2023 to 01-09-2023.
4. Excursion Tour to Garhi Chandan Plantation tour of BS Forestry (2020-24) was conducted on 13-09-2023.
5. Orientation Tour of BS Forestry (2023-27) was conducted from 03-01-2024 to 12-01-2024.
6. All Pakistan Forest Management Tour of BS Forestry (2020-24) was conducted from 14-01-2024 to 29-01-2024.
7. Excursion Tour to Garhi Chandan Plantation tour of BS Forestry (2023-27) was conducted on 16-02-2024.
8. Excursion Tour of BS Forestry (2022-26) was conducted from 05-03-2024 to 07-03-2024.
9. Forest Types Tour of BS Forestry (2021-25) was conducted from 15-05-2024 to 24-05-2024.
10. Road Survey Project Tour, Biodiversity, Climate Change and Participatory Forest Management Tour of BS Forestry (2022-26) was conducted from 31-05-2024 to 12-06-2024.


Scanned with CamScanner

PT and Games

Regular P.T and Games were conducted throughout the year.

Co-curricular Activities

All the National and International Days related to Environment and Bio-diversity were celebrated at PFI in collaboration with line departments. Students took part in these programmes by participating in Monsoon plantation day, world Environment day, World Forest day and World Mountain day.

PFI Students Annual Sports Matches

Annual Sports Matches of Forestry Students were conducted during the 2nd week of November 2023.

STUDENTS ENROLLMENT

BS Forestry Session 2020-24		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	14
2.	Punjab	05
3.	Balochistan Forest Department	03 (02 Departmental)
4.	Gilgit Baltistan	02
Total		**24**
BS Forestry Session 2021-25		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	15
2.	Punjab	06
3.	Balochistan	01
4.	AJK	01
5.	Gilgit Baltistan	01
Total		**24**
BS Forestry Session 2022-26		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	17
2.	Punjab	04
3.	Gilgit Baltistan	01
4.	AJK	02
Total		**24**
BS Forestry Session 2023-27		
S.No	**Province**	**Strength**
1.	Khyber Pakhtunkhwa	21
2.	Punjab	03
3.	Sindh	13
4.	Gilgit Baltistan	01
5.	AJK	02
Total		**40**
	Grand Total	**112**

7. ANNUAL RESEARCH PROGRAMME (2024-25)

S. No.	Name of the Research Study	Principal Investigator (s)	Location	Year of commencement	Sponsoring/ Collaborating Agencies
1	**FORESTRY RESEARCH DIVISION**				
1.1	**Silviculture Branch**				
1.1.1	Assessment of different agroforestry models using different tree species and agricultural crops.	Central Silviculturist	PFI	2022	ADP, KP
1.1.2	Assessment of different agroforestry models using hybrid olives tree species and agricultural crops.	Central Silviculturist	PFI	2023	ADP, KP
1.1.3	Establishment of demonstration cum research plot of exotic high value economic tree species in Silva Research Garden.	Central Silviculturist	PFI	2022	ADP, KP
1.1.4	Raising a model Bare rooted Nursery of 10,000 cuttings of different varieties of Poplar	Central Silviculturist	PFI	2024	ADP, KP
1.1.5	Maintenance and data collection of ongoing/current research trials and nursery.	Central Silviculturist	PFI	-	ADP, KP/ PFI regular budget
1.2	**Forest Mensuration Branch**				
1.2.1	Improving the efficiency of forest Management through the development of Volume tables, Yield tables and growth Models for the coniferous forests of Khyber Pakhtunkhwa	Director Forestry Research	KP	2022	ADP, KP
1.2.2	Development of Volume tables for major coniferous and Broadleaved species in Malakand and Hazara regions.	Director Forestry Research	KP	2022	ADP, KP
1.2.3	Development of Yield tables for major coniferous tree species (Fir/Spruce, Mixed Kail and Pure Deodar) in an even aged forest by taking permanent sample plots in Malakand and Hazara regions.	Director Forestry Research	KP	2022	ADP, KP
1.2.4	Standardization of Inventory techniques in Sub-Tropical chir pine forest and Himalayan Moist temperate forest in Malakand and Hazara regions.	Director Forestry Research	KP	2022	ADP, KP

1.3	**Watershed Management Branch**				
1.3.1	Compilation of Meteorological data recorded at Watershed Observatory Pakistan Forest Institute Peshawar	Watershed Management Specialist	PFI, Peshawar	On daily Basis	PFI
1.4	**GIS Branch**				
	Providing technical support in the mapping activities of different projects in PFI	GIS Specialist	KP	-	PFI
	Website maintenance and modification of website of NTFP.	GIS Specialist	KP	-	PFI
2.	**FOREST PRODUCTS RESEARCH DIVISION**				
2.1	Assessing growth dynamics, climate impacts and resilience of chirpine forest in Shinkiari, Khyber Pakhtunkhwa	Dr. Zahid Rauf, (DFPRD)	PFI	2024-25	PFI regular budget
2.2	Studies on DNA Fingerprinting of Important Conifers for their Molecular Identification and Illegal Trafficking Control.	Project Incharge Mr. Bilal Zia (Forest Geneticist)	PFI	2022-26	ADP
2.3	Utilization of Chir Pine Needles *(Pinus roxburghii)* and Bamboo (*Bambusa Vulgaris*) in preparation of Chipboard and Pulp and Paper	Mr. Khalid Solangi (AWTO)	PFI	2024-25	PFI regular budget
2.4	Comparative study of Deodar with imported high valued wood and the use of biodegradable preservatives for wood preservation through novel approach	Mr. Mansoor Ali Khan, Assistant Wood Seasoning Officer	PFI	2024-27	PFI regular budget
3.	**BIOLOGICAL SCIENCES RESEARCH DIVISION**				
3.1	**Forest Chemistry Branch**				
3.1.1	A Depth-Wise and Species-Wise Comparative Analysis of Soil Physical Chemical and Biological Properties in The Botanical Garden Of Pakistan Forest Institute, Peshawar	Dr. Sanam Zarif , DBSRD Dr. Salim Saifullah, Assistant Forest Chemist Muhammad Ilyas, Research Officer (Soil)	PFI	2024-25	PFI

3.2	**Forest Botany Branch**				
3.2.1	Study on different means of vegetative propagation of Bamboo	Muhammad Farooq , Assistant Forest Economist	PFI	2024-25	PFI
3.3	**Forest Pathology Branch**				
3.3.1	Understanding the Role of Soil Physiochemical Properties and Microbial Diversity in the Incidence of Shisham Die-back in Khyber Pakhtunkhwa	Mahnoor Blaoch, Research Officer (Pathology) Muhammad Ilyas, Research Officer (Soil)	PFI	2024-25	PFI
4.0	**Non-Timber Forest Produce Division**				
4.1	**Forest Entomology Branch**				
4.1.1	Survey of Wild Bee Pollinators from Coniferous Forest of KP	Dr. Naveed Ahmed, Director NTFP	PFI	2024-25	PFI
4.2	**Sericulture Branch**				
4.2.1	Comparative Evaluation of Mulberry Varieties for Enhanced Silkworm Productivity	Mr. Muhammad Salman, R.O. (S.R.)	PFI	2024-25	PFI
4.2.2	Life Cycle Assessment of Silkworm Rearing for Sustainable Silk Production	Mr. Muhammad Salman, R.O. (S.R.)	PFI	2024-25	PFI
4.2.3	Silk proteins in Biomaterials	Mr. Mir Manzar Ud Din, R.O. (C&ST)	PFI	2024-25	PFI
4.2.4	Applications of Silk proteins in medicines and cosmetics	Mr. Mir Manzar Ud Din, R.O. (C&ST)	PFI	2024-25	PFI
4.3	**Medicinal Plants Branch**				
4.3.1	Evaluation of screening nurseries of *Caralluma* species at Medicinal Plants Garden	Mr. Zia Ur Rahman, A.E.B.	PFI	2024-25	PFI
4.3.2	Optimization of Curcumin Extraction from Turmeric for Enhanced Bioavailability	Mr. Zia Ur Rahman, A.E.B.	PFI	2024-25	PFI
5.0	**Biodiversity Division**				
5.1	**Forest Genetics Branch**				
5.1.1	Screening of indigenous germplasm of *Dalbergia sissoo* (Shisham) against die back disease.	Muhammad Bilal Zia Forest Geneticist	PFI/ D.I.Khan	Regular	PFI

5.1.2	Establishment of Biotechnology Lab. at PFI. Peshawar.	Muhammad Bilal Zia Forest Geneticist	PFI Peshawar.	2022-23	ADP, KP
5.1.3	Seed collection and seed quality studies of important forest tree species.	Muhammad Bilal Zia Forest Geneticist	PFI/KP	Continuous	PFI
5.1.4	Maintenance of Field studies at PFI and at Field Stations	Muhammad Bilal Zia Forest Geneticist	PFI/KP/ Punjab	Continuous	PFI
5.1.5	Evaluation of Two ecotypes of Shisham for drought tolerance	Muhammad Bilal Zia Forest Geneticist	PFI/KP/ Punjab	Continuous	PFI
5.2	**Wildlife Management Branch**				
5.2.1	Survey of migratory birds in merged areas of KP	Mr. Barkatullah Wildlife Ecologist and Mr. Ayaz Wildlife Biologist	Merged areas	2024-25	ADP, KP
5.3	**Range Management Banch**				
5.3.1	Seed multiplication and forage yield determination of different forage species	Khalid Imran AS (Range)	PFI, Peshawar	On yearly basis	PFI
5.3.2	Performance of perennial grasses for forage production at different clipping seasons at Range Research Garden PFI and PFI Field Station D.I Khan	Khalid Imran AS (Range)	PFI, Peshawar & Field Station D.I Khan	May,2024	PFI
5.3.3	Range resource assessment surveys in merged areas of Khyber Pakhtunkhwa	Khalid Imran AS (Range)	Merged areas	2024-25	ADP, KP

APPENDIX – I

LIST OF TECHNICAL STAFF

PAKISTAN FOREST INSTITUTE, PESHAWAR

S.No.	Name & Designation	Qualification
1.	Mr. Khalid Ilyas Director General	PMS
2.	Dr. Anwar Ali Director, Forestry Research Division	M.Sc. Forestry MS Climate Change (Australia) Ph.D. (Climate Change)
3.	Mr. Naveed Ahmad Director , NTFP	M.Sc (Hons.) Agriculture
4.	Mr. Ashar Farooq Director, Biodiversity Research Division	M.Sc. Forestry M.Phil. (Forestry & Wildlife Management)
5.	Mr. Zahid Rauf Director, Forest Products Research Division	BS Chemistry M.Phil. (Inorganic Chemistry)
6.	Ms. Sanam Zarif Satti Director, Biological Sciences Research Division	M.Sc. (Bio Chemistry) M.Phil. (Bio Chemistry)
7.	Mr. Bilal Zia Forest Genetics	M.Sc. (Hons) PBG
8.	Mr. Tanvir Hussain Logging Officer	M.Sc. Botany M.Phil. (Molecular Biology)
9.	Mr. Aamir Shakeel GIS Specialist	M.Sc. Geography M.Phil. Geospatial Sciences
10.	Mr. Muhammad Atif Majeed Deputy Director (Technical)	M.Sc. Forestry
11.	Mr. Ahmad Zamir Assistant Professor of Forestry	M.Sc. Forestry
12.	Dr. Sajjad Saeed Assistant Professor of Forestry	Ph.D. Forestry Management (China)
13.	Mr. Sohaib Ahmad Assistant Professor of Forestry	M.Sc. Forestry M.Phil. Forestry & Range Management
14.	Dr. Qudsia Khanam Lady Medical Officer	MBBS
15.	Dr. Nowsherwan Zarif Central Silviculturist	Ph.D. (Silviculture) China
16.	Ms. Manahil Wahab Wildlife Management Specialist	M.Sc. Forestry M.Phil. (Wildlife Management)
17.	Mr. Zahid Mehmood Extension Specialist	M.Sc. Forestry M.Phil. Forestry & Wildlife Management
18.	Mr.Khalid Hussain Assistant Wood Technology Officer	M.Sc. Botany M.Phil. Environmental Sciences
19.	Mr. Bilal Ahmad Assistant Forest Engineer	M.Sc. Forestry
20.	Mr. Muhammad Shakeel Forest Economist	M.Sc. Forestry M.A. Economics
21.	Mr. Muhammad Ilyas Research Officer (Soil)	M.Sc.(Hons) Soil and Environmental Sciences.
22.	Mr. Barkatullah Wildlife Ecologist	Phil Wildlife Ecology Ph.D. (In progress)
23.	Mr. Ayaz Khan Wildlife Biologist	M.Phil. Zoology
24.	Mr. Hammad Ud Din Assistant Forest Geneticist	MSc. (Hons)

S.No.	Name & Designation	Qualification
25.	Mr. Salman Ahmad Research Officer (Farm Forestry)	BS (Forestry)
26.	Mr. Saifullah Khan Research Officer	M.Sc. Forestry M.Phil. (Forestry & Wildlife Management)
27.	Mr. Basheer Ahmad Research Officer (Farm Forestry)	M.Phil. (Forestry & Wildlife Management)
28.	Mr. Raza Ullah Lecture in Forestry	M.Sc. Forestry
29.	Syed Tehseen Akhtar Hussain Librarian	MLS
30.	Mr. Wadood Shah Plant Physiologist	M.Phil. (Botany)
31.	Mr. Muhammad Farooq Assistant Forest Ecologist	M.Sc. Forestry M.Sc. Botany
32.	Ms. Mahnoor Baloch Research Officer (Pathology)	M.Sc. (Hons) Plant Pathology
33.	Mr. Sajjad Durrani Assistant Silviculturist (Mensuration)	M.Phil. (Forestry & Wildlife Management)
34.	Mr. Faizan Ahmad Research Officer (Watershed Sociology)	M.Phil. (Forestry & Wildlife Management)
35.	Mr. Muhammad Salman Research Officer (Silkworm Rearing)	M.Sc.(Hons) Entomology
36.	Mir Manzar ud Din Research Officer, Cocoon * Silk Technology	M.Sc. Chemistry M.Sc. (Hons) Agriculture Entomology
37.	Mr. Zia Ur Rahman Assistant Economic Botanist	M.Sc. (Hons) Agriculture in Plant Breeding & Genetics
38.	Mr. Abdur Rahman Assistant Composite Wood Officer	M.Phil.(Chemistry)
39.	Engr Abdur Rehman Marwat Pulp & Paper Officer (Technology)	B.Sc. Chemical Engineering
40.	Mr. Asim Karim Assistant Silviculturist (Watershed)	B.Sc. Forestry
41.	Mr. Muhammad Hashim Assistant Forest Economist	M.Phil. (Economics)
42.	Engr Sulaiman Khan Assistant Forest Engineer	M.Sc. Urban Infrastructure Engineering
43.	Mr. Said Akhtar Khan Assistant Wood Technologist	DAE (Wood Technology)
44.	Mr. Mansoor Ali Khan Assistant Wood Seasoning Officer	M.Phil. (Bio-Chemistry)
45.	Engr. Muhammad Umair Khan Pulp & Paper (Chemistry)	BS (Engineering)
46.	Mr. Khaild Imran Assistant Siliviculturist (Range)	M.Phil. (Forestry & Wildlife Management)
47.	Mr. Kamal Anwar Forest Manager	M.Phil. (Forestry & Wildlife Management)