Assessement of Biomaass Expansion Factor of Picea Smithiana (WALL) Boiss

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ABSTRACT: The present study estimates the biomass expansion factor (BEF) of The native tree species Picea Smithiana in Kumrat valley. For the assessment of BEF destructive method of sampling was used. Five trees of exploitable diameter were selected. The height and diameter of each sample tree was calculated in the field. The trees were separated in their respective components such as branches, twigs, foliages, and stem/bole and stump portion. Stem volume of each sample tree was find out and converted into stem biomass. The biomass of branches, twigs, foliages and roots was calculated. The results of the present study reveled that the mean biomadd of stem was 1919.64 ±244.44, while the mean biomass of branches, twigs, foliages and root was 299.26 ±32.32, 55.46± 5.57, 65.90 ±2.87 and 435.81± 77.15 kg respectively. In total biomass the contribution of stem biomass was 66.28%, while the contribution of branches, twigs, foilages, and roots was 11.28, 2.193, 2.62 and 17.05 percent. The mean above ground biomass was 2104.055±264.814 kg while the mean total biomass was 2539.87 ±341.80 kg. The root to shoot ration was 0.206± 0.011. The mean BEF was 0.686 ±0.0027 t m3

Key words: , Picea Smithiana , biomass expansion ,root to shoot ration factor

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1 Introduction

Biomass is the components of the biota in the form of organic matter. The Biomass of a tree might be characterized as "the total amount of woody parts of shrubs, bushes or trees parts like branches, twigs, bark and stem, alive or dead without root, seed and stump" or biomass is the total dry weight of the all components of trees expressed as ton ha^{-1} (FAO, 1997)". The Biomass Expansion Factor (BEF) is "the ratio of total oven dry above ground biomass density of a tree with a specific diameter at breast height (DBH) to the oven dry biomass density of the inventoried volume (FAO, 1997)".

Forests ecosystem are the integral components of Global carbon. Kyoto Protocol recognize the forest as a potential mechanism for the stabilization and mitigation of Carbon dioxide in the atmosphere (Masera et al. 2003; Tobin and Nieuwenhusis, 2007). Forest biomass and carbon stock is normally assessed by using national forest inventory data (lehtonen et al. 2004; Teobaldelli et al. 2009; Kim et al. 2011; Adnan et al.2014). The estimation of biomass and carbon stocks of a forest based on inventory data can be figure out by using the allometric equation or by using BEF (Montagu et al. 2005; Teobaldelli et al. 2009; Kim et al. 2011). In order to report carbon stock and change in carbon stock a constant BEF of forest is used but the constant value of BEF is not applicable because the value of BEF varies with forest stand, site age and other biotic and abiotic factors (IPCC, 2003; lehtonen et al. 2004; Montagu et al. 2005; Teobaldelli et al. 2009; Kim et al. 2011).

Picea smithiana belongs to family *Pinaceae* and is an evergreen tall tree (30 to 45 m). It prefers sandy loam and loam soil and can tolerate the precipitation of 1000 to 2500 mm/yr. It is adapted to the temperature of -20 to $35C^0$ and prefer humid temperate climate. It is native to Himalaya ranges of Nepal, Pakistan, India and Afghanistan. In Pakistan it is found in temperate forest over higher elevation (2100 to 3600 m), in Murre hills, Kurram agency, Azad Kashmir, Dir, Swat, Hazara and Chitral. It is used in pulp and paper, railway sleepers, fuel, mulches and packing cases (Sheikh, 1993).

In Pakistan, the forest departments carried out different forest inventories on regular basis for the estimation of growing stock but there is lack of study regarding the assessments of biomass and carbon stock. The native/ indigenous species had been neglected with respect to biomass expansion factor especially for carbon stocking. *Picea smithiana* is a native species to Pakistan and up till now no study has been conducted to determine its biomass expansion factor. The present study estimates the biomass expansion factor for carbon budgeting in *Picea smithiana*. The objectives of the study were; To estimate biomass of tree components (branches, foliages, stumps, twigs, roots and stem/bole) *of Picea smithiana*. To determine variation of biomass in all components (biomass expansion factor) and to determine the root-to-shoot ratio of exploitable diameter tree and BEF.

2. Materials and method

Study Area

The study was carried out at Kumrat valley of district Dir upper Khyber Pukhtoonkhwa Khwa. The study lies in Hindu Raj Mountains. The geographic location of the study site is 36° 33'12.45''N, 72°14'46.03''E. The elevation of study site ranges of 2200-3000 m . The rocks are mostly metamorphic and igneous rocks are. The average precipitation ranges from 750mm to 1000mm, while the temperature varies from 5-15C°.

Research Design and Tree selection

Five trees were selected with exploitable diameter of 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m. Destructive sampling method was carried out in order to get the biomass expansion factor. The trees were selected from the center of forest stand avoiding the edge effect. Trees of good health were selected (no pest/insect attacked, not diseased and not effected by human cutting etc.

Tree Measurement and biomass calculation

Diameter at breast height was measured for each tree. The trees were felled above the ground level. The lengths of the stem were determined with the help of measuring tape and the diameters were recorded after each 3 meter by diameter tap. The trees were separated into their respective components such as branches, twigs, foliages, stem/bole and stump portion. The fresh weights of different components such as foliages, twigs and branches were measured in the field with the help of spring balance. As tiresome and time consuming to detach the foliage from all the tree, and so for it we weight the twigs and leaves together and then take 1 kg sample from it and detach the leaves from the samples. After then we weight the foliages and twigs separately of the samples and found the ratio of foliages and twigs and then extrapolates the values so as to get the separate weight of foliages and twigs. The sub samples of each component (foliages, twigs, stem/bole, roots and branches) approximately of one kilogram were separated. These sub samples were then dried in the laboratory by keeping at oven at 72C^o getting the dried weight as biomass (Kg). The moisture content percent were calculated for each sample and were extrapolated to respective components of tree to determine the above ground biomass. The roots were excavated as with the manual procedure, digging around the tree was carried out at the dimension of 1m x 1m to collect roots (main, medium and fine roots). The roots were cleaned with the help of rubbing and hand wash with water. The fresh weight was determined. The sample of one kg of roots were dried in the laboratory by keeping in oven at 72C^o to determine the moisture content %. The determined moisture content % was extrapolated to the remaining roots, (Abbas et al. 2011). Stem biomass (kg) was calculated by using following elation.

$W = D_b \times V$(FAO, 1997).

Where W is oven dried biomass in kilograms, D_b is basic wood density in kilogram per cubic meter and V is the volume in meter cube. Stem volume was determined by using the following formula of (Philips, 1994).

$V= (\pi/4)\ d^2\ hf$ (h= tree height, f= form factor, d= tree diameter at breast point) The biomass was obtained from the product of basic wood density and volume. The biomass (Oven dried weight) of the trees was estimated from the sum of the weight of the various components of trees like main stem, foliage, branches, twigs and roots.

Roots to Shoots Ratio

All the dried components of tree above the ground except the stump were included in the above ground biomass. The weight of above ground components were divided on the all the dried components of the roots like coarse roots, medium roots and fine roots in order to get root shoot ratio. The root to shoot ratio was find out by using the following equation.

R = BGB/AGB (Sanquetta *et al.*, 2011)

Where R is root-to-shoot ratio, BGB is below ground biomass i.e. oven dry weight of root and AGB is above ground biomass i.e. oven dry weight of tree components excluding roots.

Biomass Expansion Factor

The biomass expansion factor refers to the ratio of the biomass of stem, foliages, branches and twigs to main stem/bole volume, i.e. BEF is equal to the aboveground biomass divided by the volume of stem expressed by the following equation.

BEF = W / V

Where W is the dry weight of all the components of the tree above the ground in kilograms while V refers to the volume of main stem/bole in meter cube (Lehtonen *et al*, 2004).

3. RESULTS AND DISCUSSION

Tree Height and Volume

The height (m) of the each sample tree was different with respect to their diameter (m). The height of the trees having diameter 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m, were 30.74 m, 31.62 m, 33.528 m, 34.60 m and 35.22 m respectively. The Mean height was 33.1416±1.91m. The volume (m^3) of each sample tree was also assessed. Details of tree volume (m^3) and height (m) are given in table no 1. It can be seen from the table that the height (m) and volume (m^3) of the tree increase with the increase in the diameter (m) of the tree. The relation of tree diameter with tree volume and height is best described in figure no 1 and 2. The relationship is Polynomial Quadratic With R^2 0.98 and 0.99 respectively.

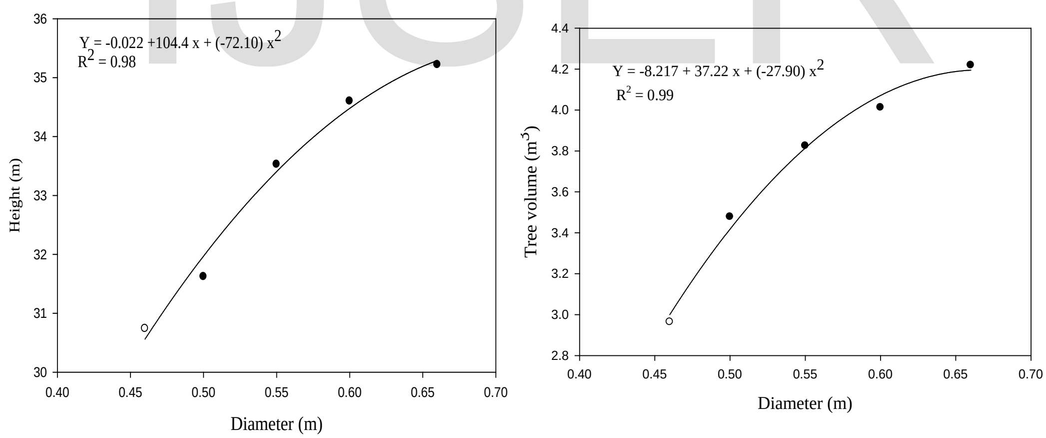
Table No. 4.1: Diameter (m), Height (m) and Volume (m^3) of each sample tree

S/ no	Diameter (m)	Height (m)	Volume (m^3)
1	0.46	30.74	2.964
2	0.50	31.62	3.478
3	0.55	33.528	3.825
4	0.60	34.6	4.013
5	0.66	35.22	4.219
Mean	0.554	33.14	3.699
Standard deviation	0.079	1.915	0.493
Standard errors	0.035	0.857	0.221
CV%	14.304	5.87	13.33

Biomass of the Stem, branches, twigs, leaves

In present study the biomass of stem, branches, twigs, leaves and roots of the each sample tree was calculated. The biomass of stem ranges from 1348.7255 kg to 1919.6467 kg. The mean stem biomass was 1683.419 ± 224.4403 kg. In present it was found that the biomass of stem is the function of the diameter, with increase in stem diameter the biomass of stem also increases. In order to study the relation between stem diameters and stem biomass regression model was developed. The relation between stem diameter and stem biomass was Polynomial Quadratic (fig: 3) the value of R^2 was 0.99.

Figure No 1 and 2: Relation b/w diameter and height (m) , Volume (m^3)



The mean biomass of branches was 299.2616 ± 32.3212 kg . The minimum biomass of branches was recorded as 250.66 while the maximum branches biomass was recorded as 336.732 kg. The twigs biomass of the trees with diameter of 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m, were 47.345, 52.643, 56.787, 59.232 and 61.324 kilograms respectively with mean average biomass of 55.4662 ± 5.5714. Leaves biomass of the each sample tree was also calculated. Details of the leaves biomass is given in table no 2. it can be seen from the table that the biomass of leaves ranges from 62.345, to 69.826 kilograms respectively with mean biomass of 65.9078 ± 2.8758. The biomass of the branches, twigs and leaves also increase with increase in the diameter of the tree. Figure 4, 5, and 6 showed the relation between stem diameter and the biomass of branches, twigs and leaves.

Table No. 2: Stem biomass, Branches biomass, Twigs Biomass, Leaves biomass, aboveground biomass, Root biomass and total biomass in kg.

S/No	Stem biomass(kg)	Branches biomass (kg)	Twigs biomass (kg)	Leaves/foliages biomass(kg)	Aboveground biomass (kg)	Root biomass	Total biomass

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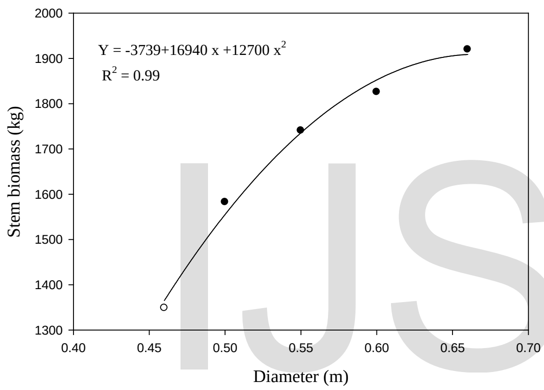
1	1348.725	250.66	47.345	62.325	1709.075	324.724	2033.80
2	1582.581	287.343	52.643	64.454	1987.021	397.404	2384.425
3	1740.405	309.24	56.787	65.380	2171.812	456.081	2627.892
4	1825.738	312.333	59.232	67.534	2264.837	475.616	2740.453
5	1919.647	336.732	61.324	69.826	2387.529	525.256	2912.785
Mean	1683.419	299.26	55.466	65.908	2104.055	435.816	2539.871
S.Deviation	224.44	32.32	5.571	2.876	264.814	77.154	341.803
St Error	100.372	14.45	2.492	1.286	118.428	34.504	152.859
C.V %	13.332	10.80	10.045	4.363	12.586	17.703	13.457

Above Ground Biomass

The above ground biomass refers to the sum of the biomass of all components of the tree that are above the ground level i.e. Sum of stem biomass, branches biomass leaves/ foliages biomass and twigs biomass. The above ground biomass of the trees with diameter of 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m, were 1710.075, 1988.021, 2178.812, 2248.837 and 2387.529 kilograms respectively with mean biomass 2102.655 ± 262.479 (table 2). The above ground biomass increases with increase in tree diameter (fig 7)

Fig 3 and 4 relationship of Diameter with stems and branches biomass (kg)



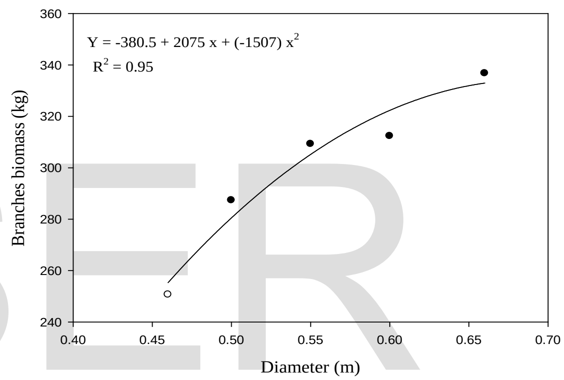
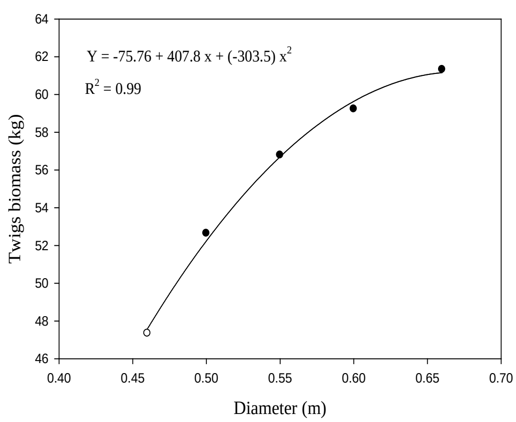


Fig no 4 and 5 Relationship of diameter (m) with twigs and leaves biomass (kg) ,



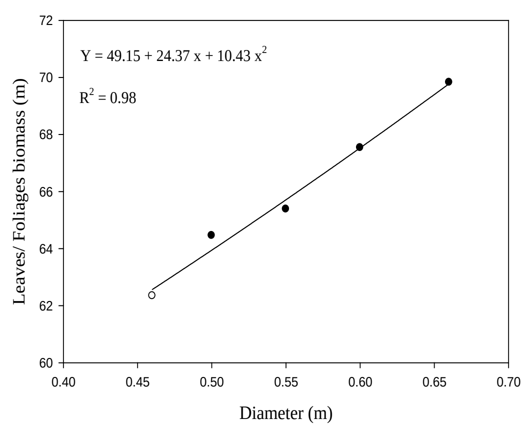


Fig no 7 and 8 Relationship of diameter (m) with above ground biomass and roots biomass (kg)

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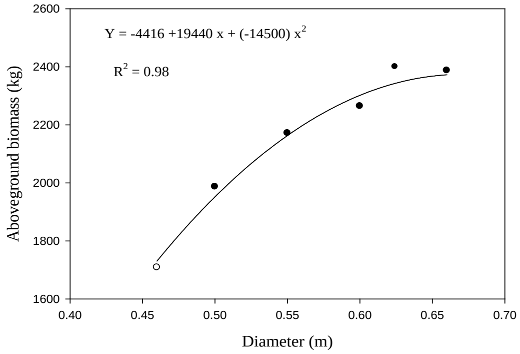
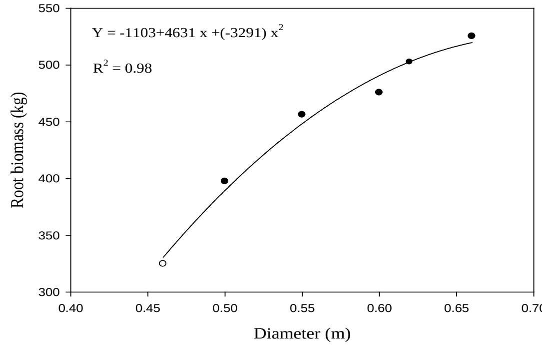




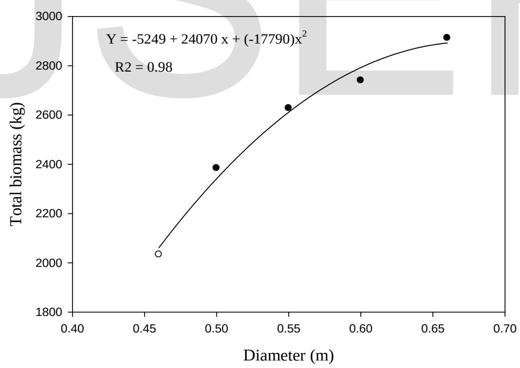
Biomass of Roots

Root biomass include all the portion of the tree below the ground level including main root fine roots etc and are refer to the below ground biomass. The root biomass of the trees with diameter of 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m, were 342.015, 397.4042, 456.0805, 475.6158 and 525.2563 kilograms respectively with mean root biomass of 435.8162± 77.1542. The relation of root biomass and tree diameter is given in figure no 8.

4.2.7: Total Biomass

The total biomass of the tree is the total above and below ground biomass or it is the biomass of all tree components i.e. root, stem, leaves/ foliages, branches, twigs etc. The total biomass of the trees was different according to their diameter. The total biomass of the trees with diameter of 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m, were 2033.8, 2384.425, 2627.892, 2740.453 and 2912.785 kilograms respectively while the mean was 2539.871 ± .341.803.The total biomass of the trees increases with increases in the diameter of tree (fig 9) . In the total mean biomass the contribution of stem biomass was 66.28% of the total biomass. While the contribution of branches, twigs, leaves, and roots were 11.28, 2.193, 2.62, and 17.05 percent respectively.

Fig no: 9: relationship b/w diameter and total biomass



Biomass Expansion Factor

Biomass expansion factor is ratio of total tree biomass to volume of the stem. In present study the biomass expension factor was developed by using the following equation

BEF = W /V

BEF is Biomass expansion factor (kg/m^3), W is Total tree biomass (kg) and V is Volume of the stem (m^3)………. (Lehtonen *et al*, 2004).

The BEF of trees were different according to the diameter of the tree. The biomass expansion factor of the trees with diameter of 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m, were 0.686, 0.686, 0.0.687, 0.683 and 0.691 ton/ m^3 with mean biomass expansion factor of 0.686 ± 0.0026.

ROOT TO SHOOT RATIO

The root to shoot ratio were determined by using the following relationship

R =Wroot / Waboveground (Sanquetta et al. 2011)

The root to shoot ratio were different according to the diameter of the trees. The root to shoot ratio for the trees with diameter of 0.46 m, 0.50 m, 0.55 m, 0.6 m and 0.66 m, were 0.19, 0.2, 0.21, 0.21and 0.22 respectively with mean root to shoot ratio of 0.206 ±

0.011.

Figure no: 10, 11: Relationship of tree diameter (m) with BEF and Root to Shoot Ratio

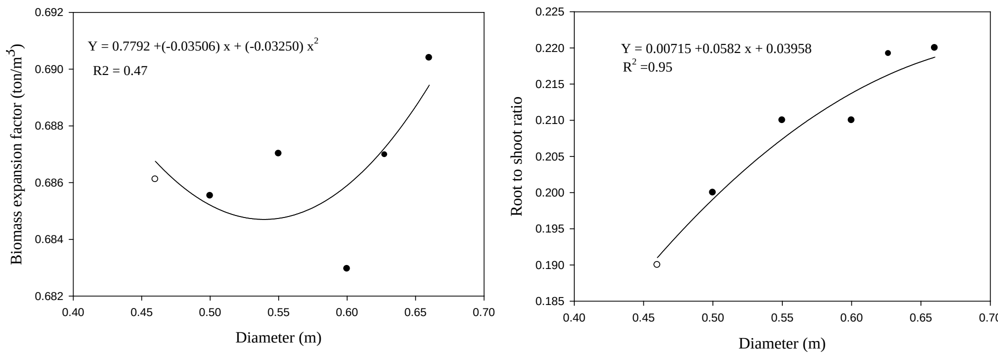


Table No. 3: Root to shoot ratio and biomass expansion factor

S/no	Root to shoot ratio	Biomass expansion factor (tones/m³)
1	0.19	0.686
2	0.20	0.685
3	0.21	0.687
4	0.21	0.683
5	0.22	0.690
Mean	0.206	0.686
S. deviation	0.0114	0.0027
Standard error	0.005	0.0012
C V %	5.535	0.392

DISSCUSSIONS

The biomass and carbon stock at the nation and regional level is estimated from the growing stock using the BEF ration. The value of BEF is given by (IPCC). The IPCC gives the constant value of BEF. But according to various study conducted by (IPCC, 2003; lehtonen et al. 2004; Montagu et al. 2005; Teobaldelli et al. 2009; Kim et al. 2011) concluded that variation occurred in the value of BEF. There for the biomass and carbon stock should be calculated by using the BEF value corresponded to the site, and stand density classes. (Kim et al., 2011) The present study was carried to assess the BEF of *Picea smithiana* in the Kumrat valley for the reporting of carbon stock.. Tree diameter, height and volume are the important factors in assessing the BEF of a species. Forest biomass have a close relation with the trees height (Brown and Schroeder, 1999; Wang et al. 2013 ; Lehtonen et al. 2004 ; Levy et al. 2010). For the measurement of the exact carbon pool and fluxes it is necessary to know about the volume of tree and total biomass (Houghton et al. 1999).

Stem biomass is the integral part of the total biomass of a tree. In present study it was found that the percentage of stem biomass in total biomass was 66.31. The results of the present study are similar with (Adhikari, 1994; Rana and Sing, 1989). In present study the contribution of branches biomass in total tree biomass was 11.82%. Khadka,(2000) estimated the contribution of branches in total biomass of *Pinus carabaea* as 9.14%. The results of the present study conclude that the contribution of the, twigs, leaves, and roots were 11.28, 2.193, 2.62, and 17.05 percent respectively. These results are consisted with the results of (Adhikari,1994; Rana and Sing,1989). In present study the BEF of Picea smithiana was calculated as 1.50 (0,686 t m³). Sanquetta et al (2011) estimated BEF for Pinus in Brazil as 1.47, while levy et al. (2012) calculated BEF of *Picea sitchensis* as 1.438. In the present study the root to shoot ratio was also assessed and was 0. 206 ± 0.01. Sanquetta et al. (2011) estimated root-to-shoot ratio for Pinus in Brazil as 0.17. Wang et a.l (2008) determined the variation of root to shoot allocation in northeast China that ranged between 0.09 and 0.67, with a mean of 0.27. Son et al. (2005) estimated root to shoot ratio for *Q. mongolica* and *Q. variabilis* as 0.2643 and 0.2453.

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CONCLUSION

Pakistan is the member of the Kyoto protocol. Being a signatory to the protocol each member countries should report there carbon stock in the forest. For the estimation of total carbon stock in a forest we need the local data regarding BEF of the specie. The present study provides a details information about the BEF of the *Picea smithiana* tree that has been widely grown in the moist and dry temperate forests of Pakistan. The present research not only outline the total above and below ground biomass of the *Picea smithiana*, but the study also reveled the contribution of different tree components like stem, branches, leaves, twigs and roots in the total biomass . The developed biomass expension factor will be help in the estimation of biomass and carbon stock for the reporting under Keyto protocol.

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