

EFFECT OF CANOPY COVER ON NATURAL REGENERATION OF *PINUS WALLICHIANA* IN MOIST TEMPERATE FOREST OF YAKH TANGAY, DISTRICT SHANGLA, SWAT PAKISTAN

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خلاصہ

یہ مطالعہ 2013-14 کے دوران شانگلہ کے نم معتدل جنگل پنج ٹنگے میں منعقد ہوا جو کہ وادی سوات میں 31.3 تا 33.08 عرض بلد اور 72.33 تا 73.01 طول بلد پر واقع ہے۔

اس تحقیق کا مقصد علاقے میں کابل کے قدرتی تخلیق پر اثر انداز کرنے والی چھت کا احاطہ، قدرتی تخلیق کی کیفیت اور دیگر عوامل کا مطالعہ کرنا ہے۔ مختلف اونچائی میں چالیس نمونے کے پلاٹ (پلاٹ کا سائز 25 x 25 میٹر) لیے گئے تھے جو کہ (1707-1920 میٹر)، (1921-2134 میٹر) اور (2135-2347 میٹر) تھے۔ ہر پلاٹ میں قدرتی تخلیق کی کیفیت اور چھت کا احاطہ ماپا گیا۔ کیسائی خواص (ہائڈروجن کی طاقت، بجلی کی ترسیل، نمک کی حل پذیری) اور زمین کی زرخیزی (نامیاتی مرکبات، نائٹروجن فاسفورس اور پوٹاشیم) کو جانچنے کے لئے علاقے کی مٹی کے نمونے کے ٹیسٹ کئے گئے۔ چھت کا احاطہ کم اونچائی یعنی (1707-1920 میٹر) پر بند تھا جبکہ (2134-1921 میٹر) بلندی پر کم تھا۔ تنخی پودے اور نو نہال پودے بالترتیب اوسط (37 فی پلاٹ) اور (23.5 فی پلاٹ) اور (2134-1921 میٹر) بلندی پر زیادہ تھے۔ تنخی پودے اور نو نہال پودے اوسط (31.8 فی پلاٹ) اور (21.5 فی پلاٹ) جنوبی پہلو پر زیادہ مقدار میں تھے۔ درخت اوسط (28.4 فی پلاٹ) شمالی پہلو میں زیادہ گئے تھے۔

اچھی تخلیق کی کیفیت پہلی بلندی پر (28 فیصد)، شمالی پہلو پر (20 فیصد)، کھلے چھت کی احاطہ پر (31 فیصد) زیادہ مقدار میں تھی جبکہ تیسری بلندی پر (9 فیصد)، جنوبی پہلو پر (15 فیصد) اور معتدل بند چھت کی احاطہ پر (27 فیصد) کم مقدار میں تھی۔ مناسب اچھی تخلیق کی کیفیت پہلی بلندی پر (34 فیصد)، شمالی پہلو پر (40 فیصد) اور بند چھت کی احاطہ پر (69 فیصد) زیادہ مقدار میں تھی جبکہ تیسری بلندی پر (33 فیصد)، جنوبی پہلو پر (30 فیصد) اور معتدل بند چھت کی احاطہ پر (27 فیصد) کم مقدار تھی۔ کمزور تخلیقی کیفیت پہلی بلندی پر (15 فیصد)، شمالی پہلو پر (15 فیصد) اور معتدل بند چھت کی احاطہ پر (9 فیصد) زیادہ مقدار تھی جبکہ تیسری بلندی پر (10 فیصد)، شمالی پہلو پر (15 فیصد) اور بند چھت کی احاطہ پر (6 فیصد) کم مقدار میں تھی۔ عدم تخلیق کی کیفیت تیسری بلندی پر (29 فیصد)، دونوں پہلو میں (20، 20 فیصد) برابر اور معتدل بند چھت کی احاطہ پر (37 فیصد) زیادہ مقدار میں تھی جبکہ دوسری بلندی پر (16 فیصد) اور بند چھت کی احاطہ پر (25 فیصد) کم مقدار میں تھی۔ نئی تخلیق کی کیفیت دوسری بلندی پر (25 فیصد)، جنوبی پہلو میں (35 فیصد) اور کھلے چھت کی احاطہ پر (61 فیصد) زیادہ مقدار میں تھی جبکہ پہلی بلندی پر (15 فیصد)، شمالی پہلو اور بند چھت کی احاطہ پر (5 فیصد) کم مقدار میں تھی۔ کاکل کی نئی تخلیقی کیفیت کا مشاہدہ مٹی میں ہائڈروجن کی طاقت (6.82)، بجلی کی ترسیل (0.71)، نمک کی حل پذیری (0.004)، نامیاتی مرکبات (2.88)، نائٹروجن (0.3)، فاسفورس (14.00) اور پوٹاشیم (88.00) کی گتیا جبکہ کمزور تخلیقی کیفیت مٹی میں ہائڈروجن کی طاقت (7.22)، بجلی کی ترسیل کی طاقت (1.36)، نمک کی حل پذیری (0.007)، نامیاتی مرکبات (0.28)، نائٹروجن (0.0015)، فاسفورس (7.50) اور پوٹاشیم (80.50) بالترتیب پائے گئے۔ موجودہ مطالعہ مستقبل میں جنگل کی پائیدار انتظام میں مدد دے گی۔

Abstract

This study was conducted in the moist temperate forest of Yakh Tangay, District Shangla during 2013-14. It is situated in the Valley of Swat having Latitude 34°-31' to 33°-08' and Longitude 72°-33' to 73°-01'. This study aimed to establish the canopy cover, natural regeneration status and other factors affecting natural regeneration of *Pinus wallichiana* in the study area. Forty sample plots (Plot size 25m x 25m) were taken at different altitudinal gradient i.e. (1707-1920 m), (1921-2134 m) and (2135-2347 m). The Canopy cover was closed at lower elevation gradient i.e. (1707-1920 m) while open at elevation gradient i.e. (1921-2134 m). Canopy cover and natural regeneration status was measured in each sample plot. Soil samples of study area were tested for chemical properties (pH, EC and TSS) and soil fertility (OM, N, P, and K). Density of Seedlings and Saplings were higher (Mean = 37/plot) and (Mean= 23.5/plot), respectively at elevation gradient of (1921-2134 m). Seedlings and Saplings were maximum (Mean = 31.8/plot) and (Mean = 21.5/plot) at Southern aspect, respectively. The trees were more dense (Mean=28.4) at Northern aspect. Good regeneration status was maximum (28 %) at first elevation gradient, (20 %) at Northern aspect, (31 %) in the region of open canopy

cover while minimum (9 %) at third elevation gradients, (15 %) at Southern aspect and (27 %) in the region of moderately closed canopy cover. Fair regeneration status was maximum (34 %) at first elevation gradient, (40 %) at Northern aspect, and (69 %) at closed canopy cover whereas minimum (33 %) at third elevation gradient, (30 %) at Southern aspect and (27 %) at moderately closed canopy cover. Poor regeneration status was maximum (15 %) at first elevation gradient, (15 %) at Northern aspect and (9 %) in moderately closed canopy cover but was minimum (10 %) at third elevation gradient, (15 %) at Northern aspect and (6 %) in Closed canopy. None category of regeneration status was maximum (29 %) at third elevation gradient, (37 %) in moderately closed canopy and same (20, 20 %) at both aspects although minimum (16 %) at second elevation gradient, and (25 %) closed canopy cover. New regeneration status was maximum (25 %) at second elevation gradient, (35 %) at Southern aspect and (61 %) at open canopy cover even though minimum (15 %) at first elevation gradient, (5 %) at Northern aspect and in closed canopy cover. New regeneration of *Pinus wallichiana* was observed with soil pH (6.82), EC (0.71 dS.m⁻¹), TSS (0.0041 %), OM (2.88 %), N (0.38 %), P (14.00 ppm) and K (88.00 ppm) while poor regeneration occurred with soil pH (7.22), EC (1.36 dS.m⁻¹), TSS (0.0070 %), OM (0.28 %), N (0.015 %), P (7.50 ppm) and K (80.50 ppm) respectively. The present study will help in the sustainable management of the forest in future.

Introduction

Canopy cover influences the natural regeneration of the species. When mature trees are more in number in an area there are less number of seedlings due to non availability of sun light to the seedlings (Halil *et al.*, 2010). Elevation also influences on natural regeneration because some plants grow in high altitude while some grow on lower altitude. There are some factors such as aspects, elevation gradient and canopy cover of the forest that affect the natural regeneration of plant species. Forest managers need to decide whether or not to occur to respase naturally regenerating trees to a density and pattern closer to that found in conventional stands (Bill, 2010). An essential part of forest stewardship involves the careful planning and management of young trees and seedlings. When an opening is created in the forest canopy, either from timber harvest or following a natural disturbance event such as wind storm or fire there is an opportunity to influence what plants or trees establish (Castro *et al.*, 2002). Regeneration of tree stands depends on a combination of factors controlling seed availability, germination, seedling growth and establishment (Dovciak *et al.*, 2003) whereas environmental conditions play an important role in establishment and distribution of seedlings (Bonnet *et al.*, 2005). Conifer regeneration fails due to soil compaction, unavailability of nutrients and poor management of the area. In the absence of high severity natural fires the canopy keystone species (*Pinus wallichiana*) fails to regenerate successfully mainly due to limitation of favorable condition (Mallik, 1999). The moist temperate Himalayas, as one of the major ecological zone in Pakistan, deserve specific attention to the conservation of environment and the sustainable development of natural resources. During the last hundred years, the area has been subject to major structural changes leading to a decrease of about fifty percent of the potential forest area (Ibrar, 2003). *Pinus wallichiana* is an evergreen tree which is distributed from Afghanistan to all Himalayan region including Nepal, Bhutan and India. Plant regeneration is one of the problems in the ecological field in recent decades. Pakistan covers about 4 % of forested area. Major part of these forests occurs in the Northern parts of Pakistan. These forests include conifers and broad leaved species and are being rapidly deteriorated mainly due to anthropogenic factors reported by various ecologist and foresters (Khan *et al.*, 2010). In Pakistan, Conifer forests are located mainly in Khyber Pakhtunkhwa (KP), Azad Jammu and Kashmir (AJK), Northern Areas, Balochistan and Northern Punjab. They are found at altitudes ranging from 1000 to 4000 meters. *Pinus wallichiana* generally attains large heights with horizontally spreading branches. The young shoots are glaucous green and each dwarf shoot has five needles. They are largely found in areas where rainfall is 1000-2000 mm annually (Jackobsen *et al.*, 1994). *Pinus wallichiana* also found naturally in District Shangla. It is commonly used in hilly areas for timber and fuel production. The forests in Pakistan particularly Conifer forests return huge climatic and physiographic contrasts and are under constant pressure due to population growth, human activities and commercial harvesting for fuel wood and timber utilization (Anon., 2007). *Pinus wallichiana* is an important source of timber and fuel for villagers in mountain valleys and is also important in protecting the upper parts of mountain watersheds. The local communities near to the forest area rapidly cut down the precious species from conifer forest which is decreasing day by day in the area. In Shangla *Pinus wallichiana* is dominant species but due to continuous felling of the species it is under threat. The regeneration status of the species is investigated in Yakh Tangay forest of District Shangla. Comprehensive knowledge of how forest structure develops in response to natural disturbances and canopy cover influences regeneration in a forest is essential to evaluate current forest conditions and to promote sustainable silviculture and conservation systems in the future (McCarthy, 2001).

Materials and Methods

Study area: The current research study was conducted in the moist temperate forest of Yakh Tangay, District Shangla (Fig.1) during 2013-14 which is situated in the Valley of Swat having Latitude 34° - $31'$ to 33° - $08'$ and Longitude 72° - $33'$ to 73° - $01'$. The average elevation of the District Shangla is 2000 to 3000 m.

Data collection: Forest department Shangla was visited and through discussion with different forest officers all the information regarding forest was provided that helped us to achieve the objectives of the study. Study area was divided into aspects, Northern and Southern. Each aspect was further divided into three elevation gradients through GPS which were from 1707-1920 m, 1921-2134 m and 2135-2347 m respectively. In each aspect and elevation gradients $25\text{ m} \times 25\text{ m}$ sample plots were established for data collection. The individuals of *Pinus wallichiana* were classified into three groups as seedlings, sapling and mature trees. The number of seedlings, sapling and mature trees were counted in each plot (Williamson, 1997). The height and collar diameter of seedlings within each plot were measured by measuring tape and Dia tape (Edwards *et al.*, 1995).

Measurement of canopy cover: Canopy cover of each plot was measured by densitometer and classified as open, moderately closed and closed. Canopies were classified as Open Canopy = 10-39% of the sky is obstructed by tree canopies, Moderately Closed = 40-69% of the sky is obstructed by tree canopies, Closed Canopy = 70-100% of the sky is obstructed by tree canopies.

Measurement of Regeneration status: Regeneration status of *Pinus wallichiana* in the study area was calculated as “Good” when seedlings $>$ saplings and saplings $>$ mature trees, “Fair” when seedlings $>$ sapling and sapling $<$ mature trees, “Poor” when species survived only in sapling stage and not in the seedling stage, “None” when only trees were present while “New” when adults absent but sapling and seedling stage present (Chauhan *et al.*, 2008).

Soil analysis: Eight Soil samples were collected from the sample plots of new regeneration, good regeneration, fair regeneration and poor regeneration status plots at depth range from 0-15 cm and 15-30 cm for analysis of soil texture, pH, Soil Electrical Conductivity (EC), Soil Organic Matter (OM), Soil Nitrogen (N), Soil Phosphorous (P), Soil Potassium (K) by the methods applied by Tiwari *et al.*, 2013. The soil samples were carried out in air tight bags from the study area to the Soil Testing Laboratory at Model Farm Services Center Agriculture (Extension) Haripur and Abbotabad.

Statistical analysis: Collected data was analyzed applying Microsoft office excels for making graphs and SPSS software for descriptive statistics.

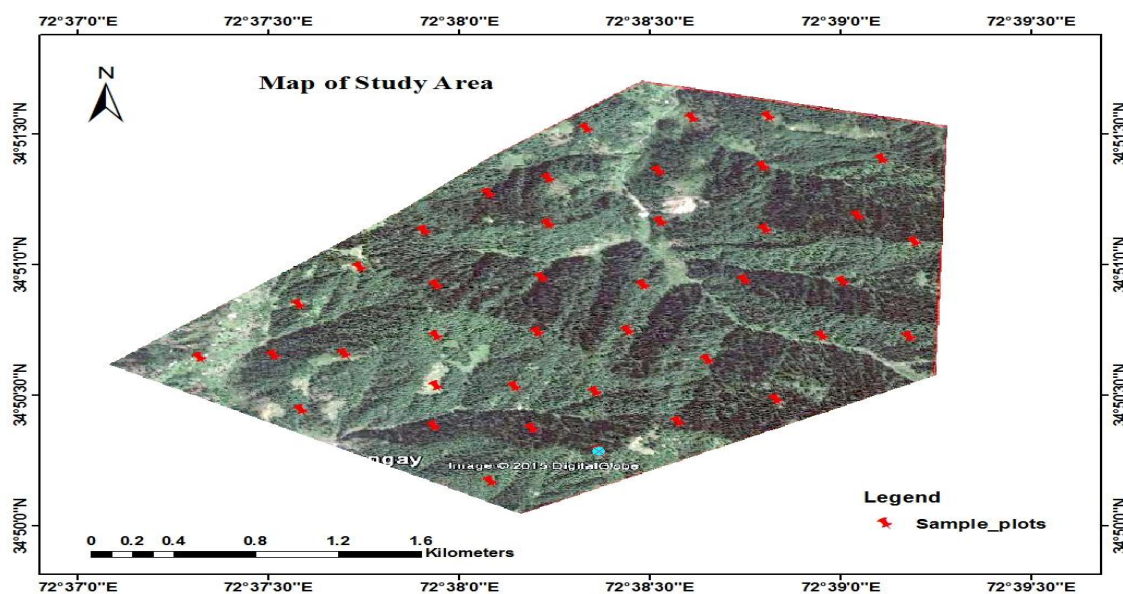


Fig.1. Map the study area Yakh Tangay, District Shangla, Swat Pakistan

Results and Discussion

Impact of elevation gradient on canopy cover percentage

Study area map was shown in Fig.1. It was observed from data presented in Table 1 that there was considerable effect of elevation gradient on canopy cover of *Pinus wallichiana* in two elevation in the study area. Statistical analysis showed that maximum canopy cover percentage was (57.86 %) at first elevation gradient i.e. 1707-1920 m while minimum (46.67 %) at second elevation gradient i.e. 2134-2347 m. Further, it was found that moderately closed canopy of *Pinus wallichiana* was higher at third elevation gradient while closed canopy cover % age was lowest at first elevation gradient as shown in Table 1. The results of the study showed that canopy cover percentage was maximum at lowest elevation gradient because of larger number of mature trees lower number of seedlings and saplings. At middle elevation gradient mature trees were in less number due to which canopy cover percentage was lower than first elevation gradient. It showed good condition of the *Pinus wallichiana* at lower elevation.

Table 1: Impact of elevation on canopy cover % of *Pinus wallichiana*.

Elevation	Canopy Cover	Std. Error
1707-1920	57.86	11.119
1921-2134	46.67	8.009
2135-2347	56.19	5.710

Impact of aspects on canopy cover percentage

It was found from data presented, that there was significant effect of aspects on canopy cover of *Pinus wallichiana* in the study area. Statistical analysis showed that the Northern aspect was rich ($62.50 \pm 4.91\%$) in canopy cover as compared to the Southern aspect which was $44.75 \pm 4.46\%$. Canopies were more closed in Northern than in the Southern aspect (Fig, 2). The canopy cover at Northern aspect may be due to low fire damage, more number of mature trees, less steep topography and higher moisture contents as compared to Southern aspect. Similar results have been also reported by Chris *et al.*, (2007) that Northern and Southern aspect have a significant divergence in canopy cover.

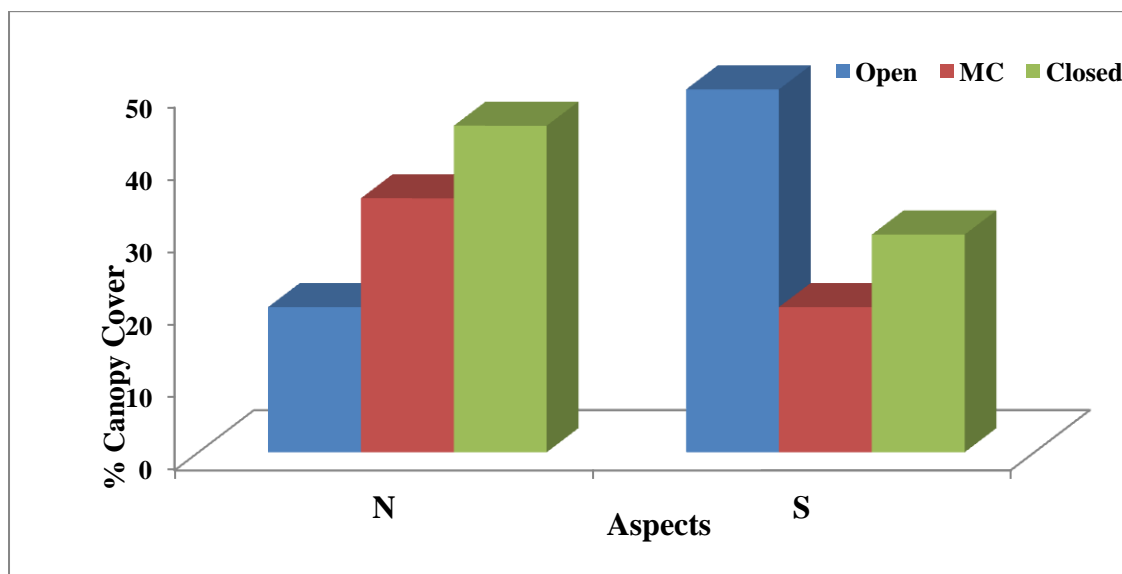


Fig.2. Impact of aspects on canopy cover % of *Pinus wallichiana*.

*Impact of elevation on different growth stages of *Pinus wallichiana**

There was considerable effect of elevation on the different developmental stages of *Pinus wallichiana*. The seedlings were higher (37.00) at second elevation i.e. 1921-2134 m, high (29.00) at first elevation i.e. 5700-1920 m while less (14.00) at third elevation gradient i.e. 2135-2347 m. The results for Saplings were similar to Seedlings and it was found that Saplings were higher (23.50) at second elevation gradient i.e. 1921-2134 m, high (20.29) at first elevation gradient i.e. 5700-1920 m while less (10.43) at third elevation i.e. 2135-2347 m. Further data was analyzed for mature trees which were higher (29.29) at third elevation gradient i.e.2135-2347 m, high (28.29) at first elevation gradient i.e. 5700-1920 m while less (23.08) at second elevation gradient i.e. 1921-700 m as shown in Table 3. Results obtained showed maximum seedlings and saplings at middle elevation because of more fertility in the soil. Moderately closed canopy cover influenced the growth of seedlings and

saplings. At high altitude trees were maximum as compared to seedlings and saplings because environmental stresses such as more snow fall, severe climatic conditions and unfavorable conditions unfavoured the early growth of plants. Similar results were reported by Sharma *et al.*, (2009) who reported that species was rich in lower altitude than higher altitude. At higher altitude the species were in random pattern while in lower altitude the species richness was in contiguous pattern. Similar results of Li *et al.*, (2013) reported that elevation and canopy cover had greatly significant effects on seedling size. He found that the seedlings were significantly higher under open canopy cover and at middle elevations than at higher elevations. Mahmoudi *et al.*, (2015) also found that seedlings and saplings were decreased in the high elevations but were satisfactory in lower elevation. Since the high-elevation wind velocity is more and for this reason the intensity of vaporization is more, so the high elevation is less favorable for plant growth. Our results are similar to that of Yu *et al.*, (2013). The canopy closure and competition for light appear to be the key factors that halt pine regeneration in pine forests.

Table 3: Impact of Elevations on different growth stages of *Pinus wallichiana*

Elevation	Growth Stages	Mean (No of <i>Pinus wallichiana</i>)	Std. Error
1707-1920	Seedlings	29.00	5.542
	Saplings	20.29	2.504
	Trees	28.29	8.297
1921-2134	Seedlings	37.00	11.457
	Saplings	23.50	6.628
	Trees	23.08	5.052
2135-2347	Seedlings	14.00	2.868
	Saplings	10.43	1.364
	Trees	29.29	4.727

Impact of Aspect on different growth stages of *Pinus wallichiana*

There was significant effect of aspect on plant species of *Pinus wallichiana* in Yakh Tangay, District Shangla (Table 4). Seedlings were maximum (31.75/plot) at Southern aspect as compared to Northern aspect which were 15.30/plot. Saplings were also analyzed which were maximum (21.50/plot) at Southern aspect than (10.65/plot) which were at Northern aspect. Analysis of data for trees showed maximum (28.40/plot) at Northern aspect while minimum (26.10/plot) at Southern aspect as shown in Table 4. Results obtained from the study about plant growth and aspect in which seedlings and saplings were abundant at Southern aspect as compared to Northern aspect because at Southern aspect maximum availability of sunlight found due to which temperature was suitable for the growth of seedlings. Ground flora was minimum due to which there was a little competition for food and *P. wallichiana* plant growth was satisfactory. The number of trees was maximum at Northern aspect because it was rich in soil organic matter, humidity was more and mostly the species was found in shaded areas. Similar results were reported by Yu *et al.*, (2013) that seedlings and saplings are also affected by aspects because in Southern aspect light and warmth was more and it influenced the density of seedling and saplings. Contrast results were reported by Mahmoudi *et al.*, (2015) that there was no significant difference between the Northern and Southern aspects.

Table 4: Impact of aspects on different growth stages of *Pinus wallichiana*.

Aspect	Plant Species	Mean	Std. Error
N	Seedlings	15.30	3.167
	Saplings	10.65	1.664
	Trees	28.40	3.866
S	Seedlings	31.75	7.227
	Saplings	21.50	3.996
	Trees	26.10	5.185

Impact of elevation gradient on natural regeneration status of *Pinus wallichiana* in study area

Natural regeneration of *Pinus wallichiana* was significantly affected by elevation gradient in study area. Good regeneration status was maximum (28 %) at first elevation gradient i.e. 1707-1920 m while minimum (9 %) at third elevation i.e. 2135-2347 m and medium (25 %) at second elevation i.e. 1921-2134 m. Fair regeneration status was maximum (34 %) at first elevation gradient, medium (34 %) at second elevation while minimum (33 %) at third elevation. Poor regeneration status was maximum (15 %) at first elevation gradient but minimum (10

%) was at third elevation. None category of regeneration status was maximum (29 %) at third elevation while minimum (16 %) at second elevation. Further results showed that New regeneration status was maximum (25 %) at second elevation, medium (19 %) at third elevation although minimum (15 %) at first elevation as shown in Table 5. The present study carried out to point out the impact of elevation gradient on natural regeneration status of *Pinus wallichiana*. In study area the plant species were more or less on different elevation. The results showed maximum good regeneration status in first elevation because lower elevation was the best zone for the growth of species and seedlings were found more in number than saplings while saplings were also found more in number than mature trees. The study of Yu *et al.*, (2013) showed similar results that in pine oak mixed forest the elevation, had momentous effects on the seedling and sapling densities. It was also concluded in the study area that fair regeneration status was rich in first elevation because at that stage seedlings were more than saplings but mature trees were also recorded more in number than saplings. Poor regeneration status was also found in lower elevation because mostly sapling stage was found seedlings were not originated there. At high elevation gradient mature trees were found in more number but seedlings and saplings were not established it was due to less human interference in high altitude for felling purposes. At medium elevation gradient natural regeneration was found most suitable because seedlings and saplings were more in number while mature trees were just about absent at that elevation. In our study it was concluded that different growth stages of species were decreased or increased on different elevation gradient. Similar results were conducted by Mahmoudi *et al.*, (2015) that distribution of species decreased with increasing elevation. At high elevation wind speed is more and vaporization also more there, therefore for plant growth the high elevation is less favorable. Altitude is associated openly to a diversity of environmental factors that have significant effects on plant growth (Yu *et al.*, 2013).

Table 5: Impact of elevation gradient on natural regeneration (%) status of *Pinus wallichiana* in study area

Regeneration Status	1707-1920 (m)	1921-2134 (m)	2135-2347 (m)
Good	28	25	9
Fair	42	34	33
Poor	15	0	10
None	0	16	29
New	15	25	19

Impact of Aspect on natural regeneration status of *Pinus wallichiana* in study area

The data collected from study area showed in Table 6 that aspect was extensively affected the natural regeneration status of the study area. Good natural regeneration was maximum (20 %) at Northern aspect while minimum (15 %) at Southern aspect. Fair regeneration status was maximum (40 %) at Northern but minimum (30 %) at Southern aspect. Poor regeneration status was maximum (15 %) at Northern aspect. None group of regeneration status was same (20, 20 %) at both aspects. Moreover New regeneration was found maximum (35 %) at Southern aspect however it was minimum (5 %) at Northern aspect. Northern aspect was more sustainable than Southern aspect for the regeneration of *Pinus wallichiana*. Results of study were also conducted to know the natural regeneration status on Northern and Southern aspects in the study area. Good regeneration status was rich in Northern aspect than Southern aspect due to more number of seedlings than saplings and trees because the aspect was rich in soil moisture contents than Southern. The species distribution diverse in different aspect, Northern aspect has the most amount of distribution Mahmoudi *et al.*, (2015). In Northern aspect seedlings were also more than saplings but trees were more than saplings so fair regeneration status was also found on Northern aspect due to dense forest which blocks the direct solar radiation. Poor regeneration status was satisfactory in Northern aspect because only saplings were found there. The numbers of mature trees were also calculated in both Northern and Southern aspects which were equal so regeneration status was considered as none because of unavailability of seedlings and saplings in that point. Inger *et al.*, (2015) also reported that Northern facing forests had more tree species and superior tree thickness than the forests in front of Southern. Maximum number of seedlings and saplings were found at Southern aspect than Northern aspect but there were no mature trees, hence new regeneration status was found at Southern aspect in the study area because solar radiation falls for longer time in Southern aspect which is necessary for the developmental stages of plant growth. Our results also similar to Mahmoudi *et al.*, (2015) that in Southern aspect moisture contents were less because sun rays focused on Southern aspect for longer time than Northern aspect. So it was concluded that soil moisture showed positive correlation with altitude and aspects.

Table 6: Impact of aspect on natural regeneration status of *Pinus wallichiana* in study area

Regeneration Status	Northern	Southern
Good	20 %	15 %
Fair	40 %	30 %
Poor	15 %	0 %
None	20 %	20 %
New	5 %	35 %

Impact of canopy cover on natural regeneration status of *Pinus wallichiana* in study area

The significant effect of canopy cover on natural regeneration of *Pinus wallichiana* in the study area (Table 7). Good regeneration was maximum (31 %) in open canopy cover while minimum (27 %) in moderately closed canopy cover. Fair regeneration was maximum (69 %) at closed canopy cover but minimum (27 %) at moderately closed canopy cover. Poor regeneration was maximum (9 %) in moderately closed canopy cover, minimum (6 %) in Closed canopy while medium (8 %) in open canopy cover respectively. None status of regeneration was maximum (37 %) in moderately closed but it was minimum (25 %) closed canopy cover. New regeneration was maximum (61 %) at first elevation. In present study seedlings of *Pinus wallichiana* showed significant relation with canopy cover. Regeneration was found in good condition in open canopy cover region because there were less number of mature trees than seedlings and saplings. Regeneration status was fair in closed canopy cover because of maximum number of mature trees in that area than seedlings and saplings. Results also showed that in moderately closed canopy cover *Pinus wallichiana* was found only in sapling stage and because of that reason it was considered poor regeneration status. Comparable results were also given by Sudhakar *et al.*, (2008) that in dry deciduous forest, *Shorea roxburghii* regeneration was poor represented by smaller number of young species in the forest. Due to change in the forest structure mature trees were reduced. Regeneration status was also found in ‘None’ category in moderately closed canopy cover because some sample plots showed more mature trees than seedlings and saplings because at that stage seedlings were found to a large extent in competition with other herbaceous and shrubby flora. In open canopy cover there were no mature trees and only seedlings but rarely saplings were found in highest quantity, hence at that canopy cover new regeneration status was considered. It was found from the results that canopy cover had a significant relation with natural regeneration of *Pinus wallichiana* in the study area because in open area direct fall of solar radiations play a vital role in the growth of early stages of plants. Neil *et al.*, (2004) have reported that forest species increased with decreasing canopy cover.

Table 7: Impact of canopy cover on percent natural regeneration status of *Pinus wallichiana* in the study area

Regeneration Status	Open Canopy	Moderately Closed Canopy	Closed Canopy
Good	31	27	0
Fair	0	27	69
Poor	8	9	6
None	0	37	25
New	61	0	0

Different properties of soil affecting natural regeneration of *Pinus wallichiana* in study area
Impact of chemical properties of soil on natural regeneration status of *Pinus wallichiana*

Data (Table 8) revealed that natural regeneration of *Pinus wallichiana* badly affected as chemical properties of soil (pH, EC & TSS) increased. New regeneration was observed with soil pH (6.82), EC (0.71 dS.m⁻¹) and TSS (0.0041 %) while poor regeneration of *Pinus wallichiana* occurred with soil pH (7.22), EC (1.36 dS.m⁻¹) and TSS (0.007 %) as shown in Table 8. Results of Ahangar *et al.*, (2012) were similar to our study that increase in Soil pH had adverse relation with fertility because soil organic matter decreased in high pH soil. pH greater than 8.5 are harmful for plant growth because it becomes sodic soils. The results also showed that when EC of soil was maximum the plant regeneration was poor but in low EC soil the regeneration status was in rich condition. The study supported by Douglass *et al.*, (2005) that plant growth occur maximum at EC level from 1.8 – 2.2 dS m⁻¹ ranges. Optimal range up to 2.5 dS m⁻¹ was best for the growth black spruce and white spruce seedlings. So for maintaining plant growth 1.2 and 2.5 dS m⁻¹ EC level is suitable. Further soil TSS also showed their importance in the growth of plants. Similar results with our study was carried out by Christian *et al.*, (2006) and reported that soil pH had great effect on plant growth where pH decreased to acidic condition there were good condition for plant growth while increase in EC affected the plant growth badly. Natural regeneration

was in good condition when the value of TSS was minimum although as the value of TSS increased in the soil, the species showed poor regeneration status.

Impact of soil fertility on natural regeneration status of *Pinus wallichiana*

Data (Table 8) also demonstrated that natural regeneration of *Pinus wallichiana* was affected as fertility of soil (OM, N, P, and K) decreased (Table 8). New regeneration status was observed with soil OM (2.88 %), N (0.38 %), P (14.00 ppm) and K (88.00 ppm) while poor regeneration of *Pinus wallichiana* occurred with soil OM (0.28 %), N (0.015 %), P (7.50 ppm) and K (80.50 ppm). It was found that soil OM was in maximum amount in new regeneration status of species. As the amount of OM decreased in the soil, the plant growth affected adversely and showed poor regeneration status in the study area. Ahangar *et al.*, (2012) has also reported that nitrogen contents was low in semiarid region because OM were in less amount but available phosphorus and potassium in the soil showed important effects on the color of the pine needles. Amount of Nitrogen was also analyzed in the soil sample in the study area. Nitrogen was found minimum in poor regeneration status while maximum in new regeneration status that showed the impact of N on regeneration status of species. James (2013) had presented the similar results that Nitrogen was found in all soils, and is required by all living creatures. In plants, nitrogen is the nutrient required in the largest amounts. It was also concluded from the soil analysis that P was more in new regeneration but less in the poor regeneration status showed that less amount of P decreased the regeneration status of the study area. Soil sample were analyzed for the calculation of K in the study area. Potassium was found maximum in new regeneration although it was minimum in the poor regeneration status plot. It was concluded from the study that increase in soil fertility showed good regeneration status while reduction in soil fertility showed weak and poor regeneration status of *Pinus wallichiana* in the study area. Results from the study of Christian *et al.*, (2006) presented that Phosphorus and potassium are the best predictors of plant seedling but all soil has different yields which are variable in different sites.

Table 8: Different properties of soil affecting natural regeneration of *Pinus wallichiana*

Parameters	New Regeneration	Good Regeneration	Fair Regeneration	Poor Regeneration	LSD value
pH	6.82 a	6.92 a	7.11 a	7.22 a	0.48 ^{NS}
EC (dS.m ⁻¹)	0.71 b	0.71 b	0.93 ab	1.36 a	0.54*
T.S.S (%)	0.0041 a	0.025 a	0.0048 a	0.007 a	0.045 ^{NS}
OM (%)	2.88 a	1.48 ab	0.76 b	0.28 b	1.50*
N (%)	0.38 a	0.13 a	0.058 a	0.015 a	0.53 ^{NS}
P (ppm)	14.00 a	10.50 b	9.50 bc	7.50 c	2.16*
K (ppm)	88.00 a	86.50 a	84.00 ab	80.50 b	4.86*

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