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Floor management studies at different locations and elevations of *Quercus leucotrichophora* a Camus

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Abstract
Ban oak is an ecologically and economically important species of Himalayan region which experiences a problem in its regeneration due to various factors in forests. The present investigation entitled "Floor management studies at different locations and elevations of *Quercus leucotrichophora* A Camus" was carried out during the year 2018-19 in Chail forests of district Solan, Kufri forests of district Shimla, Sarahan and Churdhar forests in Sirmaur district of Himachal Pradesh with three elevations i.e., E1 (<1500 m), E2 (1500-1800 m) and E3 (>1800 m) in each to assess the effect of different floor management treatments. The floor management was carried out by plotting 2 m x 2 m beds for each treatment at each elevation as: P_1 (Without removal of leaf litter (Control)), P_2 (Removal of leaf litter, P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter), P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) with three replications. The results showed that P_3 was best among all other treatments for regeneration, growth of seedlings and biomass while P_4 treatment showed least effect on acorn germination and other seedling parameters. The natural regeneration under floor management was highest in Kufri forests and can be concluded as: Kufri forests > Chail forests > Churdhar forests > Sarahan forests.

Keywords: Ban oak, floor management, elevations, locations etc.

Introduction
Quercus leucotrichophora commonly known as banjh oak, ban oak and banj oak belongs to family fagaceae is a multipurpose tree species of Himalayan region. Ban Oak flowers in April to May and fruits in the month of December. It is extensively lopped for fuelwood and its wood has a high calorific value and good burning properties. *Quercus leucotrichophora* forests are under chronic anthropogenic disturbances (Silori 2001, Singh 1998) [1, 2] due to indiscriminate harvesting (Purohit 2009) [3] and are facing the danger of extinction. *Quercus leucotrichophora* A. Camus is the dominant Oak species in the central Himalaya which is distributed between 1200-2300 m in the Himalayas. *Q. leucotrichophora* is used by the local inhabitants for fodder, fuel wood, agricultural implement and leaves for animal bedding etc. Acorns (seeds) act as food for animals like *Macaca mulata* (Monkeys), *Presbytis entellus* (Langurs), *Pteropus giganteus* (Flying foxes) and many species of birds (Bhatt *et al.* 2015) [4]. Under *Quercus*, leaf litter is thick and poses problem for seeds/acorns to germinate. Sometimes stand characteristics such as stand height, diameter, crown and light penetrance etc. also affect the regeneration of the species. These forests are important for inflow and spring recharge of water for drinking and domestic uses of local residents. The future of these forests depends upon the regeneration of the species which is very low. So, it is important to do research on the natural regeneration of ban oak. Present study is based on the floor management in the forests to assess the effect of different floor management treatments on the regeneration of ban oak seedlings.

Material and methods
The present investigation entitled "Floor management studies at different locations and elevations of *Quercus leucotrichophora* A Camus" was carried out during the year 2018-19 in Chail forests of district Solan, Kufri forests of district Shimla, Sarahan and Churdhar forests in Sirmaur district of Himachal Pradesh with three elevations i.e., E1 (<1500 m), E2 (1500-1800 m) and E3 (>1800 m) in each.

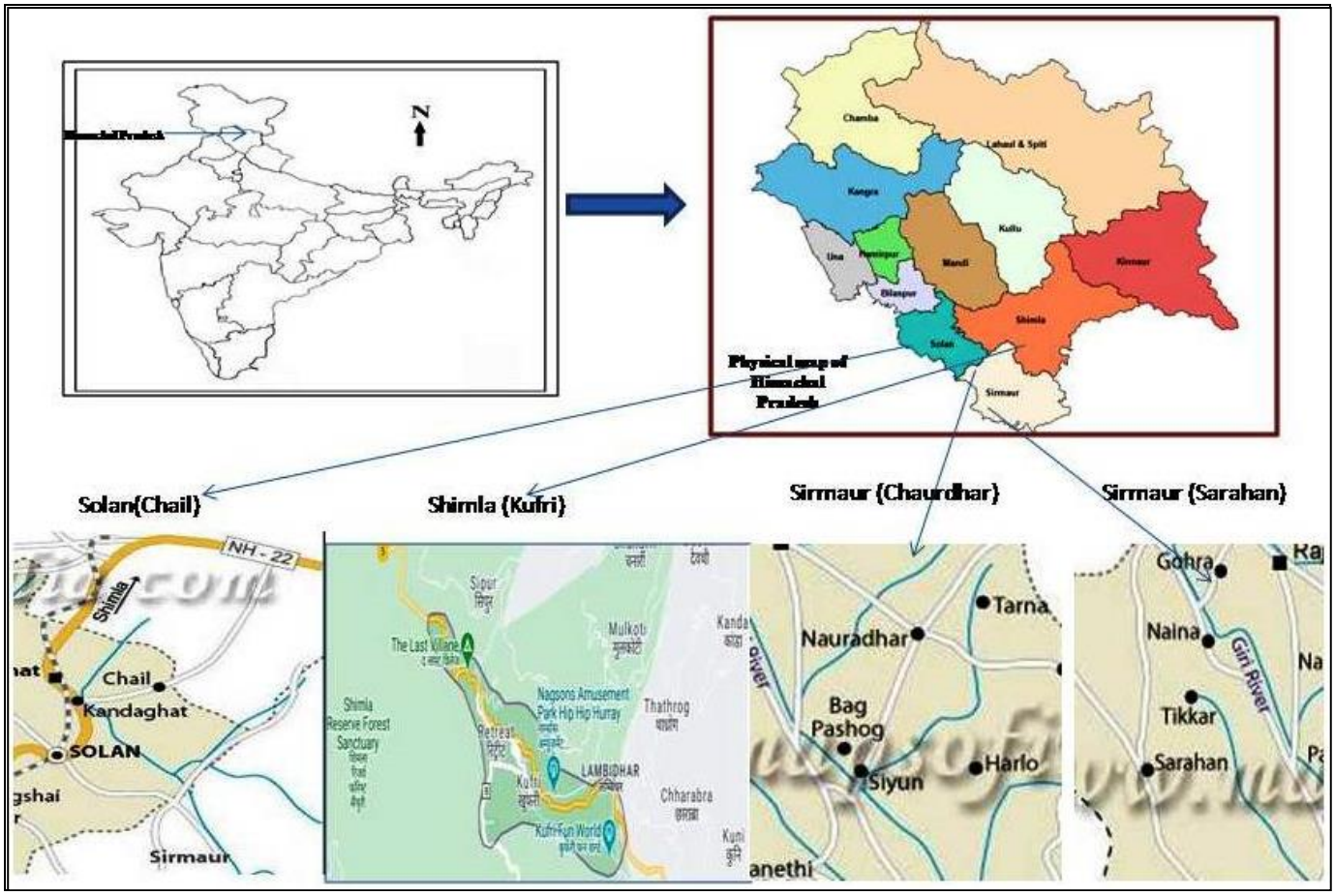

Fig 1: Study area Map

The regeneration of *Quercus leucotrichophora* was recorded by making permanent quadrat of 2m x 2m for each treatment under the ban oak forest floor so that the acorns fall into the ground and germinate naturally. For this experiment, the bed management was done as:

P_1: Without removal of leaf litter (Control)
P_2: Removal of leaf litter
P_3: Hoeing i.e., 15 cm approx, without removal of leaf litter
P_4: Hoeing i.e., 15 cm approx, with removal of leaf litter

The beds were examined after one year to record the germination. Thereafter, sample seedlings were collected from the beds and different parameters were recorded.

Results and Discussion

After bringing the seedlings from the treatment beds are evaluated in the laboratory of UHF, Nauni to record different seedling parameter, so as to know how the growth was affected by the floor management treatments. The parameters recorded and analysed which are presented (Table 1-9) are as under:

P_1: Without removal of leaf litter (Control)

P_2: Removal of leaf litter

P_3 : Hoeing i.e., 15 cm approx, without removal of leaf litter

P_4 :Hoeing i.e. 15 cm approx, with removal of leaf litter

Regeneration under forest floor (N /ha)

Forest floor treatments had a significant effect on natural regeneration of the ban oak seedlings with maximum regeneration (283.57 N /ha) under treatment P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter) followed by P_2 (Removal of leaf litter) (208.33 N ha), P_1 (Without removal of leaf litter) (121.53 N /ha) and lowest in P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) (104.17 N /ha). Elevation was found to show a significant effect as: E1 > E2 > E3 in all the locations. The maximum value (225.69 N /ha) was recorded at E1 elevation followed by E2 (177.95 N /ha) and minimum (134.55 N /ha) at E3 elevation while the interaction effects of locations and elevations (L x E), treatments and elevations (P x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded significant for regeneration of ban oak seedlings.

Collar diameter (mm)

The treatments have shown a significant effect on collar diameter of ban oak seedlings with highest value of 1.94 mm in P_3 (Hoeing i.e., 15 cm approx, without removal of leaf

litter) followed by P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) (1.85 mm), P_2 (Removal of leaf litter) (1.73 mm) and lowest (1.62 mm) in P_1 (Without removal of leaf litter) treatment. The interaction between location and elevation (L x E) exhibited a significant effect on collar diameter with maximum value (2.10 mm) at E2 elevation of Kufri forests which was recorded at par with E1 of Sarahan forests (1.93 mm) and with same value of 1.89 mm at E2 of Chail forests and E1 of Kufri forests and lowest (1.32 mm) at E1 of Chail forests. However, the effect of locations, elevations and the interaction effects of treatments and elevations (P x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded non-significant for collar diameter of ban oak seedlings.

Seedling Height (cm)

The effect of elevations on seedling height of ban oak was recorded significant with maximum value of 9.58 cm at E1 elevation followed by E3 (8.50 cm) and lowest (8.05 cm) at E3 elevation. The effect of locations, treatments and all the interaction effects of locations, treatments and all the interactions has shown no significant variation for height of ban oak seedlings.

Number of leaves

The effect of locations, elevations, treatments and the interaction effects of treatments and elevations (P x E), location and elevation (L x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded non-significant for number of leaves of ban oak seedlings. However, P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) treatment was recorded with maximum (4.29) number of leaves and minimum (3.94) in P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter) treatment. The maximum value of 4.25 at E1 elevation followed by E3 (4.05) and lowest (4.04) at E3 elevation.

Shoot length (cm)

Locations exhibited a significant effect on shoot length of ban oak seedlings with highest length of 9.76 cm in Kufri forests which was found at par with Sarahan forests (9.14 cm) followed by Chail forests (8.82 cm) and smallest (8.61 cm) in Churdhar forests. The interaction of locations and elevations was recorded significantly highest (10.63 cm) at E2 of Kufri forests which were recorded at par with E3 of Chail forests (10.13 cm) while the lowest value (7.40 cm) was observed at E1 of Chail forests. The effect of elevations, floor management treatments and the interaction effects of treatments and elevations (P x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded non-significant for shoot length of ban oak seedlings.

Root length (cm)

The floor management treatments showed a significant effect on root length of ban oak seedlings with largest length of 12.74 cm in P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) treatment which was recorded at par with P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter) treatment (12.25 cm) and smallest (10.55 cm) in P_1 (Without removal of leaf litter) treatment. However, the effect of locations, elevations and interaction effects of treatments and elevations (P x E), location and elevation (L x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded non-significant for root length of ban oak seedlings.

Shoot weight (g)

The effect of locations, elevations, treatments, interaction effects of treatments and elevations (P x E), location and elevation (L x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded non-significant on shoot weight of ban oak seedlings. However, the maximum shoot weight (0.53 g) was recorded in P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter) treatment followed by P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) (0.51 g) and lowest in P_2 (Removal of leaf litter) (208.33 N ha) treatment (0.42 g).

Root weight (g)

The root length was significantly affected by forest floor treatments with highest value (0.85 g) in P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter) treatment which was found at par with P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) treatment with value 0.76 g and lowest (0.42 g) in P_1 (Without removal of leaf litter) treatment. Similarly, locations exhibited a significant effect on root length with maximum value (0.85 g) in Chail forests which was recorded at par with Kufri forests (0.71 g) and minimum in Churdhar forests (0.46 g). The effect of elevations on root weight also showed a significant effect on ban oak seedlings and followed a decreasing trend as: E1 (0.76 g) > E2 (0.68 g) > E3 (0.45 g). The interaction effect of locations and elevations (L x E) was recorded significant with maximum value of 1.35 g at E1 elevation of Chail forests which was found at par with E2 elevation of Kufri forests (1.30 g) and minimum (0.29 g) at E2 elevation of Churdhar forests whereas the effect of treatments and elevations (P x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded non-significant for root weight of ban oak seedlings.

Total dry biomass (g)

The total dry biomass was significantly affected by forest floor treatments with highest value (1.38 g) in P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter) treatment which was found at par with P_4 (Hoeing i.e. 15 cm approx, with removal of leaf litter) treatment with value 1.27 g and lowest (0.82 g) in P_1 (Without removal of leaf litter) treatment. Similarly, locations exhibited a significant effect on total dry biomass with maximum value (1.45 g) in Chail forests which was recorded at par with Kufri forests (1.23 g) and minimum in Churdhar forests (0.86 g). The effect of elevations on total dry biomass also showed a significant effect on ban oak seedlings and followed a decreasing trend as: E1 (1.32 g) > E2 (1.16 g) > E3 (0.83 g). The interaction effect of locations and elevations (L x E) was recorded significant with maximum value of 2.22 g at E1 elevation of Chail forests which was found at par with E2 elevation of Kufri forests (1.97 g) and minimum (0.66 g) at E2 elevation of Churdhar forests whereas the effect of treatments and elevations (P x E), locations and treatments (L x P) and treatments, locations and elevations (L x E x P) was recorded non-significant for total dry biomass of ban oak seedlings.

The results of floor management led us to a conclusion that P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter), in general, was best among all other treatments for regeneration, growth of seedlings and biomass while P_4 (Hoeing i.e., 15 cm approx, with removal of leaf litter) treatment was noted to

show least effect on acorn germination of ban oak seedlings. This may be due to the reason that hoeing without leaf litter removal leads to proper aeration which may improve the decomposition of leaf litter and increase the availability of nutrients which creates favorable conditions for the germination of ban oak seedlings. As P_4 (Hoeing i.e., 15 cm approx, with removal of leaf litter) treatment showed least germination of ban oak seedlings which may be due to the removal of leaf litter. Adequate numbers of seed bearers, proper shade and site conditions are necessary for germination of acorns in the forests.

The effect of shade on the establishment of seedlings was briefly described by Harmer (1994) [5]. The findings of Singh *et al.* (1990) [6] revealed that reduced leaf litter layer before the seed falls have the direct relationship with the oak regeneration. The survival and growth of oak advance regeneration is often limited by shade tolerant species that are abundant in the understorey of oak stands was reported by Hutchinson *et al.* 2012. Li and Ma (2003) found that oak seedlings grew faster, taller and accumulated more dry mass when they occupy large gap in canopy. Similar results were obtained by Anuradha (2014) [9] while working on regeneration status in different oak associations under different treatments. Dense canopy in forests such as MQLF, MQFF, and MRAF contained lower densities of seedlings at various elevations (Tiwari *et al.* 2018) [10]. According to Harper (1977) [11] and Harcombe (1987) [12] the most drastic and observable change in life history of trees was noticed during the seedling stage. However, Dai *et al*. (2002) [13] have suggested that soil moisture is a critical factor restricting the germination and survival of seedlings. The topographic position maintains seedling establishment in temperate forests and determines the species composition on ridge tops.

Seiwa and Kikuzawa (1996) [14] and Seiwa (1997) [15] have also reported that seedling survival is often inhibited by water deficit and litter accumulation. Low seedling density at mid-altitudes (1800–3230 m a.s.l.) in Mixed *Rhododendron arboretum* forests may be referred to low light intensity on the forest floor due to the dense canopy of broad leaved tree species. Barik *et al*. (1992) [16] and Tripathi (2002) [17] have also suggested that low light intensity on the ground floor due to dense overhead canopy may check the growth of seedlings. Although the response of tree seedlings to the changing climate has not yet been fully explored, Nautiyal *et al*. (2004) [18] and Chaturvedi *et al*. (2007) [19] observe that changes in snow pattern and fluctuating temperature affects the distribution and phenology of some plants.

Acorns production is highly erratic from year to year and seed loss due to insect, birds and mammal's predation can be very high. Since seeds of Oak suffer heavy predation from a variety of animals and insects infestation therefore natural regeneration may be unsuccessful unless these are adequately controlled. Greeley and Ashe (1907) [20] and Foster and Ashe (1908) [21] observed that the infestation by insect resulted in the scarcity of Oak reproduction in eastern hardwood forests. *Q. leucotrichophora* produces seed crops that vary widely in quantity from year to year (mast crop to no crop). Seeds under litter are deprived of light and cannot root easily as they differ in their ability to penetrate litter (Sydes and Grimes 1981) [22] thus fail to germinate many times.

In the present study, regeneration of ban Oak seedlings decreased with increasing altitude. The results are comparable with Majila and Kala (2010) [23] who also studied forest structure and regeneration along the altitudinal gradient in the Binsar Wildlife Sanctuary of Uttarakhand Himalaya. The results reveal that along altitudinal gradient, there were three types of forest communities in the Sanctuary *viz*., chir pine (*Pinus roxburghii*), Oak-chir pine (*Quercus leucotrichophora* and *P. roxburghii*) and Oak (*Q. floribunda* and *Q. leucotrichophora*). In general, the regeneration potential in most of the tree species declines with the altitude. The density of saplings and seedlings also represented the dominant species at each altitudinal range, which indicates the cyclic regeneration of forests in the Sanctuary area.

Bargali *et al*. (2013) [24] studied the regeneration status of tree species in two adjacent sites (site I- undisturbed open area and Site II- moderately disturbed area) in mixed oak forest zone at Nainital Catchment, Uttarakhand India. In both the sites, *Quercus leucotrichophora* and *Q. floribunda* have higher proportion of individuals in younger girth classes indicating expanding type of population structure. Thus it was concluded that oak species of Kumaun Himalayan region have ability to regenerate when anthropogenic pressures are negligible.

Kufri forests were recorded with highest germination which may be due to the presence of favorable conditions such as fast decomposition rate of the leaf litter and also due to collection of fodder from the forests by the villagers leads to less leaf litter accumulation in the forests. Other factors may be aspect, slope, light which favours germination of ban oak seedlings in these forests as compare to other forest locations under study.

Plieninger *et al*. (2011) [25] reported that regeneration densities of *Q. ilex* and *Q. suber* were positively correlated with all understorey variables, suggesting that the presence of pioneer shrubs represent a major safe site for early tree recruitment, independent from specific shrub species. A study on depletion of oak forest in the Western Himalaya by Singh and Rawat (2012) [26] revealed that forest away from the village (> 4 km) significantly showed higher tree density of 463 trees/ha and regenerating individuals (seedlings 2490 ind ha^{-1} and saplings 481 ind ha^{-1}) in comparison with village forest and forest near sanctuary. The decrease in tree density and a consequent decrease in regeneration of the trees was due to the over dependency of villagers for their basic needs on the nearby forests.

Singh *et al.* (2016) [26] studied the diversity and regeneration status of some oak forests in Garhwal Himalaya, India. A total of 18 tree species belonging to 16 genera and 12 families were reported in the study area. Species richness varied for trees (40-7), saplings (3-10), and seedlings (2-6). Seedling and sapling densities (Individuals per hectare) varied between 1,376 Indv./ha and 9,600 Indv./ha and 167 Indv./ha and 1,296 Indv./ha, respectively. Maximum tree species (20–80%) had "good" regeneration. *Quercus floribunda*, the dominant tree species in the study area, showed "poor" regeneration along with other tree species that show poor or no regeneration.

Forest floor and soil are also modified and may limit the regeneration of many woody species. The influence of litter type (pine needles vs. oak leaves), litter depth (0, 3, 6 and 14 cm), and litter cover (3 cm vs. 0 cm of loose litter on top of sowed acorns) on the emergence and growth of seedlings of *Quercus rugosa*, a dominant tree in pine-oak forests was studied by Lopez and Gonzalez (2001).

In the present study, regeneration of *Quercus leucotrichophora* decreased with increasing elevation which may be due to the reason that presence of *Pinus roxburghii* and *Cedrus deodara* increases with increase in elevation and the needles of pine have slow decomposition rate which creates thick litter layer of litter and thereby creating unfavourable conditions for the germination of ban oak

seedlings. This is also illustrated by thickness of forest floor litter which in the present study increased with increase in elevation. Pine dominance also brings about modifications in the soil and forest floor (Switzer *et al*. 1979; Klemmedson 1992; Romero Najera 2000) [28, 29, 30] that may affect germination and establishment of broadleaved species. Germination of acorns may be affected by seed burial, acorn size (Bonfil 1998) [31], herbaceous cover (Tripathi and Khan 1990) [32], soil moisture (Nyandiga and McPherson 1992) [33], and litter (Barik *et al*. 1996) [34].

Due to increased competition for resources and space in forests among understorey vegetation inhibit the growth of seedlings. Crow (1988) [35] also found that shrubs and herbaceous vegetation inhibit growth of seedlings and saplings of trees. According to Moktan *et al*. (2009) [36], the presence of abundant shrubs and herbs impedes seedling establishment of both shade-tolerant and intolerant species. The seedlings are more prone to competition from herb and shrubs than saplings (Gairola *et al*. 2012) [37].

Table 1: Effect of floor management on natural regeneration in a ban Oak at different locations and elevations.

Locations (L)	**Chail Forests**				**Kufri Forests**				**Churdhar Forests**				**Sarahan Forests**				**(P X E)**			
Elevations (E) Treatment (P)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (P)
P_1: Without removal of leaf litter	138.89	138.89	69.44	115.74	138.89	138.89	69.44	115.74	69.44	138.89	69.44	92.59	208.33	208.33	69.44	162.04	E1	E2	E3	121.53
P_2: Removal of leaf litter	277.78	138.89	208.33	208.33	277.78	208.33	208.33	231.48	277.78	208.33	208.33	231.48	277.78	138.89	69.44	162.04	277.78	173.61	173.61	208.33
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	347.22	277.78	277.78	300.93	347.22	347.22	277.78	324.07	347.22	277.78	208.33	277.78	347.22	208.33	138.89	231.48	347.22	277.78	225.70	283.57
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	138.89	69.44	69.44	92.59	138.89	69.44	69.44	92.59	138.89	69.44	69.44	92.59	138.89	208.33	69.44	138.89	138.89	104.16	69.44	104.17
Mean (E)	225.69	156.25	156.25	179.40	225.69	190.97	156.25	190.97	208.33	173.61	138.89	173.61	243.06	190.97	86.80	173.61	225.69	177.95	134.55	

Factors	**CD $_{0.05}$**
Location (L)	NS
Elevation (E)	48.23
Location x Elevation (L X E)	NS
Floor management treatments (P)	55.70
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 2: Effect of floor management on collar diameter (mm) of ban Oak seedlings at different locations along altitude.

Locations (L)	**Chail Forests (L_1)**				**Kufri Forests (L_2)**				**Churdhar Forests (L_3)**				**Sarahan Forests (L_4)**				**(P X E)**			
Elevations (E) Treatment (P)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (P)
P_1: Without removal of leaf litter	0.84	1.67	1.47	1.33	1.86	1.46	1.96	1.76	1.48	1.66	1.68	1.60	1.89	1.63	1.78	1.77	1.52	1.60	1.72	1.62
P_2: Removal of leaf litter	1.46	1.94	1.93	1.78	1.68	1.75	1.45	1.63	1.84	1.49	1.72	1.69	1.92	1.69	1.82	1.81	1.73	1.72	1.73	1.73
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	1.93	2.00	1.83	1.92	1.91	2.57	1.76	2.08	2.31	1.77	1.75	1.94	1.95	1.70	1.85	1.83	2.02	2.01	1.79	1.94
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	1.04	1.95	2.01	1.67	2.10	2.62	1.58	2.10	1.68	1.78	1.79	1.75	1.97	1.75	1.88	1.87	1.70	2.02	1.82	1.85
Mean (E)	1.32	1.89	1.81	1.67	1.89	2.10	1.69	1.89	1.83	1.67	1.74	1.75	1.93	1.69	1.83	1.82	1.74	1.84	1.77	

Factors	**CD $_{0.05}$**
Location (L)	NS
Elevation (E)	NS
Location x Elevation (L X E)	30.18
Floor management treatments (P)	0.18
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 3: Effect of floor management and elevations on height (cm) of ban oak seedlings.

Locations (L)	Chail Forests (L_1)				Kufri Forests (L_2)				Churdhar Forests (L_3)				Sarahan Forests (L_4)				(P X E)			
Elevations (E) Treatment (P)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE))	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (P)
P_1: Without removal of leaf litter	8.90	5.89	8.50	7.76	9.50	10.17	8.00	9.22	7.57	8.40	7.23	7.73	8.30	7.73	7.93	7.99	8.57	8.05	7.92	8.18
P_2: Removal of leaf litter	10.23	7.22	9.60	9.02	9.40	9.07	9.07	9.18	9.13	7.30	8.00	8.14	9.50	8.33	7.98	8.61	9.57	7.98	8.66	8.74
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	9.57	9.81	8.50	9.29	11.17	8.23	9.23	9.54	8.67	7.23	8.57	8.16	12.33	9.77	9.00	10.37	10.43	8.76	8.83	9.34
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	10.10	4.71	7.67	7.49	10.67	7.53	9.73	9.31	9.50	9.40	8.67	9.19	8.67	8.07	8.33	8.36	9.73	7.43	8.60	8.59
Mean (E)	9.70	6.91	8.57	8.39	10.18	8.75	9.01	9.31	8.72	8.08	8.12	8.31	9.70	8.48	8.31	8.83	9.58	8.05	8.50	

Factors	$CD_{0.05}$
Location (L)	NS
Elevation (E)	0.72
Location x Elevation (L X E)	NS
Floor management treatments (P)	NS
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 4: Effect of floor management on number of leaves at different sites and elevations of ban Oak seedlings.

Locations (L)	Chail Forests (L_1)				Kufri Forests (L_2)				Churdhar Forests (L_3)				Sarahan Forests (L_4)				(P X E)			
Elevations (E) Treatment (P)	**E1 <1500m**	**E2 1500-1800m**	**E3 >1800m**	**Mean (PxE)**	**E1 <1500m**	**E2 1500-1800m**	**E3 >1800m**	**Mean (PxE))**	**E1 <1500m**	**E2 1500-1800m**	**E3 >1800m**	**Mean (PxE)**	**E1 <1500m**	**E2 1500-1800m**	**E3 >1800m**	**Mean (PxE)**	**E1 <1500m**	**E2 1500-1800m**	**E3 >1800m**	**Mean (P)**
P_1: Without removal of leaf litter	5.67	3.33	5.00	4.67	4.33	4.33	3.00	3.89	3.67	4.33	3.33	3.78	4.00	4.00	3.67	3.89	4.42	4.00	3.75	4.06
P_2: Removal of leaf litter	4.00	3.67	4.33	4.00	4.00	3.67	3.67	3.78	5.67	3.00	3.33	4.00	5.33	4.33	5.00	4.89	4.75	3.67	4.08	4.17
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	3.33	4.67	4.00	4.00	4.33	3.33	4.33	4.00	3.67	3.33	4.33	3.78	4.00	4.00	4.00	4.00	3.83	3.83	4.17	3.94
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	5.33	6.00	5.67	5.67	3.67	4.00	3.67	3.78	3.67	4.33	4.33	4.11	3.33	4.33	3.17	3.61	4.00	4.67	4.21	4.29
Mean (E)	4.58	4.42	4.75	4.58	4.08	3.83	3.67	3.86	4.17	3.75	3.83	3.92	4.17	4.17	3.96	4.10	4.25	4.04	4.05	

Factors	$CD_{0.05}$
Location (L)	NS
Elevation (E)	NS
Location x Elevation (L X E)	NS
Floor management treatments (P)	NS
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 5: Effect of floor management on Shoot Length (cm) of *Quercus leucotrichophora* seedlings

Locations (L)	Chail Forests (L_1)				Kufri Forests (L_2)				Churdhar Forests (L_3)				Sarahan Forests (L_4)				(P X E)			
Elevations (E) Treatment (P)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE))	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (PxE)	E1 <1500m	E2 1500-1800m	E3 >1800m	Mean (P)
P_1: Without removal of leaf litter	6.39	8.87	9.93	8.40	8.50	10.00	10.55	9.68	6.37	7.45	9.27	7.69	8.83	7.72	8.52	8.36	7.52	8.51	9.57	8.53
P_2: Removal of leaf litter	7.72	9.97	9.93	9.21	9.57	9.90	9.45	9.64	7.72	8.68	8.50	8.30	9.93	8.83	8.57	9.11	8.73	9.35	9.11	9.06
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	10.31	8.87	10.07	9.75	9.73	11.55	8.62	9.97	9.52	7.45	9.20	8.72	11.15	10.27	9.50	10.31	10.18	9.53	9.35	9.69
P_4: Hoeing i.e. 15	5.16	8.03	10.60	7.93	10.23	11.05	7.92	9.73	9.55	11.05	8.60	9.73	8.82	8.66	8.83	8.77	8.44	9.70	8.99	9.04

cm approx, with removal of leaf litter																			
Mean (E)	7.40	8.93	10.13	8.82	9.51	10.63	9.13	9.76	8.29	8.66	8.89	8.61	9.68	8.87	8.86	9.14	8.72	9.27	9.25	

Factors	CD $_{0.05}$
Location (L)	0.81
Elevation (E)	NS
Location x Elevation (L X E)	1.41
Floor management treatments (P)	NS
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 6: Effect of floor management on root length (cm) of *Quercus leucotrichophora* seedlings

Locations (L)	**Chail Forests (L_1)**				**Kufri Forests (L_2)**				**Churdhar Forests (L_3)**				**Sarahan Forests (L_4)**				**(P X E)**			
Elevations (E) Treatment	E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3	
	<1500 m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (P)
P_1: Without removal of leaf litter	6.17	12.37	9.77	9.43	12.33	11.40	14.37	12.70	7.37	10.43	9.43	9.08	11.03	11.17	10.73	10.98	9.23	11.34	11.08	10.55
P_2: Removal of leaf litter	10.11	9.17	12.17	10.48	10.50	10.43	9.23	10.06	14.77	9.27	12.10	12.04	12.00	11.20	12.55	11.92	11.84	10.02	11.51	11.12
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	12.25	12.83	9.40	11.49	11.83	12.67	9.60	11.37	11.87	11.53	12.60	12.00	15.73	12.50	14.17	14.13	12.92	12.38	11.44	12.25
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	10.20	17.00	12.67	13.29	12.43	14.33	11.63	12.80	12.43	9.93	13.67	12.01	14.83	11.70	12.00	12.84	12.48	13.24	12.49	12.74
Mean (E)	9.68	12.84	11.00	11.17	11.77	12.21	11.21	11.73	11.61	10.29	11.95	11.28	13.40	11.64	12.36	12.47	11.62	11.75	11.63	

Factors	CD $_{0.05}$
Location (L)	NS
Elevation (E)	NS
Location x Elevation (L X E)	NS
Floor management treatments (P)	1.37
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 7: Effect of floor management on shoot weight (g) of *Quercus leucotrichophora* seedlings

Locations (L)	**Chail Forests (L_1)**				**Kufri Forests (L_2)**				**Churdhar Forests (L_3)**				**Sarahan Forests (L_4)**				**(P X E)**			
Elevations (E) Treatment	E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3	
	<1500 m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (P)
P_1: Without removal of leaf litter	0.34	0.33	0.36	0.34	0.75	0.33	0.78	0.62	0.36	0.71	0.20	0.42	0.41	0.42	0.31	0.38	0.46	0.45	0.41	0.44
P_2: Removal of leaf litter	1.07	0.32	0.35	0.58	0.24	0.27	0.26	0.25	0.60	0.21	0.35	0.39	0.42	0.51	0.39	0.44	0.58	0.33	0.34	0.42
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	1.29	0.74	0.49	0.84	0.23	0.81	0.32	0.45	0.82	0.28	0.29	0.46	0.42	0.33	0.35	0.36	0.69	0.54	0.36	0.53
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	0.77	0.48	0.70	0.65	0.68	1.28	0.26	0.74	0.29	0.25	0.40	0.31	0.30	0.32	0.35	0.32	0.51	0.58	0.43	0.51
Mean (E)	0.87	0.47	0.48	0.60	0.47	0.67	0.41	0.52	0.52	0.36	0.31	0.40	0.39	0.39	0.35	0.38	0.56	0.47	0.39	

Factors	CD $_{0.05}$
Location (L)	NS
Elevation (E)	NS
Location x Elevation (L X E)	NS
Floor management treatments (P)	NS
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 8: Mean effect of floor management on Root Weight (g) of *Quercus leucotrichophora* seedlings

Locations (L)	Chail Forests (L_1)				Kufri Forests (L_2)				Churdhar Forests (L_3)				Sarahan Forests (L_4)				(P X E)			
Elevations (E)	E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3	
Treatment	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (P)
P_1: Without removal of leaf litter	0.56	0.36	0.18	0.37	0.17	0.42	0.45	0.35	0.22	0.16	0.29	0.22	0.65	0.59	0.47	0.57	0.40	0.38	0.35	0.38
P_2: Removal of leaf litter	1.16	0.46	0.44	0.69	0.43	0.52	0.37	0.44	1.19	0.19	0.24	0.54	0.58	0.32	0.41	0.44	0.84	0.37	0.37	0.53
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	1.87	1.06	0.69	1.21	0.25	2.45	0.32	1.01	0.94	0.37	0.42	0.57	0.69	0.59	0.55	0.61	0.94	1.12	0.50	0.85
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	1.81	0.87	0.76	1.15	1.11	1.82	0.24	1.05	0.27	0.46	0.76	0.49	0.27	0.29	0.51	0.35	0.86	0.86	0.57	0.76
Mean (E)	1.35	0.69	0.52	0.85	0.49	1.30	0.34	0.71	0.65	0.29	0.43	0.46	0.55	0.45	0.49	0.49	0.76	0.68	0.45	

Factors	$CD_{0.05}$
Location (L)	0.27
Elevation (E)	0.23
Location x Elevation (L X E)	0.46
Floor management treatments (P)	0.27
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Table 9: Effect of floor management treatments on total dry biomass (g) of *Quercus leucotrichophora* seedlings

Locations (L)	Chail Forests (L_1)				Kufri Forests (L_2)				Churdhar Forests (L_3)				Sarahan Forests (L_4)				(P X E)			
Elevations (E)	E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3		E1	E2	E3	
Treatment	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (PxE)	<1500m	1500-1800m	>1800m	Mean (P)
P_1: Without removal of leaf litter	0.89	0.69	0.55	0.71	0.93	0.75	1.24	0.97	0.58	0.88	0.50	0.65	1.06	1.01	0.78	0.95	0.87	0.83	0.77	0.82
P_2: Removal of leaf litter	2.23	0.78	0.79	1.27	0.67	0.79	0.62	0.69	1.79	0.40	0.60	0.93	1.01	0.83	0.80	0.88	1.42	0.70	0.70	0.94
P_3: Hoeing i.e.,15 cm approx, without removal of leaf litter	3.17	1.79	1.18	2.05	0.48	3.25	0.64	1.46	1.77	0.64	0.70	1.04	1.11	0.91	0.91	0.97	1.63	1.65	0.86	1.38
P_4: Hoeing i.e. 15 cm approx, with removal of leaf litter	2.58	1.35	1.46	1.80	1.78	3.10	0.49	1.79	0.56	0.71	1.16	0.81	0.57	0.61	0.86	0.68	1.37	1.44	1.00	1.27
Mean (E)	2.22	1.15	0.99	1.45	0.96	1.97	0.75	1.23	1.17	0.66	0.74	0.86	0.93	0.84	0.84	0.87	1.32	1.16	0.83	

Factors	$CD_{0.05}$
Location (L)	0.40
Elevation (E)	0.35
Location x Elevation (L X E)	0.69
Floor management treatments (P)	0.40
Location x Floor management treatments (L X P)	NS
Elevation x Floor management treatments (E X P)	NS
Location x Elevation x Floor management treatments (L X E X P)	NS

Conclusion

It can be concluded from the study that ban oak seedlings faces low regeneration problem which is governed by different factors such as stress, competition, thick leaf litter, browsing, grazing, human and animal interferences. Floor management treatments were given to the forest floor so as to assess the cause of low regeneration in the ban oak forests. From the results, it can be concluded that P_3 (Hoeing i.e., 15 cm approx, without removal of leaf litter), in general, was best among all other treatments for regeneration, growth of seedlings and biomass while P_4 (Hoeing i.e., 15 cm approx, with removal of leaf litter) treatment was noted to show least effect on acorn germination of ban oak seedlings. The presence of thick layer of leaf litter poses problem in germination of the seedlings which can be dealt with 15 cm hoeing to attain good germination of ban oak seedlings. Among locations, Kufri forests showed maximum regeneration of the seedlings. Seedlings germination showed a decreasing trend with an increasing elevation.

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