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Assessment of Plant Competition and Tree Typical Crown Area in Thinned and Un-Thinned Stands of Community Managed Pine Plantation

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ABSTRACT

The forest conditions of Nepal can be enhanced by the application of proper management techniques and sivicultural treatments like thinning. Nepal has been implementing thinning practices in some of the forests and their effect has been visibly observed on the plant completion and tree typical crown area. Thus, this research work was objectively carried out to assess and compare the plant competition and tree typical crown area in thinned and un-thinned stands of planted Pine forest. Three community forest namely Srcihhap Deurali, Bajhbisauna and Sansari Danda were selected as the study site. Total 30 circular sample plots having an area of 100m^2 were established in each of the community forest such that 15 plots each were allocated to thinned and un-thinned stands. The diameter, crown width and the distance between subject tree and its competitors were measured and competition indices and tree typical crown area were estimated.

The result in Sansari Danda Community Forest showed that the intensity of plant competition was slightly higher on un-thinned stands than in thinned. With the application of Independent Samples-t test it was found that the results were not significantly different at 5 % level of significance between thinned and un-thinned stands. Similar results were observed in other community forests as well. . It was found that the typical tree crown area was about 31.52 ($\pm$0.88) m^2 in the thinned stand which was comparatively higher than in un-thinned stand having value 20.88 ($\pm$3.71) m^2 in Sansari Danda Community Forest. The results were significantly different between thinned and un-thinned stands with the application of Mann-Whitney U test (P=0.031) at 5% level of significance. This research illustrates the effect of thinning on pine plantation and its importance on present Nepalese context. Therefore, it will be helpful tool for scientific community and decision makers who are involved in silviculture science.

Keywords: *Thinning, plant competition, tree typical crown area*

INTRODUCTION

Thinning is one of the major silvicultural treatments that have been applied time and again to manage the dense and overstocked stands. Thinning is the reduction of trees in an immature stand which intends in improving growth and form residual trees without permanently breaking the canopy (Khanna, 2011). Thinning reduces above and below ground plant competition among residual trees as the amount of incident light is amplified (Smith et al., 1997). A plant competition index, used to calculate the intensity of plant completion, distinguishes the degree to which the growing space of an individual plant is shared with other neighbouring plants (Burton 1993). Although, thinning is primarily aimed at improving the value of residual stems, other benefits now being recognized are that thinning improves stand stability reducing fire hazard and stand mortality (Ritchie et al., 2007). Thinning interventions create gaps in the canopy as stems are cut down. This brings reduction in the support that neighbouring trees provide each other with and provide doorway for wind leading towards reduction in the stability of the stand. On the contrary, the remaining trees retain deeper crowns and develop better rooting and tapering of the stem, so that their individual stability improves. With time the stand stability recovers and improves beyond the original level due to improved stability of each individual tree as gaps in the canopy close (Kerr and Haufe, 2011). This causes expansion in tree typical crown area which is defined as the area of a vertical projection of the crown to a horizontal plane.(Fabian C.C. Uzoh, Ritchie, 1996)Pine plantation holds a three decade long history in the mid- hills namely in Sindhupalchowk and Kavrepalanchowk district. During 1970s and

1980s, Nepal Australia Community Forestry project jointly undertook the pine plantations in the mid-hills. With financial and technical support of Australian government and involvement of local communities, Department of Forest commenced the massive plantation program in more than 22,000 hectares of barren and degraded hills (Hunt et al., 2001). The forests were gradually handed over to local communities after the promulgation of Forest Act 1993 and Forest regulation act 1995. Those forests are now being managed by Community Forest User Groups. The plantation forests are now 30-47 years old and mostly overstocked due to lack of appropriate management practices. Forestry in Nepal has been limited to protection, plantation and to some extent thinning, pruning, fodder and grass cutting and removal of 4-D (Dead, Deformed, Decayed and Diseased) trees (Paudel et al., 2017; Hunt et al., 2001). Conservative thinning has been being practiced in the forests of our Nepal. Nonetheless, there are very few cases of thinning according to thinning guidelines 2007 published by then Ministry of Forest and Soil Conservation in coordination with Nepal Australia Community Resource Management for Pine. In this context, this research assesses plant competition index and tree typical crown area in newly thinned stands and compare the same parameters with un-thinned stands in order to address the effect of thinning.

MATERIALS AND METHODS

Sampling Process

The digital map of the study area was extracted from GIS. The already stratified thinned and un-thinned stands having equivalent areas were chosen from operational plan of Community Forests. After that, the no. of sample plots was allocated using fishnet. Altogether, 90 samples were collected from three CFs. Moreover, 15 circular plots were established in each thinned and un-thinned stands of three community forests. The survey was carried out using GPS receiver. The sample plot size for trees and poles was taken as $100m^2$ with radius of 5.64m, for saplings $25m^2$ with radius of 2.82m and for seedlings $10m^2$ with radius 1.78m

Measurement and Recording

For the measurement of competition indices, a healthy tree was selected as a subject tree and its DBH was recorded. Again, the DBH of three neighbouring trees of subject tree were measured. Also, the distance between neighbouring trees and subject trees were measured.

Crown width was measured from two sides as CW1 and CW2 to find the average crown width.

Data Analysis

Competition Index and tree typical crown were calculated using following mathematical formulae:

- Competition Index ($CI_{i)} = n \sum_{j=1}^{n} (D_j/D_i)*R_{ij}$

  Where,

  Di = DBH of subject tree

  Dj = DBH of competitor tree (neighbouring tree)

  R_{ij} = distance in meter between subject tree and neighbouring tree

  n = number of trees included in the sample (Daniels and Burkhart, 1975)

- Crown Area = $\pi(CW_1+CW_2)^2/4$ (where $CW_1$and CW_2 are different crown width of the same tree)

Statistical Analysis

For the statistical analysis, both descriptive as well as inferential statistics were used. At first, Kolmogrov Smirnov and Shaphiro Wilk normality tests were performed to test whether the data were normal or not. Afterwards parametric test i.e. Independent-samples t-test was performed and non parametric test i.e. Mann- Whitney U test was performed for not normal data. Software like Arc GIS 10.2, SPSS 20.00 and Microsoft excel were used as major tools for the statistical analysis of data.

RESULTS

The results illustrate the intensity of plant competition and tree typical crown area in thinned and un-thinned stands of different community forests along with the statistical tests applied.

Comparison of Plant Competition in Thinned and Un-Thinned Stands of Community Forests

The calculated competition index value was 0.55 in the un-thinned stand whereas it was 0.59 in the thinned stand of Sansari Danda

CF. Similarly, the competition index value was 0.84 in the un-thinned stand whereas it was 0.85 in the thinned stand of Srcihhap CF. The result is in similar line in Bajhbisauna Community forest where the competition index value was 0.86 in the un-thinned stand whereas it was 0.91 in the thinned stand of Bajhbisauna Community Forest. The plant competition was more evident in un-thinned stands as depicted in figure 2:

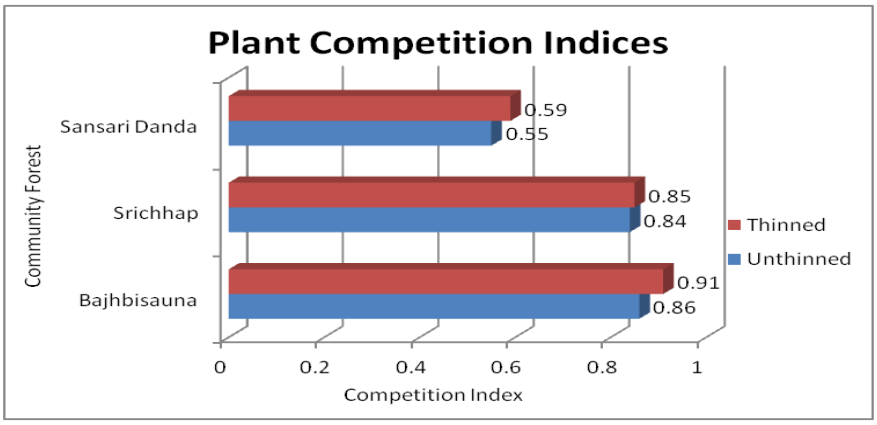

Figure2.*Competition Indices value in thinned and un-thinned stands of Community Forests (Competition Intensity α 1/CI)*

Statistical Comparison of Plant Competition between Thinned and Un-Thinned Stands of Different Community Forests

The application of Independent Samples-t test showed that, there were no significant differences in the plant competition between thinned and un-thinned stands at 5% level of significance in all three community forests namely Sansari Danda CF, Srichhap CF and Bajhbisauna CF (Table 1)

Table1.*Statistical tests for differences of plant competition between thinned and un-thinned stands of Community Forests.*

CF	Normality test	Test applied	Significance	Result
Sansari Danda	Normal	Independent Samples-t test	0.830	Not significant
Srichhap	Normal	Independent Samples-t test	0.698	Not significant
Bajhbisauna	Normal	Independent Samples-t test	0.944	Not significant

Table 2.*Descriptive statistics for tree typical crown area of Sansari Danda CF*

Stands	Community Forests		
	Sansari Danda	Srichhap	Bajhbisauna
Un-thinned	20.88 ±3.71	27.36 ±4.22	18.06±1.95
Thinned	31.52±0.88	16.93±3.07	30.01±3.73

Comparison of Tree Typical Crown Area of Thinned and Un-Thinned Stands of Community Forests

The result depicts that the mean value tree typical crown area is 31.52 (±.88) m^2 in the thinned stands which is comparatively more than in un-thinned stands having value 20.88 (±3.71) m^2 in Sansari Danda Community Forest. It was found that the mean typical tree crown area was 27.36 (±4.22) m^2 in un-thinned stand which was more than tree typical crown area value in thinned stand i.e. 16.93(±3.07) m^2 in Srichhap Deurali CF. Moreover, The mean tree typical crown area was 30.01(±3.73) m^2 in the thinned stands which is comparatively more than un-thinned stands having value 18.06(±1.95) m^2. The result is demonstrated in the table below.

Statistical Comparison of Tree Typical Crown Area Between Thinned and Un-Thinned Stands of Different Community Forests

The application of Mann-Whitney U test/ Independent Samples t test showed that the result was statistically significant in two of the

community forest i.e. Sansari Danda and Bajhbisauna but not in the third one i.e. Srichhap Deurali (Table 3)

Table 3.*Statistical comparison of tree typical crown area between thinned and un-thinned stands of different community forests.*

CF	Normality test	Test applied	Significance	Result
Sansari Danda	Not Normal	Mann- Whitney U- test	0.031	Significant
Srichhap	Normal	Independent Samples-t test	0.055	Not significant
Bajhbisauna	Normal	Independent Samples-t test	0.008	Not significant

DISCUSSION

Variation in plant competition of thinned and un-thinned stands of pine plantation**.**Competition occurs in plant communities when individuals use resources that would otherwise have been used by their neighbour had they not been nearby (Donald, 1963). NACRMLP, (2006) states that, thinning reduces the competition among trees for light, food and space which is supported by Smith et al. (1997) in his book. Most of the studies on the effect of competition on adult-tree growth normally use diameter at breast height as the size measure of neighbouring competitors (Canham et al., 2004; Uriarte et al., 2004) as used in this research; however in some research effect on crown has been assessed (Thorpe et al., 2010). Many previous studies have defined relationships of subject tree with its competitors and their competitive effects on subject trees (Bella, 1971; Stoll et al., 1994) as described in this research.

The result shows that, in studied community forests, the competition intensity was higher in un-thinned stands i.e. smaller value of competition index than in thinned stands. However, the results were not significantly different. This implies that thinning reduces the competition however; it may take many more researches to prove that competition is significant in un-thinned stands as time plays an important role in the manifestation of effects of thinning. In addition, pre commercial thinning is done to reduce competition among tree species which is likely to improve the health as seen in *Pinus ponderosa*. (Fiddler et al., 1989), the study had shown similar result in case of tree competition.

Variation in Tree Typical Crown Area in Thinned and Un-Thinned Stands of Pine Plantation

It has been demonstrated elsewhere for many tree species, and confirmed here for pine, that thinning has significant effect on the expansion of tree typical crown area. The significant difference between tree typical crown area in thinned and un-thinned stands are witnessed in this research as well. In two community forests (Sansari Danda and Bajhbisauna), it was found that the tree typical crown area is significantly more in thinned stands in comparison to un-thinned stands. However, in Srichhap Community Forest, the tree typical crown area was found to be more in un-thinned stand because the number of trees per hectare were not much different i.e. 494 stem/ha in un-thinned stand and 446 stem/ha in thinned stand. No significant difference was seen in tree typical crown area since the foliage expansion was almost equal due to corresponding number of trees. The growing space surrounding a trees seem to increase after the after the execution of thinning operation, which further assists the crown expansion as shoots, roots and foliages grows vigorously (NACRMLP, 2006). Furthermore, the results on study carried out on radiate pine in New Zealand indicates that in the absence of thinning the crown length remains nearly constant leading to constant crown area(Beekhuis, 1965). In addition, Beekhuis mentioned that the proper thinning regimes in such stands considering both stand density and stand height will lead towards reliable crown depth. Moreover, Stiell (1966) on *Pinus resin osa* and Siemon et al. (1976) on *Pinus radiata* observed similar results regarding the effect of thinning on tree typical crown area.

In another study carried out by Maguire et al. (2009), increased crown wood was demonstrated in thinned plots of Douglas-Fir, in contrast to un-thinned plots. Similarly, keeping the diameter at breast height and total height of the trees constant, longer crowns with larger branches resulting larger crown area were resulted from thinning. Thinning increased the yield of stands of Loblolly Pine in terms of larger foliage and more biomass of branches; however in the same study, no such result was obtained in control plots (Baldwin et al., 2000).

The results from this study are in same pattern as earlier results.

CONCLUSION AND RECCOMENDATION

The result of the study illustrates that competition intensity among plants is found to be greater in un-thinned stands than thinned stands of all three community forests; however, the result was statistically insignificant at 5% level of significance. The most probable reason for result being insignificant is the time factor as the thinning operations were carried out only a year ago. Therefore, it is suggested to carry out more researches in the same study site. On the contrary, the tree typical crown area is significantly more in thinned stands suggesting that thinning assist crown expansion. Hence, it is clear that thinning has positive effect on lessening the plant competition and expanding tree typical crown area. Therefore, thinning should be carried out annually in different compartments to minimize plant competition and promote crown expansion.

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