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Effect of seed sowing distance on germination and growth of sal (*Shorea robusta* Gaertner f.) at nursery stage

B.Sc. Thesis

BY

Manish Kumar Bala

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This work has been prepared and submitted to Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh for the partial fulfillment of B.Sc. Degree in Forestry.

Dedicated To.....

My Father

DECLARATION

I declare that the work in the thesis entitled "Effects of seed sowing distance on germination and growth of sal (Shorea robusta) at nursery stage" has been performed by me under direct supervision of Associate professor Md. Sharif Hasan Limon in the Discipline of Forestry and Wood Technology, Khulna University, Khulna and it has not been accepted or submitted for a degree in any other University.

I hereby, give consent for my thesis, if accepted, to be available for any kind of photocopying and for inter library loans.

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APPROVAL

This thesis submitted to the Forestry and Wood Technology Discipline, Khulna University, Khulna, Bangladesh, in partial fulfillment for the Honors of Science degree in Forestry. I have approved the style and format of the thesis.

29.12.13

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Abstracts

In a nursery optimum healthy seedling production is a challenge for a nursery owner. We tried to find out the effect of seed sowing distance on seed germination and growth in a nursery. We selected sal (*Shorea robusta*) tree species, considering its economic and ecological value. We found that there is no significant ($p>0.05$) effect of seed sowing distance in seed germination and growth of sal (*Shorea robusta*). We also found that spacing have an effect on height growth, 4 inch spacing can be produced highest height growth of seedling and 2 inch spacing can be produced highest number of seedling. So if a nursery owner wants to produce large amount or healthy seedling of sal (*Shorea robusta*) it will helps him.

CONTENTS

TITLE	PAGE NO.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

1.1 Introduction

Bangladesh is a densely populated country. The demand for wood is ever increasing for the growing population. However, the per capita forest has gone below 0.01 hectares (FAO, 2011). The dwindling forest cover hardly can meet the demand of the need of the people. To meet the demand of the people and increase the forest cover of the country, Forest Department has launched different social forestry afforestation project countrywide since early eighties. Apart from it to make tree plantation as a social movement, Forest department has encouraged tree fair and tree plantation campaign nationwide (FD, 2010). A large number of tree nurseries have been developed countrywide in the both government and private sector to participate in the program and at the same time as small scale business enterprise.

Many private nurseries have been developed as income generating sector and playing role in poverty alleviation. Most of these nurseries are small in size and has limitation in the production capacities. On the other hand Forest Department has reduced its subsidized nursery raising program for social forestry program, the demand for tree seedling is rising (Pers.comm with FD). The scarce land, limited capital and workforce for private nurseries are imposing challenge in tree seedling market.

In a nursery seedling is raised in both container and bare-root. For bare root seedling, earthen bed is broadcasted with desired seed and nursed for a desired period of time. Sowing distance or density of sowing is determined by experience or by chance, which very often is the cause of wastage of seeds, inferior quality of seedling and additional labor investment for seedling thinning. These entire factors affect the cost of production and the price of the seedling. Species wise optimum sowing distance can provide an important tool for nursery owners to take decision to optimized use of land for their seedling production with less effort and more success and profit. However, there is no available information for optimum sowing distance for tree seedling in Bangladesh.

Sal (*Shorea robusta*) is an important forest species of plain land forest in Bangladesh. Like the most other dipterocarp species, this species also lose seed viability quickly and thus make seed very valuable (Das and Alam, 2000). Maximum utilization of seed is thus important issue for sal seedling in a nursery.

In this study, effect of sowing distance of sal seedling on germination and growth was investigated.

1.2 Objectives

The objective of this work is to investigate the effect of sowing distance on germination and growth (height and diameter increment) of sal (*Shorea robusta*) seedling.

CHAPTER TWO

2. Literature review:

The production of nursery seedlings has increased considerably in the last decade (Tinus and McDonald, 1979) because nursery can grow more seedlings per unit area. The growing management in a nursery can influence seedling development since the physical restriction of the root system affects the availability of both water and nutrients (McConnughay and Bazzar, 1991). Consequently, density influences the physiology and morphology of seedlings both in the nursery and in the field after out planting (Marien and Drovin, 1978). Different species shows different types of performances for specific density in the nursery (McConnughay and Bazzar, 1991). Early stand development is a seemingly chaotic period characterized by rapid seedling growth and rapid changes in species composition. The environment, growth pattern, and size of each plant change more dramatically during this stage than during any other period (Oliver andLarson, 1996).

So it is important to determine which variable has the greatest influence on seedling morphology and subsequent performance (Marien and Drovin, 1978; Romero *et al.*, 1986; Piotto, 1988; Marcelli and Piotto, 1993; Benoit de Coignac and Gruez, 1987).

Considering the silvicultural potential of many native timber tree species for reforestation, either for forestry or agroforestry purposes, research is urgently needed to establish their requirements, which are generally unknown (Sawyer,1993).

In this study, the effect of sowing distance on seedling survival of sal (*Shorea robusta)* was investigated. Because sal *(Shorea robusta)* forests are among the most disturbed types of forest in Southeast Asia (Sapkota *et al.,* 2009), due to their high timber value and socio-economic importance for fodder, fuel-wood, leaf litter and minor forest products.

2.1 Mortality

Seedling survival percentage is important for any tree species in forest land. But seedling survival percentage varies from species to species (McConnughay and Bazzar, 1991). Various characteristics of the parent plants can increase the chances of seedling survival; although seedlings depend on their own morphological and physiological characteristics to cope with the various factors threatening their survival (Fenner, 1987). For example, effective dispersal ensures escape from dominance by the parent plant; dormancy and gap detection mechanisms facilitate escape through time from competition with established plants, while synchronous fruiting and germination produce large seedling cohorts, possibly resulting in the satiation of predators (Silvertown, 1980; Fenner, 1987).

Some factors controls seedling mortality (Yoda et al., 1963). It is important to determine which variable has the greatest influence on seedling morphology and subsequent performance (Marien and Drovin, 1978; Romero et al., 1986; Piotto, 1988; Marcelli and Piotto, 1993; Benoit de Coignac and Gruez, 1987). The causes of seedling mortality are drought, diseases, damage from insects and browsing mammals, as well as uprooting or burial by termite activity (Augspurger, 1983, 1984a, b.c; Swaine et al., 1988, 1990; Gerhardt, 1993, 1994).

2.2 Space

For all seedling growth factors, only sowing distance of seed man can control easily (Burkes, 2003). Because man only maintain sowing distance of seed when seed sown in the soil. At common planting densities, much of the naturally occurring change in forest communities comes about as a result of competition among individuals for limited resources. Competition for light, water and nutrientscreates stresses such that relative growth rates change and some individuals in the community come to dominate others. In the process, density dependent mortality reduces the total number of individuals. Further, the proportion of individuals that die over a particular period of time increases as the initial density increases above a certain threshold level (Yoda et al., 1963). Seedling growth mainly (Gerhardt, 1995) occurred in the rainy period and mortality was low during this period. Seedling mortality was high during the dry season particularly in the first year. As seedlings in a nursery grow they occupy an increasingamount of space, so eventually the gaps betweenthem are filled up and individuals begin to interferewith each other's access to resources such as light, water and nutrients (Silvertown and Charlesworth, 2001).The more closely spaced plants are, the higher the density (Gregory, 1995).The density also influences seedling development. High density leads to seedlings with small collar diameter and less height growth following out planting (Marien and Drovin, 1978; Landis et al., 1990). Early stand growth increases with increasing planting density (e.g., Worst, 1964; Shelton, 1984; Harms et al., 1994, 2000; McCrady and Jokela, 1996) due to greater resource uptake and use from environment. Closely spaced plants were significantly taller than the more widely spaced plants of the same age (Srivastava et al., 1999).

2.3 Soil

The characteristics of soil play a big part in the plant's ability to extract water and nutrients. If plants are to grow to their potential, the soil must provide a satisfactory environment for plant growth. The effect of planting density on tree physiology is fundamentally mediated by competition for resource acquisition, including light, water and nutrients (Benomar et al., 2012). The depth of the soil can also be important, especially for species with a strong taproot (Silvertown and Charlesworth, 2001).

2.4 Root

On the other hand, species with heavylateral root development do not grow well in nursery if it has limitation of soil below the ground (Marien and Drovin, 1978).One of the bad sides of producing seedlings in nursery is root deformation caused by the limited rooting volume (Marcelli, 1984; Benoit de Coignac and Gruez, 1987). These deformations can affect seedling performance several years after out planting (Marien and Drovin, 1978; Halter and Chanway, 1993; Lindstrom, 1990), although the degree of deformation varies within and between species (Kinghorn, 1978). Seedlings do not have coarse roots (Roots that have undergone secondary thickening and have a woody structure) and so cannot inform us about the way coarse roots respond to environmental factors (Ovington, 1957; Werner and Murphy, 2001; Ritson and Sochaki, 2003).

2.5 Branch

Higher seedling densities may restrict branch development and potentially reduce the time for natural branch shedding. Increasing initial stockings have been shown to reduce maximum (Kearney, 1999; Neilsen and Gerrand, 1999; Garber and Maguire, 2005) and average branch size (Malimbwi et al., 1992; Pinkard and Neilsen, 2003) and cause an earlier rise of the green crown above the ground relative to stands established at lower seedling densities across the seedling and sites (Bramble et al., 1949; Wardle, 1967; Opie et al., 1984; Neilsen and Gerrand, 1999; Baldwin et al., 2000).

High densities may be unfavorable if branch angles become more acute or individual seedling size is severely reduced. In dense stands acute branch angle may be associated with the combined effects of reduced wood and foliage mass, reduced branch size (James, 2001; Medhurst and Beadle, 2001) and greater competition for light (Henskens et al., 2001; Comeau et al., 2006).

Furthermore, the increased competition for environmental resources (light, water and nutrients) with increased stocking density can reduce average collar diameter within the stand (e.g. Bramble et al., 1949; van Laar and Bredenkamp, 1979; Scho¨nau and Coetzee, 1989; Niemisto¨, 1995; Kearney, 1999; Neilsen and Gerrand, 1999).

Branch development is critical to both quantity and quality of timber produced from plantations (Clark and Saucier, 1989; Barbour and Kellogg, 1990; Ma¨kinen and Colin, 1999). The size and vitality status (live or dead) of branches along the stem and the natural branch shedding habits of the species influence the development andpersistence of knots and knot-related defects (Fisher, 1978; Borough and Humphreys, 1996).

2.6 Biomass

Above-ground biomass can be estimated using standard forest inventory data and allometric relationships between easily measured tree dimensions such as diameter at breast height and above-ground biomass (e.g. Eamus *et al.*, 2000; Keith *et al.*, 2000; Montagu *et al.*, 2005). However, tree roots can account for a significant proportion of total forest biomass but there is limited information on the proportion of forest biomass stored below-ground and the factors that influence the proportion (Raich and Nadelhoffer, 1989). The trees at wider spacing had higher individual biomass than those at closer spacing (Srivastava, 1999).

2.7 Light

Tree seedlings showed increased growth rates with increasing light (Rincon and Huante, 1993). Seedling growth is displayed at the higher density higher stem height, lower stem diameter, higher specific leaf area and higher mass-based leaf nitrogen contents indicating that increased seedling density mainly accentuated competition for light (Marron, 2013).

2.8 Growth

Early-successional species have high inherent growth rates (Kitajima 1996). Seedlings of late-successional, shade tolerant tree species appear to be especially impacted by forest modifications (Benı´tez-Malvido, 1998; Benı´tez-Malvido and Martı´nez-Ramos, 2003; Farwig *et al.*, 2008). Late-successional seedlings are often declining in disturbed and fragmented forests (Chapman et al., 1999; Benı´tez-Malvido and Martı´nez-Ramos, 2003; Farwig et al., 2008a). In fast growing seedling of hardwoods, seedling height has been shown to increase, decrease, or remain unchanged with increasing planting density (Alcorn et al., 2007; Benomar et al., 2012; DeBell et al., 1996; Pinkard and Neilsen, 2003).

2.9 General overview of *Shorea robusta* Gaertner f.

2.9.1 Taxonomy

Domain: Eukaryota
Kingdom: Plantae
Subkingdom: Viridaeplantae
Phylum: Tracheophyta
Subphylum: Euphyllophytina
Infraphylum: Radiatopses
Class: Spermatopsida
Subclass: Rosidae
Superorder: Malvanae
Order: Malvales
Family: Dipterocarpaceae
Subfamily: Dipterocarpoideae
Tribe: Shoreae
Genus: Shorea - Roxburgh ex C.F
Specific epithet: robusta
Botanical name: - *Shorea robusta* Gaertner f.

2.9.2 Morphology

Trees to 40 m tall,tardily deciduous;trunk to 2 m in diam.; crown spreading. Bark gray to dark reddish brown, becoming fissured and flaky; inner bark not laminated; wood hard; heartwood dark brown. Branchlets densely buff scabrous-pubescent. Stipules fugacious, lanceolate, small, lepidote; petiole 2-2.5 cm, buff scabrous-pubescent; leaf blade 10-40 × 5-24 cm, ovate to oblong, thinly leathery, midvein prominent abaxially and conspicuous adaxially, lateral veins ca. 12 pairs prominent abaxially, tertiary veins densely scalariform, glabrous, base obtuse to cordate, apex acuminate. Flowers subsessile, on panicles to 25 cm; branches racemose, secund; bracts caducous, minute. Petals strongly contorted, creamy-yellow or sometimes with a medium pink stripe, 1-1.5 cm × ca. 5 mm, linear. Sepals ovate, to 2 mm in bud, subequal, densely buff pubescent. Stamens many; anthers panduriform, setose toward apex; connective appendages short, stout, exceeding anther apex, sparsely setose. Ovary ovoid, densely buff pubescent. Fruit sepals unequal, spatulate, sparsely pubescent, 3 longer to 8 × 1.5 cm, 2 smaller to 3.5 × 0.5 cm; nut ovoid, ca. 5 × 12 mm.

2.9.3 Phenology

Depending on edaphic factors and microclimate, a sal forest's phenology ranges from deciduous to evergreen and extends from tropical to sub-tropical. Leaf fall usually starts in late winter (February) and is completed by the end of April (Misra, 1969). Maximum leaf fall is from mid-February to mid-May (Singh et al., 1993a). Sal trees produce seeds every year; a good seed year is normally every third year. Seed production in sal varies (up to 500 kg ha−1 was recorded during the early 1980s) from year to year and from tree to tree (Sharma, 2002). Seeding is normally from mid-May to mid-June.

2.9.4 Distribution

Sal (*Shorea robusta* Gaertn. f.) occurs gregariously on the southern slopes of the Himalayas and is distributed in Bangladesh, India and Nepal. Its presence is indicated in Bhutan and South China (Zhang, 1996), too. Broadly, Sal's natural range lies between the longitudes of 75° and 95° E and the latitudes of 20° to 32° N. Within this range, the distribution is controlled firstly by climate and then by edaphic factors.

Sal forests are distributed on the plains and lower foothills of the Himalayas including the valleys (Gautam, 1990). It penetrates through mid-mountain range (Mahabharata region) to the far north along river slopes and valleys. Sal forests cover ~110 000 ha in Bangladesh (Alam, 1996), 10 million ha in India (Sharma, 2002) and 1 million ha in Nepal. This forest type extends from a few metres to 1500 m above mean sea level.

2.9.5 Soil

Sal grows on a wide range of soil types, except in the very sandy, gravely soils immediately adjoining rivers and in waterlogged areas (Jackson, 1994). It can grow on alluvial to lateritic soils (Sharma, 2002), and prefers slightly acidic to neutral sandy loam (pH = 5.1–6.8) with organic carbon content between 0.11 and 1.8 per cent.

2.9.6 Climates

Sal forests extend into the tropical and sub-tropical regions, and to the zones where precipitation ranges from 1000 to 2000 mm and above, and the dry period does not exceed 4 months (Sharma, 2002). Sal tolerates some frost, but annual heavy frosts occurring in frost hollows are detrimental to seedlings .The maximum temperature recorded in sal forest is 49°C (Singh, 1992).

CHAPTER THREE

3. Materials and methods:

3.1 Site Characteristics

The nursery of Forestry and Wood Technology at Khulna University in Bangladesh was the research area. Khulna is humid during summer and pleasant in winter. Khulna has an annual average temperature of 26.3 °C (79.4 °F) and monthly means varying between 12.4 °C (54.3 °F) in January and 34.3 °C (93.7 °F) in May. Annual average rainfall of Khulna is 1809.4 millimeters (71.2 in). Approximately 87% of the annual average rainfall occurs between May and October.

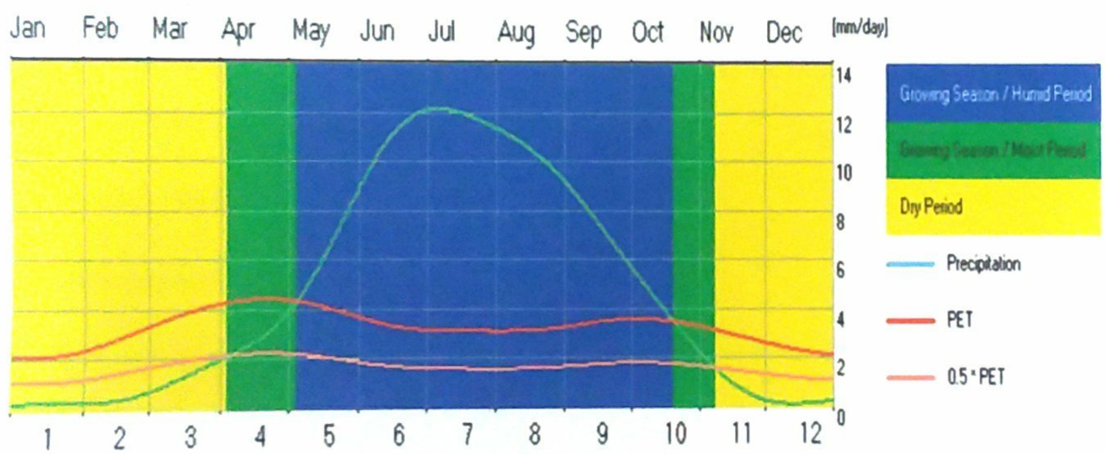

Fig: Climate map of Khulna.

3.2 Study species and Seed collection

In this study, the influence of density on seedling survival of *Shorearobusta* was investigated .Seeds were collected from Madhupur Sal Forest in Bangladesh in the month of April 2013.

3.3 Experiment set up

3.3.1 Soil Preparation

Nursery soil was used for the experiment.

3.3.2 Soil Preparation

A total of 9 boxes were collected made of cork. The dimension of the box was 18x12x10 inch.A soft plastic wrapper was laid inside the box to prevent leaching of nutrient and prevent moisture drain out. Each box was filled with 16 kilograms of soil. Each box was identified as a replication. There were there were three replication for each treatment.

3.3.3 Seeding

Seeds were sown with a distance of 2 inch, 3 inch and 4 inch. Each sowing distance is considered as a treatment. Therefore in this experiment, there are three treatments and three replications for each treatments. A total of 54, 24 and 12 number of seeds was sownrespectively for 2, 3 and 4 inch of sowing distance..

3.4 Data collection

3.4.1 Germination

When the root was visible to emerge from the seed was considered as germination. Germination was counted daily and each germinated seed was marked with a tag to avoid recounting.

3.4.2 Height measurement

Randomly 6 seedlings were selected for height measurement from each box. These seedlings were identified by using tag. One month interval height was measured by using scale. Length from base of the seedling to the base of the new leaf was considered in height measurement.

3.4.3 Collar diameter measurement

The same 6 seedlings which were selected for height measurement from each box also selected for Collar diameter measurement. By using permanent marker, base of the collar area was marked where Collar diameter was measured. Two measurements perpendicular to each other was documented and averaged to get collar diameter using a digital slide caliper..

3.4 Analysis

Data were organized in Microsoft Excel and analyzed using Minitab 16 (Full functional trial version). Data were tested using One Way Analysis of Variance (ANOVA). Significant relation was further tested using multiple comparisons using Tukey HSD method. Graphs were prepared using MS Excel.

CHAPTER FOUR

Results and Discussion

4.1 Results

4.1.1 Germination

In case of germination there is no significant difference (p>0.05) among the treatments (Table1). Here all the factors which are responsible for seed germination was same except distance of seed sowing.

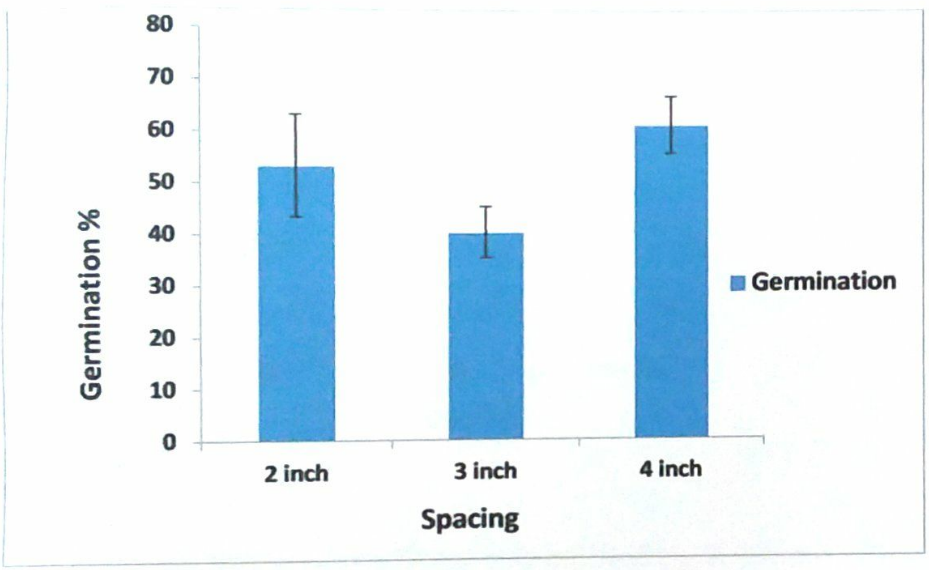

Fig.1: Germination of sal (*Shorearobusta*) seedling at different distance.

Table1: One-way ANOVA: for germination under different distance of sowing.

Source	DF	SS	MS	F	P
Spacing	2	662	331	2.14	0.199
Error	6	928	155		
Total	8	1590			

4.1.2 Height

Distance of seedling had a strong influence on seedling height growth of sal (*Shorea robusta*) (Table 2). In case of height growth there is a significant difference (p<0.05) among the treatments (Table 3). Height increase of 2 inch and 3 inch spaced seedlings were significantly (p<0.05) different than 4 inch distance seedlings.

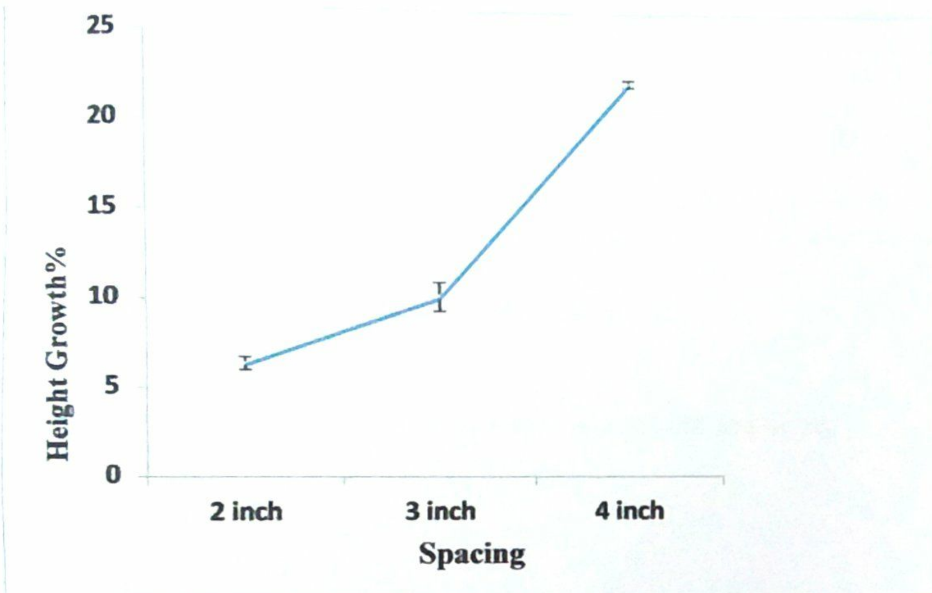

Fig. 2: Height growth of sal (*Shorea robusta*) seedling at different distance.

Table 2.ANOVA for seedling height growth under different distance of sowing

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	420.088	2	210.044	32.405	.001
Within Groups	38.891	6	6.482		
Total	458.980	8			

Table 3: Multiple Comparisons (Tukey HSD) for seedling height growth.

(I) Treatment	(J) Treatment	Mean Difference (I-J)*	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2	3	-3.85225	2.07877	.2320	-10.2305	2.5260
	4	-16.0298	2.07877	.0006	-22.4080	-9.6516
3	2	3.85225	2.07877	.2320	-2.5260	10.2305
	4	-12.1776	2.07877	.0026	-18.5558	-5.7993
4	2	16.0298	2.07877	.0006	9.6516	22.4080
	3	12.1776	2.07877	.0026	5.7993	18.5558

*. The mean difference is significant at the 0.05 level.

Table 4: Means for groups in homogeneous subsets are displayed.

Height growth

Tukey HSD

Treatment	N	Subset for alpha = 0.05	
		1	2
2	**3**	**6.2863**	
3	**3**	**10.1385**	
4	**3**		**22.3161**
Sig.		**.232**	**1.000**

4.1.3 Diameter

In case of diameter growth there is no significant difference (p>0.05) among the treatments (Table 5). It indicates distance independent diameter growth at the early stage of the seedling.

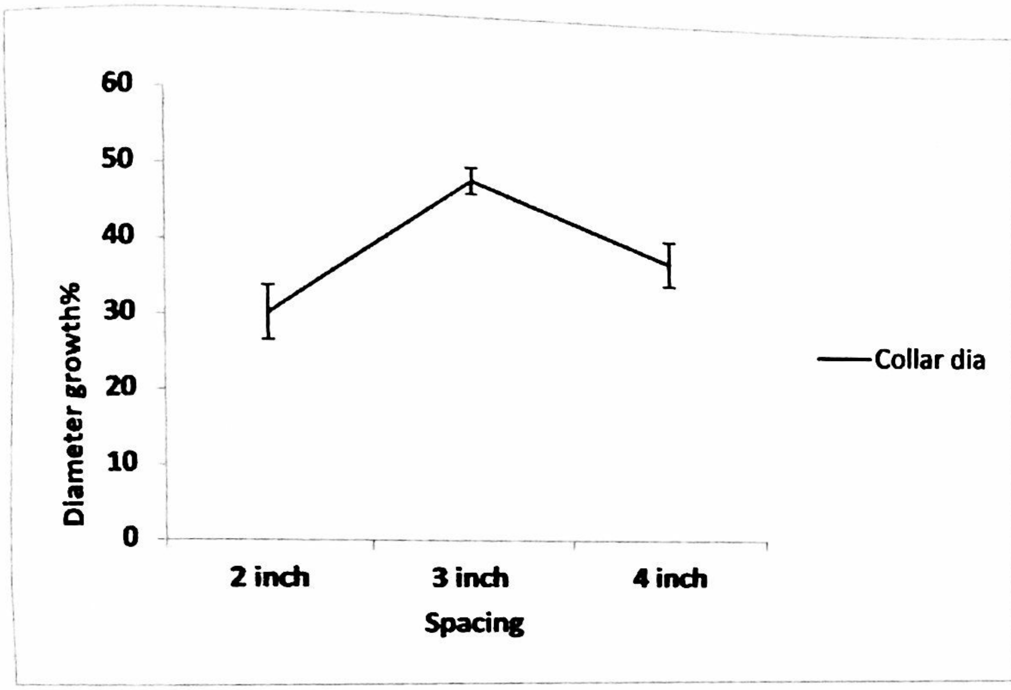

Fig.3: Diameter growth of sal (*Shorea robusta*) seedling at different distance.

Table 5 :ANOVA of seedling diameter growth

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	505.223	2	252.611	1.375	.322
Within Groups	1102.282	6	183.714		
Total	1607.505	8			

4.2 Discussions

4.2.1 Germination:

Germination is believed to be influenced by adjoining seeds. Density or spacing of sowing of seeds determines the closeness of the seeds which might influence the success of germination. Watie and Hutchins (1978) commented that chemical release of the seeds often influence the germination of the sowed seeds. However this phenomenon was not observed in our study. Elhag and Osman (2013) did not find any effect of sowing density in case onions. Therefore high density sowing in the nursery bed is possible for sal (*Shorea robusta)* seedlings.

4.2.2 Height

Close spacing of seedling stimulates height growth as the competition for light is intense as a growth limiting factor (Kimmins, 2001). The scenario for sal seedling in this experiment was also the same. Height growth was found significant ($p<0.05$). However in this experiment both 2 inch and 3 inch sowing distance did not produce any significant variation in height growth. Reduced sowing distance also found to reduce height growth by others (Marien and Drovin, 1978; Landis *et al.,* 1990)

4.2.3 Diameter

Plants have different growth forms. At different stages of a tree, it maintains different growth strategies (Smith, 2000). Generally, at the seedling stage a plant wants to avoid competition from weed and other herbs which promotes them to increase the investment in the height growth of the seedling than diameter growth (Troups, 1952). In this study sal seedling did not produce any significant diameter increase. This might be due to the reason of the inherent growth strategy. Besides, the increased competition for environmental resources (light, water and nutrients) can inhibit diameter increase at the seedling stage (Bramble et al., 1949; van Laar and Bredenkamp, 1979; Scho¨nau and Coetzee, 1989; Niemisto¨, 1995; Kearney, 1999; Neilsen and Gerrand, 1999).

CHAPTER FIVE

Conclusion and Limitation

5.1 Conclusion

The natural forest area of the world day by day has been reducing. On the contrary plantation forest area has been increasing. Population growth and urbanization is the main reason of natural forest area reduction. However in case of plantation forest, nursery is essential for seedling production. So in a nursery healthy seedling production is a challenge for a nursery owner. But the owner of a nursery failed to produce healthy seedling because lacking knowledge of seed sowing spacing. But the owner of a nursery uses a definite area for seedling production and every owner wants to produce large number of healthy seedling.. So we can say to know "Effect of seed sowing distance on germination and growth of sal (*Shorea robusta*)" is very important. Because spacing has an effect of seedling height of sal (*Shorea robusta*).So it will be beneficial for worldwide forestation and it will create many job opportunities to the people.

5.2 Limitation

- Number of replication was less
- It merely covered a season, but for proper result it needs at least one year

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