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Indigenous Natural Regeneration Protocol of Sal (*Shorea robusta*) with Specific Concern to Changing Climate in India Affecting its Distribution and Germination Pattern

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Abstract: MDGs goal no. 7 focuses on ensuring environmental sustainability. The WSSD provided a platform to achieve sustainable development under the WEHAB (Water, Energy, Health, Agriculture and Biodiversity) initiative framework. In view of the aforesaid framework, CGSMPB had developed Tradition Regeneration and Conservation technique of *Shorea robusta* with community participation in forest of Chhattisgarh State, India. *Shorea robusta* is a climax species of tropical deciduous forest of Central India which forms pure stands in Chhattisgarh state but it is most affected by development programmes. Sal it self is a Medicinally valuable Species & supports many of the medicinally valuable tree, shrubs & herbs in the rich plant biodiversity.

Though the Regeneration of “SAL” in some areas is profuse but conservation of regeneration, however, has been a serious problem in Sal forest management. Hence a traditional regeneration protocol is developed with participation of community. The aim was to develop "***Traditional Natural Regeneration Conservation Protocol of Sal and assessing the effect of Termite Mounds Soil on the germination behavior of Shorea robusta Seeds involving community***”. The seeds were collected from Sal forests of 3 agro-climatic zones of state and sown by traditional practice and progress of germination was observed & recorded weekly upto 14 days. Statistical “W” (Shapiro-Wilk normality) were applied. The population class analysis was derived by a regression equation based on negative exponential model. The 15 sites in Chhattisgarh under 3 **Agro Climatic Zones** were Bastar Platue, Chhattisgarh Plains and Northern Hills. We observed that Site no. 1, 2, 3, 10 and 13 had shown good regeneration status, site no. 9, 12 and 14 had shown fair regeneration status where as site no. 4, 5, 6 and 11 had shown promising regeneration and site no. 7 and 8 had shown poor regeneration. The Study indicates that the regeneration technique may lead us to achieve the target of Millennium Development Goals.

Keywords: Traditional Natural Regeneration, Conservation, Medicinal, Termite Mounds Soil, Millennium Development Goals

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1. Introduction

SAL forests are spread across 10 million hectare (m ha) in India. Globally, the natural range of sal forests lies between 20–32°N lat. and 75–95°E long., where the distribution is primarily controlled by climate and edaphic factors. In India, the species is dominantly distributed on the plains and lower foothills of the Himalayas and also along the valleys. The spread of Sal forests have demarcated in ranges of Uttarakhand in the north up to Andhra Pradesh in the south and Tripura in the east; covering Himachal Pradesh, Haryana, Uttar Pradesh (UP), Bihar, West Bengal, Odisha, Madhya Pradesh, Chhattisgarh, Maharashtra, Jharkhand, Sikkim, Assam and Meghalaya. Sal forests occur in consociation and/or association based on location, climatic conditions and interspecific exchanges. Climate has significant influence on the distribution, structure and ecology of the forests. It is evident from the projections of global models that as a result of changes in temperature, precipitation and soil moisture availability due to increase in greenhouse gases, majority of the forests will undergo shifts. Certain climatic regimes are associated with particular plant functional types, hence it is reasonable to assume that changes in climate would alter the distribution pattern and composition of forest ecosystems. Recent studies have been conducted to assess the impacts of climate change on forests in India, which cover approximately 21% of the total geographical area of the country. Due to global warming by 1–2°C, most ecosystems and landscapes will be altered through changes in species composition, biodiversity and productivity and would exhibit peculiar patterns of distribution. Thus, assessing the likely impacts of projected climate change on forests, particularly at the species level, is the need of the hour.Although Sal forests can survive in cooler and warmer temperatures, it would be difficult to modify the phonological cycle to maintain the semi-evergreen habit under temperature rise during future years. The forests would tend to shift to suitable areas to maintain the survival rate and proper growth. India experiences four distinct monsoonal periods, viz. southwest (SW) summer monsoon (June–August), northeast (NE) winter monsoon (December–February), spring (March–May) and autumn (September–November). The large spatial variability in monsoonal activity is the main reason for diverse vegetation types across the country.

Germination is the process of growth initiation of embryo from the dormant state to active growth life. Seeds germinate only when appropriate environmental conditions including air, water, temperature and some time specific quality of lights arc available (Noggle & C Fritz, 1968). Sal (*Shorea robusta*) is a large gregarious tree mainly propagated by means of seeds. Temperature and substratum play very significant role during the process of seed germination (Anon, 1993; Kumar and Toky, 1996; Shringishi etai, 2001). Very high and very low temperature may cause the inhibition of seed germination (Eiliot and French, 1959; Baird &c Dickens, 1991). The optimum temperature is that under which the highest percentage of germination takes place within

the specified time. The seed germination of Sal (*Shorea robusta*) trees is greatly affected by temperature and substratum (Puri ct al. 1983; Dutta, 1994). Dutta (1994) recorded maximum germination of *Shorea robusta* seeds at 27 ^{0}C and minimum germination at 50 ^{0}C and 40 ^{0}C. The seeds lose their viability to germinate at prevailing high or lower temperature. It is interesting to note that Sal seeds fail to germinate at low temperature (Chain et al., 1983). Possible cause of such phenomenon may be the production of some endogenous inhibiting substances which arrested embryo growth, or low temperature may interfere with certain enzymatic systems which control the release or synthesis of formative food for embryo growth. It is generally agreed that release and synthesis of readily soluble components from food reserves is enzymatically controlled and the activation of enzymatic system is greatly influenced by environmental temperature (Stokes 1965; Lam, 1968). The larger earth mounds are usually homes of the termites *Macrotermes natalensis*. Using chimneys and inlets at ground levels, the termites regulates the temperature inside the mounds, within a very narrow range. The cellulose of termite excrement is broken down into digestive fertile produce by several enzymatic processes. The wide range range of activities within the termitarium makes the soil very fertile and moist, enabling easy germination of seeds (Lowveld & Kruger Guide; Jacana, Johannesburg, 2004). The present investigation was also carried out to find whether the termite mounds used as fertilizer (traditional approach) affected germination of Sal seeds or not. Such information would be of value both in understanding the nature of seed germination and viability period in Sal seeds.

Regeneration of Sal (*Shorea robusta* Gaertn. f.; family Dipterocarpaceae) is a complex and baffling problem (Bisht, 1989). A lot has been said and done to enhance the regeneration potential of Sal in entire India. Regenerating forests can be presence of seedlings, sapling and trees of different age groups, from young to old (Chauhan, 2001; Chauhan et al.; 2001). Characteristics of size and age distribution provide important information about regeneration probability of a species. If the distribution diameter class is such that a maximum number of individuals are present at the seedling stage and then decreases subsequently at the next model, the model is named as reverse 'J' shaped curve. This signifies good regeneration potential of the forest site.

Sometimes bell shaped curve may also occur in the areas of even aged crop in which management has been done under conversion system. In addition to this sometimes there is a probability of 'J' shape curve in old growth forest as a result of failure in regeneration. On the basis of the three population curves, we classified the five stands (study sites) into four groups viz. good, fair, poor and promising regeneration areas.

2. Methodology

Data was collected in June & July months. Quadrats were laid along a transect line using nested quadrat methods. A total 165 quadrat each for saplings and seedlings were sampled from five groups of fifteen sites. The size of quadrat for saplings and seedlings were 3m x 3m and 1m x 1m respectively. Data of shoot height and collar diameter for saplings and seedlings was collected from each quadrat. Site characteristic is given in the Table 1. Graph was plotted taking diameter on X-axis and normalized diameter percent on Y-axis. The population class analysis was derived by a regression equation based on negative exponential model (Schmelz and Lindsey, 1965; Bisht and Sharma, 1987). The negative exponential model assumes a constant depletion rate (Bisht and Sharma, 1987). The negative exponential distribution is:

$Y=Y^o\ e^{-bx}$

Where:

Y is the number of individuals in any class,

Y^o is the initial input into population at time zero,

b is the depletion rate.

Traditional Natural Regeneration Protocol

The seeds were manually collected from matured Sal (*Shorea robusta*) trees of Sal forests of 3 agro-climatic zones of Chhattisgarh i.e. Bastar Platue, Chhattisgarh Plains and Northern hills. A field trial was done at place for 3 hours. The germination tests were carried by sowing the seeds in their natural habitat via digging 20 cm diameter pit using only wood appliances. The seeds were properly handled via holding it by its petals and not touching the viable seed cod. Two to four seeds were planted in each pit to avoid regeneration failure. Termite mounds crushed in coarse powder was carefully spread over the pits and moisted with small amount of water. The fallen Sal leaves were also kept over the plantation to retain moisture for longer time. Seed germination observation was carried out in three five groups of fifteen sites. The germination of seeds was observed and recorded weekly upto 14 days from the date of seed sown. A seeds was considered to be germinated when the radical length was about 1 cm in length. The germination percentage was recorded. The average germination value was calculated according to Trompsert (1985). Finally, “W” tests (Shapiro-Wilk normality test) were applied to prove whether they were statiscally significant or not. Germination pattern of the seeds was observed and recorded.

Demonstration on Traditional Natural Regeneration Protocol

Traditional Natural Regeneration at day 0, 10, 15, 18 and 20

Regeneration mapping and community engagement

3. Results and Discussion

The present investigation showed comparatively higher percentage of germination of sal seeds by the traditional approach using termite mounds (Table 1).

Table 1: Germination of Sal (*Shorea robusta*) seeds at different agro-climatic zone

Site No.	Agro –Climatic Zone	Sites	Germination % using Traditional Practice
1	Bastar Plateu	Keshkal	96±0.89
2		Kondagaon	95±1.20
3		Bastar	96±0.97
4	Chhattisgarh Plains	Raigarh	90±1.30
5		Dharamjaygarh	87±0.96
6		Marwahi	92±0.87
7		Korba	92±0.88
8		Katghora	84±1.50
9		Kanker	92±1.00
10		Gariyaband	96±0.87
11		Dhamtari	94±0.94
12	Northen Hills	Jashpur	93±0.92
13		Sarguja	95±0.91
14		Balrampur	90±1.00
15		Surajpur	90±1.10

Maximum seed germination (96.00 percent) in Keshkal & Bastar followed by 95.00, 94.00 percent seeds germinated in Kondagaon and Dhamtari, was recorded respectively. The data from the different agro-climatic zones shows that the traditional approach adopted for seed plantation and use of termites mounds were favourable for germination of Sal seeds. However comparatively lower germination value was recorded in Dharamjaygarh and Katghora. This could be attributed to the difference in the agro-climatic environments in the three zones. Dutta (1994) also recorded lower percentage of seed germination of *Shorea robusta*, stored at 5^0C and 40^0C. Chain et al. (1983) too reported no seed germination of *Shorea acuminata* at temperature below 5^0C. Seeds of *Shorea robusta*, took 2-3 days each for the occurrence of radicle and completed the germination process within 7 days. Dutta, (1994) reported the dormancy period to be 3 days for the seeds stored at 27 ^{0}C.

Fig.1. Germination of Sal (*Shorea robusta*) seeds at different agro-climatic zone

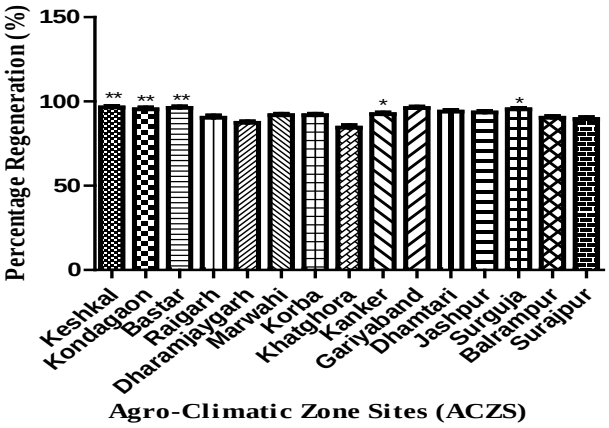


Table 2 shows a very significant effect on the germination of seeds at different agro-climatic zones using traditional regeneration approach. It shows highly significant value towards Bastar platue across all three sites. Similarly significant value of regeneration is observed in Chhattisgarh plains and Northern hills. From the above results it is clear that the regeneration using traditional approach was favorable for germination of Sal seeds in all three agro-climatic zone i.e. Bastar Platue>Northen hills>Chhattisgarh Plains. This is probably due to the fact that, at variation in temperature condition, the enzymes become inactive which effect seed germination (Puri, etal. 1983). It can be presumed that at lower temperature facilitated by the agroclimatic zone of Bastar plateu, the seeds of *Shorea robusta* retain their viability for an extended period (14 days). Many earlier workers reported about the short viability period of seeds of *Shorea robusta* which extended for a few days only (Elliot & French 1959; Puri et al. 1983; Dutta 1994; Khanna, 1996; Nanhare & C Sharma, 2002; Gnutam & C Devoc 2005). But the present investigation shows that the seeds of Sal (*shorea robusta*) trees

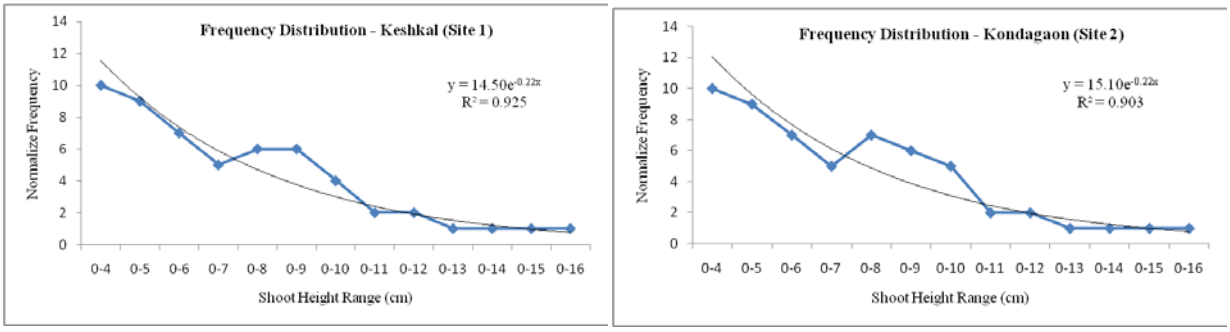
remain viable for 14 days provided if this traditional approach of plantation is adopted after collection. The medicinally valuable associated species found in the SAL forests were suphelia, nagar motha, ban kachra, bhui aonla, balyari, stevia, koria, kapuri, bela, kali musli etc.

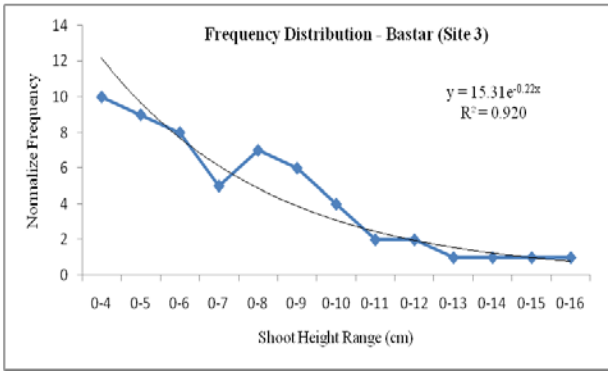
Table 2: Shapiro-Wilk normality test "W" for germination of Sal (*Shorea robusta*) seeds at different agro-climatic zone

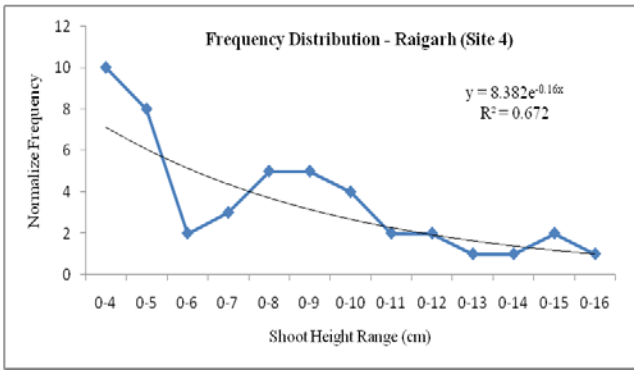
Site No.	Agro –Climatic Zone	Sites	Obtained "W" value	Probability
1	Bastar Plateu	Keshkal	0.84	0.0037**
2		Kondagaon	0.84	0.0035**
3		Bastar	0.82	0.0019**
4	Chhattisgarh Plains	Raigarh	0.97	0.7190
5		Dharamjaygarh	0.95	0.3505
6		Marwahi	0.94	0.2093
7		Korba	0.93	0.1864
8		Katghora	0.96	0.4643
9		Kanker	0.94	0.2360
10		Gariyaband	0.88	0.0205*
11		Dhamtari	0.94	0.2521
12	Northen Hills	Jashpur	0.94	0.2664
13		Sarguja	0.91	0.0437*
14		Balrampur	0.92	0.1222
15		Surajpur	0.97	0.7664

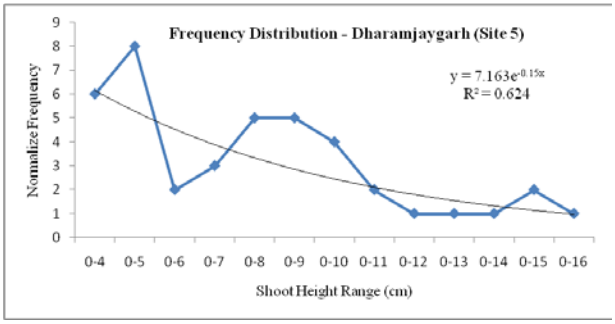
*Normality Test (alpha=0.05); confidence interval 95%

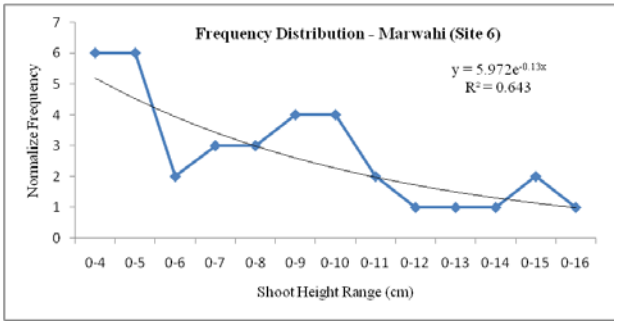
Fig 2: Frequency distribution of Sal (*Shorea robusta*) seeds at different agro-climatic zone

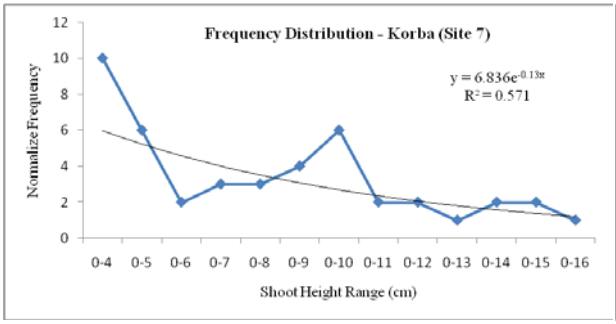


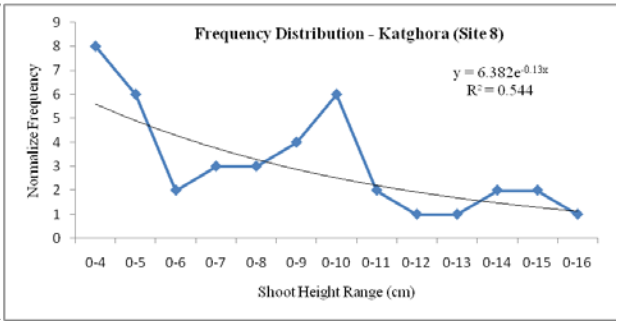

Frequency Distribution - Bastar (Site 3)
y = 15.31e^-0.22x
R² = 0.920
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16

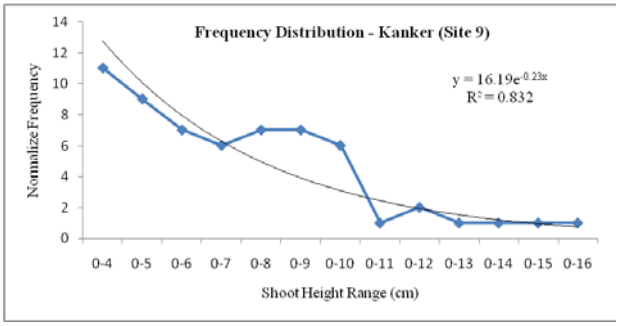

Frequency Distribution - Raigarh (Site 4)
y = 8.382e^-0.16x
R² = 0.672
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16

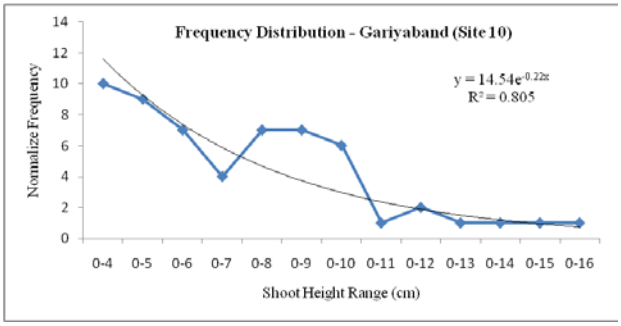

Frequency Distribution - Dharamjaygarh (Site 5)
y = 7.163e^-0.15x
R² = 0.624
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16

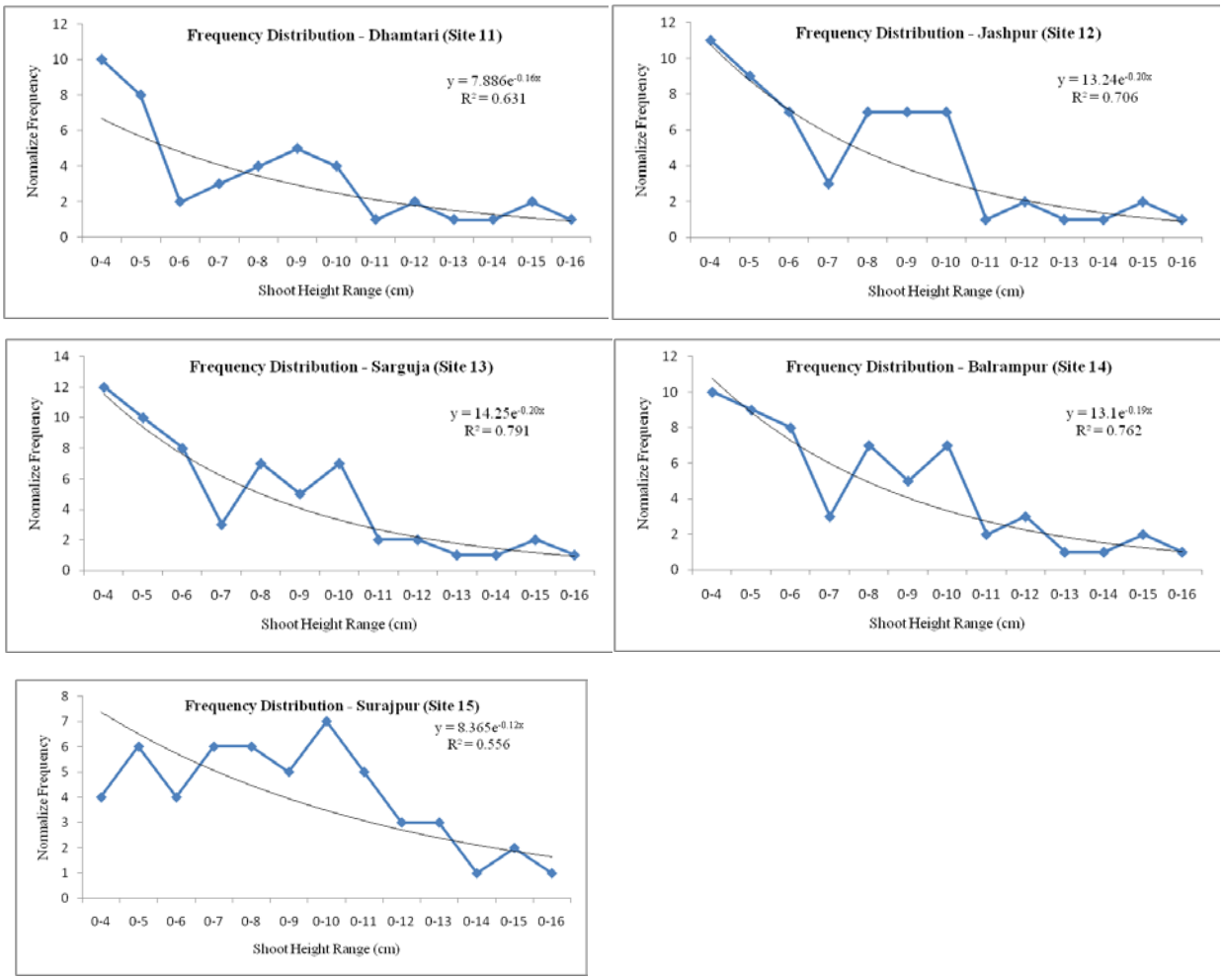

Frequency Distribution - Marwahi (Site 6)
y = 5.972e^-0.13x
R² = 0.643
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16


Frequency Distribution - Korba (Site 7)
y = 6.836e^-0.13x
R² = 0.571
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16


Frequency Distribution - Katghora (Site 8)
y = 6.382e^-0.13x
R² = 0.544
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16


Frequency Distribution - Kanker (Site 9)
y = 16.19e^-0.23x
R² = 0.832
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16


Frequency Distribution - Gariyaband (Site 10)
y = 14.54e^-0.22x
R² = 0.805
Normalize Frequency
Shoot Height Range (cm)
0-4 0-5 0-6 0-7 0-8 0-9 0-10 0-11 0-12 0-13 0-14 0-15 0-16



Results of the present study reveals that 1, 2, 3, 10 and 13 sites had reverse 'J' shaped model of distribution (Fig 2). The values of coefficient of determination (r2) for these sites ranged between 0.925 and 0.791, and they were designated as good regeneration sites. In case of site 9, 12 and 14 the values of r2 was as high (0.832 and 0.762) as in case of good regeneration category, but, it was kept in fair regeneration group. The latest group with two sites (8 and 7) having r2 value ranging from 0.544 to 0.571 was designated under poor regeneration group. The next group compromised of site 4, 5, 6 and 11 having r2 value ranges from 0.624 to 0.672, and was categorized as promising regeneration category. Sites 1, 2, 3, 10 and 13 supposed to be good area for regeneration of Sal as the population distributed in these sites strictly adheres to reverse 'J' shape curve having appreciable amount of seedling and sapling population. Among all the above mentioned sites 1, 2 and 3 (having high value of r2) appears to be very good for regeneration. This can be sustained by the balanced proportion of seedlings that gets transform to sapling and other age groups. Such a system will maintain the population for a longer period of time.

Site 9, 7 and 14 are fair regenerating areas. Site 8 and 9 can be designated as poor regenerating sites. Site 4, 5, 6 and 11 are following similar pattern of population distribution. The population structure can be modified into the regenerated reverse 'J' shape curve by adopting the traditional regeneration approach.

4. Conclusion

Sal (*Shorea robusta*) is one of the most valuable medicinal as well as timbers yielding plant in India. The wood is very hard, durable and strong. As a result, the wood of Sal trees are used for making frame of doors and windows, Railway sleepers, furniture, piles etc. It has vast medicinal values and been documented in traditional practices from ancient times. It is used in the treatment of excessive perspiration, wounds, ulcers, neuralgia, burns, pruritus, fractures, fever diarrhoea, dysentery, hiccough, asthma, haemorrhaoids, gonorrhoea. Menorrhagia, splenomegaly, obesity, cephalalgia. Odontalgia and burning sensation of the eyes. Also the medicinally valuable associated species found in the SAL forests were suphelia, nagar motha, ban kachra, bhui aonla, balyari, stevia, koria, kapuri, bela, kali musli etc. Since, the distribution of this species is much confined to some areas of our country and at the same time there is destruction of Sal forests throughout the country due to anthropogenic factors, this species need immediate attention for its conservation including management. In this case the seed germination through traditional practice of the species may help in seeds germination at suitably favorable temperature within three agro-climatic zones for comparatively more days, to keep its viability longer than in its natural state. Sites 1, 2, 3, 10 and 13 across all three agro-climatic zones supposed to be good area for regeneration of Sal as the population distributed in these sites strictly adheres to reverse 'J' shape curve having appreciable amount of seedling and sapling population. Further multi dimensional studies like laboratory testing for soil nutrient status, germination in controlled laboratory conditions, community protocol, medicinal value of sal and its ethano pharmacological studies are recommended to rationalize the use of traditional regeneration practices as advocated above.

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References

[1]. Bisht, A.P.S. 1989. Microsite Mosaic and under canopy vegetation Dynamics of sal communities in East and West Dehra Dun Forest Division. D. phil. Thesis, Garwal University, Srinagar, Garhwal India.

[2]. Bisht, A.P.S. and Sharma, S.C. 1987. Disturbance regimes in sal (*Shorea robusta*) forests of Dehra Dun Forest Division. Int. J. Ecol. Environ. Sci., 13: 87-94.

[3]. Chauhan, P.S. 2001.Sal (*Shorea robusta* Gaertn. f.) Mosaic characterization in Doon valley. D. Phil. Thesis, Deemed University, Forest Research Institute, Dehra Dun, India.

[4]. Chauhan, P.S., Manhas, R.K. and Negi, J.D.S. 2001. Demographic and Diversity Analysis of trees species in sal (*Shorea robusta* Gaertn. f.) Forests of Doon Valley. Ann. For., 9 (2): 188-198.

[5]. Joyeeta, S.C, Nirmal R, Jeeva V and Singh S, 2017. Status of tree species regeneration with special reference to the role of termite mounds in moist deciduous sal forest of doon valley. Indian Forester, 143 (2) : 128-134.

[6]. Schmelz, D.V. and Lindsey, A. .A. 1965. Size class structure and old forests in Indiana. For. Sci., 71: 258-264.

[7]. Tewari, D. N., A Monograph on Sal (*Shorea robusta* Gaertn. f.), International Book Distributors, Dehradun, 1995.

[8]. V. S. Chitale and M. D. Behera., Can the distribution of sal (*Shorea robusta* Gaertn. f.) shift in the northeastern direction in India due to changing climate? current science, vol. 102, no. 8, 25 april 2012. Centre for Oceans, Rivers, Atmosphere and Land Sciences, Indian Institute of Technology, Kharagpur 721 302, India.