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Ecological Hindrances for Establishment of Mass Population of Sal (***Shorea robusta***) in Forest Gardens Overtaking

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ABSTRACT

Sal (*Shorea robusta* L.) is a valuable forest timber which has immense innumerable uses in national as well as international livelihood. Though, there are various ecological hindrances but, still, it has occupied its first position as forest plantation plant species in India. We had also faced certain edaphic problems while planted thousands of plants in different forest gardens under Burdwan Forest Division in early and late-monsoon in the year 2017. The seedlings of three four weeks aged were plated in the field in early and late monsoon i.e. in the month of June-July and August-September, 2017 respectively. Thereafter, a devastated situation was occurred by nature within a couple of months just after plantation in late-monsoon months. The stagnant water could not drained out for a few days only. The plants were withering away gradually. Our observation was started for exploring the cause behind this withering away of plants in course of rapid way. Indeed, we could explore the reason of it and could able to check this condition of withering away of sal seedlings. The main aims and objects of this observation were to study the problems and to make its remedy without further delay. All these interesting findings have been illustrated in this context.

Keywords**:** Ecological hindrances, forest plantation, edaphic problems, devastated situation, withering away remedy, interesting findings.

1. INTRODUCTION

LOCAL NAMES

Bengali (sal,shal,sakhu); English (sal); French (damar de l'Inde); German (salharzbaum,salbaum); Hindi (borsal,hal,sagua,sakhu,sakhwa,sal,shal); Nepali (agrakh, sakhua, sal, sakwa); Sanskrit (shal); Tamil (kungiliyam (resin)); Trade name (sal).

BOTANICAL DESCRIPTION

Shorea robusta is a large, deciduous tree up to 50 m tall and with a dbh of 5 m; these are exceptional sizes, and under normal conditions S. robusta trees attain a height of about 18-32 m and girths of 1.5-2 m; bole is clean, straight and cylindrical, but often bearing epicormic branches; crown is spreading and spherical. Bark dark brown and thick, with longitudinal fissures deep in poles, becoming shallow in mature trees; provides effective protection against fire. The tree develops a long taproot at a very young age. Leaves simple, shiny, glabrous, about 10-25 cm long and broadly oval at the base, with the apex tapering into a long point; new leaves reddish, soon becoming delicate green. Flowers yellowish-white, arranged in large terminal or axillary racemose panicles. Fruit at full size about 1.3-1.5 cm long and 1 cm in diameter; it is surrounded by segments of the calyx enlarged into 5 rather unequal wings about 5-7.5 cm long.

BIOLOGY

S. robusta is a hermaphroditic, self-incompatible species. Pollen vectors in its natural habitat are insects from the family Thysanoptera. Heavy flowering of the tropical timber genus Shorea has is usually correlated with the previous drought period. Beginning at about age 15, S. robusta bears fruit regularly every 2 years or so, and a good

seed-bearing year can be expected every 3-5 years. Major seed dispersal agents include wind and water. Harvesting - Leaves collected and used to make lacquered bowls.

ECOLOGY

Of the 2 factors of habitat, climate and soil, the former decides the general distribution of *S. robusta*; among the climatic factors, rainfall is by far the most important. Annual precipitation normally comes with a dry season lasting 4-8 months (monsoon climate). At higher elevations, S. robusta can be damaged by frost. *S. robusta* occurs in both deciduous dry and moist forests and in evergreen moist forest. It accounts for about 14% of the total forest area in India. For example, southwest Bengal harbours luxuriant *S. robusta* forests. Fire is normally responsible for its frequent occurrence in pure stands or as the dominant species of mixed stands, as *S. robusta* is better equipped to survive conflagrations than other tree species.

BIOPHYSICAL LIMITS

Altitude: 100-1500 m, Mean annual temperature: (min. 1-7) 22-27 (max. 34-47) deg. C, Mean annual rainfall: 1000-3000 (max. 6600 mm).

Soil type: *S. robusta* flourishes best in deep, well-drained, moist, slightly acid sandy to clayey soils. It does not tolerate waterlogging. The most favourable soil is a moist sandy loam with good subsoil drainage. Availability of soil moisture is an important factor determining the occurrence of S. robusta. *Shorea robusta*, commonly known as sal, belongs to the *Dipterocarpaceae* family. Sal is an important non timber forest product (NTFP) and it is available in many south Asian countries like India, Pakistan, Nepal, Bhutan, Bangladesh, and Myanmar. The planning commission of India has recommended sal seed as potential NTFPs for enterprise development in India. The estimated availability of sal seed in India per year is 1.5 million tons. About 20–30 million forest dwellers depend on collection of sal seeds, leaves, and resins (Patnaik, 2015_Patnaik, S. (2015). *Non timber forest product, enterprise and forest governance*. Bhubaneswar: Center for Peoples Forestry. Sal is a large deciduous tree and it grows up to 50 m height. Sal tree requires well-drained, moist, and sandy loam soil. It is mostly propagated through cutting. Sal sheds leaves under dry condition from February to March and new leaves appear in the month of April and May. Fruiting and ripening occurs in summer between June and July. Sal seeds are around 10–15 mm in length and 10 mm in diameter and have five wings of unequal size and shape. The sal seed contains about 34.6%, (w/w) oil, 8.46% (w.b) moisture, and 6% ash (Singh, Soni, Kumar, & Singh, 2014_Singh, V., Soni, A., Kumar, S., & Singh, R. (2014). Pyrolysis of sal seed to liquid product. *Bioresource Technology*.

Natural zone of sal forests (shaded dots for sal forests, after Stainton, 1972; FAO, 1985).

Sal forets are distributed on the plains and lower foothills of the Himalayas including the valleys (Gautam, 1990). It penetrates through mid-mountain range (Mahabharat 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 (Tewari, 1995) and 1 million ha in Nepal (HMG, 1989). This forest type extends from a few metres to 1500 m above mean sea level.

In the past, sal forests were managed solely in the interests of the ruling elite; accordingly, management norms were developed to maximize revenue (Gadgil, 1990; Gautam, 1991b; Gadgil and Guha, 1993). As timber emerged as an important commodity, the government attempted to manage sal forests for commercial timber production in order to increase revenue. Eventually, the governments saw sal forests more as a timber source rather than for other forest products. But the sal forests, to the contrary, extend to the most heavily populated zones and local people access sal forests for different uses, irrespective of whether they are designated as protective (Kumar *et al.*, 1994; Lehmkuhl, 1994; Bhat and Rawat, 1995; Aryal *et al.*, 1999) or productive forests (Nair, 1945; FRIB, 1947; Mathauda, 1958; Verma and Sharma, 1978; Rana *et al.*, 1988; Maithani *et al.*, 1989; Patnaik and Patnaik, 1991; Rajan, 1995; Tewari, 1995; Gupta *et al.*, 1996; Ganeshaiah *et al.*, 1998; Melkania and Ramnarayan, 1998; Gautam and Devkota, 1999; Pokharel *et al.*, 1999; Pokharel, 2000). It is evident that sal forests have the potential to yield other forest products, too. A sal tree in addition to timber and fuelwood, produces fodder (Panday, 1982; Gautam, 1990; Pandey and Yadama, 1990; Mathema, 1991; Upadhyay, 1992; Thacker and Gautam, 1994; Fox, 1995; Shakya and Bhattarai, 1995; Edwards, 1996; Gautam and Devkota, 1999); leaves for plates (Rajan, 1995; Gautam and Devkota, 1999); seed for oil (Verma and Sharma, 1978; Sharma, 1981); feed (Rai and Shukla, 1977; Sinha and Nath, 1982), resin or latex from heartwood (FRIB, 1947) and tannin and gum from bark (Narayanamurti and Das, 1951; Karnik and Sharma, 1968). Besides, associates of sal are known to produce edible fruits, fodder and compost, fibres, leaves for umbrellas, medicinal plants, thatch, grass, brooms and many other products depending on the species composition (Stainton, 1972; Jolly, 1976; Panday, 1982; Amatya, 1990; Gautam, 1990; Gilmour and Fisher, 1991; Mathema, 1991; Chettri and Pandey, 1992; Upadhyay, 1992; Schmidt *et al.*, 1993; Bhatnagar and Hardaha, 1994; Chandra, 1994; Jackson, 1994; Tamrakar, 1994; Thacker and Gautam, 1994; APROSC, 1995; Fox, 1995; Shakya and Bhattarai, 1995; Tewari, 1995; Edwards, 1996; Sah, 1996; Dwivedi, 1997; Melkania and Ramnarayan, 1998; Poudyal, 2000; Webb and Sah, 2003). Moreover, there are interesting facts of traditional practices of lopping, browsing and litter collection in sal forests of Nepal and elsewhere (Dinerstein, 1979; Agrawal *et al.*, 1986; Prasad and Pandey, 1987a; Chopra and Chatterjee, 1990; Pandey and Yadama, 1990; Mukhopadhyay, 1991; Upadhyay, 1992; Saxena *et al.*, 1993; Sundriyal *et al.*, 1994; Bahuguna and Hilaluddin, 1995; Bhat and Rawat, 1995; Nepal and Weber, 1995; Banerjee and Mishra, 1996; Rao and Singh, 1996; Melkania and Ramnarayan, 1998).

The evidence of such diverse products from sal forest indicates that many associate species of sal forests are capable of producing products given the appropriate management. Ecosystem-based management, i.e. ‘managing ecosystems in ways compatible with both ecological processes and people's needs’ (Oliver and Larson, 1996:397), could be the best option for sal forests producing ‘product mixes’, as required for community forestry development. Any deviation from ecosystem-based management would be neglecting the forests for the majority of the users, and eventually threatening the ecological processes of sal forests. Thus, ecosystem-based management is the present concern for sustainable management of sal forests used and managed by their local communities. Efforts are needed to design silvicultural regimes for sal forest to produce a range of products including timber. Designing silvicultural regimes to produce multiple products over the large range of species and sites requires an understanding of the

ecology and productivity of sal forests, and the influences of anthropogenic factors on its ecology and productivity. We aim to bring together the published information on ecology, productivity and anthropogenic factors relating to sal forest management. Furthermore, we are aware of the efforts to integrate various non-timber products, which are used by local communities from sal forests, into sal forest management, and have attempted to review and discuss these efforts.

2. MATERIALS AND METHODS

Materials

i) Sal seeds, ii) modern nursery in forest garden, iii) necessary field area for plantation, iv) attention of the member of FPC and JFM.

Photography Table-1: From nursery bed in forest garden, Burdwan Forest Division

Fig.-A: Grown up seedlings in early-monsoon

Fig.-B: Grown up seedlings in early-monsoon

Fig.-D: Grown up seedlings in late-monsoon

Fig.-C: Grown up seedlings in early-monsoon

Fig.-E: Grown up seedlings in late-monsoon

Fig.-F: Grown up seedlings in late-monsoon

Methods

Sal seeds collected from different forest gardens in winter-summer months as routine task of the forest department. Modern nursery having all adequate facilities was availed for growing the seedling providing uniform measures in all cases. Thousands of seedlings were grown, some are early and remaining are late grown seedlings. Proper observation were provided and the data were recoded properly. It was observed that the plants were developing

gradually after plantation both the early monsoon and late monsoon lots. Some plants were become affected severely after devastated condition. Some were also withering away rapidly. Research team visited the garden and started their work. First the team was collected the soil sample of the flood affected gardens and kept all the photographic documents which have been cited below. Portable soil testing kits (????) were used for the analyses of soil samples. The soil testing results of all gardens were tabulated in a single table to see all the components at a glance so that it can assessed easily to visualized the effect of deficiency or surplus the soil components over the plant population.

3. RESULTS AND DISCUSSION

After planting the saplings in the forest garden under Burdwan Forest Division it has been found that the plants planted in late-monsoon become affected much than that of early-monsoon plantation

Results:

Soil samples were collected from the forest gardens of Burdwan Forest Division before and after devastation condition of the forest gardens. Then the soil samples were analysed in laboratory to measure its macronutrients and physical properties which have been cited in the tables separately:

Table 1: Soil Analyses of different Forest Gardens under Burdwan Forest Division

Location	pH	Carbon	N_2 (nitrate)	N_2 (ammoniacal)	Phosphate	Potash
Chatimdanga, Mouza–Orgram, 2015	6.0 (slightly acidic)	Below 0.5% (Low)	18lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)
Chatimdanga, Mouza–Orgram, 2018	6.0 (slightly acidic)	Below 0.5% (Low)	18lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)
Jadabgunj, Mouza–Jadabgunj, 2015	6.0 (slightly acidic)	Below 0.5% (Low)	18lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)
Jadabgunj, Mouza–Jadabgunj, 2018	6.0 (slightly acidic)	Below 0.5% (Low)	18lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)
Behind Aduria Beat office Mouza-Punrijhurgh, 2015	6.0 (slightly acidic)	Below 0.5% (Low)	9lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100-250 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)
Behind Aduria Beat office Mouza-Punrijhurgh, 2018	6.0 (slightly acidic)	Below 0.5% (Low)	9lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100-250 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)
Near DVC canal, Mouza–Punrijhurgh, 2015	6.0 (slightly acidic)	Below 0.5% (Low)	9lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100-350 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)
Near DVC canal, Mouza–Punrijhurgh, 2018	6.0 (slightly acidic)	Below 0.5% (Low)	9lbs/acre as N or 8.16 kg/ acre (Medium)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100-350 lbs/acre as (K) or 45.36 kg/acre (All 3 lines are visible low)

Biler dhar, Mouza-Ausgram, 2015	6.0 (slightly acidic)	Below 0.5% (Low)	4 lbs/acre as N or 1.81 kg/ acre as N (very low)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	0 Lbs per acre as P_2O_5 or 0 kg/acre (Blank)	Below 100 lbs/acre as (K) or 45.36 kg/acre (all three lines are visible low)
Biler dhar, Mouza-Ausgram, 2018	6.0 (slightly acidic)	Below 0.5% (Low)	45 lbs/acre as N or 20.41 kg/ acre as N (High)	13 Lbs per acre as N or 5.89 kg/acre as N (Low)	Above 65 lbs per acre as P_2O_5 or 29.48 kg/acre (High)	Below 100 lbs/acre as (K) or 45.36 kg/acre (all three lines are visible low)

Discussion:

Stand structure

Sal is gregarious and dominant in its stand (Champion and Osmaston, 1962; Troup, 1986). It is considered to be deciduous as it changes leaves every year, and evergreen as the tree is hardly leafless. A sal tree was recorded with 45 m height, 25 m clear bole and a girth of 8 m in Nepal (Troup, 1986). Sal forest's top canopy reaches a height of 30–35 m and trees have a girth of 4 m in favourable localities, and the forest consists of many other layers of trees and shrubs. Stainton (1972) recorded species in various strata of Bhabar/Tarai and Hill sal forest, and Rana *et al.* (1988) noted species in two types (by age) of sal forests. The other species reveal the various types of sal forests, i.e. dry, moist or wet, and are found in varying densities depending on the edaphic and biotic conditions, and constitute a stratified height structure.

1) Edaphic factors

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 (Tewari, 1995), 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 (Rana *et al.*, 1988; Gangopadhyay *et al.*, 1990). 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 (Tewari, 1995). Sal tolerates some frost, but annual heavy frosts occurring in frost hollows are detrimental to seedlings (Prasad and Pandey, 1987b). The maximum temperature recorded in sal forest is 49°C (Singh and Chaturvedi, 1983).

2) Soil nutrient

Mineral nutrition appears to be an important factor in sal forest productivity. Kaul *et al.* (1963) calculated the nutritional uptake of a 35-year-old sal stand, on the basis of samples collected from different parts of India. They found that nutrient requirements for all site qualities decreased in the order of Ca, N, K, P and Mg. The Ca requirement (by percentage of oven-dry material) was determined to be 1.5 times that of N, 2 times that of K, and 5 and 7 times that of P and Mg, respectively. The study reflected that on better sites, or where the rate of stem timber production is greater, the nutrient requirements are much higher. On poor sites, nutrient status is lower, and a higher proportion of the uptake goes into the production of foliage. Kaul *et al.* (1966) studied the effect of mineral (N, P, K, Ca, Mg and S) deficiencies in sal seedlings, and showed that the deficiency of each of these nutrient elements except sulphur causes prominent symptoms (e.g. smaller leaves, thin tap root, premature defoliation, slow shoot

growth) both on shoot and root. Deficiencies of N, P and Mg affected height growth. Deficiencies of Ca and Mg produced a shorter tap root and sparse lateral roots while N- and K-deficient seedlings had thinner, longer tap roots.

Photographs Table 2: Before flooded & After flooded condition of the forest garden






The nutrient rates calculated in the four studies show little differences in the estimates of each nutrient. The climate of measurement years, age of the forest and methods of measurements may have contributed to these differences. One study (Kaul *et al.*, 1979) was in 21-year-old coppice forests, whereas the others were older than 35 years when they were measured. Similarly, the destructive method (trees were felled) was followed in the case of the study by Kaul *et al.* (1979) while the others followed the litter-plot method (collected throughout the year at monthly or quarterly intervals from the plots laid out in the forests).

Litter (leaves and twigs) production in sal forests ranged from 1010 to 6210 kg ha^{-1} $year^{-1}$ depending on the species composition and canopy cover (Misra, 1969; Pokhriyal *et al.*, 1987). Leaf litter decomposition is faster than twig decomposition (Pande and Sharma, 1993). Maximum decomposition was in the rainy season, and turnover time to decompose the litter was 144 days (Munshi *et al.*, 1987). With the advent of rainfall usually in the last week of June, litter starts decomposing rapidly and by the time the next litter fall starts, most of it decomposed and incorporated into the soil (Misra, 1969). Decomposition rate increased with increasing litter moisture and air temperature and decreased with increasing altitude and lignin content (Mehra and Singh, 1985; Upadhyay and Singh, 1986). After a period of 1 year, the loss of litter for sal was observed to be 56 per cent of initial dry weight.

Of the total decomposition, 40–45 per cent of litter was lost from May to August due to higher temperatures and humidity (Singh and Ramakrishnan, 1982). Total loss reached over 85 per cent by 365–669 days depending on the site and species under study (Upadhyay, 1987). During the transformation from green foliage to raw humus some of the elements (Ca, Mg, K, Na and P) were leached out while others (Si and Fe) accumulated (Gangopadhyay and Banerjee, 1987).

1) Nitrogen translocation

Pokhriyal *et al.* (1987) recorded a progressive increase in the nitrogen content of canopy foliage from the bottom to the top. The nutrient moves towards the upper canopy, and leaves in the lower canopy start the translocation process earlier (Pokhriyal *et al.*, 1988). Pokhriyal (1988) studied the monthly changes in N content in the canopy and litter, and estimated the retranslocated N in a natural sal forest. Foliage nitrogen content in the sal canopy was greatest (90 kg ha^{-1}) in January/February and least (36 kg ha^{-1}) in April (Pokhriyal *et al.*, 1987, 1988; Pokhriyal, 1988). Monthly N content (in percentages) in canopy, litter and storage parts (retranslocated N that sustains the growth of new foliage) of sal foliage. Leaf litter contributed the most nutrient return, release and accumulation. Sal trees translocate nutrients from the leaves prior to leaf fall (Sharma and Pande, 1989). Translocation of N to other parts is initiated once the live canopy content peaks in January/February before leaf shedding starts. From January to April, canopy nitrogen is either translocated (0 per cent in January to maximum 42.5 per cent in April) to other parts or returned to the ground through litter (Pokhriyal *et al.*, 1987).

Remedy – 1% N_2 foliar spray was applied twice in a week for instant recovery and to increase photosynthetic rate of plant population by redox mechanism of plant physiological hypothesis.

4. CONCLUSION

Proper drainage system is essential in 1^{st} year plant population along with balanced soil nutrient components and non acidic adequate soil pH should be maintained for proper growth and survivility of plant population.

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