

Seasonality of Leaf Fall and Litter Production in Sal (*Shorea Robusta* Gaertn. F.) ANR Forest in Tarai East Forest Division, Haldwani



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ABSTRACT

Sal (Shorea robusta), which is widely spread in both moist and dry forests in across the tropics, has been inconsistently described as either deciduous, semi-deciduous or evergreen species. To assess this contradiction, a quantitative record of the sal leaf dynamics (via monthly counts on tagged leaf falls and twigs) was made in different ANR sites of the Tarai East Forest Division, Haldwani. By using sample plots, the annual leaf fall data was collected and analyzed. The annual litter production (leaf fall & twigs) was maximum (8003.38 kg ha⁻¹ yr⁻¹) recorded in Surai (Jhankiya) followed by Kishanpur (Horai) 5434.52 kg ha⁻¹ yr⁻¹; Jaulasal (Bera) 5291.03 kg ha⁻¹ yr⁻¹ and its seasonality (month of leaf-fall) was 12-16% in (1st February – 1st March), 22.0-30.0% in (1st March – 1st April) and 40.0-43.0% in (1st April to 1st May) in Summer. In the species level the *Shorea robusta* (86-90%) has maximum leaf fall coverage in ground, followed by *Largestoennia* sp. (6.0-10.0%), *Terminalia* sp. (2.0-6.0%), *Schleichera oleides* (0-2.0%) and *Bauhinia* sp. (0-2.0%) was observed. Throughout in March – April (the transitio-nal month for the leafing pheno-phase); the two phenological variation were observed and reflecting significant functional diversity in sal trees. These variation were as follows; variation (a). Leaf fall completed and new leaf flushing begins; variation (b). Leaf fall and new leaf flush overlapping together. The presence of these variants are indicating that the most of individual of sal trees have semi-deciduous or evergreen characters in the division.

Keywords: Phenology, Leaf fall, Tarai East Forest, Sal ANR, Tropical Sal forest.

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INTRODUCTION

The seasonal patterns of tropical trees phenology are typically influenced by the duration and intensity of seasonal drought [1] and even trees of the of the same species can undergo varying level of drought stress [2]. In tropical trees, the seasonal period of leafing, flowering and fruiting espesically decided through phenological behavior or events. These phenological events are not entirely independent among woody species, as flowering may be partially or entirely dependent on leafing activity [3], [4]. The classification of sal (*Shorea robusta*) regarding leaf phenology has always been ambiguous due to the evergreen versus deciduous dilemma. Some researchers have classified sal (*S. robusta*) as a deciduous species [5], while others have categorized it as semi-deciduous [6]; Additionally, some have identified it as an evergreen species [7], [8], leading to various interpretations of *S. robusta* as either deciduous or as exiting on the borderline between evergreen and deciduous.

In numerous evergreen species and various deciduous types, (leaf flushing and flowering) often take place simultaneously on the same new shoot. The intense drought faced by different tree species can reliably be signified by the period of leaflessness (deciduousness), which represents a cumulative effect of seasonal drought, tree traits, and soil moisture levels [2]. During the period of seasonal drought, the leafless state in trees aids in the rehydration of the stem or twig, which is a precondition for the following flowering or leaf flushing [9], [10].

The production of litter is plays a very important role in the

dynamics of terrestrial ecosystem, particularly through nutrient circulation between plant and soil as well as moisture retention [11], [12]. The litter fall is key input of organic matter and nutrients in the soil being proportional to primary productivity in the natural sal forest, the amount of the litter fall is one of the major processes of the ecosystem and determine the type of cycling of nutrients in forest ecosystems [13].

Therefore, the litter fall may be considered as one of the most valuable decisive factor for the assessment of the changes undergone by the disturbed ecosystems. The ecology related to litter and forest floor in forest ecosystems emphasizes their role in carbon balance, nutrient cycling and soil health. It is thus essential to measure the amount of forest floor and litter fall [14], [15]. Despite extensive litter studies in tropical forest ecosystems [2], [16], [17], [18], [19], [20], [21] The Studies on litter dynamics in disturbed forests especially in reference to tree leaf falls and impact of seasonality is very limited.

The present aims of research article is to assess the impact of seasonality of leaf fall pattern and analysis total annual Sal litter production (leaves & twigs) of Sal ANR in Tarai East Forest Division Haldwani, and tried to highlight the phenological variant, reflecting, and considerable functional diversity in sal trees in the division.

MATERIALS AND METHODS

Study area

Tarai East Forest Division (TEFD) is a part of the vast Tarai Arc

Landscape (TAL) of Uttarakhand, India and comprises an area of 82,429.0 ha of Tarai and Bhabar tracts and lies between N28°.43' to N29°10' Latitude and E N79°30' to N80°10' Longitude. It has also connected with the Nandhaur Wildlife Sanctuary (NWS) and the Pilibhit Tiger Reserve (PTR) through Kilpura-Khatima-Surai corridor of tropical dry deciduous of central India. The area is home to very important wildlife species like elephants, tigers, crocodiles etc. Increasing population and dependency on forests, encroachment, overgrazing, poaching etc. are some of the challenges that threaten wildlife and its habitat. The division has covered a total of 9 ranges namely Kilpura, Khatima, Surai, Gaula, Ransali, Dauli, Barakoli, Kishanpur and Jaulasali. these ranges are highly covered with Sal Forests. This forest division is characterized by Moist Tarai and Bhabar Sal forest (3C/C2c & 3C/C2b) [22] and coving a total of 28% area of the Sal Forest of Division. In the division, the soil condition is predominantly characterized by a brown color, exhibiting an acidic to neutral reaction, and has a texture ranging from sandy loam to fine loamy.

The total annual rainfall was maximum average 1738.5 mm recorded (during the monsoon season from mid-June to September). The maximum average temperature of recorded in May – June (37.8 -39.1°C) and minimum (6.6-9.1°C) in January-February months of the division.

Selection of Study Sites

For the study, the three ANR sites, namely Kishanpur Range (Horai), Jaulasali Range (Bera) & Surai range (Jhankiya) were selected and covered Western to Eastern part of the division (Fig.1).



Photo.1. Sample Plot 5 × 5 M² for study of Sal Leaf Pattern in ANR Site of Tarai East Forest Division, Haldwani



Photo.2. Collection leaf litter from Sample plots

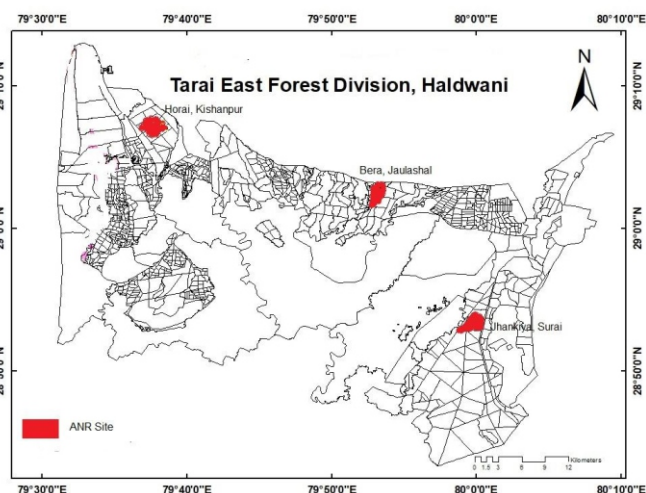


Fig.1. Location Map of Selected Site of Tarai East Forest Division, Haldwani

Methodology

Litter Collection and measurement of litter sample

The study on litter fall was conducted across various Sal-ANR locations by establishing litter plots with dimensions of 5m x 5m through ground random sampling techniques. A total of 5 (5m x 5 m) plots were laid in one hectare in each site. All plant matter and dead organic debris were thoroughly cleaned, weighed (with litter fractions recorded individually) and taken away. Litter that accumulated on the plots was gathered weekly basis on a predetermined date (January to December) over the entire year. The litter was sorted into distinct components (leaves, twigs) and weighed for each sample plot (Photo1.). In the study area, the climate is characterized by four distinct seasons viz., monsoon (June to September), winter (December to January) and summer (April to June) and spring (February to March), respectively. (Photo.1,2,3).



Photo.3: Measuring the leaf fall in Surai range, Tarai East Forest Division, Haldwani

RESULTS AND DISCUSSION

The Phenology of *Shorea robusta* (Sal)

During survey, the phenology of Sal (*Shorea robusta*) was observed as follow; the leaf fall was started from the month of January to end of April and new leaves sprout started from March to April month. The flowering take place from the month of (March to 1st May) and fruiting began in the last week of May or 1st week of June in TEFD division (Fig.2).

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Leaf Fall	**	****	*****	**								
New leaf			###	#####								
Flowering			+++	+++++	+							
Fruiting					+++	+++++						
Intensity of colour characterize the maturity of Sal leaf												
Leaf Fall Leaf Flushing (new leaf) Green Leaf Mature leaf												

Fig.2. Phenology of Sal (*Shorea robusta*) of Tarai East Forest Division, Haldwani

Total Annual Litter fall of Sal

The annual litter production (Leaf fall & twigs) was maximum ($8003.38 \text{ kg ha}^{-1} \text{ yr}^{-1}$) recorded in Surai (Jhankiya) followed by Kishanpur (Horai) $5434.52 \text{ kg ha}^{-1} \text{ yr}^{-1}$; Jaulasal (Bera) $5291.03 \text{ kg ha}^{-1} \text{ yr}^{-1}$. The contribution of leaf fall was maximum $7800.00 \text{ kg ha}^{-1} \text{ yr}^{-1}$ in recorded in Surai (Jhankiya) followed by Kishanpur (Horai) $5328.0 \text{ kg ha}^{-1} \text{ yr}^{-1}$; Jaulasal (Bera) $5228 \text{ kg ha}^{-1} \text{ yr}^{-1}$. Similarly, the contribution of twigs was maximum in Surai $203.38 \text{ kg ha}^{-1} \text{ yr}^{-1}$ and minimum in Jaulasal (Bera) 62.63 kg ha^{-1} . Table.1 & Fig.3.

Table.1 Total Annual litter fall of Sal ANR site of TEFD

Period	Kishanpur (Horai)			Surai (Jhankiya)			Jaulasal (Bera)		
	Leaf (kg/ha)	Twig (kg/ha)	Total (kg/ha)	Leaf (kg/ha)	Twig (kg/ha)	Total (kg/ha)	Leaf (kg/ha)	Twig (kg/ha)	Total (kg/ha)
Nov- Dec	-	-	-	-	-	-	-	-	-
Jan- Feb	240	1.45	241.45	292	1.74	293.74	208	1.30	209.30
Feb- Mar	840	5.88	845.88	960	6.92	966.92	760	3.8	763.8
Mar- Apr	1160	23.20	1183.20	2360	68.44	2428.44	1400	21	1421
Apr- May	2280	66.12	2346.12	3240	113.4	3353.4	2080	29	2109
May-June	720	7.06	727.06	856	10.27	866.27	704	5.84	709.84
June- July	88	2.82	90.82	92	2.612	94.612	76.4	1.68	78.08
July- Aug	-	-	-	-	-	-	-	-	-
Sep-Oct	-	-	-	-	-	-	-	-	-
Oct-Nov	-	-	-	-	-	-	-	-	-
	5328	106.52	5434.52	7800	203.38	8003.38	5228.4	62.63	5291.03

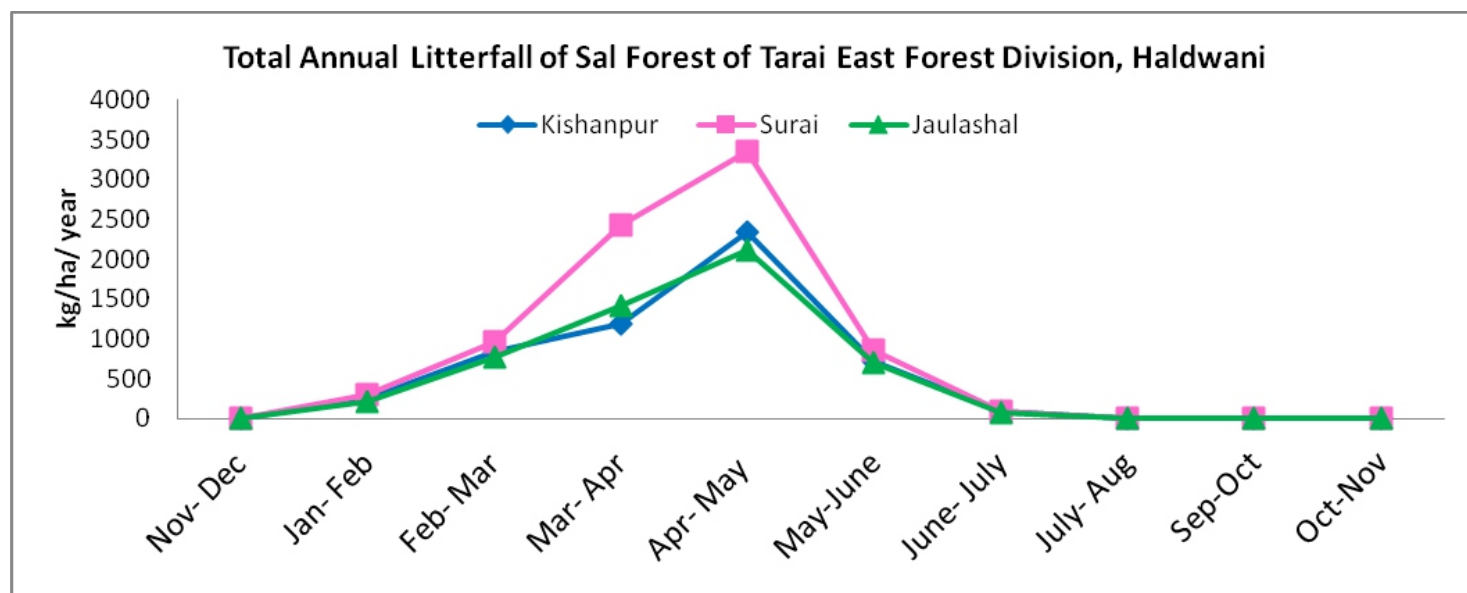


Fig.3. Total Annual Litterfall of Sal Forest of Tarai East Forest Division, Haldwani

Leaf fall of Sal and its seasonality

Sal is a summer deciduous species, which seldom remains leafless. It shows a set pattern of leaf fall synchronizing with the climatic conditions prevailing in its natural zone. Leaf fall precedes the emergence of new foliage. Leaf fall in the sites differed considerably. The annual seasonality of leaf fall was 12-16% in (1st Feb – 1st March) month, 22.0-30.0% (1st March – 1st April) month and 40.0-43.0% in (1st April- 1st May) month respectively (Fig.4).

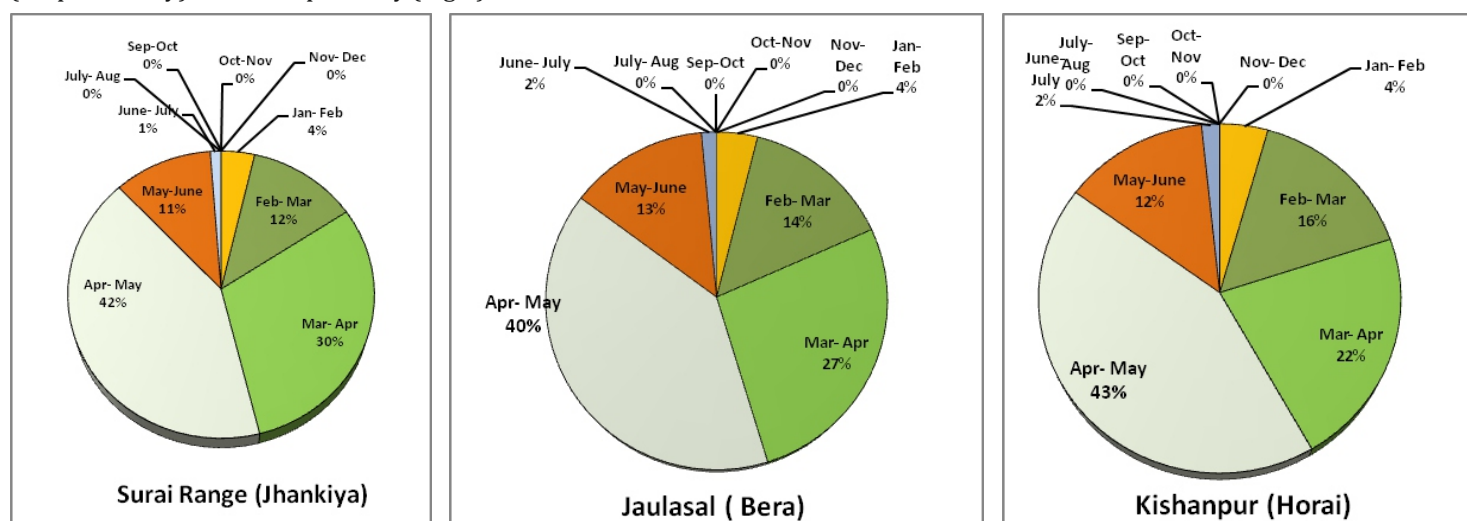


Fig.4. Monthly leaf fall percentage in Surai Range, TEFD

Leaf fall of coverage of Sal Associate species

In species level the *Shorea robusta* (86-90%) was maximum leaf fall coverage in ground followed by *Largestoenia* sp. (6.0-10.0%), *Terminalia* Sp. (2.0-6.0%); *Schleichera oleides* (0-2.0%) and *Bauhinia* sp (0-2.0%) was observed respectively.(Fig.5).

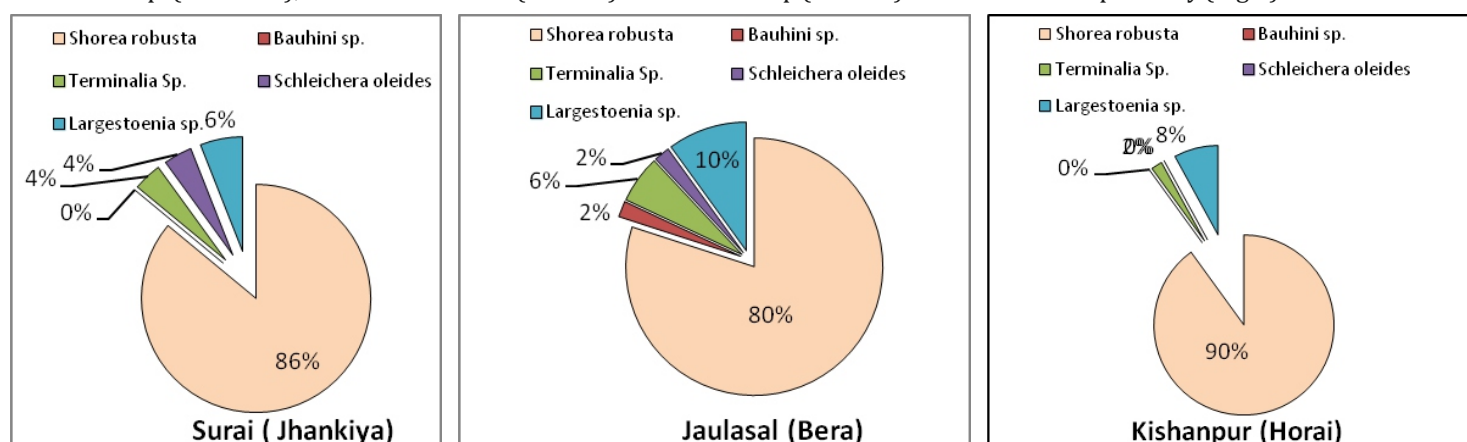


Fig.5. Leaf fall of coverage of Sal Associate species in TEFD

Temperature and Humidity trends during the climax period of leaf fall

During the climax period of the leaf fall was considerably from March to April Month. For analyzing variation of the Temperature & humidity in different sites, the weekly Temperature was collected and analyzed of these peak period. Based on the collected data the maximum Temperature was recorded 37.1°C in March-April in Surai (Jhankiya) range followed by Kishanpur (Horai) range 33.43°C, 32.26°C in Jaulasal (Bera) and minimum in respectively (Fig.7, Fig.8). Similarly in humidity was maximum recorded (63.8%) in Jaulasal (Bera) followed by (42.6%) Kishanpur, (Horai) and (37.1%) in Surai (Jhankiya). (Fig.9, Fig.10). A positive trend was showing in between the Temperature and leaf fall and negative trend was observed with humidity and leaf in the ANR sites. (Fig.6).

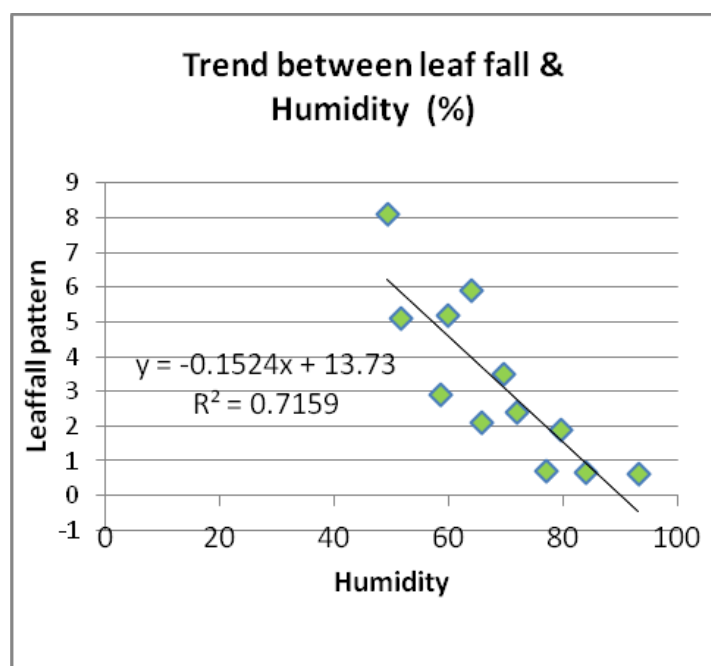
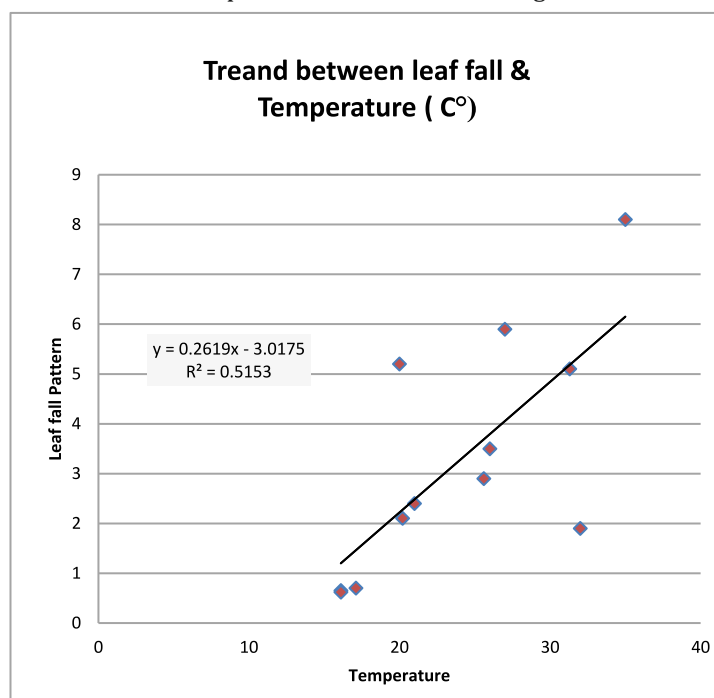


Fig.6. Trend among the leaf fall, Temperature and humidity in TEFD.

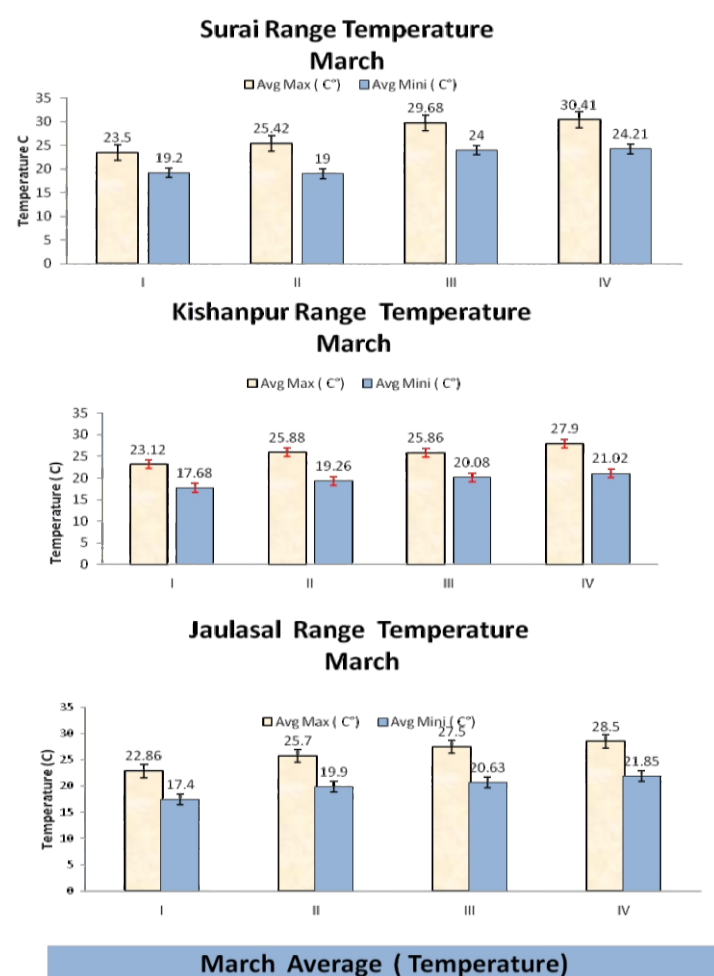


Fig.7. Weekly Average Temperature of March month of selected site

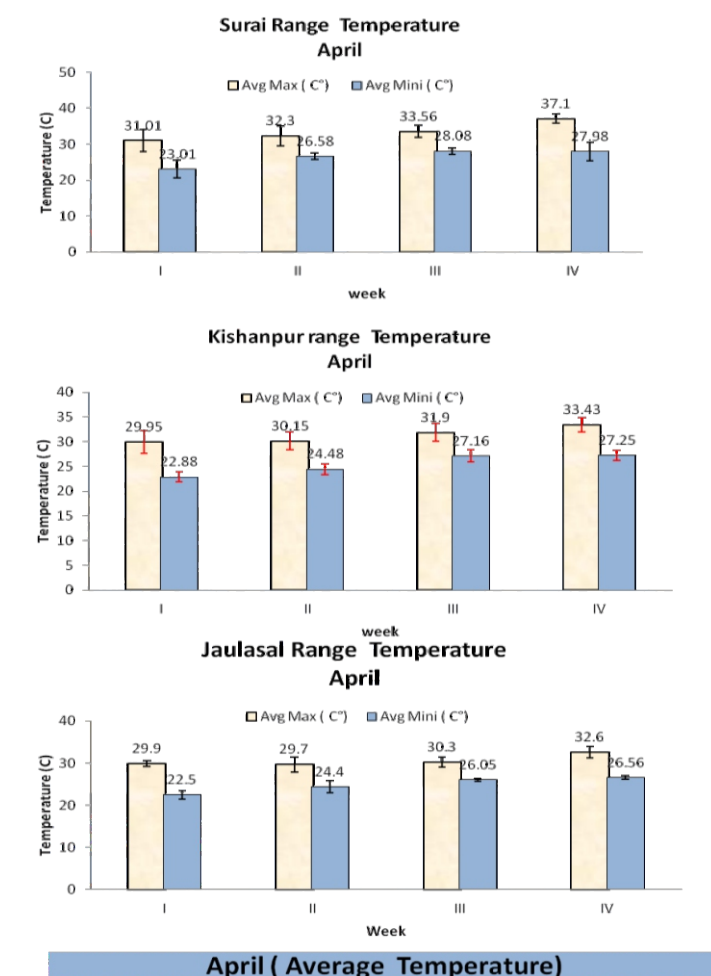


Fig.8. Weekly Average Temperature of April Month of selected site

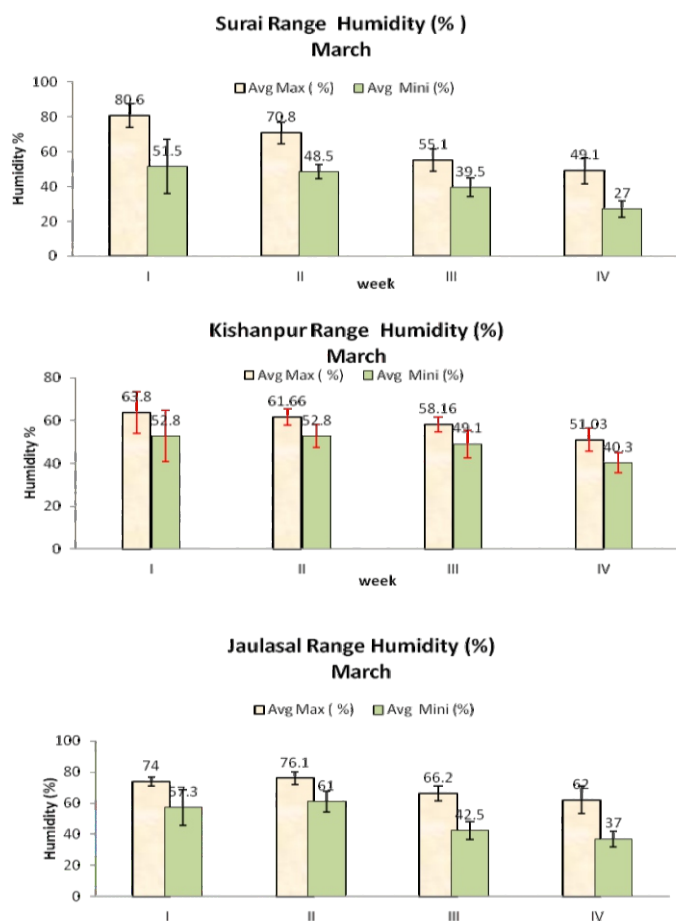


Fig.9. Weekly Average Humidity (%) of the March Month of selected site

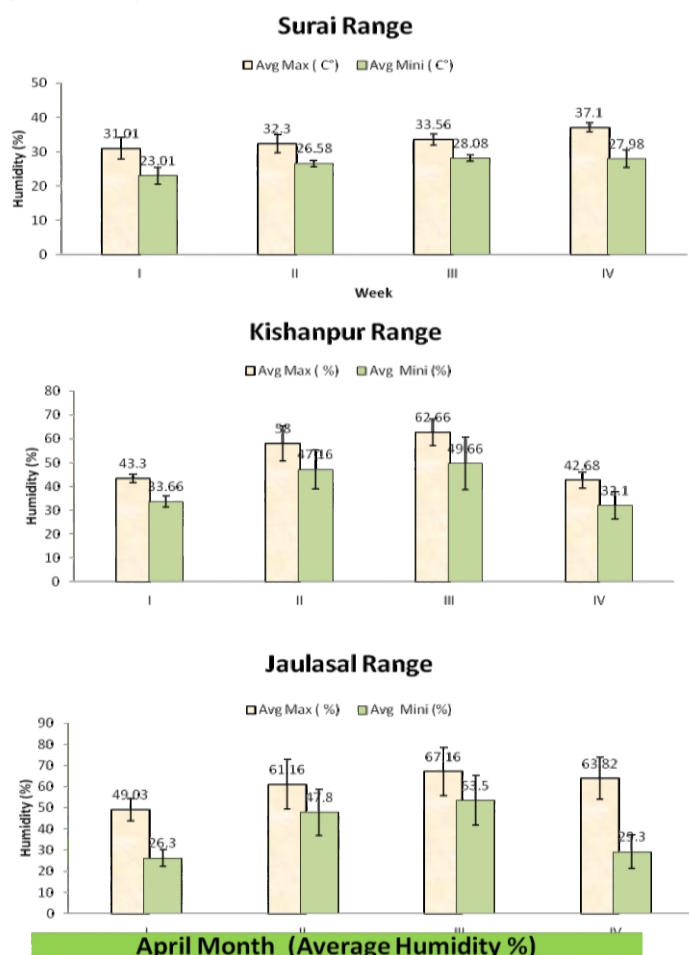


Fig.10. Weekly Average Humidity (%) of April Month of selected site

Phenological variants of *Shorea robusta* (Sal)

In contrast to the deciduous tree species that typically exhibit summer-flushing (with vegetative bud breaks occurring during the hot-dry summer months of May-June); the Sal (*Shorea robusta*) is classified as a spring-flushing species, with vegetative bud breaks occurring around the time of spring equinox, specifically in March and April, within Indian dry tropical forests [2]. The period surrounding the spring equinox is important because of the overlap of leaf fall, leaf flushing, and flowering/fruitlet in sal (*S. robusta*) [2]. The phenomenon of annual leaf exchange (ALE) in Sal (*Shorea robusta*) within tropical dry deciduous forests prompts several inquiries [2]. (i). Is this species evergreen or deciduous? (ii) Do the trees exhibit a uniform phenological response? [2]. To address these inquiries, phenological data was gathered during the periods of leaf fall and leaf flush at selected sites within the division.

In the current study, the two phenological variants of Sal (*Shorea robusta*) were notable based on their contrasting leaf phenological events observed during March and April (Photo.5. & Photo 6.). These variants were: (i). (variant a) - leaf fall completed and leaf flush begins; (ii). (variant b)- leaf fall and leaf flush overlapping. In months (March -April) in each of ANR sites has : (i) 60 % individuals of sal tree showed completion of leaf fall and beginning of leaf flush and 40% individuals showed overlapping in leaf fall and leaf flushing.

leaf flushing (New Leafing out) in Sal Forest



Photo 5. Variant (a), leaf fall completed and leaf flush begins in March-April month



Photo.6. variant (b), leaf fall and leaf flush overlapping (evergreen) in March-April month

Conclusion

The Annual leaf exchange time (leaf fall & leaf flushing) depends on the micro-climatic conditions and the accessibility of sub-soil water reserves in drought season in sal forests. The litter fall was highest (81-84%) in summer season (February- May) in the sal forest. In present study, the *Shorea robusta* shows an opportunistic leaf phenological nature, most of the individuals being able to tolerate deciduous, semi-deciduous or evergreen species. Based on the finding on phenology, it may be predicted that, the enough moisture content and temperature during the favorable growth season of *S. robusta*, *M. philippinensis*, *Largestoennia* sp., *Terminalia* Sp. The data of litter fall in different ANR site can help to assess the carbon stock of the sal forest ecosystem of the division. The data set is also suggest that few implications e.g. waterholes that needs for increasing the soil moisture and humidity particularly in dry area in Surai & Kishanpur range in nearby Sal ANR sites; few of amount of the ground litter (leaf fall) of *Shorea robusta* can be utilized for organic leaf manure and support to reduce the forest fire. The present data set will also support on developing plans related to impact of climate change in Sal forest, mitigation of forest fire, soil nutrients and micro- organisms studies in division.

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