

## **Analysis of Seasonal Variation in Spectral Properties of Tropical Forest Canopies in Madhupur Sal Forest**

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### **Abstract**

Seasonal variation in spectral properties of Madhupur Sal Forest cover canopies were investigated using multi-temporal Landsat 8 OLI data. The spectral response characteristics of 'Sal forest' and 'Rubber plantation' of the Madhupur forest region were generated from digital images of Landsat 8 OLI of different dates from September 2015 to March 2016 as a function of spectral bands representing spectral range covering visible to near infrared region of the solar spectrum. Analysis of data shows that a single date image is not adequate for the characterization of spectral behavior of 'Sal forest' and 'Rubber plantation' from the rest of the vegetation therein. The use of multi-date images particularly one in November/December and another in February/March can provide the reasonable accuracy in classification and interpretation. Thus it has been observed that the month of November/December and another in February/March are optimum time for satellite data acquisition for 'Sal forest' study in 'Madhupur Sal Forest' region.

**Key words:** *'Madhupur Sal forest', Landsat8 OLI, Spectral behavior, Data Acquisition time.*

### **1.0 Introduction**

The characterization of forest phenological properties of tropical forest canopies is important for better understanding of earth-atmosphere-climate interactions or biogeochemical cycles [1]. The net exchange of carbon between plant and atmosphere is also important and the net exchange is directly related to phenological behavior of plant which is generally understood as shedding and new flushing of leaves particularly for the deciduous species over the season. Satellite remote sensing can be effectively utilized for large-scale monitoring of leaf phenology though the seasonal dynamics of forest canopy reflectance is not only influenced by the presence of leaf on a unit area but the radiometric variation is also depends on the canopy structure, relative leaf area, leaf age and physiological status [2]. These variations may also be influenced by seasonal changes in the atmosphere, such as aerosol concentrations [3], or uncorrected Bidirectional Reflectance Distribution Function (BDRF) effects, such as the seasonal variation in sun height [1]. Several studies have been carried out in the boreal, temperate and tropical forest regions to understand the seasonal behavior of reflectance pattern of forest canopies. Spring phenology of temperate deciduous and evergreen forest has been investigated with low-cost spectral sensors for Gwangneung Experimental Forest, Korea [4]. Leaf phenology of seasonally moist tropical forests in South America was analyzed with

multi-temporal MODIS images [5]. Quantification of deciduousness was conducted in West-Central African forests with MODIS, SPOT-5 and GeoEye data [1]. Characterization of seasonal variation of forest canopy in a temperate deciduous broadleaf forest was done in White Mountain National Forest in north central New Hampshire, USA using daily MODIS data [6]. Seasonal changes in leaf area index were analyzed for a boreal forest site in central Finland using MODIS vegetation products [7]. Seasonal changes in understory reflectance properties of Canadian boreal forests and its influence on canopy vegetation indices was analyzed [8]. The study related to seasonal behavior of Sal forest canopy is typically missing. Remote sensing technology has been successfully employed in various studies like forest inventory, monitoring of forest cover changes, forest damage assessment etc.

Therefore the present study has been undertaken to investigate the seasonal behavior of Sal forest canopy in Madhupur Sal forest. A combined remote sensing and GIS approach has been adopted for the present study.

## 2.0 Objective

The objective of this study is to analyze the seasonal variation in spectral properties of forest cover canopies.

## 3.0 Study area

The study area is located in Madhupur Sal forest region that is situated in Tangail and Mymensingh district. Figure 1 shows the study area. The area extends from N 24° 32' 44" to N 24° 44' 42.7" and E 89° 59' 49.5" to E 90° 10' 34.6" and is about 120 km away from the capital city of Dhaka. Relatively high land in one part and lowland areas in adjacent part characterize landscape of the area. The area is fragmented into small patches and intermingled with the neighboring settlements. The forest of the study area is classified as tropical moist deciduous forest [9]. Sal (*Shorea robusta*) is the main species in the natural forest. The climate of this area is tropical. The average rainfall of this is about 205 cm. Average temperature gradually rises from February and reaches to its maximum in April (around 35° C). In January minimum temperature is recorded 15° C.

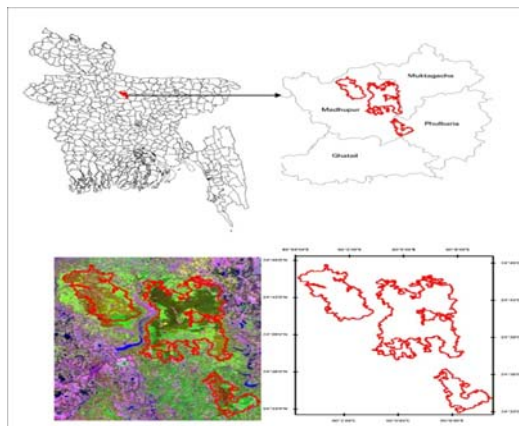


Figure 1: Location map of the study area.

The presence of other species like Koroi (*Albizzia procera*), Azuli (*Dillenia pentagyna*), Sonalu (*Cassia fistula*), Bohera (*Terminalia belerica*), Haritaki (*Terminalia chebula*), Kanchan (*Bauhinia acuminata*), Jarul (*Lagerstroemia speciosa*), Jam (*Syzygium spp*) etc. is also noticed.

#### 4. Data used

Various types of data have been used for the present study. Table 1 provides a list of the satellite data that have been used for the present study.

Table 1: List of satellite data used for the study

Satellite/Sensor	Acquisition Dates
Landsat 8 OLI	26 September, 17 October, 22 November and 30 December, 2015.
	15 January, 16 February and 3 March, 2016.

Besides these, historical maps and *insitu* data of this area have also been used. Field photographs acquired by digital camera have also been used.

#### 5. Methodology

Cloud-free Landsat 8 OLI data over the dry period (September-March) have been downloaded from United States Geological Survey (USGS) website. Extraction of different bands data has been done and then layer stacking of has been conducted for making the multi bands images.

Landsat 8 OLI observation of Madhupur Sal Forest and its adjacent areas Band 6, 5 and 4 (R, G, B) in 26 September, 17 October, 22 November, 30 December, 2015, have been shown in Figure 2, 3, 4 and 5 respectively.

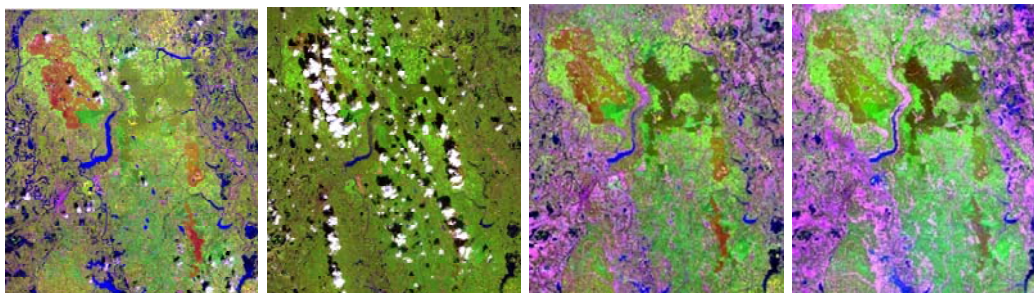


Figure: 2

Figure: 3

Figure: 4

Figure: 5

Figure 2, 3, 4 & 5: Landsat 8 OLI observation of Madhupur Sal Forest and its adjacent areas Band 6, 5 and 4 (R, G, B) respectively in 26 September, 17 October, 12 November and 30 December 2015.

Landsat 8 OLI observation of Madhupur Sal Forest and its adjacent areas Band 6, 5 and 4 (R, G, B) in 15 January, 16 February and 3 March 2016 have been shown in Figure 6, 7 and 8 respectively.

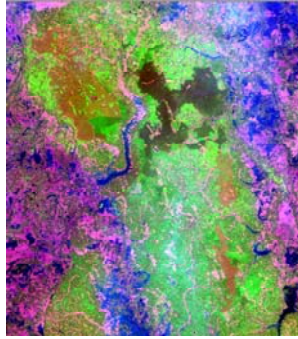


Figure: 6

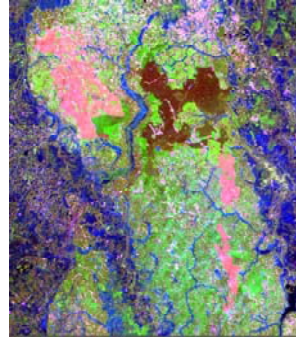


Figure: 7

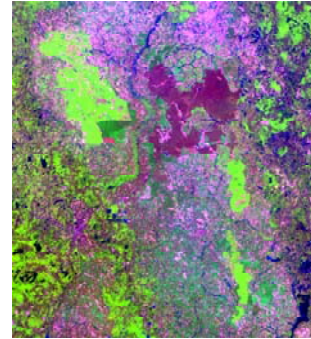


Figure: 8

Figure 6, 7 and 8: Landsat 8 OLI observation of Madhupur Sal Forest and its adjacent areas Band 6, 5 and 4 (R, G, B) respectively in 15 January, 16 February and 3 March, 2016.

Spectral response pattern of forest canopies in the study area have been analyzed throughout the dry season (September to March). Field verification has also been conducted in several times to relate with the forest canopy reflectance with the ground vegetation coverage throughout the study period. Figure 9 shows the whole methodology of the research. Ground photographs of forest canopies will be collected for different seasons.

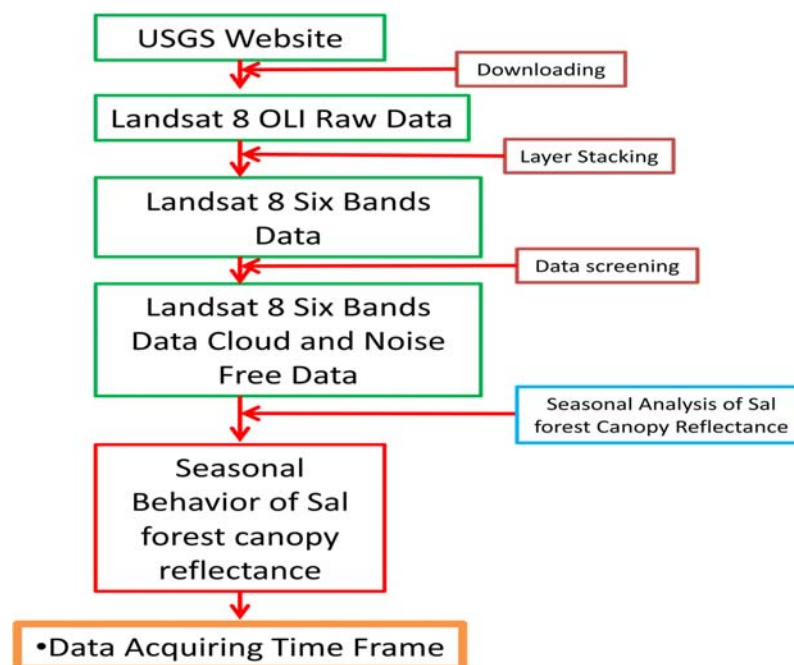


Figure 9: Shows the methodology of the study



## 6. Result and discussion

The seasonal variation in spectral properties of ‘Sal forest’ and also the ‘Rubber plantation’ have been analysed and the results and discussions are given below sub-sections.

### 6.1 Seasonal variation in spectral properties of ‘Sal forest’

‘Sal forest’ in Madhupur area is a deciduous forest and the dominating species is the Sal (*Shorea robusta*). The spectral response characteristics of ‘Sal forest’ of the Madhupur forest located at 90° 05' 01.35" E 24° 42' 30.81" N and generated from digital images of Landsat 8 OLI of different dates (September 2015 to March 2016) as a function of spectral bands representing spectral range covering visible to near infrared region of the solar spectrum has been shown in figure 10 to 15 and summarized in figure 16.

A significant variation in spectral response on different dates has been observed. The observed variability in spectral response between different dates during the study period is due to the variation in absorption and scattering level by the growth stages, vegetation density and the background soil of ‘Sal forest’. In such processes, phenological changes in the vegetation and moisture content in soil layer adds a time varying component to their spectral responses.

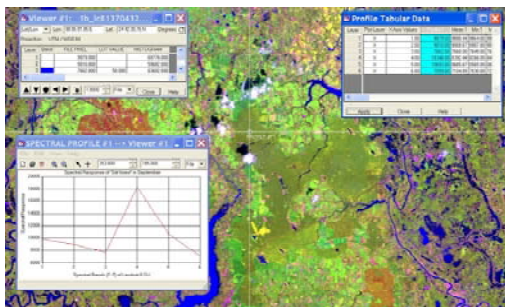


Figure 10:

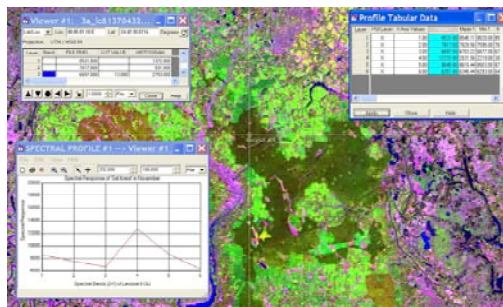


Figure 11:

Figure 10 & 11: Spectral profile analysis of ‘Sal forest’ in the month of September and November, 2015.

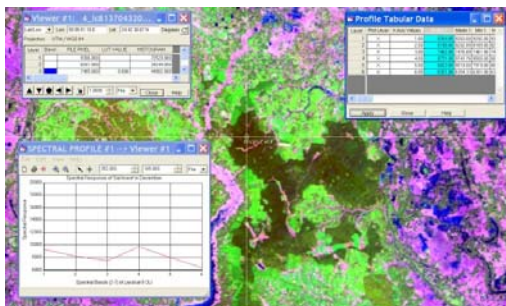


Figure 12:

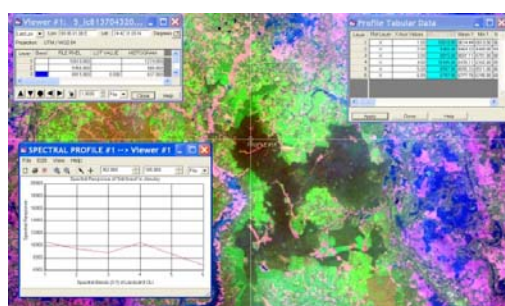


Figure 13:

Figure 12 & 13: Spectral profile analysis of ‘Sal forest’ in the month of December, 2015 and January, 2016.

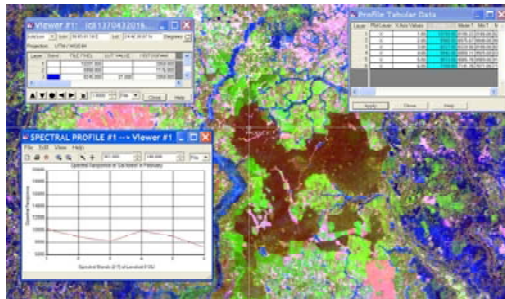


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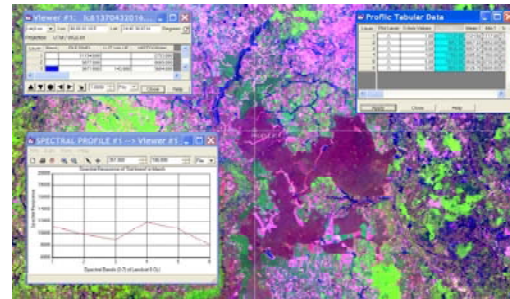


Figure 15:

Figure 14 & 15: Spectral profile analysis of 'Sal forest' in the month of February and March, 2016.

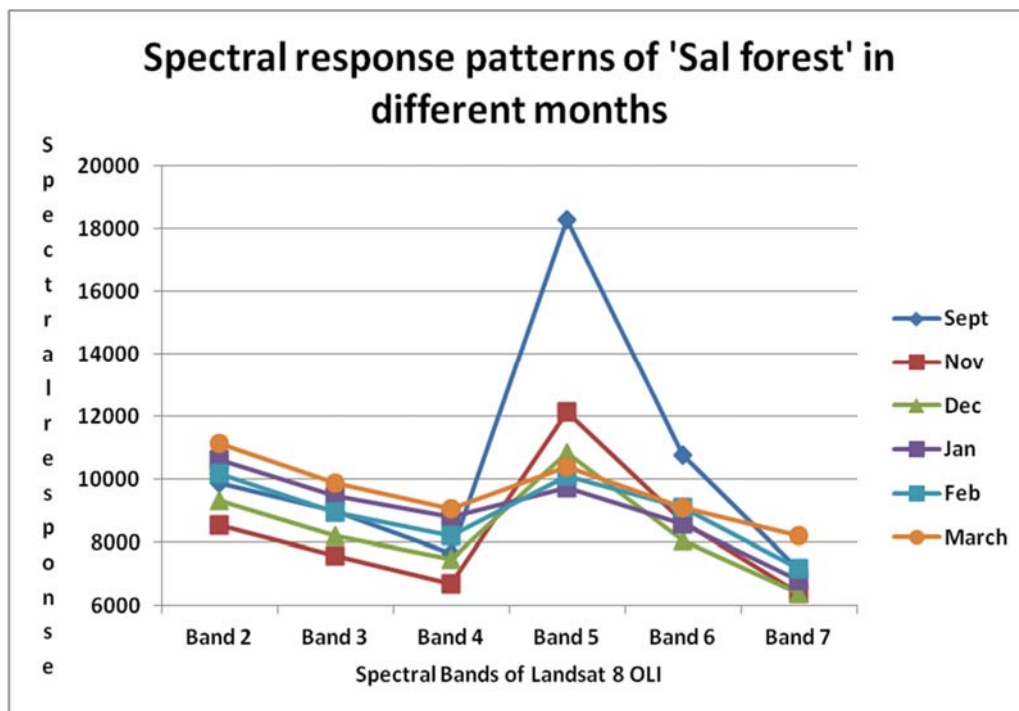


Figure 16: Spectral profile analysis of 'Sal forest' during the month of September 2015 to March 2016.

Spectral response shows relatively lower values in bands 2 (blue band), 3 (green band) and 4 (red band), which are situated in the visible region (0.45 to 0.67) of the solar spectrum. Green vegetation absorbs a significant portion of incoming solar radiation in the photosynthetic region for maintaining its photosynthetic activities. Greater is the chlorophyll content in the leaf element higher is the absorption due to photosynthetic activity and lower is the reflectance of the surface.

On the other hand, the leaf and stems of ‘Sal forest’ trees as well as the relatively dry soil background cause higher scattering of the incident solar radiation in the near infrared region (NIR) corresponding to band 5 (0.85-0.88) of Landsat 8 OLI and as such the observed spectral response over the ‘Sal forest’ canopy is high in the near infrared region. This spectral response values in NIR band goes down from September and goes up to January as the senescence progress. Then in February to March it goes little bit higher than January (but less than December) as the leaf fall starts in February. This is due to relatively dry leaf and stems of ‘Sal forest’ and also the comparatively dry soil background (Figure 16). This change in colour is because ‘Sal forest’ is a deciduous forest and during early April, the tree becomes almost leafless. Leaf fall usually starts in late winter (February) and is completed by the end of April [10-11]

## 6.2 Seasonal variation in spectral properties of ‘Rubber plantation’

‘Rubber plantation’ in Madhupur area is a deciduous forest and the dominating species is the *Hevea brasiliensis*. The spectral response characteristics of ‘Rubber plantation’ of the Madhupur forest located at 90° 00' 31.01" E 24° 44' 13.99" N and generated from digital images of Landsat 8 OLI of different dates (September 2015 to March 2016) as a function of spectral bands representing spectral range covering visible to near infrared region of the solar spectrum has been shown in figure 17 to 22 and summarized in figure 23.

A significant variation in spectral response on different dates has been observed. The observed variability in spectral response between different dates during the study period is due to the variation in absorption and scattering level by the growth stages, vegetation density and the background soil of ‘Rubber plantation’. In such processes, phenological changes in the vegetation and moisture content in soil layer adds a time varying component to their spectral responses.

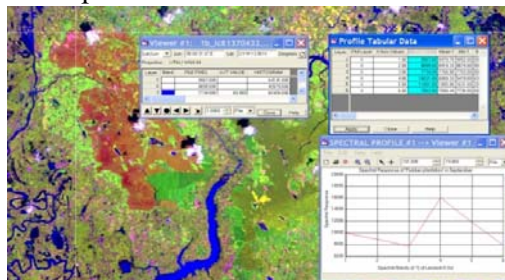


Figure 17:

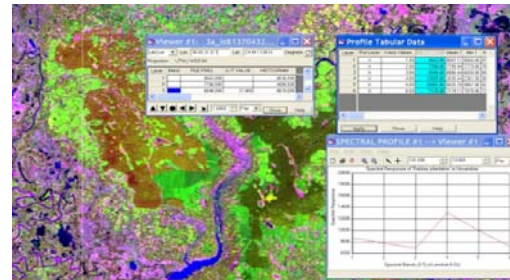


Figure 18:

Figure 17 & 18: Spectral profile analysis of ‘Rubber plantation’ in the month of September and November, 2015.





Figure 19:

Figure 20:

Figure 19 & 20: Spectral profile analysis of 'Rubber plantation' in the month of December, 2015 and January, 2016.

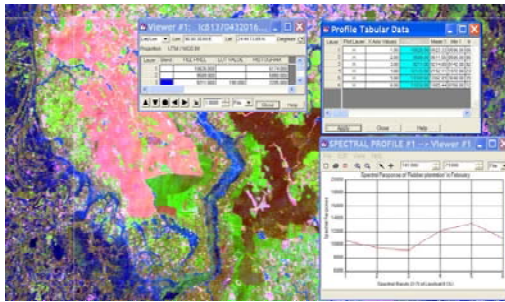


Figure 21:

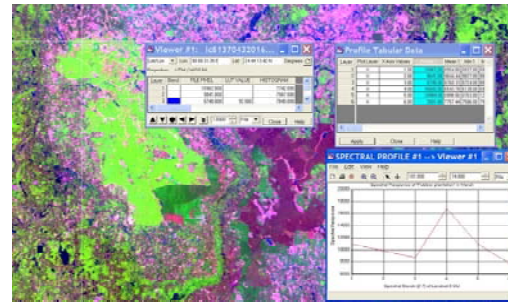


Figure 22:

Figure 21 & 22: Spectral profile analysis of 'Rubber plantation' in the month of February and March, 2016.

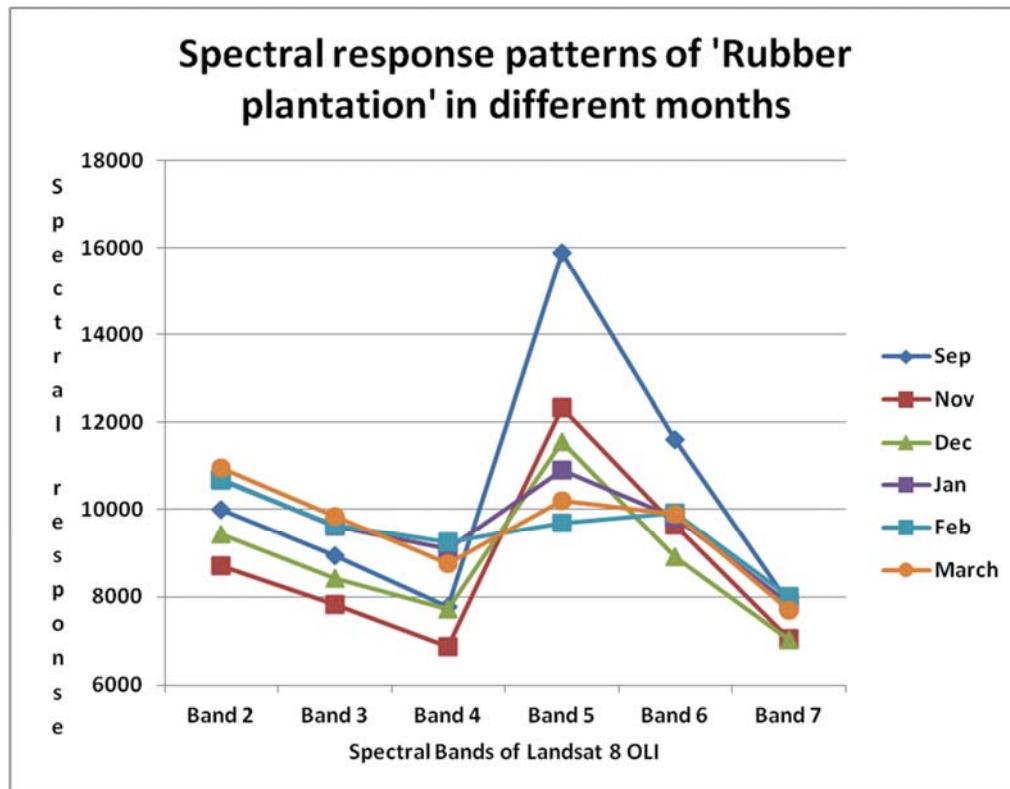


Figure 23: Spectral profile analysis of 'Rubber plantation' during the month of September 2015 to March 2016.



Spectral response shows relatively lower values in bands 2 (blue band), 3 (green band) and 4 (red band), which are situated in the visible region (0.45 to 0.67) of the solar spectrum. Green vegetation absorbs a significant portion of incoming solar radiation in the photosynthetic region for maintaining its photosynthetic activities. Greater is the chlorophyll content in the leaf element higher is the absorption due to photosynthetic activity and lower is the reflectance of the surface.

On the other hand, the leaf and stems of 'Rubber plantation' trees as well as the relatively dry soil background cause higher scattering of the incident solar radiation in the near infrared region (NIR) corresponding to band 5 (0.85-0.88) of Landsat 8 OLI and as such the observed spectral response over the 'Rubber plantation' canopy is high in the near infrared region. This spectral response values in NIR band goes down from September and goes down to December as the senescence progress. Then in January to February it goes further down as the leaf fall ended in February and again the young buds If leaves started to come up after the first shower of the March and the plantation become green again within April of the year (Figure 23). The situation is well demonstrated in the spectral response characteristics in April where the vegetation nature of the rubber plant canopy is restored.

Rubber plants are deciduous by nature. The deciduous action generally occurs around January-February and as such the area appeared to be in dark maroon colour to light pink during that time. Rubber plantations shade their leaves successively from January to February of the years. As a result spectral response characteristics corresponding rubber plantation shows some specialty in the nature which occurs around February and the vegetation properties is not reflected in its spectral response as the plant contains almost no green biomass.

## 7. Conclusion

Analysis of data shows that a single date image is not adequate for the characterization of spectral behavior of 'Sal forest' and 'Rubber plantation' from the rest of the vegetation therein. However, the use of multi-date images particularly one in November/December and another in February/March can provide the reasonable accuracy in classification and interpretation.

It has been observed that the month of November/December and another in February/March are optimum time for satellite data acquisition for 'Sal forest' study in 'Madhupur Sal Forest' region.

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