DISEASE DETECTION FROM FIELD SPECTROMETER DATA

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ABSTRACT: Oil palm plants have been planted in a large scale of areas. However, Ganoderma disease has been recognized and diagnosed in the oil palm plants that has infected almost a half of the oil palm plants in Malaysia. To deal with this problem, the use of vegetation indices analysis on hyper spectral field data, this paper examines the ability of spectral data in identifying the stages of Ganoderma disease. The favourable result will be helpful to control the spreading of the diseases. By using vegetation indices, the oil palm plants could be classified into three categories, namely: 1 (T1 healthy), 2 (T2 semi healthy) and 3 (T3 severe damage). The results show that the best vegetation index is the Modified Red Edge Simple Ratio (MSR705) among the vegetation indices to identify the oil palm health stages. Moreover, it has been observed that the index of Narrowband greenness VIs has been exhibited an acceptable outcome in differentiating between the oil palm plant stage 1 (T1 healthy) and stage 2 (T2 semi healthy).

ABSTRAK: Tanaman kelapa sawit ditanam secara meluas. Penyakit ganoderma dikenali dan didiagnosikan menjangkiti hampir separuh tanaman kelapa sawit di Malaysia. Untuk mengawal penyakit ini daripada merebak, analisis indeks tanaman dijalankan ke atas data kawasan spektrum melampau di mana keupayaan data ini diuji dalam membezakan peringkat-peringkat penyakit Ganoderma terhadap tanaman kelapa sawit. Dengan menggunakan indeks tanaman, kelapa sawit dapat diklasifikasikan kepada 1 (T1 sihat), 2 (T2 separa sihat) dan 3 (T3 rosak); kelas tanaman dengan tepat. Keputusan menunjukkan indeks tanaman terbaik sebagai *Modified Red Edge Simple Ratio* (MSR_{705}) yang merupakan indeks tanaman dalam membezakan peringkat kesihatan kelapa sawit. Adalah didapati pengubahsuaian terhadap indeks *Modified Red Edge Simple Ratio* (MSR_{705}) yang juga indeks Jalur Sempit Hijau VI telah memberikan keputusan yang munasabah dalam membezakan peringkat tanaman kelapa sawit peringkat 1 (T1 sihat) dan peringkat 2 (T2 separa sihat).

KEYWORDS: *Oil palm; Vegetation indices; Spectrometer; MSR; Ganoderma.*

1. INTRODUCTION

Approximately, 70 percent of the Earth's land surface is covered with vegetation [1]. Furthermore, vegetation provides a basic foundation for all living beings and it is one of the most important components of the ecosystem [1, 2].

Dealing with disease problem in oil palm plantation involves a variety of curative measures in which disease detection and mapping play a central role. Hyperspectral remote sensing data offer a better chance of disease detection [3]. Vegetation indices are widely used for the estimation of crop and vegetation variables by using visible and Near Infrared Regions (NIR) of the electromagnetic spectrum. Healthy plant typically displays very low reflectance and transmittance in visible region and very high reflectance and transmittance in NIR [3]. Sixteen vegetation indices and four modifications were tested on hyper spectral field data. Thus the presence of stresses in oil palm trees will be associated with the chlorophyll absorption in reflectance and the normalized pigment chlorophyll vegetation indexes which will be showing a loss of chlorophyll pigment compared to healthy oil palm plants [3].

Basal stem rot in oil palm is caused by *Ganoderma boninense* and it is the most severe fungal disease of oil palm in Malaysia. It has the ability to infect oil palms from as young as 12-24 months [4] to over 24 years after field planting [5]. High incidences of this disease have been reported in oil palms planted on coastal soil and peat [6-8]. The incidence of Ganoderma inland soils was relatively low and confined to waterlogged area [6].

Ganoderma is a white rot fungus. The organism causes economic loss of oil palm (OP) in various regions around the world including Southeast Asia [9], where the current author has had considerable experience of the crop disease. The basic premise of this review is that it is important for the control of *Ganoderma* disease to consider it specifically as a white rot fungus. This can be integrated with other approaches [10, 11]. The term white-rot is derived from the fungus degrading specifically the lignin component of wood while leaving white cellulose exposed. Typically the fungus may attack already weakened oil palm plants as *Ganoderma* seldom seriously infects undamaged trees. A classic example is *Ganoderma adspersum*, which causes [12].

2. MATERIALS AND METHODS

The data that have been used in this study is taken by the APOGEE spectroradiometer (300 - 1000 nm) with spectral resolution of 0.5 nm. These data were offered from nursery managed by Malaysian Palm Oil Board (MPOB), Bangi on November 2007. The measurement taken from 1 healthy and 2 unhealthy oil palms leaves, and classified as T1 (Healthy), T2 (Light Symptom) and T3 (Severe Symptom). Each wavelength in the data has 24 samples. Sixteen vegetation indices were applied for 24 samples at three stages to extract the results of vegetation indices to know if the results are within the green vegetation range or not and also to find out which index can exhibit the best way to differentiate between the oil palm disease stages. Figure 1 shows the overall flow of the steps that had been implemented in this study [6, 8, 12].

2.1 Determine the Best Vegetation

Vegetation Indices (VIs) are combinations of surface reflectance at two or more wavelengths designed to highlight a particular property of vegetation [13, 14]. They are derived using the reflectance properties of vegetation described in Plant Foliage. Each of the VIs is designed to accentuate a particular vegetation property. Sixteen equations were applied for 24 samples at three stages to extract the results of vegetation indices to know if the results are within the green vegetation range or not and also to find out generally, this study is comprised of two important parts. The first determined the best vegetation index

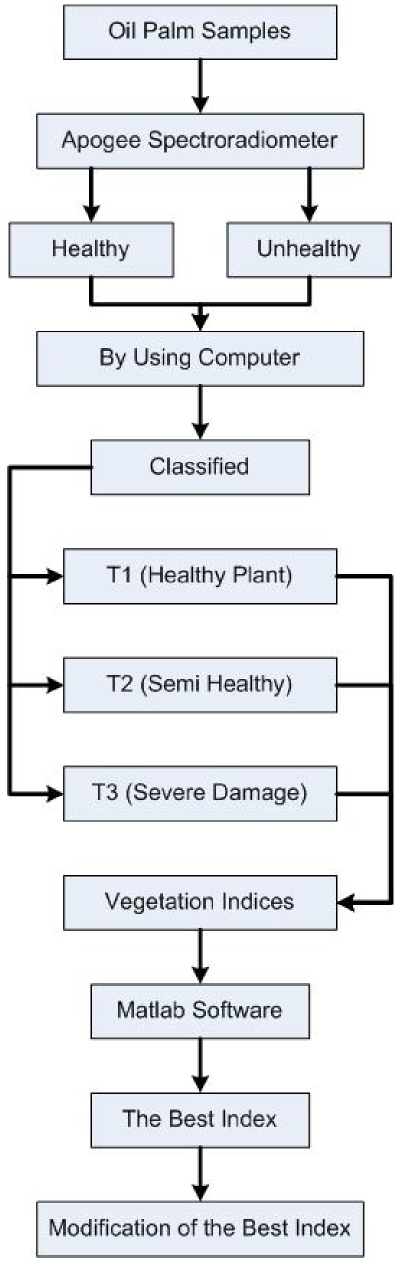

Fig. 1: Flowchart of methodology.

and the second was modified the best vegetation index [15, 11, 16]. The Matlab software package ver.6.5 was used to determine the results of the vegetation indices Broadband Greenness (4 indices) [12, 17, 14, 15]:

$$NDVI = \frac{P_{NTR} - P_{RED}}{P_{NTR} + P_{RED}} \quad (1)$$

$$SR = \frac{P_{NTR}}{P_{RED}} \quad (2)$$

$$EVI = 2.5\left(\frac{P_{NTR} - P_{RED}}{P_{NTR} + 6P_{RED} - 7.5_{BLUB} + 1}\right) \tag{3}$$

$$ARVI = \frac{P_{NTR} - (2P_{RED} - P_{BLUB})}{P_{NTR} + (2P_{RED} - P_{BLUB})} \tag{4}$$

which index can exhibit the best way to differentiate between the oil palm disease stages. The indices are grouped into categories that calculate similar properties. The categories and indices are Narrowband Greenness (6 indices) [10, 16, 18]:

$$NDVI_{705} = \frac{P_{750} - P_{705}}{P_{750R} + P_{705}} \tag{5}$$

$$mSR_{705} = \frac{P_{750} - P_{460}}{P_{705} + P_{460}} \tag{6}$$

$$mNDVI_{705} = \frac{P_{750} - P_{705}}{P_{705} + P_{705} - 2P_{460}} \tag{7}$$

$$VOG1 = \frac{P_{740}}{P_{720}} \tag{8}$$

$$VOG2 = \frac{P_{740} - P_{747}}{P_{715} + P_{726}} \tag{9}$$

$$VOG3 = \frac{P_{734} - P_{747}}{P_{715} + P_{720}} \tag{10}$$

Light Use Efficiency (2 indices) [19-21]:

$$Modification4 = \frac{P_{910} - P_{460}}{P_{553} + P_{460}} \tag{11}$$

$$SIPI = \frac{P_{800} - P_{460}}{P_{800} + P_{680}} \tag{12}$$

Leaf Pigments (4 indices) [22, 23]:

$$CRI1 = \left(\frac{1}{P_{510}}\right) - \left(\frac{1}{P_{550}}\right) \tag{13}$$

$$CRI2 = \left(\frac{1}{P_{510}}\right) - \left(\frac{1}{P_{100}}\right) \tag{14}$$

$$ARI1 = \left(\frac{1}{P_{550}}\right) - \left(\frac{1}{P_{100}}\right) \tag{15}$$

$$ARI2 = p_{800}\left[\left(\frac{1}{P_{550}}\right) - \left(\frac{1}{P_{100}}\right)\right] \tag{16}$$

The Broadband Greenness equations represent the surface reflectance in an image band with a center wavelength as follows: P_{NIR} = 800 nm, P_{RED} = 680 nm and P_{BLUE} = 450 nm.

2.2 Modified Best Vegetation Index

The best vegetation index can only differentiate between T1 (healthy plant) and T3 (severe damage) and cannot differentiate between T1 (healthy plant) and T2 (semi healthy). So to make this index able to differentiate between T1 (healthy plant) and T2 (semi healthy) a modification on this index is needed. Using the default best index to differentiate between T1 (healthy plant) and T2 (semi healthy) is not detectable and it is difficult to specify the right stage for the plant. By randomly selecting a different wavelengths and substituting in the default best index, it can be shown that a four modified best indices can be obtained. These four indices can differentiate clearly between T1 (healthy plant) and T2 (semi healthy) that's mean that simply we can distinguish between the plant stages. The four obtained modified best indices are [23]:

$$Modification1 = \frac{P_{910} - P_{460}}{P_{690} + P_{460}} \tag{17}$$

$$Modification2 = \frac{P_{738} - P_{460}}{P_{554} + P_{460}} \tag{18}$$

$$Modification3 = \frac{P_{910} - P_{460}}{P_{554} + P_{460}} \tag{19}$$

$$Modification4 = \frac{P_{910} - P_{460}}{P_{553} + P_{460}} \tag{20}$$

3. RESULTS AND DISCUSSION

The Modified Red Edge Simple Ratio (MSR_{705}) index provides the best result than the other indices. The Modified Red Edge Simple Ratio (mSR_{705}) index results and the average of each stage of this index are obtained for 24-samples. Table 1 contains the obtained results of (MSR_{705}).

Figures 2, 3 and 4 show the (MSR_{705}) index range of each stage. Figures 5 and 6 show the graphs of (MSR_{705}) range of the three stages with the 24-samples and their averages. The common range for green vegetation is 2 to 8.

Table 1: Results of (MSR_{705}) index for the 24 samples and their average at each stage.

MSR_{705}		
T1	**T2**	**T3**
1.9289	1.9542	1.6241
2.2812	2.1408	2.0042
1.8115	1.8775	2.1952
1.8115	1.9241	2.3484
1.8115	2.3953	2.132
2.333	2.3014	2.1979
1.9777	2.3463	1.7486
2.1524	2.0096	1.8433
1.964	2.0096	1.4375
1.8322	1.9871	1.9948
2.0387	2.0841	1.9395
2.4495	2.0074	2.1526
2.4867	2.1664	1.6989
2.0708	1.9931	1.611
1.8841	1.8922	1.6973
1.9262	2.0325	1.5515
2.3315	1.9102	1.5636
1.9963	1.9185	1.5636
1.9963	1.8371	1.8672
2.1426	2.1424	1.6576
2.1426	2.1137	1.5725
2.1426	1.9396	1.8166
2.1279	2.1267	1.7602
1.6596	1.772	1.6241
Average	**Average**	**Average**
2.0541	2.0367	1.8168

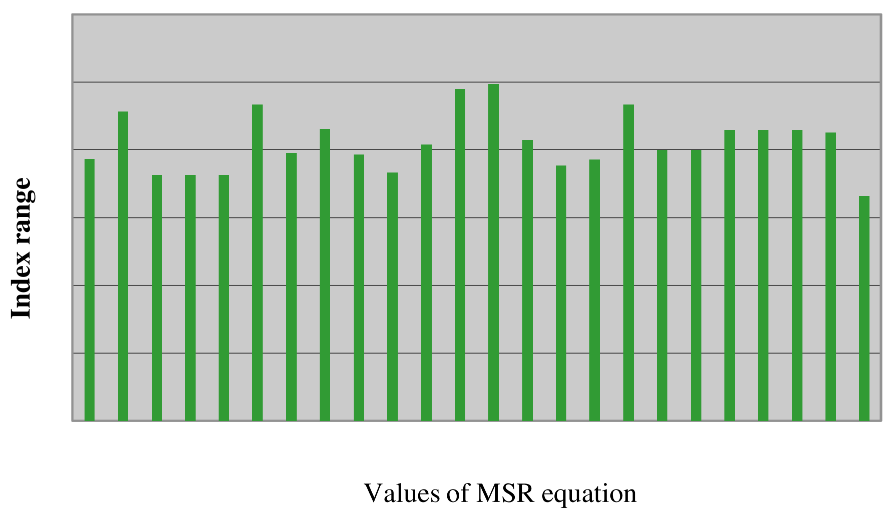

Fig. 2: The (MSR_{705}) index results of T1.

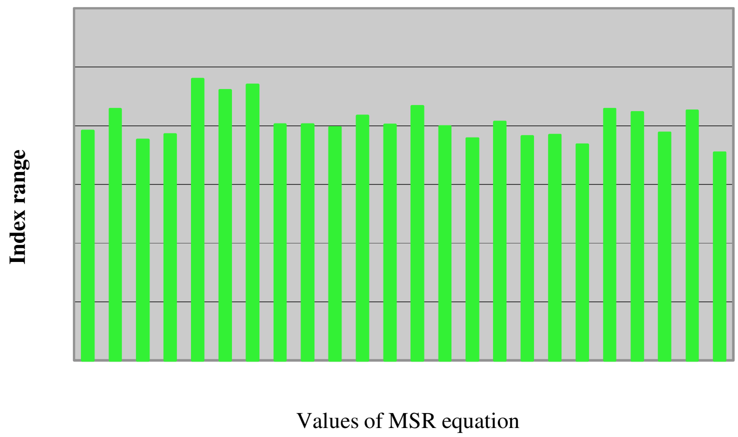

Fig. 3: The (MSR_{705}) index results of T2.

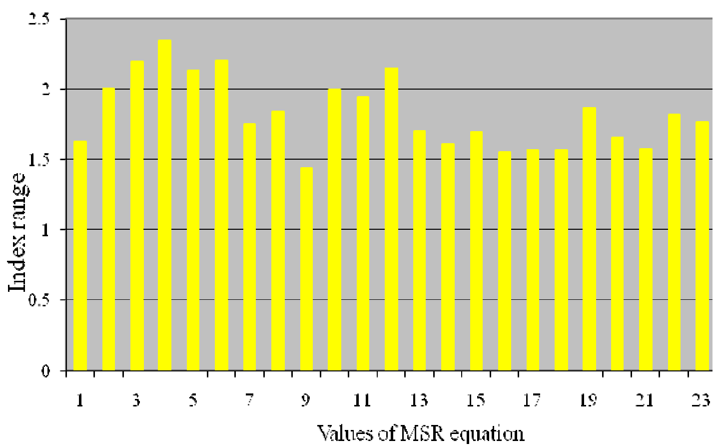

Fig. 4: The (MSR_{705}) index results of T3.

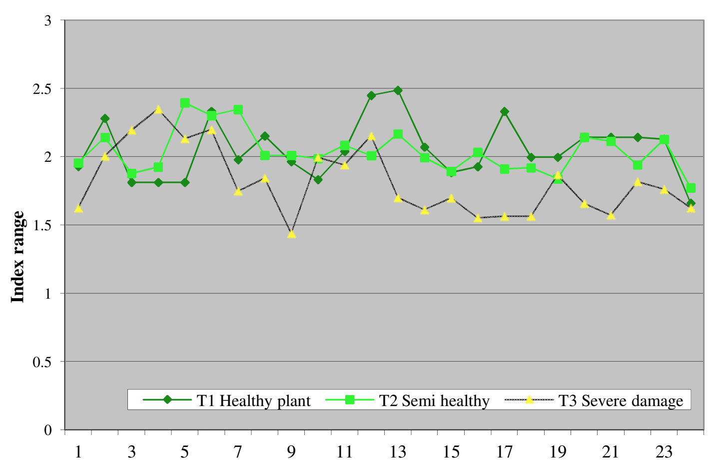

Fig. 5: The (MSR_{705}) index results of 24 samples of T1, T2 and T3.

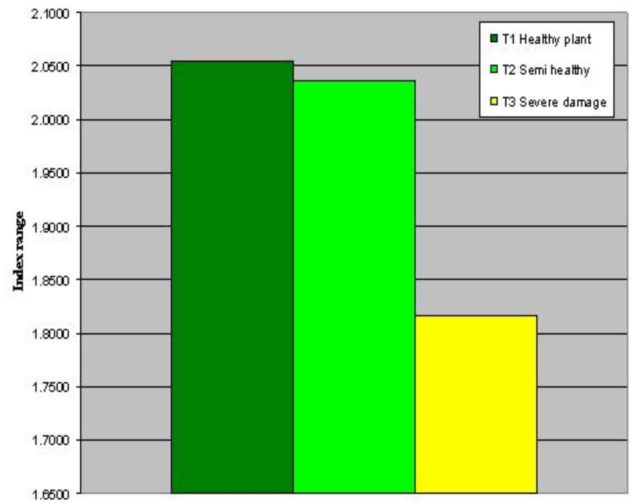

Fig. 6: The average of 24 results of the (MSR_{705}) index of T1, T2 and T3.

By using the Jeffries-Matusita (JM) Distance method, it has been found that the MSR_{705} index is the best index to differentiate between T1 (healthy plant) and T3 (Severe damage), by providing the maximum distance 0.9900167 and the percentage 70.015 % between T1 and T3 shown in Table 2. By using the Jeffries-Matusita (JM) Distance method, it has been found that the Modification 1 index is the best index to differentiate between T1 (healthy plant) and T2 (Semi healthy), by providing the maximum distance and the highest percentage which was 70.715 % from among the four modification indices shown in Table 3.

Table 2: The Jeffries-Matusita (JM) Distance calculation for MSR_{705}.

	T1	**T3**
Sun	49.2993	43.6022
Average	2.0541375	1.816758333
aVT1-aVT3	0.237379167	
Sum(T1+T2)	92.9015	
DJM	0.990167233	
%	70.015	

Table 3: The Jeffries-Matusita (JM) Distance calculation of all modification indices.

	Modification 1		**Modification 2**		**Modification 3**		**Modification 4**	
	T1	T2	T1	T2	T1	T2	T1	T2
Sum	123.2413	119.8307	123.0741	120.4596	121.9408	119.6175	124.6445	122.067
average	5.135054	4.992946	5.128088	5.01915	5.080867	4.984063	5.193521	5.086125
Sum(T1+T2)	243.072		243.5337		241.5583		246.7115	
avT1-avT2	0.142108		0.108938		0.096804		0.107396	
D_{JM}	1.000069992		1.000040997		1.000032825		1.000038976	
%	70.715		70.713		70.712		70.713	

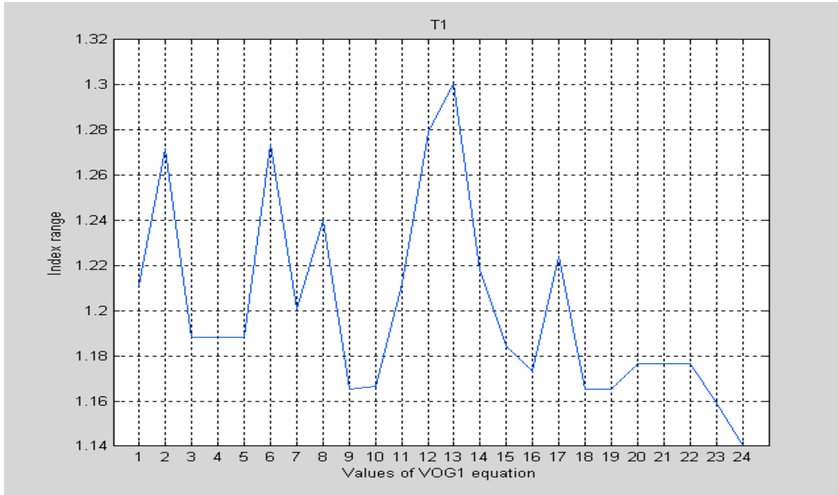

Fig. 7: The (VOG1) index results of 24 samples of T1.

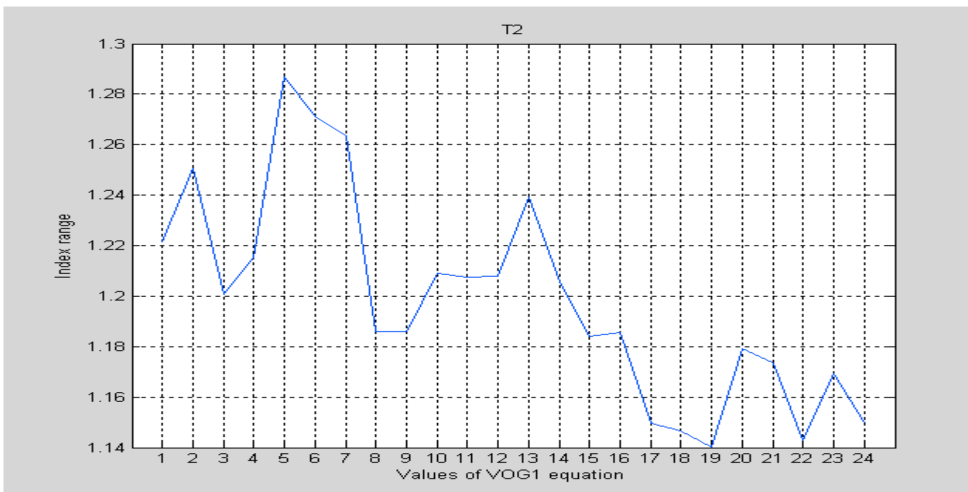

Fig. 8: The (VOG1) index results of 24 samples of T2.

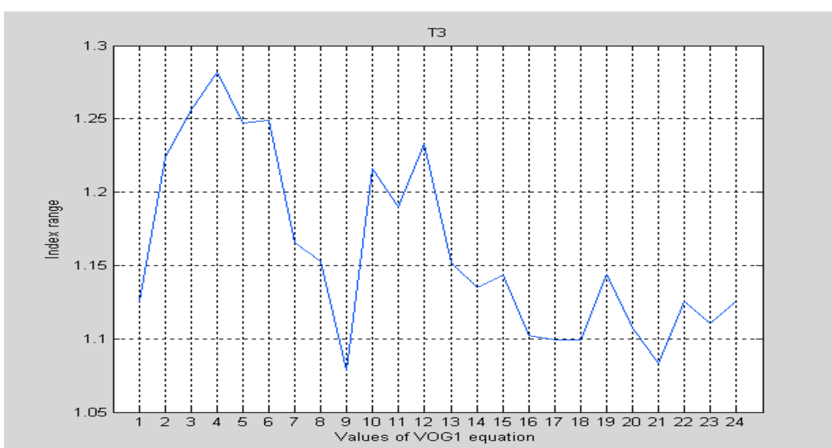

Fig. 9: The (VOG1) index results of 24 samples of T3.

4. CONCLUSION

According to the results it was realized that the Modified Red Edge Simple Ratio (MSR_{705}) index of Narrowband greenness VIs has been exhibited an acceptable results as well as it can differentiate between the oil palm plant stage 1 (T1 healthy) and stage 3 (T3 severe damage) using the default equation index because of the healthy plant has a high amount of chlorophyll than severe damage plant. Also the modification equation of Modified Red Edge Simple Ratio (MSR_{705}) index of Narrowband greenness VIs was applied on stage 1 (T1 healthy) and stage 2 (T2 semi healthy) and exhibited an acceptable results as well as it can differentiate between them.

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