Spectral Feature of Rice Leaves Infected by Blast

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ABSTRACT:

The rice blast, caused by *Pyricularia oryzae* Bri. et Cav., is one of the most serious diseases in rice production of Japan. The final objective of our study is to construct the modeling for predicting the damage of disease using remote sensing. In this paper, the relationship between spectral feature and symptom of the disease was discussed as the preliminary report, using the measurement of spectral characteristics for the infected rice leaves with blast. As the results of this measurement, it was identified to have peak reflectance in the regions of 340, 640, 800, 1,450 and 1,940 nm (R340,R640,R800,R1,450,R1,940). According to this fact, the relationship between the following three kinds of spectral indices and the different rating of damaged area were discussed:

1) (R640-R340)/(R640+R340), 2) (R800-R640)/(R800+R640), 3) R1,450+R1,940

As the results of this study, combining five reflectances using indices operation was proved to be effective for the identification of diseased symptom. In near future, more detail discussion and the modeling for predicting the damage of disease would be possible by accumulating the data for spectral feature and their physical characteristics for infected leaves.

1. INTRODUCTION

1.1 Food Problem and Rice Blast

The food problem, the population problem, these are necessary to be solved at the global scale and important for human being.
In Asian countries including Japan, people can live on rice and its stable provision is discussed at each countries together. Particularly in Japan, the food problem related to rice, is reported in newspaper every few years.
The bad rice crop in 1993, is known as the worst harvested after world war II. In this year, at the main rice production regions such as Miyagi, Fukushima and Kanto, the outbreak of rice blast has occurred by the record-breaking cool summer and continuous unseasonable weather so that the worst yield has recorded. Some of social problems such as an imported rice, rice price upswing and etc., have occurred in succession by this worst yield.

1.2 What is Rice Blast ?

Generally the rice blast is infected on rice leaves or its ear and proceeds to occurrence, infection and to almost dead in the worst case.
Rice blast is classified to following two main types, one is leaves blast, disease infected on leaves, the other is ear blast, disease infected at an ear of rice.
The spores of the disease stay over the winter season with straw and unhealed rice. It begins to be active at the same time as the beginning of rice cultivation in the next crop year. Furthermore not only the weather but also the sort of rice, manuring and the site specification are influence to the occurrence of disease. It has high probability of the sudden outbreak under the cool summer condition with high humidity.
Particularly serious disasters by rice blast often occur at Fukushima prefecture and it's surrounding region. In this study, the authors investigated the disease symptom of leaves blast and its spectral feature.

2. SPECTRAL FEATURE MEASUREMENT

2.1 Diseased Rice Leaves with Blast as Measurement Target

The infected leaves with blast and healthy leaves of rice as the measurement targets were collected at farmer's rice fields on 16th July, 1995. Its field was located at Funahiki-town, tamura-district, Fukushima-prefecture.
At about the same time, blast had already started to proceed so that the rice leaves infected by blast could be easily identified around its rice field.
The type collected rice was "Hatsuboshi". Collected rice leaves had different symptom of disease.

2.2 How to Measure Spectral Feature ?

The measurement of spectral feature for the infected rice leaves with blast was carried out under the uniform condition with 20 degree centigrade using four lamps with 2,500 candela, 80 degree irradiation angles respectively in the phytotron that located in Fukushima Prefecture Agricultural Experiment Station.
The used measurement instrument was multi-purpose spectral-radiometer MSR-7000 that produced by OPTO research corporation. The spectral region of this measurement was from 280 to 2,500nm and its interval was 5nm. The reflectance from target can be calculated by relative reflective energy from the target based on the standard white board.

The measurement targets with different disease rating of area were prepared using collected rice leaves with the symptom of progress disease.

2.3 Results of Measurement and Discussion

Fig.1 shows the spectral feature's comparison of adaxial, abaxial, and mixed with both sides leaves with healthy condition.

It was proved to have almost same spectral characteristics for every case and they also had a typical spectral feature from healthy vegetation.
It had relatively low reflectance with about 5% in the visible region from 300 to 490nm.
On the other hand, it had relatively high with over 60% in the near infrared from 760 to 1,140nm.
It had lowest reflectance in the spectral region of 340nm and highest in 800 nm respectively.

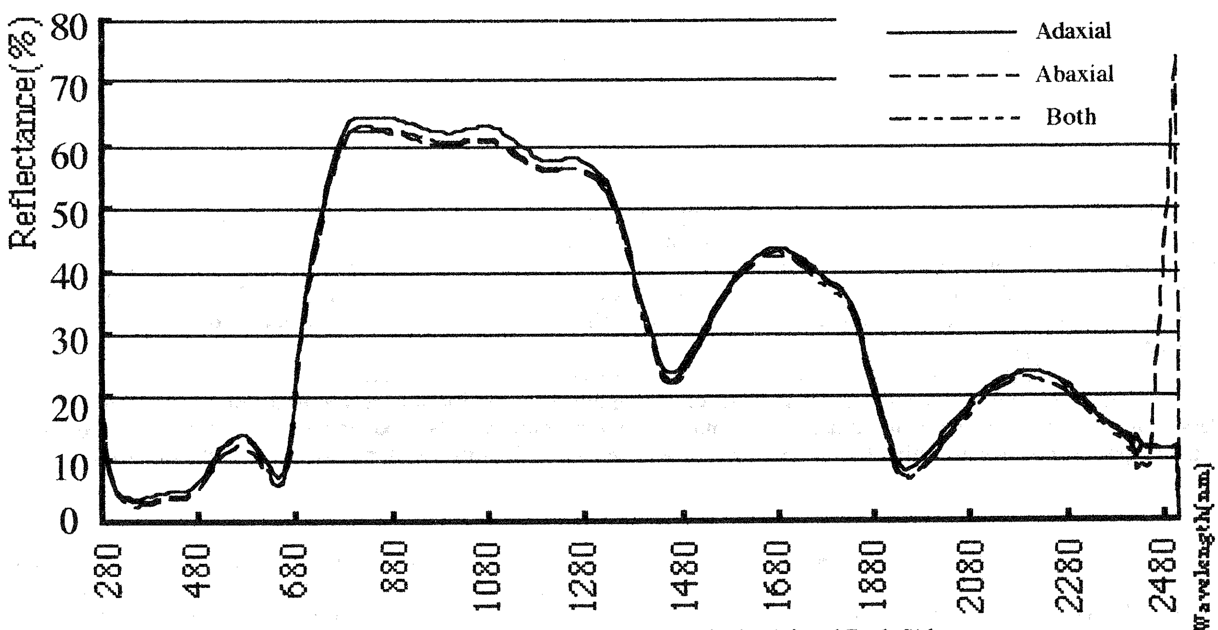

Fig.1 Spectral Feature of Adaxial,Abaxial and Both Side

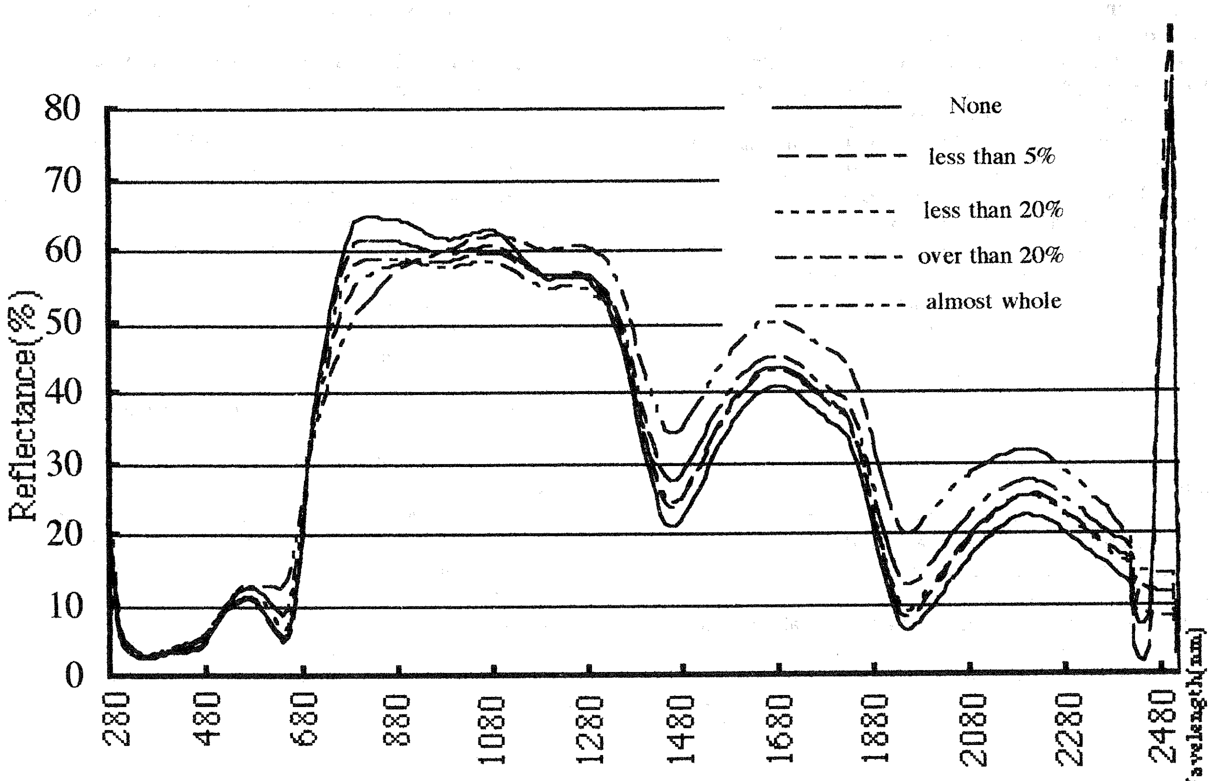

Fig.2 Relationship between Spectral Feature and Different Rating Damaged Area

Fig.2 shows the relationship between spectral features and different rating of area with the symptom of progress disease.
In the spectral region of 640nm, the reflectance decreased with rating of the damaged area, those were almost whole area damaged, over 20 percent area damaged, less than 20 percent, less than 5 percent and none by turn.
In the middle infrared region more than 1,400nm, it had also same order as the visible region.
On the other hand, it had reverse order of the above mentioned wavelength in the near infrared region of 800 nm.

3. SPECTRAL INDICES AND SYMPTOM OF DISEASE

3.1 Why and How to Calculate Indices ?

Through the spectral feature measurement, it was identified to have peak reflectance in the region of 340, 640, 800, 1,450 and 1,940nm.
Rationing is known as one of the spectral enhancement methods. NDVI(Normalized Difference Vegetation Index) is the typical index using spectral rationing.
As the effect of rationing, it is possible to reduce some of influences based on the environmental condition such as sunlight illumination angle, shadow and etc..
According to the results of spectral measurement, the relationship between spectral indices and the different rating of damaged area was discussed. The damaged area had progress symptom of disease.
As first, in order to enhance spectral information, following three indices based on the five reflectance peaks were used:

$$(R640 - R340) / (R640 + R340) \quad ....1)$$
$$(R800 - R640) / (R800 + R640) \quad ....2)$$
$$R1,450 + R1,940 \quad ....3)$$

Equation 1) is the normalized difference of maximum and minimum reflectances in the region of visible wavelength. Particularly 340nm had lowest reflectance in the whole measurement spectral region.
Equation 2) is also the normalized difference by combining the reflectance in visible red and near infrared region, it seems to have almost same physical characteristics of Normalized Difference Vegetation Index.
Equation 3) is the summation of lowest two reflectances in water absorption regions, those are 1,450 and 1,940nm.

3.2 Indices and Different Rating of Damaged Area

Fig.3.1 and 3.2 show the relationship between the index and different rating of damaged area.
Indices' values from 1) increased with increasing of the damaged area.
The value based on 3) had also same trend as 1).
On the other hand, the value from 2) was identified to have an inverse trend as the other two indices.
As the results, the differences based on the difference of rating damaged area were more clear or accurate than the comparison of reflectance.
Accordingly the above mentioned indices were proved to be effective for not only spectral information enhancement but also target feature extraction.

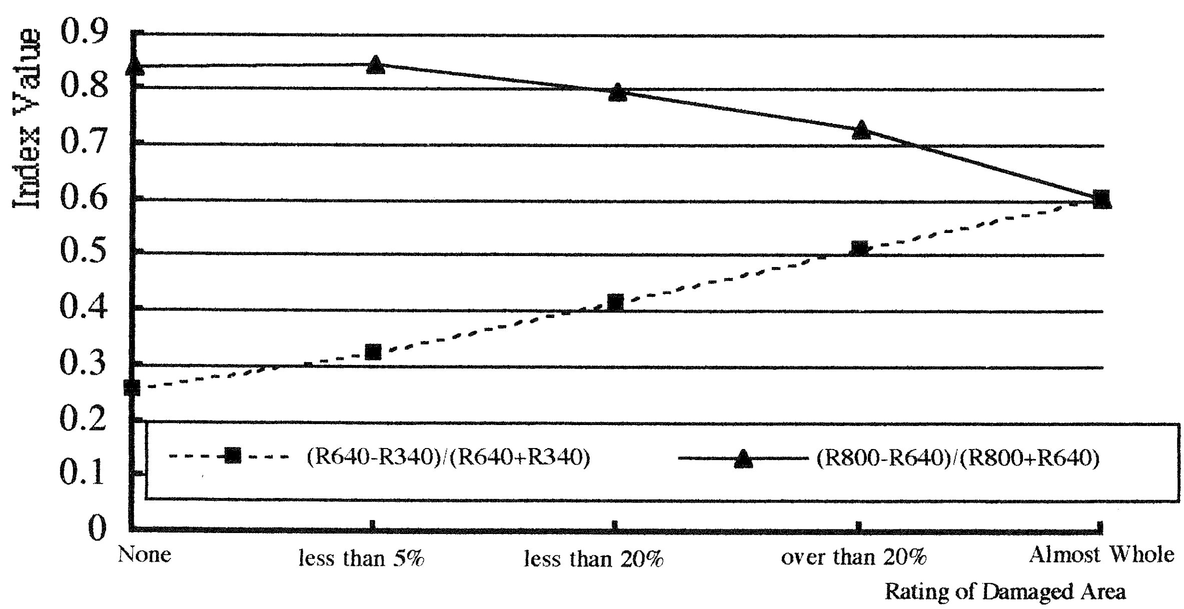

Fig.3.1 Relationship between Index and Different Rating Damaged Area

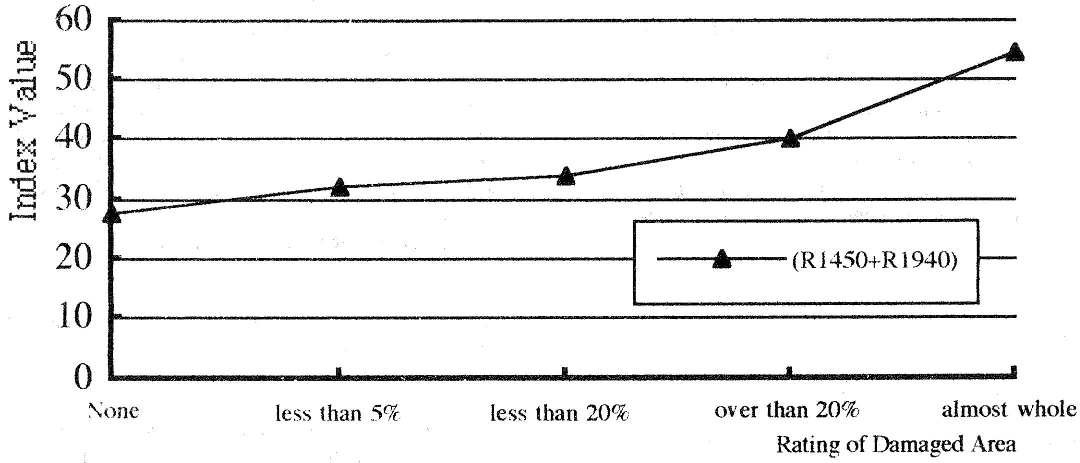

Fig.3.2 Relationship between Index and Different Rating of Damaged Area

4. CONCLUSION

The relationship between spectral feature and symptom of disease was considered in this study.

Through this discussion, following results were obtained:

1) Every target had peak reflectance in the region of 340, 640, 800, 1,450 and 1,940nm.
2) Infected leaves had typical spectral feature depend on the different rating of damaged area.
3) It was possible to enhance spectral information by these indices equations:

(R640-R340) (R640+R340).......1)
(R800-R640) (R800+R640).......2)
R1,450+R1,940 ....3)

Accordingly proposed combined spectral measurement and indices calculation method was proved to be effective for the identification of the disease symptom for the diseased rice leaves with blast.

In near future, more detail discussion and the modeling for predicting the damage of disease would be possible by accumulating the information for spectral features and their physical characteristics for infected leaves.