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A Field Experiment Study on the Use of OSMI Wave Bands for Agricultural Applications

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Abstract : The aim of this study is to assess the OSMI (Ocean Scanning Multi-spectral Imager), whose central bands are 443nm, 490nm, 510nm, 555nm, 670nm, and 865nm, for agricultural applications. Radiance measurements, used to determine per cent reflectance of canopies and soils, were acquired with spectro-radiometers (Li-1800;330~1,100nm, GER-SFOV;350~2,500nm, and MSR-7000; 300~2,500nm) in situ for crops and indoors for soils. OSMI equivalent bands and their ratio values were prepared(20nm interval for bands 1~5; 40nm interval for band 6) by averaging spectral reflectance values to the real OSMI bands and analyzed as to crop growth parameters, leaf area index (LAI), total dry matter, and growth index in crops and physiochemical properties in soils. Spectral variations for each growth stage in rice and for crop discrimination in upland crops were significant statistically. In soils, clay and water content, CEC (Cation Exchange Capacity), free iron oxide, and some cation content were correlated with the OSMI equivalent bands. The result of this study shows OSMI wave bands would be promising for agricultural application in terms of spectral information and resolution.

Key Words : OSMI, soils, crops, effective wave bands

1. Introduction

It is almost time to launch the first earth observing satellite, KOMPSAT-1, which has two sensors, EOC (Electro-Optical Camera) and OSMI (Ocean Scanning Multi-spectral Imager), in Korea. Mission of OSMI is to perform biological oceano- graphy by observing seawater color. Furthermore, OSMI images would be utilized for the observation of marine resources and environment over the world (Cho and Paik, 1996). OSMI has six central wave bands(20nm and 40nm interval), which are 443, 490, 510, 555, 670, and 865nm, and 1km of spatial resolution.

Spectral reflectance signatures in agricultural fields are shown to be different from surface condition, which are crop species, developmental stage, cropping pattern, cropping environment, soil moisture, and soil colors etc.. Spectral analysis on land surface features, crops and soils, should be examined for the use of OSMI wave bands as the previous study in agricultural fields.

This research was performed to find out the effective OSMI wave bands for the estimation of crop environment and the relationship between

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land & crop surface features and spectral reflectance in terms of OSMI wave bands.

2. Materials and Methods Used

1) CROPS (rice and upland crops)

For the measurement of spectral reflectance, rice (Ilpum-byeo) which is medium-late maturing variety was cultivated in the paddy field of National Institute of Agricultural Science and Technology (NIAST), Suwon City, Kyunggi Province. Ilpum-byeo was transplanted in May 25 and harvested in October 16. And major upland crops, 3 corn varieties, 1 soybean line, 2 peanut varieties, were grown for the measurement of spectral reflectance at the field of National Crop Experiment Station (Suwon) in 1998. Varieties or line used in measurement and their developmental stages are shown in Fig. 1. In corn varieties, rs510 and sw19 are for silage and w5102 is for grain.

We measured spectral reflectance of paddy rice canopies (Ilpum-byeo) using spectroradiometer (GER Inc. SFOV:0.35~2.50μm) in situ weekly or biweekly from transplanting to ripening stage(Fig. 2). GER SFOV (Single Field of View) Infra Red Intelligent Spectroradiometer has two types of detectors, silicon diode for short wavelengths (2nm interval) and PbS for longer wavelengths (4nm interval). Distance from the canopy to radiometer was kept about 70cm perpendicularly. Barium sulfate plate was used for getting the incidental solar radiation.

Radiance measurements, used to determine per cent reflectance of canopies, were acquired with a spectroradiometer (Li-1800, 330-1100nm) in situ with 5nm spectral interval at 10:00 to 11:00 in the morning for upland crops(Fig. 2). The Li-1800 measures the spectral distribution of radiation by dispersing the radiation with a diffraction grating monochromator, and measuring the energy in the various wave bands of the resulting spectrum with a silicon detector. Measurements were made throughout each growing season at approximately weekly intervals. The spectroradiometer was elevated 50cm above the crop canopies. Data were taken only when there were no clouds in the vicinity of the sun and when the solar elevation was at least 51°. Measurements of incident solar

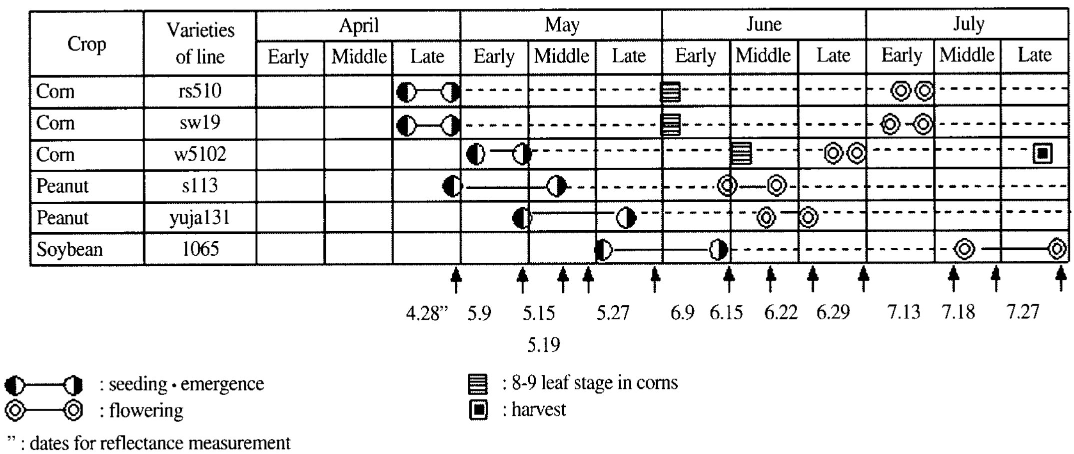

Fig. 1. Upland crops and their development stage.

Fig. 2. Field measurement for spectral reflectance of rice and corn canopy (NIAST).

radiance and reflective radiance from canopies were made after the instrument was leveled for a nadir view angle. The spectroradiometer has a 60° field of view. Per cent spectral reflectance was calculated as the ratio of canopy radiance to the incident solar radiance.

2) Soils

37 Soil samples (14 soil series), which are largely distributed and typical of that area, were collected in Hyundeog-myeon, Pyongtaek-gun, Kyunggi Province by using detailed soil map (1:25,000) published in NIAST. Top soils (5cm) of the 1m × 1m quadrat were sampled for each soil with 3 replications(some exceptions)(Table 1). Each soil was sieved with 2mm sieve after air-dried and then was used as the material for the spectral reflectance measurement. Rice straws, which were composted during 5 years, were added to the soils for the measurement of spectral reflectance at the different levels of organic matter.

Soil texture was determined by hydrometer method with 5% sodium hexametaphosphate. Soil moisture was controlled by tensiometer (Soil Moisture Equipment Inc. USA) with pressure plate and membrane apparatus, and were adapted to 0.1, 0.3, 3, and 5 bar. And they were used for the measurement of soil moisture and the mass soil water content.

Soil pH was measured by pH meter after extracting with water(soil:H_2O=1:5), EC, by electric conductivity meter and organic matter, by Walkley-Black method. Cation exchange capacity(CEC) was measured by Schollenberger method by saturation with 1N-ammonium acetate (pH 7.0). ICP (Induced Coupled Plasma spectrophotometer) and AA (Atomic Absorption spectrophotometer) were used for the analysis of exchageable cations(1N-ammonium acetate; pH 7.0) and free iron oxide(dithionite-citrate).

Spectral reflectance of each sample was measured by spectroradiometer (MSR-7000;

Table 1. Morphologic characteristics of soil used in this study.

Soil Series	Parent Material	Drainage	Texture
Bongnam	Fluvio-marine deposits	Imperfectly	Fine clayey
Buyong	Colluvium on granite	Imperfectly	Fine clayey
Chunpo	Fluvio-marine deposits	Imperfectly	Fine silty over coarse silty
Gimjae	Fluvio-marine deposits	Imperfectly	Fine clayey over fine silty
Gongdeog	Fluvio-marine deposits	Poorly	Fine loamy
Jeonnam	Residumn on granite	Well	Fine loamy
Jisan	Local alluvium	Imperfectly	Fine loamy
Mangyeong	Residumn on granite	Imperfectly	Coarse silty
Ogcheon	Local alluvium	Poorly	Fine loamy
Poseong	Fluvio-marine deposits	Poorly	Coarse silty
Samgag	Residumn on granite	Very well	Coarse loamy
Songjeong	Residumn on granite	Well	Fine loamy
Yesan	Residumn on granite	Well	Coarse loamy
Yonggi	Local alluvium	Mod. well	Fine loamy

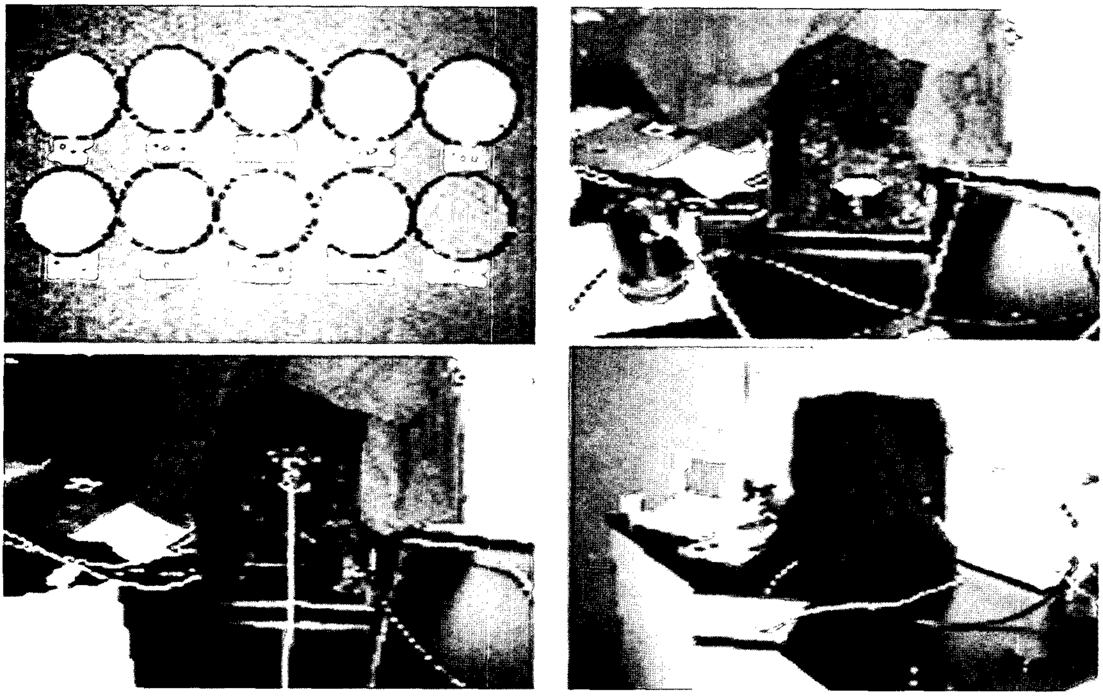

Fig. 3. Soil sampling vessel and MSR-7000 spectroradiometer.

280~2500nm) 2cm over the soil surface of black-coated petri dish(ϕ9cm) in the dark box(Fig. 3). Percent spectral reflectance was calculated as the ratio of soil radiance to the incident radiance into barium sulfate plate.

3. OSMI(LRC) Equivalent Bands Preparation

OSMI(LRC) equivalent band set and its logarithmic band set were prepared for the analysis between spectral reflectance and crop and soil parameters(Table 2). The term, LRC, will be used from here, instead of OSMI equivalent band. LRC bands were created by averaging measured spectral reflectance values to the real LRC band range.

4. Spectral Reflectance of Rice Plant

Spectral reflectance of the visible range (0.4~0.7μm) was decreased to below 5% and then slightly increased again after panicle initiation stage, while spectral reflectance of the near-infrared range (0.7~1.1μm) was increased to 40~50% and then decreased a great deal after panicle initiation stage (Fig. 4).

Leaf Area Index (LAI) and Total Dry Matter (TDM) are the very important physiological parameters to evaluate rice growth and final yields. Scatterplot of correlation coefficient(r) is shown in fig. 5 after correlation analysis between

Table 2. LRC and logarithmic bands derived from spectral reflectance and used in this study.

No.	Center Wavelength	LRC bands	Logarithmic bands
1	443	Reflectance(430:450)	log10(LRC1)
2	490	Reflectance(480:500)	log10(LRC2)
3	510	Reflectance(500:520)	log10(LRC3)
4	555	Reflectance(540:560)	log10(LRC4)
5	670	Reflectance(660:680)	log10(LRC5)
6	865	Reflectance(840:880)	log10(LRC6)
7		Reflectance(1550:1750)	log10(LRC7)
8		Reflectance(2100:2300)	log10(LRC8)

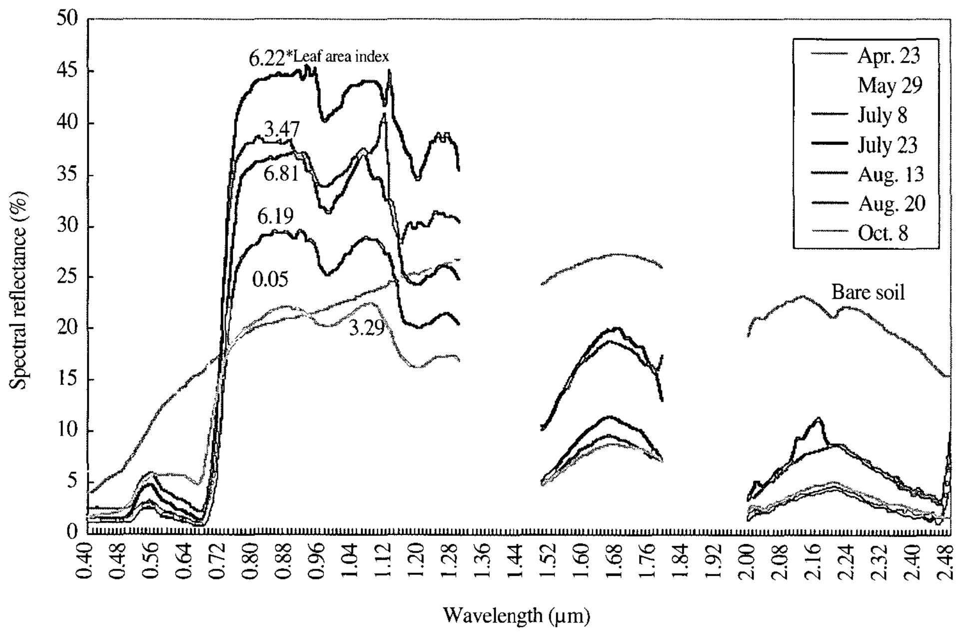

Fig. 4. Spectral reflectance profile of paddy rice plant(Ilpumbyeo) from rooting stage to ripening stage.

wavelengths and LAI & TDM for finding out effective wave band range. There were significant at 1% level at ｜r｜>0.49 and at 5% level at 0.43<｜r｜<0.49. Almost all wavelengths ranged from 0.40μm to 0.90μm were related with LAI and TDM. Then, ratio values by using spectral reflectance of near infrared(NIR) and visible

wavelengths were made and analyzed for correlation with LAI and TDM. Best 29 correlation coefficient were indicated in Table 3. LAI was related with NIR and red visible, meanwhile TDM, with NIR and green visible. Linear relationship between ratio values and LAI & TDM are shown in Fig. 6 and 7. When increases unit LAI, ratio value ($R_{0.86}/R_{0.69}$) also increase about 2.45 with 0.86 of determination coefficient. ratio value ($R_{0.76}/R_{0.55}$) increased 0.79 with the increment of 100g/m^2 in TDM,

5. Upland crop separability with LRC bands at different dates

General linear model(GLM) procedures of SAS statistics program were carried out to find out the appropriate date for crop discrimination by using LRC bands (Table 4) and their ratio values (Table 5). Corn and two other legumes were discriminated from band 1 and 5 in June 9, band 1, 2, 3, 5, and 6

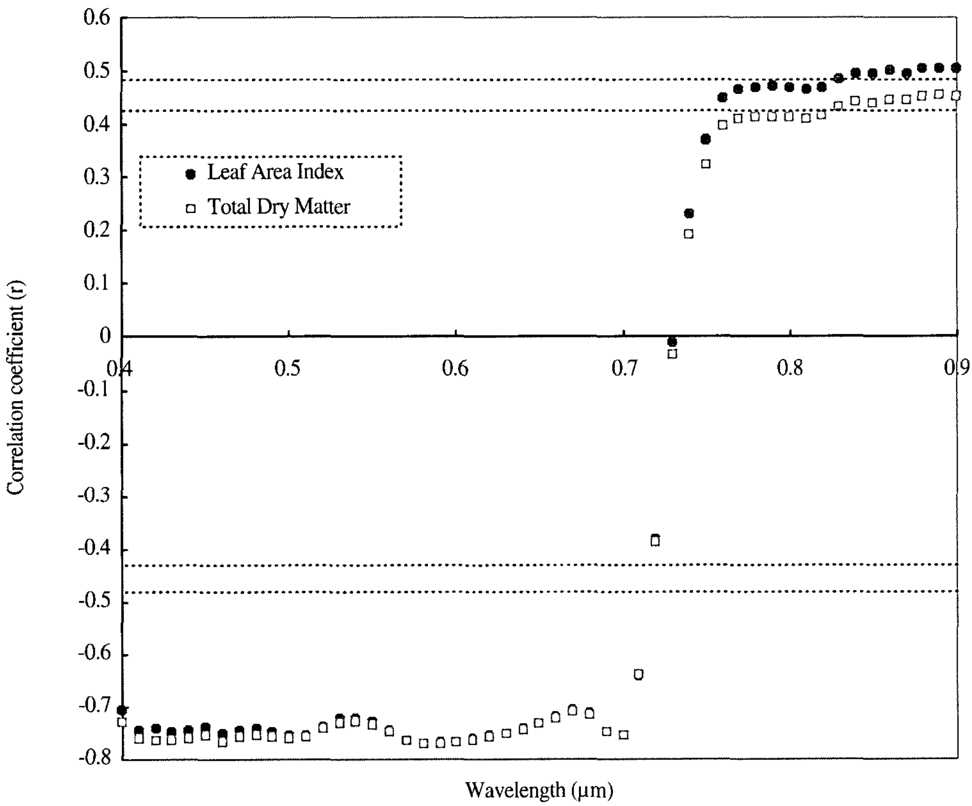

Fig. 5. Scatterplot of correlation coefficient(r) between wavelengths and leaf area index & total dry matter before heading stage(n=42).

Table 3. Ratio values(0.70~0.90μm/0.40~0.69μm combinations with 0.1μm interval) and their upper best 29 correlation coefficient for leaf area index and total dry matter before heading stage.

Leaf Area Index(LAI)		Total Dry Matter(TDM)	
Ratio Value(RV)	Correlation coefficient	Ratio Value(RV)	Correlation coefficient
0.75/0.69	0.93***	0.75/0.53	0.89***
0.76/0.69	0.93***	0.76/0.53	0.90***
0.77/0.69	0.93***	0.77/0.53	0.89***
0.78/0.69	0.93***	0.78/0.53	0.89***
0.79/0.69	0.93***	0.79/0.53	0.89***
0.80/0.69	0.93***	0.81/0.53	0.89***
0.81/0.69	0.93***	0.82/0.53	0.89***
0.82/0.69	0.93***	0.83/0.53	0.89***
0.83/0.69	0.93***	0.84/0.53	0.89***
0.84/0.69	0.93***	0.85/0.53	0.89***
0.85/0.69	0.93***	0.89/0.53	0.89***
0.86/0.69	0.93***	0.75/0.54	0.89***
0.87/0.69	0.93***	0.76/0.54	0.89***
0.88/0.69	0.93***	0.74/0.55	0.89***
0.89/0.69	0.93***	0.75/0.55	0.89***
0.90/0.69	0.93***	0.76/0.55	0.90***
0.75/0.61	0.93***	0.77/0.55	0.89***
0.76/0.61	0.93***	0.78/0.55	0.89***
0.79/0.61	0.93***	0.79/0.55	0.89***
0.76/0.62	0.93***	0.80/0.55	0.89***
0.76/0.60	0.93***	0.81/0.55	0.89***
0.76/0.59	0.93***	0.82/0.55	0.89***
0.76/0.58	0.93***	0.75/0.56	0.89***
0.76/0.56	0.93***	0.76/0.56	0.89***
0.75/0.56	0.93***	0.77/0.56	0.89***
0.76/0.55	0.93***	0.79/0.56	0.89***
0.75/0.55	0.93***	0.80/0.56	0.89***
0.76/0.53	0.93***	0.81/0.56	0.89***
0.76/0.52	0.93***	0.76/0.60	0.89***

*** : significant at 0.1 % level

in June 15, band 1, 2, 3, 4, 5, and 6 in June 22, and band 4 and 5 in June 29 (Table 4). Peanut and soybean could not be separable from each other only by using spectral reflectance signatures measured during May to July.

Effective ratio values for discriminating corn from 2 other legumes were RV 1, 2, 3, and 4 in June 9, RV 2, 3, and 4 in June 15, RV 1, 2, 3, 4, 5, and 6 in June 22, and RV 4 in June 29(Table 5). Peanut and soybean could not be separable with each other by ratio values as well. We need more spectral data collected during flowering to maturing stage and another parameter to discriminate peanut and soybean including vinyl mulching and cropping pattern. Around June 22 was the best date for corn discrimination from 2 other legumes (no significances were shown in measurement dates other than June) because all LRC bands and ratio values in June 22 were highly significant for corn separability.

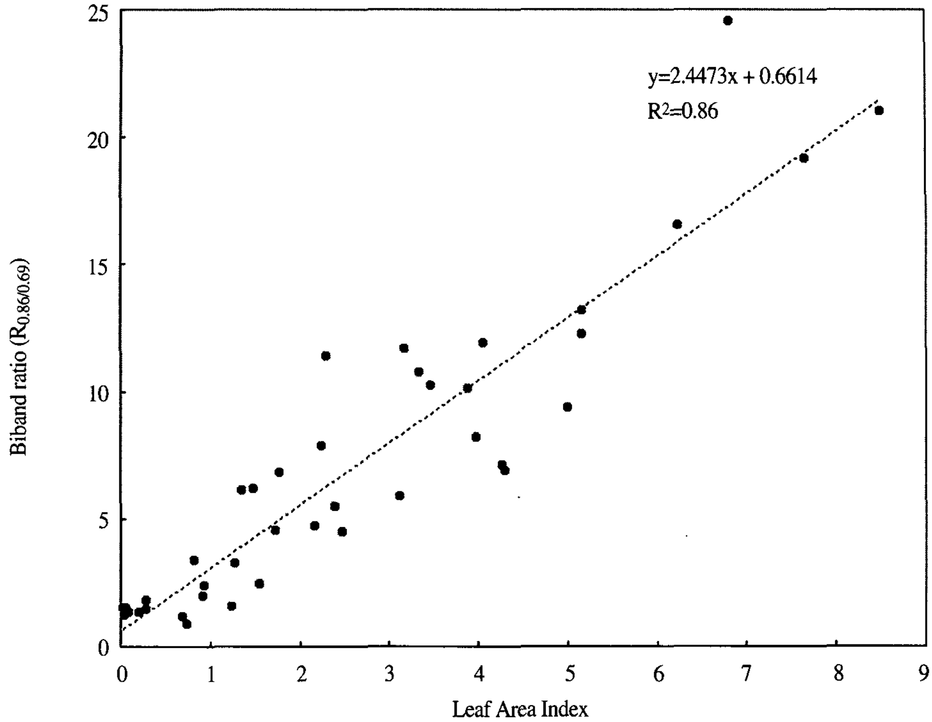

Fig. 6. Relationship between leaf area index(LAI) and ratio value($R_{860/690}$) in rice canopy before heading stage.

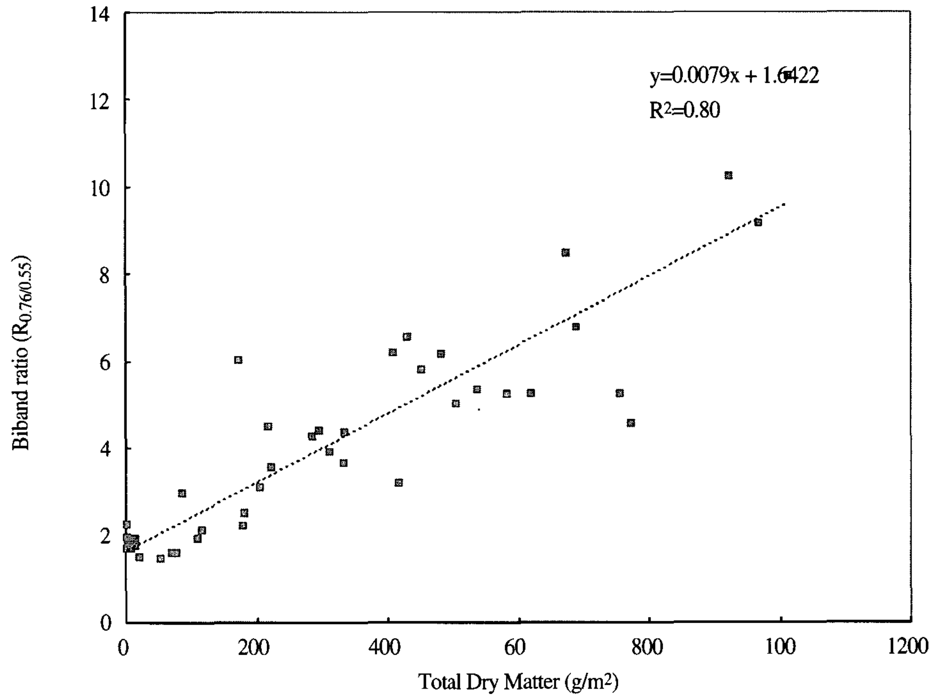

Fig. 7. Relationship between total dry matter(TDM) and ratio value($R_{760/550}$) in rice canopy before heading stage.

Table 4. Spectral reflectance signatures of corn, peanut, and soybean at LRC bands.

June 9	B1[1]	B2	B3	B4	B5	B6	June 15	B1	B2	B3	B4	B5	B6
Corn	4.03 b[2]	4.53 b	5.44 a	9.22 a	6.27 b	40.14 a	Corn	3.27 b	3.62 b	4.51 b	7.83 b	4.20 b	43.94 a
Peanut	8.16 a	9.24 a	10.44 a	14.30 a	17.28 a	27.67 a	Peanut	6.61 a	7.31 a	8.33 a	11.88 a	12.63 a	28.08 b
Soybean	6.31 ab	7.60 ab	9.07 a	12.67 a	16.96 a	24.77 a	Soybean	5.60 ab	6.61 a	7.65 a	11.38 ab	14.05 a	23.21 b
Mean	5.79	6.62	7.71	11.49	11.72	33.42	Mean	4.77	5.35	6.31	9.77	8.65	35.20
C.V.(%)	17.33	18.71	18.93	20.30	19.53	15.69	C.V.(%)	14.10	8.83	8.75	11.50	12.73	4.70
F value	10.34*	9.06	7.56	3.00	17.02*	5.02	F value	15.74*	40.94**	32.41**	8.99	49.52**	86.74 **
June 22	B1	B2	B3	B4	B5	B6	June 29	B1	B2	B3	B4	B5	B6
Corn	3.59 b	3.48 b	4.26 b	7.03 b	3.46 b	50.46 a	Corn	3.07 b	2.93 b	3.81 b	6.42 b	3.35 b	50.70 a
Peanut	5.77 a	6.69 a	7.71 a	11.53 a	12.97 a	31.11 b	Peanut	4.60 ab	4.85 ab	5.92 ab	9.89 ab	8.33 a	42.42 a
Soybean	5.12 a	6.18 a	7.41 a	11.21 a	13.80 a	27.22 b	Soybean	4.96 a	5.28 a	6.75 a	11.46 a	10.69 a	36.51 a
Mean	4.57	5.00	5.94	9.23	8.35	40.14	Mean	3.90	3.96	5.00	8.42	6.23	45.57
C.V.(%)	5.20	7.36	3.99	4.21	9.67	5.47	C.V.(%)	12.92	16.21	13.73	11.95	13.78	15.54
F value	53.63**	51.83**	150.48**	95.94**	110.63**	67.41**	F value	8.20	7.84	9.53	12.62*	36.37**	1.80

1) : LRC equivalent band

2) : Duncan's multiple range test (α=0.05)

* 0.05>p>0.01, ** 0.01>p>0.001, *** p<0.001

Table 5. Ratio values of LRC bands in corn, peanut, and soybean.

June 9	RV1[1]	RV2	RV3	RV4	RV5	June 15	RV1	RV2	RV3	RV4	RV5
Corn	10.06 a[2]	9.07 a	7.51 a	4.43 a	6.76 a	Corn	14.15 a	12.36 a	9.91 a	5.74 a	10.98 a
Peanut	3.41 b	3.01 b	2.67 b	1.95 b	1.61 b	Peanut	4.25 a	3.84 b	3.37 b	2.37 b	2.24 a
Soybean	3.92 b	3.26 b	2.73 b	1.95 b	1.46 b	Soybean	4.14 a	3.51 b	3.03 b	2.04 b	1.65 a
Mean	6.82	6.08	5.10	3.19	4.16	Mean	9.18	8.05	6.59	4.00	6.51
C.V.(%)	12.74	21.42	17.12	14.28	35.23	C.V.(%)	38.85	21.58	22.18	23.65	41.10
F value	41.87**	15.84*	22.92*	22.35*	9.46	F value	5.82	18.55*	15.60*	10.20*	8.38
June 22	RV1	RV2	RV3	RV4	RV5	June 29	RV1	RV2	RV3	RV4	RV5
Corn	14.09 a	14.62 a	11.86 a	7.19 a	14.83 a	Corn	16.75 a	17.90 a	13.57 a	8.01 a	16.02 a
Peanut	5.40 b	4.67 b	4.04 b	2.71 b	2.42 b	Peanut	9.32 b	8.85 a	7.23 ab	4.31 ab	5.09 a
Soybean	5.32 b	4.40 b	3.67 b	2.43 b	1.97 b	Soybean	7.36 b	6.92 a	5.41 b	3.19 b	3.41 a
Mean	9.73	9.60	7.89	4.90	8.55	Mean	12.71	13.05	10.10	5.97	10.27
C.V.(%)	7.66	12.86	6.94	8.19	21.12	C.V.(%)	19.80	26.67	20.29	18.26	34.82
F value	102.60**	49.70**	158.27***	97.56**	36.32**	F value	7.94	5.92	8.90	10.84*	7.81

1) : RV1=Band6/Band1, RV2=Band6/Band2, RV3=Band6/Band3, RV4=Band6/Band4, RV5=Band6/Band5,

2) : Duncan's multiple range test (α=0.05)

* 0.05>p>0.01, ** 0.01>p>0.001, *** p<0.001

6. Estimation of vegetative growth stage in corn variety(rs510) as a function of LRC bands

Hanway(1971) described the phenological growth stage of a corn plant as stage index from seeding (0.0) to physiological maturity (10.0). In this study, vegetative stage from seeding(0.0) to flowering(5.0) was examined for estimating developmental stage of a corn (rs510 variety) by using LRC bands and their ratio values. Four kinds of variable set, which were LRC bands(B), logB, ratio values(RV) of LRC bands, and logRV, were prepared for multi-regression and stepwise-regression model. As results, five significant models, 2 multi-regression model with RVs(1, 2, 3, 4, and 5; R2=0.97) and logRVs(1, 2, 3, 4, and 5; R2=0.97) and 3 stepwise-regression model with B(1, 2, and 3; R2=0.94), logB(1, 2, and 3; R2=0.94), and RV(4 and 5; R2=0.97), were obtained from the SAS procedures REG and STEPWISE.

7. Soil physiochemical properties and LRC bands

The spectral reflectance in soil was influenced by moisture content, organic matter, particle size, iron oxide, mineral composition, soluble salts, parent material, and the like(Baumgardner *et al.*, 1985).

Correlation analysis was performed and their correlation coefficients(r) were plotted to monitor effective wavelength range for free iron oxide and organic matter in Fig. 8. Effective wave band for free iron oxide was ranged from 0.40μm to 0.50μm, and organic matter, from 0.58~0.66μm. Both free iron oxide and organic matter were related with those bands negatively.

Correlation between soil physiochemical properties and spectral reflectance of each band are shown in Table 6. Almost all soil parameters are related with LRC bands except sand and silt content, calcium ion. Especially, cation exchange capacity (CEC) and soil water content

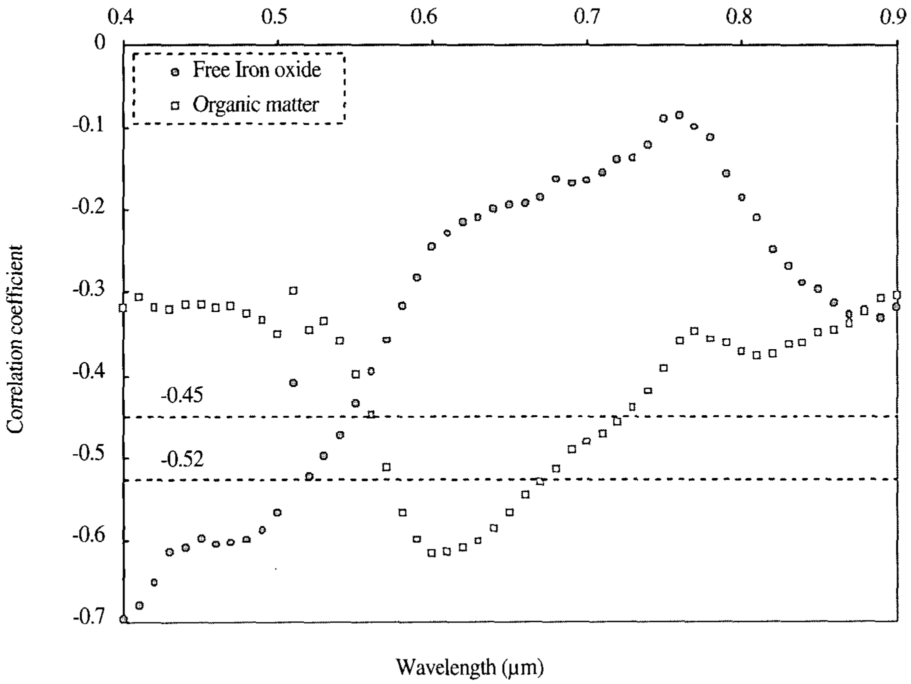

Fig. 8. Scatterplot of correlation coefficient(r) between wavelengths and free iron oxide & organic matter(*n*=36).

Table 6. Correlation between soil physiochemical properties and spectral reflectance of each band.

	BAND1	BAND2	BAND3	BAND4	BAND5	BAND6	BAND7	BAND8
SAND	0.052	0.050	0.049	0.033	0.030	0.055	−0.000	0.051
SILT	0.031	0.052	0.051	0.035	−0.091	−0.059	0.010	0.031
CLAY	−0.133**	−0.157**	−0.155**	−0.104*	0.061	−0.025	−0.012	−0.131**
pH	−0.027	−0.025	−0.034	−0.051	−0.112*	−0.161**	−0.160**	−0.071
EC	−0.038	−0.036	−0.043	−0.081	−0.143*	0.005	0.055	0.014
CEC	−0.177**	−0.201***	−0.217***	−0.274***	−0.375***	−0.311***	−0.229***	−0.198***
Ca	0.043	0.053	0.047	0.039	−0.029	−0.038	−0.044	0.009
K	−0.085	−0.127*	−0.130*	−0.103*	−0.003	−0.157**	−0.219	−0.243***
Mg	0.091	0.124*	0.129*	0.123*	−0.033	−0.078	−0.067	0.017
Na	0.136**	0.187***	0.209***	0.202***	−0.043	−0.065	0.019	0.091
Fe_2O_3	−0.161*	−0.224***	−0.229***	−0.177**	0.015	−0.193**	−0.201**	−0.245***
Soil Water Content	−0.515***	−0.580***	−0.600***	−0.653***	−0.687***	−0.689***	−0.635***	−0.721***
Tension	−0.070	−0.036	−0.023	0.001	0.045	0.154**	0.236***	0.246***
Total Carbon	−0.085	−0.097	−0.113*	−0.172***	−0.265***	−0.118*	−0.026	−0.021*

*** : significant at 0.1% level. ** : significant at 1% level. * : significant at 5% level.

Table 7. Regression equations for predicting soil properties from log(LRC) bands.

	Variable	Slope	Intercept	Prob.>F	C.V.		Variable	Slope	Intercept	Prob.>F	C.V*.
Total Carbon	log(band1)	−0.9988	4.95	0.0010	120.3	Na	log(band1)	0.2133	−0.13	0.0006	160.0
	log(band2)	−1.1155	5.51	0.0002	119.8		log(band2)	0.2279	−0.22	0.0002	159.5
	log(band3)	−1.2648	6.07	0.0001	119.2		log(band3)	0.2411	−0.29	0.0001	159.2
	log(band4)	−1.9388	8.57	0.0001	116.1		log(band4)	0.2144	−0.28	0.0012	160.3
	log(band5)	−2.8982	13.25	0.0001	111.1		log(band5)	−0.0888	0.71	0.2303	162.2
	log(band6)	−1.9447	10.08	0.0001	118.2		log(band6)	−0.1256	0.87	0.1280	162.0
	log(band7)	−0.6410	5.18	0.1159	121.6		log(band7)	−0.0251	0.49	0.7633	162.5
	log(band8)	−0.4185	4.20	0.2206	121.7		log(band8)	0.0480	0.20	0.4952	162.4
Soil Water Content	log(band1)	−10.3931	34.31	0.0001	66.2	Fe_2O_3	log(band1)	−0.6218	4.22	0.0001	35.6
	log(band2)	−10.4601	37.04	0.0001	64.9		log(band2)	−0.6598	4.48	0.0001	35.4
	log(band3)	−10.6554	38.95	0.0001	64.2		log(band3)	−0.6456	4.53	0.0001	35.5
	log(band4)	−11.6256	45.44	0.0001	63.0		log(band4)	−0.5295	4.40	0.0004	36.5
	log(band5)	−12.4857	55.44	0.0001	64.8		log(band5)	0.1333	2.22	0.5149	37.4
	log(band6)	−13.7310	62.50	0.0001	66.3		log(band6)	−0.4960	4.68	0.0185	37.1
	log(band7)	−13.2238	63.47	0.0001	68.3		log(band7)	−0.4286	4.52	0.0240	37.1
	log(band8)	−13.0910	60.71	0.0001	58.8		log(band8)	−0.4267	4.42	0.0018	36.7
CEC	log(band1)	−6.0552	28.76	0.0001	65.0	Clay	log(band1)	−7.8765	41.76	0.0001	58.6
	log(band2)	−6.2925	30.88	0.0001	64.5		log(band2)	−7.3189	42.22	0.0001	58.9
	log(band3)	−6.6563	32.71	0.0001	64.1		log(band3)	−6.9268	42.09	0.0001	59.2
	log(band4)	−8.6650	42.12	0.0001	61.7		log(band4)	−4.7824	37.70	0.0009	60.4
	log(band5)	−11.7304	57.52	0.0001	58.1		log(band5)	0.6829	20.34	0.6722	61.3
	log(band6)	−10.8132	56.07	0.0001	61.8		log(band6)	−1.4437	28.44	0.4289	61.3
	log(band7)	−7.5209	45.00	0.0001	65.5		log(band7)	−0.0168	22.93	0.9927	61.3
	log(band8)	−5.0520	34.05	0.0001	66.6		log(band8)	−4.3335	39.86	0.0046	60.7

* : C.V. is short for the coefficient of variation(%).

are related with all LRC bands negatively. Clay content was negatively related with LRC bands 1, 2, 3, 4, and 8, and blue visible of band 2 was the highest. Stoner *et al.*(1980) revealed that the smaller the particle size, the higher the spectral reflectance in sand textured soils, meanwhile opposite phenomenon, in medium to fine textured soils. This maybe infer that spectral reflectance decreased with the increment of soil water and organic matter followed by increasing clay content. The results of spectral characteristics on soil properties indoors may not be applied to the real situation for interpreting earth surface because materials were made for the measurement and experimental conditions were fixed for specific factor. Interactions among soil properties were ignored. And also, the spatial resolution of OSMI is 1km. It is needed to carry out field surveys with OSMI data at pilot sites for the further studies.

Single and multiple regression equations estimating soil properties, which were highly significant at previous study, were drawn out as a function of single log(LRC band) (Table 7 and 8). In single regression equations, log(band 8) was the best for soil water content, log(band 2) for free iron oxide, log(band 1) for clay content, and log(band 5) for CEC. Considering total observation number, n=385, equation for free iron oxide, clay content, CEC, and soil water content have feasibility to use although their coefficient of variance(CV) is a little bit high. It will be another matter to work with OSMI data after launching KOMPSAT-1. Soil spectral characteristics obtained in the laboratories and by satellites were utilizing for the studies of soil survey, soil degradation assessment : wind erosion, salini- zation, flooding, soil information systems, and so on.

8. Conclusion

This study was carried out to find out the effective OSMI wavebands for the estimation of

Table 8. Multiple regression equations for predicting soil properties from Log(LRC) bands.

Variable	Multiple Regression Equation	R^2	Prob>F	C.V.
Total Carbon	2.17+3.14LB1+15.17LB2−9.58LB3−12.14LB4−4.09LB5 −1.34LB6+10.67LB7−1.62LB8	0.548	0.001	82.8
Soil Water Content	51.13−14.18LB1+31.65LB2−16.22LB3−0.73LB4−9.09LB5 +0.42LB6+17.69LB7−21.58LB8	0.652	0.001	52.3
CEC	43.07−5.95LB1+29.04LB2−8.69LB3−22.53LB4−10.56LB5 −6.40LB6+10.87LB7+5.59LB8	0.402	0.001	53.6
Na	1.95-3.07LB1+0.65LB2+2.92LB3+0.84LB4−0.59LB5 −1.17LB6+0.28LB7−0.29LB8	0.332	0.001	134.1
Fe_2O_3	2.27+6.80LB1−12.40LB2+3.70LB3+0.73LB4+6.24LB5 −7.30LB6+2.11LB7+0.20LB8	0.632	0.001	23.1
Clay	0.93+26.77LB1−14.72LB2-55.33LB3+38.28LB4+19.92LB5 -36.65LB6+38.71LB7−14.93LB8	0.304	0.001	51.6

* : C.V. is short for the coefficient of variation(%).

crop environment and the relationship between land and crop surface features and spectral reflectance in terms of OSMI wave bands. As results, effective OSMI wave bands were selected and regression model was made to interpretate leaf area index (LAI) and biomass of rice and soil physiochemical properties.

And also, this study described herein evaluated for the feasibility of crop discrimination knowledge- based on crop calendar and spectral reflectance signatures of upland crops at OSMI equivalent bands. And also, regression models were prepared for estimating the developmental stage of a corn by using OSMI equivalent bands and their ratio values in vegetative growth stage.

For soils, correlation and regression analysis were performed to evaluate the relations between spectral reflectance and soil properties. Among them, soil water content, CEC, free iron oxide, and clay content appeared promising as a function of OSMI bands in their spectral resolution.

Based on this study, vegetation distribution map and global evapotranspiration by using vegetation index would be derived from the OSMI data for further application after launching. It would be also used for the evaluation of rice growth and the soil moisture status at global scale.

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