Optimal Hyperspectral Narrowbands in 400–2500 nm to Study Vegetation and Agricultural Crop Biophysical and Biochemical Properties and for Classification of Their Types and Species

Serial Number (#)	Wavebands Centers (nm)	Plant Variable Name
A. Blue bands		
1	405	Nitrogen, senescing: sensitivity to changes in leaf nitrogen. Significant absorption due to chlorophyll and carotenoids; reflectance changes due to pigments is moderate to low. Sensitive to senescing (yellow and yellow green leaves)
2	450	Chlorophyll, carotenoids, senescing: sensitive to chlorophyll a and b. Significant absorption due to chlorophyll and carotenoids; reflectance changes due to pigments is moderate to low. Sensitive to senescing (yellow and yellow green leaves)
3	490	Carotenoid, LUE, stress in vegetation: Sensitive to senescing and loss of chlorophyll\browning, ripening, crop yield, and soil background effects
B. Green bands		
4	515	Pigments (carotenoid, chlorophyll, anthocyanins), nitrogen, vigor: positive change in reflectance per unit change in wavelength of this visible spectrum is maximum around this green waveband
5	531	LUE, xanophyll cycle, stress in vegetation, pest and disease: Senescing and loss of chlorophyll\ browning, ripening, crop yield, and soil background effects
6	550	Anthocyanins, chlorophyll, LAI, nitrogen, LUE: sensitive to numerous vegetation variables
7	570	Pigments (anthrocyanins, chlorophyll), nitrogen: negative change in reflectance per unit change in wavelength is maximum as a result of sensitivity to vegetation vigor, pigment, and N
C. Red bands		
8	650	Pigment, nitrogen: moderate to high sensitivity to changes in pigments (chlorophyll, anthocyanins) and nitrogen
9	687	Biophysical quantities, chlorophyll, solar induced chlorophyll *fl*uorescence: LAI, biomass, yield, crop type\discrimination. Greatest soil-crop contrast. Actively induced emission peaks in red\ far-red 687 and 740 nm

Serial Number (#)	Wavebands Centers (nm)	Plant Variable Name
D. Red edge bands		
10	705	Stress in vegetation detected in red edge, stress, drought: Nitrogen stress, crop stress, crop growth stage studies. Blueshift in case of stress. Shift toward NIR for healthy vegetation
11	720	Stress in vegetation detected in red edge, stress, drought: Nitrogen stress, crop stress, crop growth stage studies. Blueshift in case of stress. Shift toward NIR for healthy vegetation
12	700–740	Chlorophyll, senescing, stress, drought: first-order derivative index over 700–740 nm has applications in vegetation studies (e.g., blueshift during stress and redshift during healthy growth)
E. NIR bands		
13	760	Biomass, LAI, Solar-induced passive emissions: NIR reference band for many indices. Solar-induced passive emissions with retrievals made in O_2 atmospheric features at 687 and 760 nm
14	855	Biophysical/biochemical quantities, heavy metal stress: LAI, biomass, yield, crop\discrimination, chlorophyll, anthocyanin, carotenoids. Sensitive to heavy metal stress due to reduction in chlorophyll. High stability in NIR band for developing indices
15	970	Water absorption band: most prominent water absorption trough. Also useful in quantifying most biophysical and biochemical properties
16	1045	Biophysical and biochemical quantities: leaf area index, wet and dry biomass, plant height, grain yield, crop type, crop discrimination, total chlorophyll, anthocyanin, carotenoids
E. Far near infrared (FNIR) bands		
17	1100	Biophysical quantities: sensitive to biomass and leaf area index. A point of most rapid rise in spectra with unit change in wavelength in far near infrared (FNIR)
18	1180	Water absorption band
19	1245	Water sensitivity: water band index, leaf water, biomass. Reflectance peak in 1050–1300 nm

Serial Number (#)	Wavebands Centers (nm)	Plant Variable Name
F. Early short-wave infrared (ESWIR) bands		
20	1450	Water absorption band: very high moisture absorption trough in early short wave infrared (ESWIR). Use as an index with 1548 or 1620 or 1690 nm
21	1548	Lignin, cellulose: plant biochemical properties
22	1620	Lignin, cellulose: plant biochemical properties. Peak reflectance in SWIR 1 for vegetation
23	1650	Heavy metal stress, Moisture sensitivity: Heavy metal stress due to reduction in chlorophyll. Sensitivity to plant moisture fluctuations in ESWIR. Use as an index with 1548 or 1620 or 1690 nm
24	1690	Lignin, cellulose, sugar, starch, protein: plant biochemical properties
25	1760	Water absorption band, senescence, lignin, cellulose: high to moderate moisture absorption in ESWIR for moisture in plant leaves. Use as an index with 1548 or 1620 or 1690 nm
G. Far short-wave infrared (FSWIR) bands		
26	1950	Water absorption band: highest moisture absorption trough in FSWIR. Use as an index with any one of 2025, 2133, and 2213 nm. Affected by noise at times
27	2025	Litter (plant litter), lignin, cellulose: litter-soil differentiation
28	2050	Water absorption band: high moisture absorption trough in FSWIR. Use as an index with any one of 2025, 2133, and 2213 nm. Not affected by noise
29	2133	Litter (plant litter), lignin, cellulose: typically highest reflectivity in FSWIR for vegetation. Litter-soil differentiation
30	2145	Water absorption band: moderate moisture absorption trough in FSWIR. Use as an index with any one of 2025, 2133, and 2213 nm. Not affected by noise
31	2173	Water absorption band: moderate to low moisture absorption trough in FSWIR. Use as an index with any one of 2025, 2133, and 2213 nm. Not affected by noise
32	2205	Litter, lignin, cellulose, sugar, startch, protein; Heavy metal stress: typically, second highest reflectivity in FSWIR for vegetation. Heavy metal stress due to reduction in chlorophyll
33	2295	Stress and soil iron content: sensitive to soil background and plant stress