Wheat salinity stress detection using VNIR spectrometry

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INTRODUCTION

Soil salinity is one of the main environmental factors that adversely affect plant growth and productivity in arid and semi-arid regions (El-Hendawy et al., 2019).

This problem is most prevalent in arid and semi-arid regions of the world such as Iran. Many studies confirm the potential of hyperspectral data in plant salinity stress detection (Hamzeh et al., 2012; El-Hendawy et al., 2021; Zhu et al., 2021).

This research aimed to investigate the capability of spectrometry in discriminating wheat salinity stress.

METHODOLOGY

Wheat (Triticum aestivum L.) species were grown in pots under controlled conditions. Here, 20 seeds were cultivated in each pot.

Five treatments were defined for irrigation based on Richards (1954): < 2 dS/m (non-saline), 4 dS/m (slight), 8 dS/m (moderate), 12 dS/m (high), and 16 dS/m (extreme). Each treatment was replicated seven times (70 pots in total). The treated samples were irrigated using saline water. The chlorophyll content for each pot was measured by the SPAD-502 instrument.

The samples' spectra were measured through the FieldSpec-3 spectrometer (Analytical Spectral Devices Inc, USA) at the canopy level. Eight spectra were collected for each sample. Splice correction and smoothing were done for all gathered spectra before processing.

The geometric parameters (area, depth, width, and position) of absorption features (AFs) in the continuum removed spectra were used to measure different levels of salinity stress (Figure 1).

The support vector machine (SVM) method was used for classifying the treatments. Cross validation method has been used for validation.

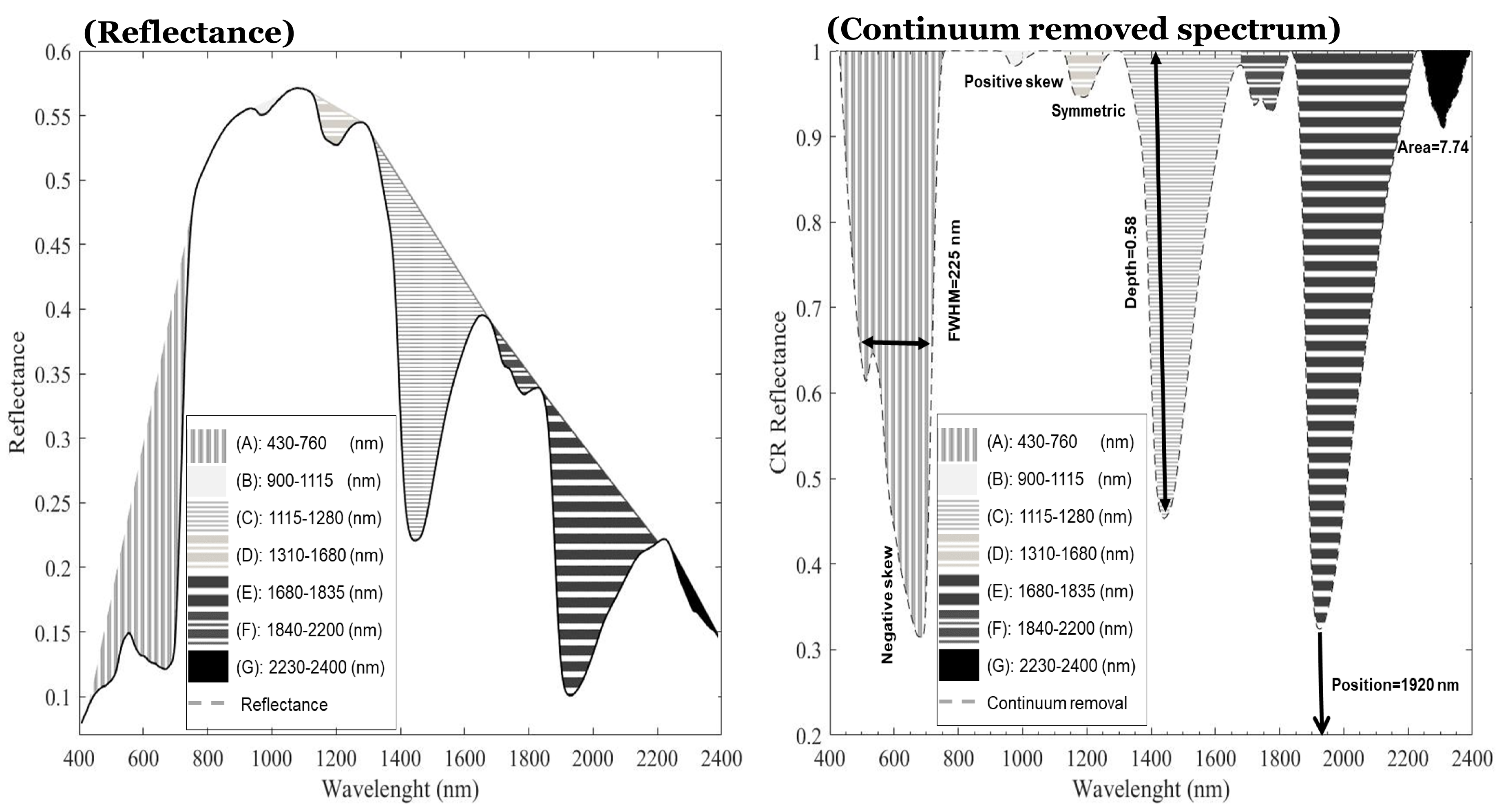

Fig. 1. Spectral reflectance and selected AFs for study, continuum removal of reflectance and geometrical indices.

RESULTS

The average of chlorophyll content of samples were 3.66, 3.11, 2.88, 2.45 and 2.33 mg/g for control, slight, moderate, high, and extreme saline treatments, respectively.

Results shows that the increase of salinity levels will increase the red and 1350-2150 nm region reflectance alongside the height and slope of red edge (680-750 nm), whereas the reflectance of 800-1250 nm will decrease.

As salinity levels increase, the red edge height and slope were decrease, and reflectance were increase in the 1350-2400 nm (Figure 2).

As salinity levels increase, depth, and width of AF located in 400-750 nm were reduced. Position of AFs located at 1350-1550 nm and 1850-2150 nm tends towards higher wavelengths (Table 1).

These results are in agreement with Hamzeh et al. (2012), El-Hendawy et al. (2019), and El-Hendawy et al. (2021).

SVM classification showed an accuracy of 92% in separating stressed from not-stressed samples and an accuracy of 81% in separating stress levels. The salt-affected wheat could be separated from not-stressed samples with good accuracy using the SVM method.

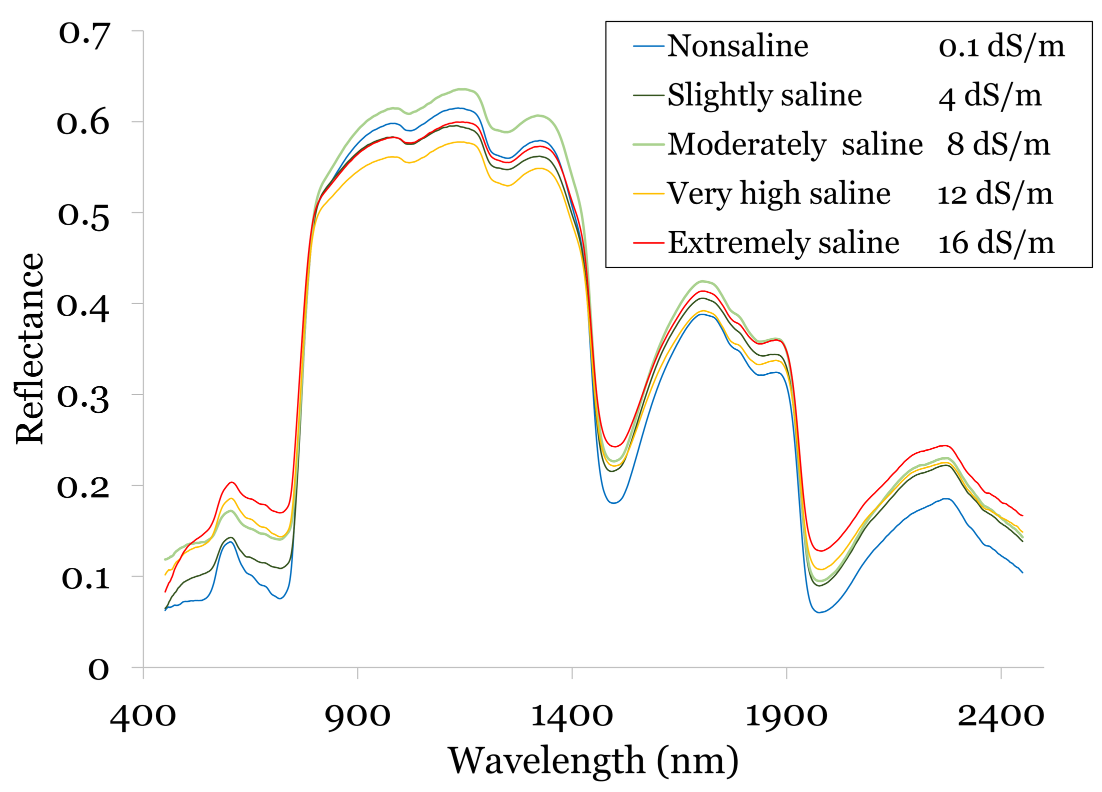

Fig. 2. Spectral reflectance of samples with different levels of salinity stress.

Table 1. Correlation and RMSE between geometrical indices and salinity stress levels.

AF		Extracted indices				
		Area	Depth	Asymmetry	FWHM	Position
A	*R*	-0.71	-0.79	0.29	-0.49	0.60
	RMS	0.25	0.22	0.35	0.21	0.3
B	*R*	-0.29	-0.34	0.35	-0.18	0.37
	RMS	0.33	0.34	0.35	0.34	0.35
C	*R*	-0.15	-0.55	0.73	-0.24	0.73
	RMS	0.33	0.36	0.22	0.36	0.25
D	*R*	-0.69	-0.72	0.22	0.17	0.09
	RMS	0.23	0.25	0.35	0.37	0.33
E	*R*	0.39	0.18	0.35	0.61	-0.59
	RMS	0.33	0.32	0.31	0.29	0.33
F	*R*	-0.84	-0.82	0.11	-0.38	-0.29
	RMS	0.19	0.21	0.31	0.34	0.368
G	*R*	0.58	0.49	0.59	0.46	0.53
	RMS	0.33	0.33	0.30	0.32	0.23

CONCLUSIONS

Salinity stress creates an obvious change in wheat's VNIR spectral.

The SVM classifier offers a rapid and non-destructive alternative approach for the early detection of salinity-induced stress.

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