Effect of Morphological Traits Over Spectral Reflectance Indices in Spring Wheat

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Introduction

Several spectral reflectance indices (SRI) have been identified that predict grain yield in diverse crops under different environments (Wiegand *et al.,* 1991).

The reflected energy from surfaces (plant canopies) depends on the geometric form of objects and is an important consideration in remote sensing systems (Lillesand *et al.*, 2004). The plant architecture is a consequence of stem and leaf arrangement (shape, angle, distribution of layers), making canopies highly heterogeneous (Serrano, 2008). As a result, canopy reflectance is highly affected by plant architecture (Datt, 1998).

The effect of some morphological traits on spikes and leaves over canopy reflectance has not been considered as important in wheat. The main goal of the present work is to determinate the effect of different morphological traits of spikes and leaves on the relationship between the SRI (vegetative indices and water indices) and grain yield during two growing seasons.

Methodology

Twenty spring wheat lines from the International Maize and Wheat Improvement Center (CIMMYT) were used. They represented morphological diversity for pubescence of spikes, leaf and spike orientation, wax content of leaves and spikes, and presence or absence of awns.

The genotypes were planted at CIMMYT's experiment station, Northwest, Mexico (27.3°N, 109.9°W 30 masl) in field plots of two raised beds 5 m long with 2 repetitions in an alpha lattice design. Experiments were conducted during two growing seasons (2007 and 2008).

Two water indices were estimated using a spectrometer (350 to 1100 nm) FieldSpec (ASD, Boulder, CO); NWI-1=R_{970}-R_{900}/R_{970}+R_{970} and NWI-3=R_{970}-R_{880}/R_{970}+R_{880}. Also, three vegetative indices were estimated; the red normalized difference vegetation index (RNDVI=R_{780}-R_{670}/R_{780}+R_{670}), green NDVI (GNDVI=R_{780}-R_{550}/R_{750}+R_{550}) and simple ratio index (SR=R_{900}/R_{680}).1

Results

Table 1. Correlation coefficients between spectral reflectance indices and grain yield in twenty spring wheat lines for 2007-2008.

Growth stage	Vegetative indices			Water indices	
	RNDVI	GNDVI	SR	NWI-1	NWI-3
	Leaf wax content				
Heading	0.69**	0.62**	0.60**	-0.82**	-0.82**
Grain filling	0.53*	0.40	0.43	-0.85**	-0.86**
Head-GF	0.65**	0.55*	0.58**	-0.85**	-0.86**

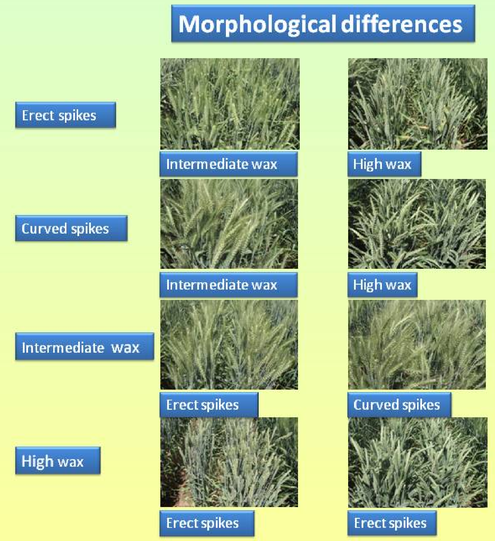
*,**Significant at the 0.05 and 0.01 probability level, respectively.

The water indices always gave a higher relationship with grain yield compared to the vegetative indices across two years when heading and grain filling measurements were combined and when all lines were compared without considering morphological effects (Table 1).

Table 2. Effect of morphological traits of spikes on the relationship between spectral reflectance indices and grain yield. Estimates were based on combined years.

Growth stage	Vegetative indices			Water indices	
	RNDVI	GNDVI	SR	NWI-1	NWI-3
	Leaf wax content				
Heading	0.67**	0.60**	0.54*	-0.82**	-0.80**
Grain filling	0.53*	0.40	0.44	-0.84**	-0.85**
Head-GF	0.62**	0.54*	0.57**	-0.85**	-0.85**
	Spike wax content				
Heading	0.70**	0.62**	0.62**	-0.81**	-0.81**
Grain filling	0.42	0.28	0.34	-0.82**	-0.86**
Head-GF	0.59**	0.46*	0.59**	-0.83**	-0.86**
	Leaf orientation				
Heading	0.78**	0.74**	0.74**	-0.82**	-0.72**
Grain filling	0.50	0.46*	0.55*	-0.42	-0.27
Head-GF	0.74**	0.72**	0.74**	-0.73**	-0.52*
	Spike orientation				
Heading	0.58**	0.57**	0.60**	-0.79**	-0.79**
Grain filling	0.31	0.17	0.27	-0.77**	-0.63**
Head-GF	0.48*	0.38	0.52*	-0.77**	-0.73**
	Awns on spikes				
Heading	0.63**	0.55*	0.55*	-0.65**	-0.63**
Grain filling	0.35	0.32	0.34	-0.57**	-0.48*
Head-GF	0.55*	0.48*	0.54*	-0.61**	-0.56**

*,**Significant at the 0.05 and 0.01 probability level, respectively.



Discussion

According to our results, leaf and spike wax content had lower influence on the relationship between SRI and grain yield (Table 2). Leaf orientation increased the same relationship for the vegetative indices, while decreased it for the water indices. The spike orientation (erect and curved) decreased the association between the vegetative indices and grain yield (Table 2). The same kind of reduction happened with the water indices and grain yield.

One of the major effects were obtained for the presence of awns over the relationship between SRI and grain yield. Vegetative and water indices reduced their association with grain yield.

Conclusions

The vegetative and water indices are negatively affected by the spike orientation and by the presence of awns. Leaf orientation inversely affected the vegetative indices and water indices. Spike and wax content did not show great effects.

References

- Lillesand T.M. *et al.* (2004) Remote sensing and image interpretation. J. Wiley & Sons, Inc. 763 p.
- Datt B. (1998) Rem. Sens. Environ. 66: 111-121.
- Wiegand C.L. et al., (1991) Rem. Sens. Env. 35: 105-119.