Weed-crop competition and the effect on spectral reflectance and physiological processes as demonstrated in maize

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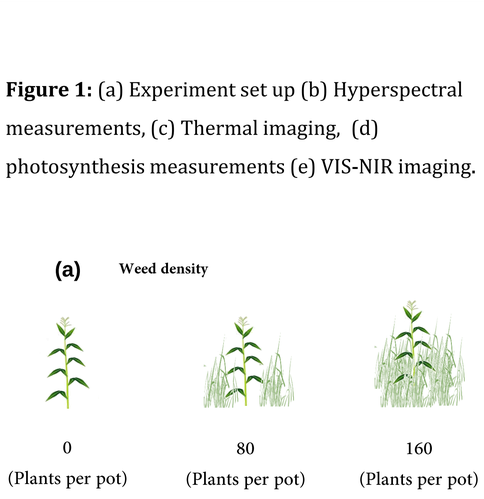
BACKGROUND & OBJECTIVE

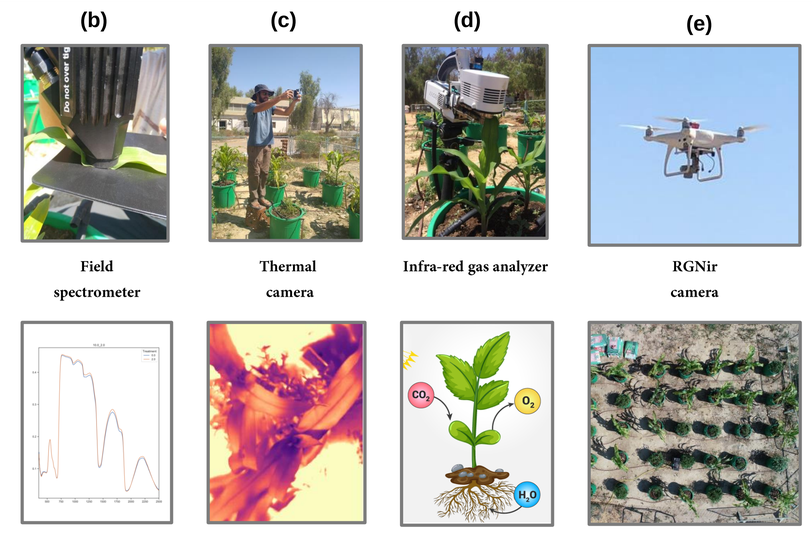
Weed interference is a major problem affecting food production. Understanding the spectral characteristics of this type of stress is a basic step in advancing precision agricultural technologies for managing weeds in agricultural fields. Weed competition with corn leads to different symptoms such as changes in pigment content, stomata closure, reduced photosynthesis, and changes in leaf biochemistry. Physiological symptoms can be detected by different sensing methods such as hyperspectral measurements and thermal imaging. Thus, the objective of this research is to characterize the physiological aspects and spectral features that are related to weed interference during early growth stages.

MATERIALS & METHODS

- A field experiment was conducted in the Sede-Boker Research Center for Desert Studies. Corn crops were examined during early growth stage with three different weed densities , and eight repetitions for every treatment (Figure 1a).
- The Corn's hyperspectral reflectance was measured at the leaf level by a field spectrometer-ASD FieldSpec Hires -4 (Figure 1b), IR images were acquired with a handheld thermal camera -Flir T6xx (Figure 1c) , photosynthesis measurements were taken using an infrared gas analyzer- Licor-6800 (Figure 1d) ,multispectral VIS-NIR images were captured by a camera mounted on a UAV- DJI (Figure 1e).

Figure 1: (a) Experiment set up (b) Hyperspectral measurements, (c) Thermal imaging, (d) photosynthesis measurements (e) VIS-NIR imaging.





RESULTS

- Regression analysis with planned contrasts, of each wavelength independently was used to analyze the spectra . The analysis revealed significant four ranges in the SWIR that were significantly affected by each treatment (Figure 2) . The average reflectance measured in those regions was consistently higher for the weed free corn, comparing to the other treatments, with the lowest reflectance values observed for the high density (Figure 3).
- Regression analysis of the gas exchange measurements acquired by the IRGA shows significant differences in photosynthesis rate (Figure 4a) and intercellular CO_2 concentration (Figure 4b), between the high weed density and the weed free corn. The effect on the corn's stomata conductance was not significant (Figure 4c).
- Weed free corn was significantly higher than weed treated corn (Figure 4d).
- The differences in canopy temperatures extracted from the thermal images were not significant (Figure 4e).
- Commonly used spectral indices were analyzed, and only the PRI index was significantly effected by the treatment (Figure 4f).

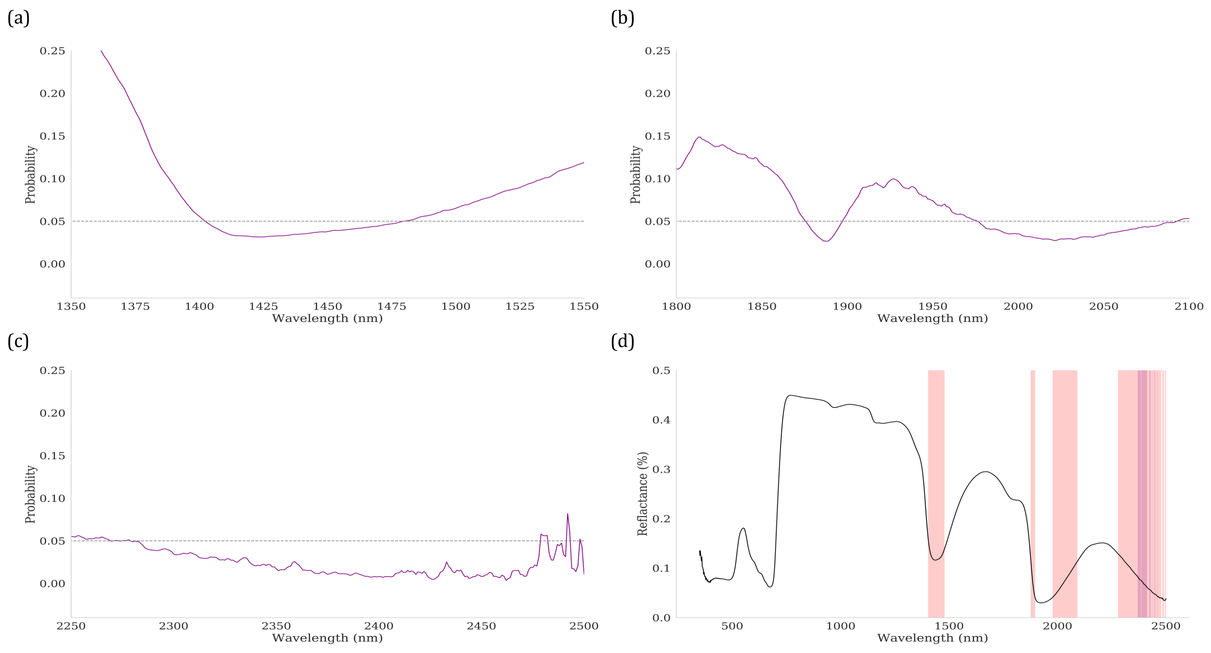
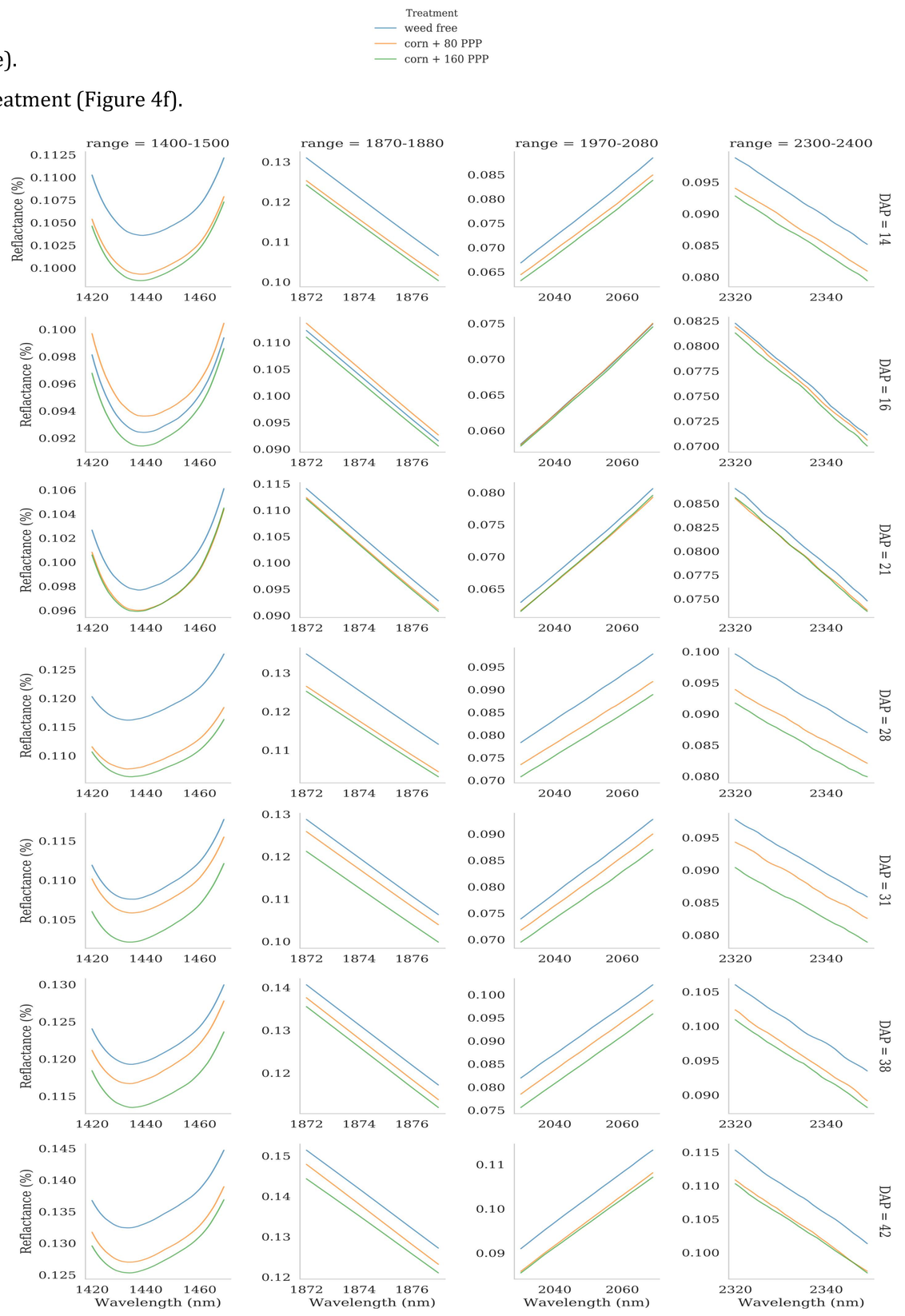


Figure 2: Regression analysis of the spectra- Differences between $R_{1350} - R_{1550}$ (a), $R_{1800} - R_{2100}$ (b) $R_{2250} - R2500$ (c). Y axis represents the probability for type I error, horizontal dashed line showing 95% confidence limit. pink regions represents significant differences between the weed free corn and the high density treatment, purple regions represents differences from the medium density treatment found by planned contrasts.



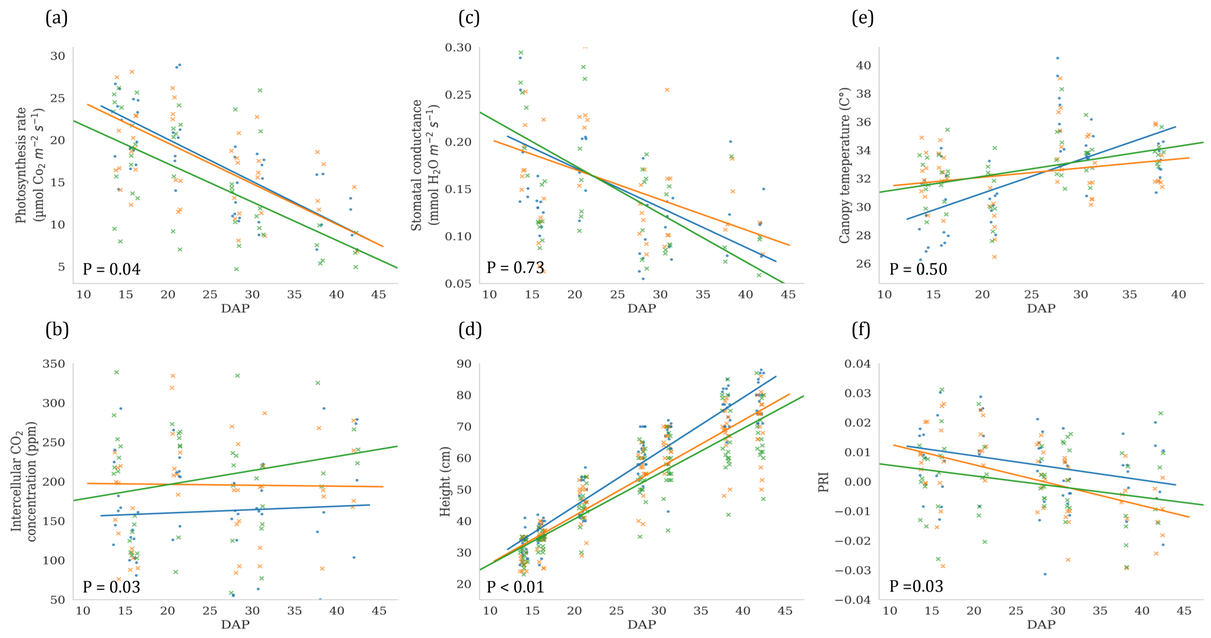


Figure 4: Regression analysis of the gas exchange measurements (a,b,c), corn's height (d) canopy temperatures extracted from the thermal images (e) and PRI index values (f)

Figure 3: Consistent reflectance trend in the SWIR- mean reflectance in spectral regions that were significantly affected by the treatment on different days during the experiment.

DISCUSSION & CONCLUSIONS

- Significant differences were found in the SWIR region that are associated with changes in leaf water content. The results indicate a consistent trend of deeper absorption in the water absorption bands (~1400nm, ~2400nm) for the weed treated corn.
- As expected, photosynthesis rate was lower for the high density weed treated corn. The high intercellular CO_2 concentration and non- significant difference in stomata conductance and canopy temperature indicates that differences in photosynthesis do not result from water stress.
- The combination of the above findings led to the assumption that other SWIR related biochemical compounds and not necessarily water, are the cause for the observed difference between the treatments. **Lignin** was suggested as a possible biochemical candidate, as it was previously shown to accumulate in the presence of weeds due to changes in light quality, and has absorption bands at the same regions that were found significant
- SWIR reflectance, together with the PRI index that was also significantly effected by the treatment, suggests that hyperspectral measurement possess the potential to detect physiological processes related to plants interaction, and may be beneficial for agricultural and research application in these context.