Bulgarian Journal of Agricultural Science, 30 (No 6) 2024, 1136–1140

A drone-based study on the possibilities of agricultural crop assessment using reflectance index in NIR

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Abstract

Atanasov, A. (2024). A drone-based study on the possibilities of agricultural crop assessment using reflectance index in NIR. *Bulg. J. Agric. Sci., 30*(6), 1136–1140

Through the reflective vegetation indices to assess plant stress, we can accurately determine the condition of the crops and plan the necessary actions. The research aims to evaluate the performance of the NIRI (Near InfraRed Index) index using a NIR camera mounted on a drone. The vegetation index NIRI compared to NDVI was studied. The results show good estimation capabilities and similar trends of change. The results of regression analysis of the relationships between NDVI and NIRI for wheat crops are Multiple R = 0.979; R Square = 0.959.

Keywords: NDVI; NIR; NIRI; vegetation indices

Introduction

This study aims to compare the applicability of the NIRI (Near InfraRed Index) reflectance index, which provides the derivation of biophysical parameters for the needs of precision agriculture. Various indices have been developed to monitor a variety of vegetation estimates under all conditions (Bannari et al., 1995). Various physical effects that influence the correct measurement of the sensor, for example: atmospheric disturbances and effects (Myneni et al.,1994), topographical features (Burgess et al., 1995), the optical properties of soil (Baret et al.,1993), specific sensor characteristics (Teillet et al.,1997). Also, saturation and linearity problems (Huete, 1988). A study of UAV NIR reflectance over barley was done by (Bendig et al.2015). The possibility of recording areas of crop damage by birds was investigated (Louhaichi et al. 2001). Accordingly, these factors increase or decrease light reflections in the red and near-infrared spectral bands, making it difficult to detect changes in vegetation. This can cause errors in the interpretation and analysis of the results. The sensitivity of sensors to the amount of chlorophyll and its effect on reflectance was investigated by (Vincini et al.2008). Hyperspectral imagery with improved band correction for classification of different agricultural crops used (Yang et al. 2008), and a two-band index (Zhangyan et al. 2008). Most of these problems can be corrected in remote sensing images by calibrating them to the conditions at the time of measurement or field measurements prior to the derivation of vegetation indices.

The working hypothesis is that: 1) the NIRI vegetation index proposed by the author can be generated by an RGN camera mounted on a drone; 2) the NIRI vegetation index gives correct information about the trends of change in the vegetation of agricultural crops.

Material and Methods

DVI-index is obtained by subtracting the red reflectance from the near-infrared reflectance. It is simplified in contrast to the NDVI-index, but is prone to measurement errors in Near Infrared (NIR) and Red (R) light because their sum is not normalized. The range of this index is infinite and the index is given in equation (1):

DVI = NIR – R (1)

NDVI – normalized difference vegetation index. It characterizes the density of vegetation, growth, the presence of diseases, forecasting yields. The indices are generated by taking pictures of green vegetation that absorbs electromagnetic waves in the visible red range and reflects them in the near infrared range. The red region of the spectrum (0.62 – 0.75 μm) accounts for the maximum absorption of solar radiation by chlorophyll, and the near infrared region (0.75 – 1.3 μm) the reflection in healthy plants is strong and in the presence of pathogens or desiccation falls to values of the red spectrum.

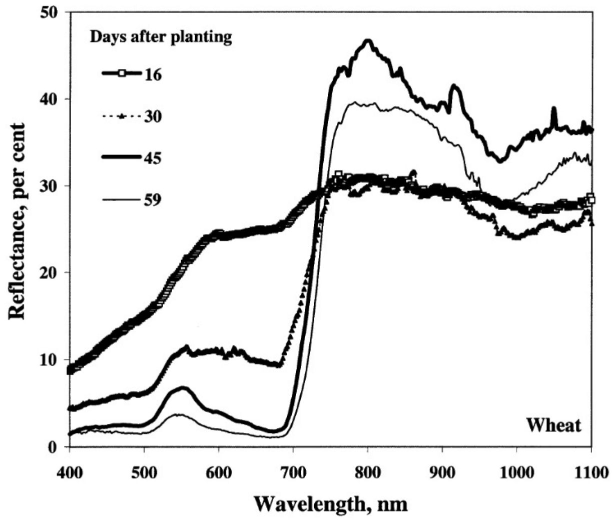


Fig. 1. The reflection spectrum during wheat vegetation [Gitelson et al., 2002]

NDVI = (Rn −Rr)/ (Rn + Rr) (2)

NDVI values are most accurate in the middle of the season, during the active growth stage of the crop (Rouse et al., 1974).

NIRI. The reflection spectrum studied by Gitelson et al. (2002). Figure 1 shows several times greater reflection of solar radiation in the NIR spectrum than the red values. This gives accurate information about the vegetation processes and the stage of development in agricultural crops. Tracking the difference between infrared and red radiation allows determining the state of the vegetation cover. To reduce the soil reflectance error, the sum of the red and green spectra is used. We can track the status of agricultural crops with the following formula:

NIRI = Rn/(Rr+Rg) (3)

The results were obtained from a survey of agricultural crops in the region of southern Dobrudja – Bulgaria with coordinates (43.548448, 27.757426 Dobrich region), (43.553364, 27.831652 Dobrich town), (43.658571, 28.025060 G. Toshevo town) (Figure 2). The shooting was done with a MAPIR Survey3W camera mounted on a DJI mavic 2 pro drone. The camera captures R – red, G – green and N – infrared light. The research was conducted at a height of 100m. Horizontal flight speed 10 m/s and overlap of 80%. The results were processed with Pix4Dmapper software.

Results and Discussion

For the needs of precision agriculture, the agrarian climatic features of the observed fields were analysed. A con-

Fig. 2. Place of experiment

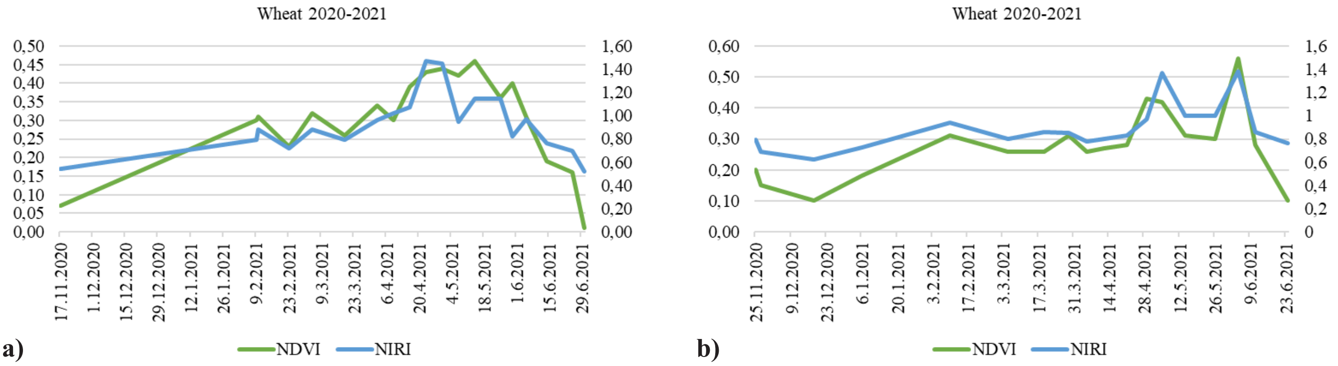
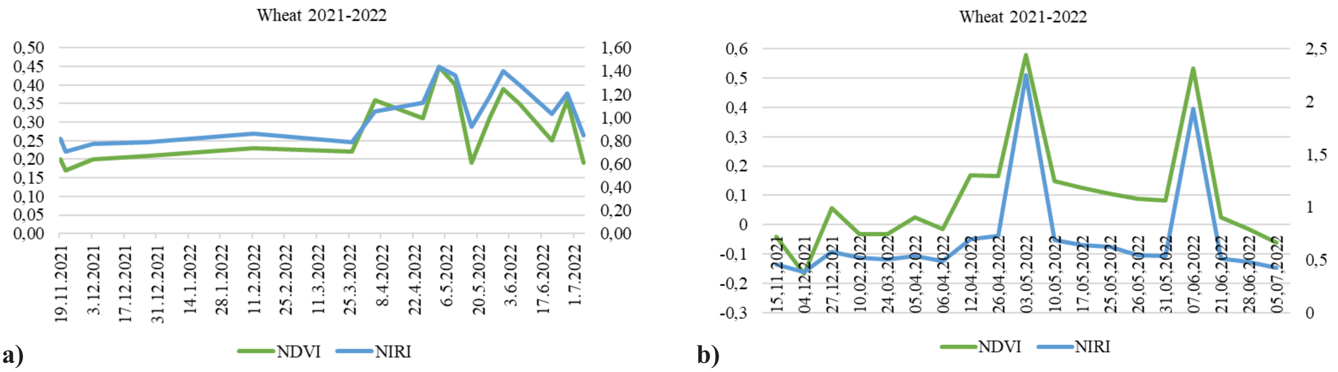


Fig. 3. NDVI and NIRI indices of wheat fields in 2020-2021 in G. Toshevo (a) and Dobrich (b)

nection was made between the obtained results and the generated vegetation indices. The most used vegetation index NDVI was compared with the proposed NIRI.

High temperatures during the winter months of 2020 favour fraternization. 2021 started with very warm January and February. March had a negative monthly anomaly. April was the coldest since 2003, with late spring frosts. May and June had small positive anomalies, but July and August were significantly warmer than normal. This corresponds to the trends of change of NDVI for a field with wheat in the town of General Toshevo (Figure 3a) and then with wheat in the town of Dobrich (Figure 3b). We have a very similar trend line in the NIRI index.

The winter of 2021-2022 has less precipitation than last winter 2020-2021. January is relatively dry as well as February. December 2021 is the wettest December since 2015. January 2022 has less precipitation than last January, and February 2022 has more precipitation than last February. The end of December and the beginning of January and the middle of February stand out as the relatively warmest pe-



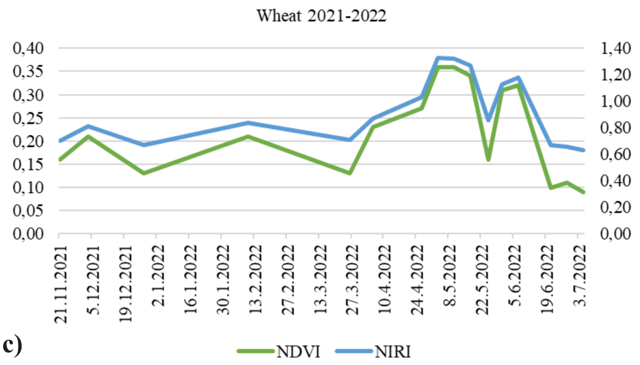
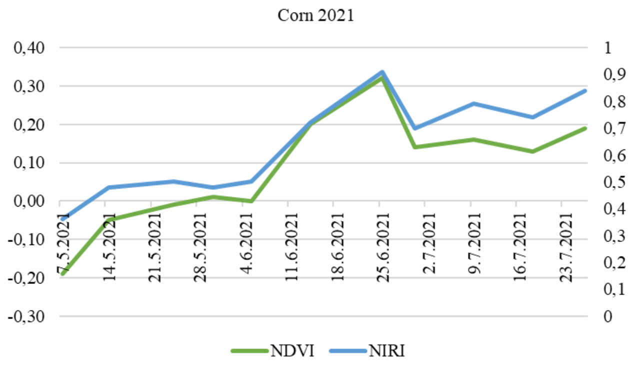
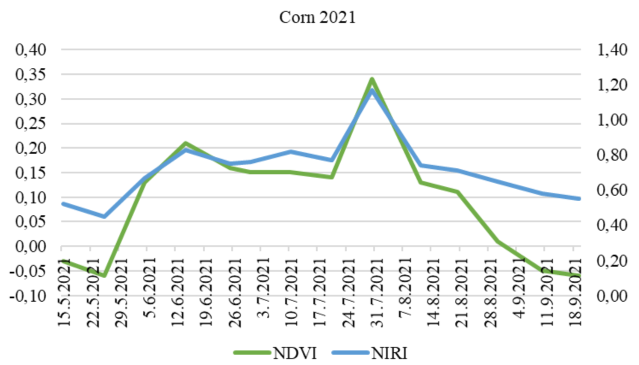


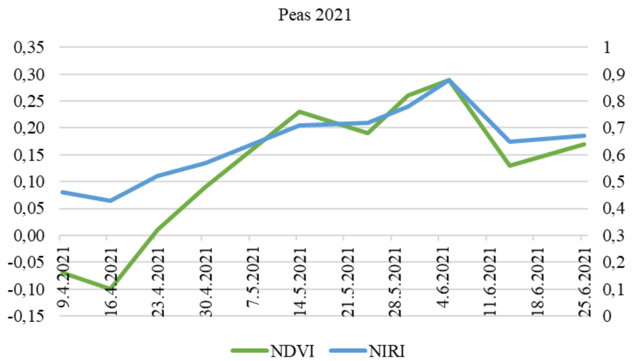
Fig. 4. NDVI and NIRI indices of wheat fields in 2020-2021 in G. Toshevo (a); Dobrich (b); Dobrich region (c)



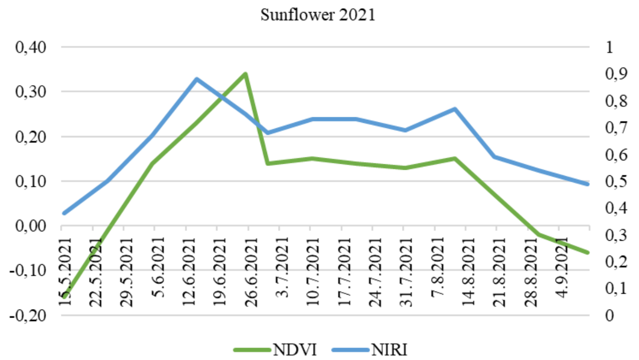
a) corn, town of G. Toshevo



b) corn, Dobrich region



c) Peas, G. Toshevo



d) Sunflower, Dobrich region

Fig. 5. NDVI and NIRI index for corn, peas and sunflower

riods, and the middle of December, the end of January and the last days of February as the relatively coldest. All three winter months are relatively warm, but to a lesser extent than the months of the previous two winters (NIMH, 2023). The change trends of NDVI and NIRI indices for 2021-2022 are shown in Figure 4. Although with different numerical values, the change curve is similar.

The variation of NDVI and NIRI for corn, pea and sunflower is shown in Figure 5. Many similar trends are reported.

The results of a regression analysis of the relationships between NDVI and NIRI for the 2020-2021 wheat crops are Multiple R = 0.979; R Square = 0.959; for 2021-2022 are Multiple R = 0.945; R Square = 0.894. For corn, Multiple R = 0.958 is obtained; R Square = 0.918. For sunflower, Multiple R = 0.911 is obtained; R Square = 0.83.

Comparing the two indices, they have similar trends. The established maximum NIRI value is 1.5. Theoretically, it can change to larger values compared to the reflected infrared light. From the study of Gitelson et al. (2002), we consider that a value of 5 is possible according to the conditions studied by the author.

Conclusion

The obtained results show the possibility of using a camera with RGN spectrum mounted on a UAV to determine the trends in the change of vegetation processes by means of NDVI and NIRI vegetation index.

The results show a very good dependence on agro-climatic conditions. The general change trends of the two indices makes it possible to use each of them for monitoring agricultural areas.

The defined NIRI index can be used to determine trends in changes in vegetation processes in agricultural crops.

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Received: **March, 07, 2023**; *Approved*: **July, 01, 2023;** *Published:* **December, 2024**