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Unmanned drone multispectral imaging for assessment of wheat and oilseed rape habitus

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Abstract

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The use of unmanned drones has been increased in precision farming. From multispectral images of terrain and crops to spraying and sowing, their application and development is becoming more and more popular in the public sector. Using different sensors and equipment farmers could take optimal management decisions.

The aim of the present study is to analyze the data from a multispectral camera, to survey the development of the crops on the field, to perform an agronomic assessment and to make recommendations for optimization of the production by soil and plant sampling in order to increase yields and reducing the cost of production.

Effectiveness of multispectral observation methods on agricultural crops was tested at the end of October 2018 in a pilot study on the territory of Northern Bulgaria. First year results are the part of a planned long-term study to identify problem areas of the terrain by spectral analysis and additional sampling. Five channel multispectral camera Parrot Sequoia was applied on a DJI Matrice 600 Hexocopter. Observed crops were wheat and oilseed rape. NDVI method permitted us to identify areas with good crop development and area with poor vegetation status. Digital elevation models (DEM) were built for both studied areas. Fields area was divided on parts with NDVI higher than 0.7 and with NDVI with lower than 0.7 for optimal fertilizers application.

Keywords: Remote sensing; multispectral survey; NDVI index; DEM; crop habitus; wheat and oilseed rape

Introduction

Agricultural production is related to the solution of questions such as how to combine land, water, raw materials such as fertilizers and plant protection products, machinery and technologies to produce the maximum amount of food and fiber. Bulgarian farmers use conventional technologies related to the use of large quantities of artificial raw materials and preparations. Searching for optimization of applied raw materials in the field, improvement of yield and quality of production and preservation of the environment, some of the farmers are oriented towards precision farming. The use of unmanned drones has been increasingly used in precision farming. From multispectral images of terrain and crops to spraying and sowing, their application and development is becoming more and more popular in the public sector. Using additional sensors and equipment, technology helps farmers to take optimal management decisions. Remote sensing studies could be applied on a regional scale (Doumit & Kiselev, 2016). Depending on the validation dataset from satellites imagery and the study area, an overall accuracy of 74–95% was achieved after the crop type maps were post-processed by mode filtering (Vasilev, 2013; Vasilev, 2015; Gikov et al., 2019). NDVI index calculated from measurements of the reflected light from the red and near infrared bands, have long been used as indirect measurement of biomass and crop yield, including that of wheat (Kamenova et al., 2017).

Study on vegetation density expression in Normalized Difference Vegetation Index (NDVI) was carried out in Jeffara plain, Lybia. Correlation between vegetation density and NDVI had a coefficient of determination R^2=0.86 (Alia, Hallett, Brewer, 2018). Studies on relation between NDVI and wheat yields have found very close correlation between with coefficient of determination R^2=0.83 (Gonti, Tiwari, 2011). Study on oilseed rape showed that the estimation model using the normalized difference vegetation index (NDVI) with a power regression model performed best through the seasonal growth dynamics, with the highest coefficient of determination (R^2 = 0.77), the smallest root mean square error (RMSE = 104.64 g/m²), and the relative RMSE (rRMSE = 21%). It is concluded that the use of selected Vegetation Index and high spatial multiple satellite data can significantly estimate above ground biomass during the winter oilseed rape growth stages, and can be applied to map the variability of winter oilseed rape at the sub-field level under different waterlogging conditions, which is very promising in the application of precision agriculture (Han et al., 2017). NDVI index could be modified for obtaining better results in agricultural studies (Gitelson, 2004).

El Sheirbeny et al. (2014) found that Normalized Deference Vegetation Index (NDVI) is used to estimate crop coefficient according to satellite data (KcSat) through simple model (KcSat = 2NDVI – 0.2). Kc depends on stage of canopy height, crop growth, architecture and cover. Yield estimations models for wheat were elaborated on NDVI and SAVI indexes (Narendra & Tiwari, 2011). Soil environment circumstances are considerable influence on partial canopy spectra and vegetation index. Consequently, it is significant to monitor the vegetation vitality changes with reverence to the soil background circumstances (Sashikkumar et al., 2017; Vani & Venkata, 2017).

The aim of the present study is to analyze the data from a multispectral camera, to survey the development of the crops on the field, to perform an agronomic assessment and to make recommendations for optimization of the production by soil and plant sampling in order to increase yields and reducing the cost of production.

Material and Methods

Effectiveness of multispectral observation methods on agricultural crops was tested at the end of October in a pilot study on the territory of Northern Bulgaria. First year results are the part of a planned long-term study to identify problem areas of the terrain by spectral analysis and additional sampling. Observed crops were wheat and rapeseed.

The survey used a DJI Matrice 600 Pro Hexocopter with flight height of 120 m above ground. An aircraft was equipped with a 5-channel multi-spectral. The Parrot Sequoia camera has one 16 mpix RGB camera with 4608x3456 pixels definition and HFOV:63.9°, VFOV: 50.1°, DFOV: 73.5°. Four 1.2 mpix global shutter single-band cameras with 1280x960 pixels definition and HFOV: 61.9°, VFOV: 48.5°, DFOV: 73.7° for every of 4 separate bands Green (550 nm) Red (660 nm) Red Edge (735 nm) and near infrared (790 nm). The sunshine sensor of the camera removes the errors due to the changes of sun light intensity depending on the time and cloud intensity Orthophoto maps are generated with the software product Pix4D and QUANTUM GIS.

The results of the field survey are aerial photography from a multi-spectral camera, a digital terrain model, and a combined aero photomosaic. The total volume of raw and processed data is about 24 Gb for each of the terrains. The obtained and analyzed maps of the NDVI index are in a georeferenced TIFF format with a resolution of 15 cm per pixel.

Healthy plants generally have a higher reflectance in the near infrared area than diseased and stressed plants (Figures 1 and 2), which can be used to distinguish one from the other. In remote studies, the so-called Normalized Difference Vegetation Index (NDVI) which is a numeric indicator using the visible and near infrared areas of the electromagnetic spec-

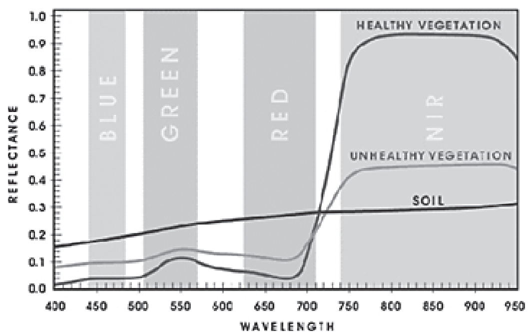

Fig. 1. Combined reflectivity of soil and vegetation. Note the difference in the near infrared range between the healthy and diseased vegetation curves (Barry Warzak, 2016)

trum for the analysis of vegetation and vegetation strength. Typically, healthy vegetation takes up much of the visible light that falls on it and reflects much of the nearby infrared area. Damaged or rare vegetation reflects more than visible light and less than the near infrared.

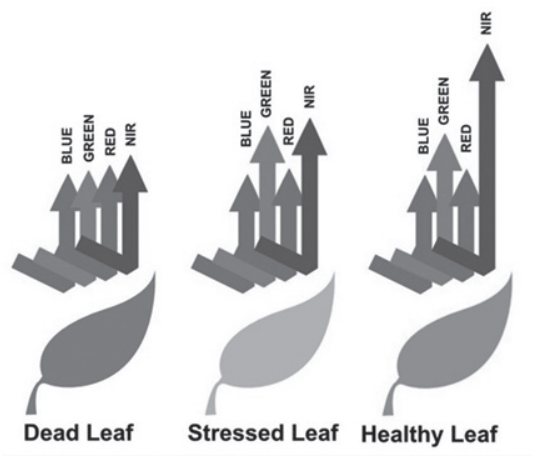

Fig. 2. Schematic presentation of the reflection ability of dead, stressed and healthy vegetation (Agribotix.com)

The traditional formula for NDVI compares Near Infrared (NIR) and Red (RED) light. It is great for measuring healthy, green vegetation over a wide range of conditions. Soil and dry plants have NDVI index less than 0.30. Healthy plants usually have NDVI index more than 0.75 (Agribotix.com, 2014; Alia et al., 2018; Han et al., 2017; Lillesand et al., 2015).

Image Color Summarizer 0.76 by Krzywinski (2020), from mkweb.bcgsc.ca was applied to determine the percentage of the area with NDVI higher than 0.7 and the area with NDVI less than 0.7

Results and Discussion

The first field is sown with wheat. The wheat stage was tillering. It is well-developed and garnished. The terrain can be divided into two main parts – Eastern and Western. In the East wheat is better developed. NDVI ranges from 0.7 to 0.8. The reason for this is both the plants density and the advancement in the development phase. The slope of the field varies from 113 to 143 meters n.m. and is a prerequisite for the development of erosion processes from West to East, according to the DEM (Figure 3). The erosion of soil materials, water and fertilizers movement accumulates nutrients and water in the East part of the field. This is also the main reason for the differences in wheat growing in both parts of

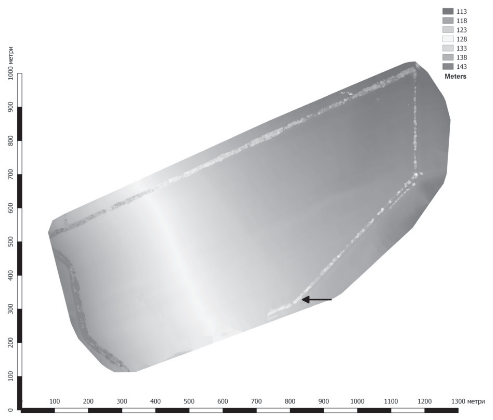

Fig. 3. Digital elevation model (DEM) of studied wheat field

the field. Sowing is done on the slope, which further enhances the erosion of the terrain. In the western part, the NDVI varies between 0.6-0.7. The value decrease is in the range of 0.1. The Image Color Summarizer application permitted us to determine the percentage of the area with NDVI higher than 0.7 and the area with NDVI less than 0.7. The area of the field with NDVI higher than 0.7 is 63.3% and the area with lower NDVI is 36.7%. It is expected that the yield in the part of the field with NDVI less than 0.7 will fall by about 20-30% in the case of one rate field fertilization. For precision fertilization before the spring vegetation of the crop, additional soil and plant samples should be taken to determine the required amount of nitrogen fertilizers (Figure 4).

The second field is sown with oilseed rape. The slope of the field varies from 103 to 127 meters n.m. and is a prerequisite for the development of erosion processes from East to

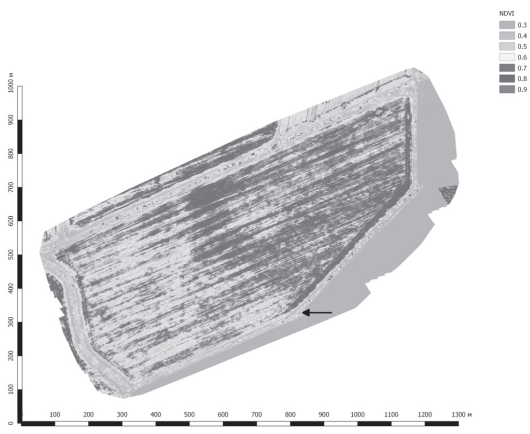

Fig. 4. NDVI map index on wheat filed

West, according to the DEM (Figure 5). The seeding is not with good quality due to poor sowing and pre-sowing preparation. NDVI of the culture is 0.8. The stage is rosette, 6 -7 leaves unfold. Lower values 0.6 to 0.7 correspond to poorly developed rape due to later germination or other causes (Figure 6). Where the harvester passes, and the straw has been poured out of the previous crop and some wheat is growing between rapeseed. An herbicide treatment killed this heat and along the filed yellow rows are observed. The presence of straw in the soil and a large quantity of wheat seeds has not allowed a good sowing and rape germination. These sites are identified with a NDVI value of 0.5-0.6.

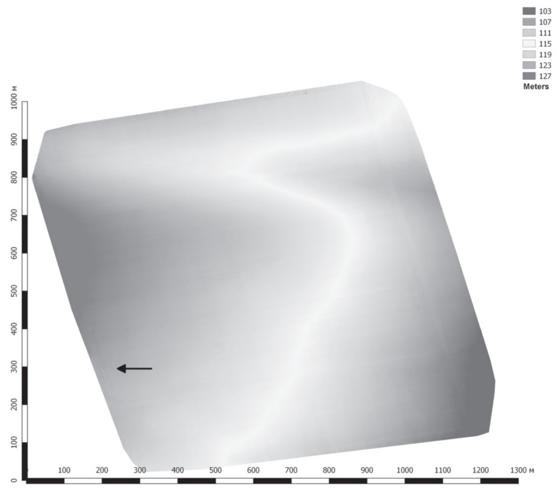

Fig. 5. Digital elevation model (DEM) of studied oilseed rape field

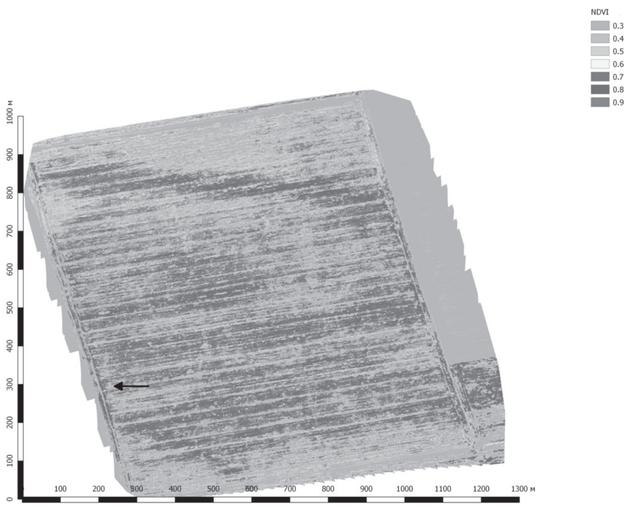

Fig. 6. NDVI map index on oilseed rape field

The field can be divided into two parts – smaller North and larger South. On the whole field there is a strong phosphorus deficiency, which is stronger in the North. Phosphorous deficiency has the character of spots or belts. The NDVI index drops sharply to 0.7. Rape plants are low and are lagging in their development. On the old leaves there is a bright pink-violet coloration. Unbalanced phosphorus malnutrition is due to the erosion processes of this field and to the appearing of lower soil horizons to the soil surface. Sowing is done along the slope, which further enhances the erosion of the terrain and flushing the profile.

Taking pictures of drones and multispectral camera can be of great help, and the test conducted clearly demonstrates it. Preventive actions can happen much earlier before crops are completely perishing and the problem is clearly visible with the naked eye.

The Image Color Summarizer application permitted us to determine the percentage of the area with NDVI higher than 0.7 and the area with NDVI less than 0.7 for the oilseed rape as well. The area of the field with NDVI higher than 0.7 is 58.1% and the area with lower NDVI is 41.9%. It is expected that the yield in the part of the field with NDVI less than 0.7 will fall by about 20-30% in the case of one rate field fertilization. Two different fertilisation rates are needed for precision fertilization before the spring vegetation of the crop based on additional soil and plant samples (Figure 6). Fertilisation must be done after separate soil sampling in both differentiated areas.

Conclusion

Taking pictures of drones and multispectral camera can be of great help, and the test conducted clearly demonstrates it. Preventive actions can happen much earlier before crops are completely perishing and the problem is clearly visible with the naked eye.

The wheat field has a NDVI higher than 0.7 on 63.3% of the area and has lower NDVI on 36.7% of the area.

The area of the field with NDVI higher than 0.7 is 58.1% and the area with lower NDVI is 41.9%.

It is expected that the yield in the parts of the fields with NDVI less than 0.7 will be lower about 20-30% than in another parts.

Separate soil sampling and variable rates of fertilizers are recommended in different field parts.

References

Agribotix.com (2014). Misconceptions about UAV-collected NDVI imagery and the Agribotix experience in ground truthing these images for agriculture https://agribotix.com/blog/2014/6/10/misconceptions-about-uav-collected-ndvi-imagery-and-the-agribotix-experience-in-ground-truthing-these-images-for-agriculture/

Alia Azalarib, S., Hallett, S. H. & Brewer, T. R. (2018). Using vegetation indices for the estimation and production of vegetation cover maps in the Jeffara Plain, Libya. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402, p- ISSN: 2319-2399. Volume 12, Issue 2 Ver. I (February. 2018), PP 23-28 www.iosrjournals.org

Doumit, J. & Kiselev, E. (2016). Comparison of Divert Vegetation Indices for Agricultural Mapping Over the Krasnodar Region. *Geo-sp Mag, 5 (15),* 11-20.

El-Shirbeny, M. A., Abd-Elraouf, M. A., Badr, M. A. &. Bauomy, E. M. (2011). Assessment of wheat crop coefficient using remote sensing techniques. *World Research Journal of Agricultural Sciences, 1(2),* 012-016, September, 2014. © ww.premierpublishers.org. ISSN: 2326-7266(2011) 39:27-37 DOI 10.1007/s12524-011-0065-7

Gikov, A., Dimitrov, P., Filchev, L., Roumenina, E. & Jelev, G. (2019). Crop type mapping using multi-date imagery from the SENTINEL-2 satellites. *Comptes rendus de l'Academie bulgare des Sciences*, *72 (6),* 787-795.

Gitelson, A. (2004). Wide Dynamic Range Vegetation Index for remote quantification of biophysical characteristics of vegetation. *Journal of Plant Physiology.* March, 2004. DOI: 10.1078/0176-1617-01176 ·

Gontia, N.K. & Tiwari, K.N. (2011). Yield estimation model and water productivity of wheat crop (*Triticum aestivum*) in an irrigation command using remote sensing and GIS. *Journal of the Indian Society of Remote Sensing* (March 2011) *39(1),* 27–37 DOI 10.1007/s12524-011-0065-7

Gontia, N. K., Kamlesh, N. &Tiwari, K. N. (2011). Yield estimation model and water productivity of wheat crop (*Triticum aestivum*) in an irrigation command using remote sensing and GIS. *Journal of the Indian Society of Remote Sensing, 39(1),* 27–37.

Han, J., Chuanwen, Wei, Ch., Chen, Y., Liu, W., Song, P., Zhang, D., Wang, A., Song, X.,, Wang, X. & Huang, J. (2017). Mapping above-ground biomass of winter oilseed rape using high spatial resolution satellite data at parcel scale under waterlogging conditions. Available. *Remote Sensing, 9(3),* 238. DOI: 10.3390/rs9030238

Kamenova, I., Filchev, L. & Ilieva, I. (2017). Review of spectral vegetation indices and methods for estimation of crop biophysical variables. Aerospace Research in Bulgaria. 29, 2017, Sofia; Bulgarian Academy of Sciences. Space Research and Technology Institute, 72-82.

Krzywinski, M. (2020). Image Color Summarizer 0.76 – mkweb.bcgsc.ca.

Lillesand, T. M., Keiefer, R. W. & Chipman, J. (2015). Remote sensing and Image Interpretation, 7ed. ISBN: 978-1-118-34328-9

Pôças, I., Paço, T. A., Paredes, P., Cunha, M. & Pereira, L. S. (2015). Estimation of actual crop coefficients using remotely sensed vegetation indices and soil water balance modelled data. *Remote Sens., 7,* 2373-2400; 2072-4292.

Sashikkumar, M. C., Selvam, S., Karthikeyan, N., Ramanamurthy, J., Venkatramanan, S. & Singaraja, C. (2017). Remote sensing for recognition and monitoring of vegetation affected by soil properties. *Journal Geological Society of India, 90,* 609-615.

Vani, V. & Mandla, V. R. (2017). Comparative study of NDVI and SAVI vegetation indices in Anantapur district semi-arid areas. *International Journal of Civil Engineering and Technology (IJCIET), 8 (4),* 559–566.

Vassilev, V. (2013). Crop investigation using high-resolution Worldview-1 and Quickbird-2 satellite images on a test site in Bulgaria*. Aerospace Research in Bulgaria, 25*, 154–171.

Vassilev, V. (2015). Crop identification mapping on the arable territory of Bulgaria using multi-temporal 100 m PROBA-V NDVI data for 2014, *C. R. Acad. Bulg. Sci., 68(6),* 761–766.

Warzak, B. (2016). Dual-bandpass filters, low-cost digital color cameras and new software make imaging applications more affordable. http://www.vision-systems.com/articles/print/volume-21/issue-10/features/dual-band-filters-target-price-sensitive-applications.html

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