Gradus Vol 10, No 2 (2023)
ISSN 2064-8014

EXAMINATION OF VEGETATION INDICES BASED ON MULTITEMPORAL DRONE IMAGES

Berzéki Marcel [0009-0007-1564-1985*], *Kozma-Bognár Veronika* [0009-0006-3150-8327] *and Berke József* [0000-0002-0190-4197]

Gábor Dénes University, Budapest
https://doi.org/10.47833/2023.2.AGR.002

Keywords:
Vegetation indices
Multitemporal
VIS Vegetation index
Unmanned Aerial Vehicles
Remote Sensing

Article history:
Received 15 October 2023
Revised 20 October 2023
Accepted 30 October 2023

Abstract
In Hungary, the use of drones (UAV) has been showing an increasing trend over the past few years. The available UAV's and the camera systems placed a significant influence and, in some cases, can even limit, their effective and reliable - also appropriate from the data security point of view - application in the assessment of plant growing areas. In addition to the generation of the data, the extractable information content of the produced visual and non-visual data can also be greatly influenced by the processing and analysis methods.
During our research, we took multitemporal aerial photographs of winter wheat at different times of the vegetation period. In our article, we will present our results for the NDVI, GNDVI, and VDVI vegetation indices, which include the processing of aerial photographs taken with two different UAVs, highlighting our analyses of the correlations between the discrete and non-discrete bands of the aerial photographs.

1 Introduction

In this article briefly present how a farmer can use cost-effective methods to make sure that the vegetation indices recorded with an UAV (Unmanned Aerial Vehicles) help his daily activities and if so, in which areas.

In many cases, the ready-made solutions available on the current market require significant investment/resources. Since this technology is less common in Hungary, the number of references that could facilitate farmers in making this decision is small.

UAV have revolutionized remote sensing for monitoring vegetation health and growth. These drones are equipped with advanced sensors, including multispectral and thermal cameras, allowing them to capture detailed data on plant characteristics [2].

Wang Xiaoqin et al. published a paper in 2015 where the authors used unmanned aerial vehicles (UAVs) to obtain high-resolution images of vegetation and extract vegetation information. They analysed the spectral characteristics of vegetation and non-vegetation in UAV images that only contained red, green, and blue bands. The authors used a bimodal histogram and histogram entropy threshold method to determine the threshold value of each vegetation index. They reported that their method had a high accuracy for extracting vegetation information from UAV RGB images [5].

Nowadays, the importance of data security is emphasized on various forums which is also of key importance in the field of agriculture, since we publish data on the value and yield of the agricultural land on the world wide web. In many cases, farmers unknowingly do not use legitimate software. In many cases, they have no resources and use cloud-based processing, which can be critical from the point of view of data security and information security.

The primary objective of the research was to ascertain whether the lower-cost cameras [3] available on the market provide reliable results, thereby providing the economic and preventive benefits that UAVs can give for small farmers and to assess the reliability of the data provided by different camera systems during the entire growing season.

*Corresponding author: Berzéki Marcell
E-mail address: mberzeki@gmail.com

2 Material and methods

The multispectral/multitemporal [2] measurements were conducted on winter wheat field, following the entire vegetation period. Aerial photography was carried out in one region in Hungary, Lengyeltóti, using two different UAV's; a DJI MAVIC 2 Pro equipped with MAPIR Survey 3 RGN camera and the professional DJI MAVIC 3 M with Multispectral camera from early March till mid-July 2023.

Vegetation indexes like NDVI (Normalized Difference Vegetation Index), GNDVI (Green Normalized Difference Vegetation Index), and VDVI (Visible Difference Vegetation Index) are derived from this data.

- NDVI assesses overall vegetation health by measuring the difference between near-infrared and red-light reflectance. Higher NDVI values indicate healthier and denser vegetation. It is widely used for crop monitoring, forest health assessment, and land-use planning [1].
- GNDVI, like NDVI, focuses specifically on the green part of the spectrum. It is effective for assessing vegetation health in areas with dense canopies and is less influenced by soil background. GNDVI is valuable in agriculture for detecting early signs of stress in crops. [4]
- VDVI, which stands for Visible Difference Vegetation Index, is used to generate a vegetation index that can be compared with the more precise NDVI. VDVI measures the difference in reflectance in the visible spectrum, using red, green, and blue bands of light. Here usual RGB cameras can be used [5].

The aerial photos were processed using several different software, creating evaluation dataset. The flight routes were planned with the DJI GS Pro software to ensure that we always fly the same route on same altitude. The collected VIS images were processed for noise filtering, vignetting with the DXO PhotoLab 5. As the raw MAPIR camera images, cannot be used directly downloaded from the camera it needed to be processed with its own software (MAPIR Camera Control Version 10/16/2019). To align, create a point cloud, texture fitting, as well as preparing the orthophoto Agisoft Mateshape Professional Version 1.6.4 build 102928 (64 bit) were used. For the calculation of the vegetation indices, the freely available QGIS 3.26.3-Buenos Aires (64 bit) version were used.

3 Results

In the following visual comparison of the two systems; Mavic 3M, discrete (band1: 560 ± 16 nm, band2: 650 ± 16 nm, band3: 730 ± 16 nm and band4: 860 ± 26 nm) and Mavic 2Pro with MAPIR Survey 3 RGN as non-discrete camera will be presented by the different indices with the comparison of the visual aerial images (Figure 1,2).

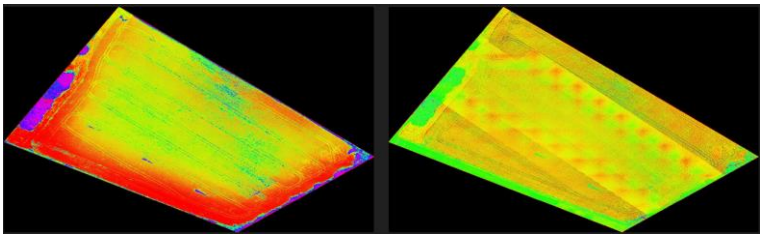


Figure 1. NDVI image of the discrete bands on the left and the non-discrete bands on the right side in the end of the vegetation period, on visual examination, no real similarities

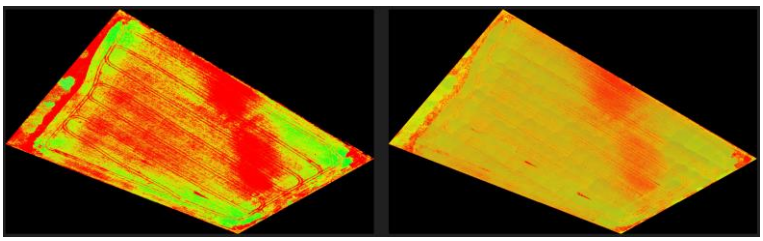


Figure 2. GNDVI image of the discrete bands on the left and the VDVI image non-discrete bands on the right side in the end of the vegetation period, slight similarities

3.1 NDVI discrete and NDVI non-discrete comparison

Below the NDVI, Normalized Difference Vegetation Index comparison of the two systems shows that the indices are in the same range, very low relation between the acquired data (Figure 3,4).

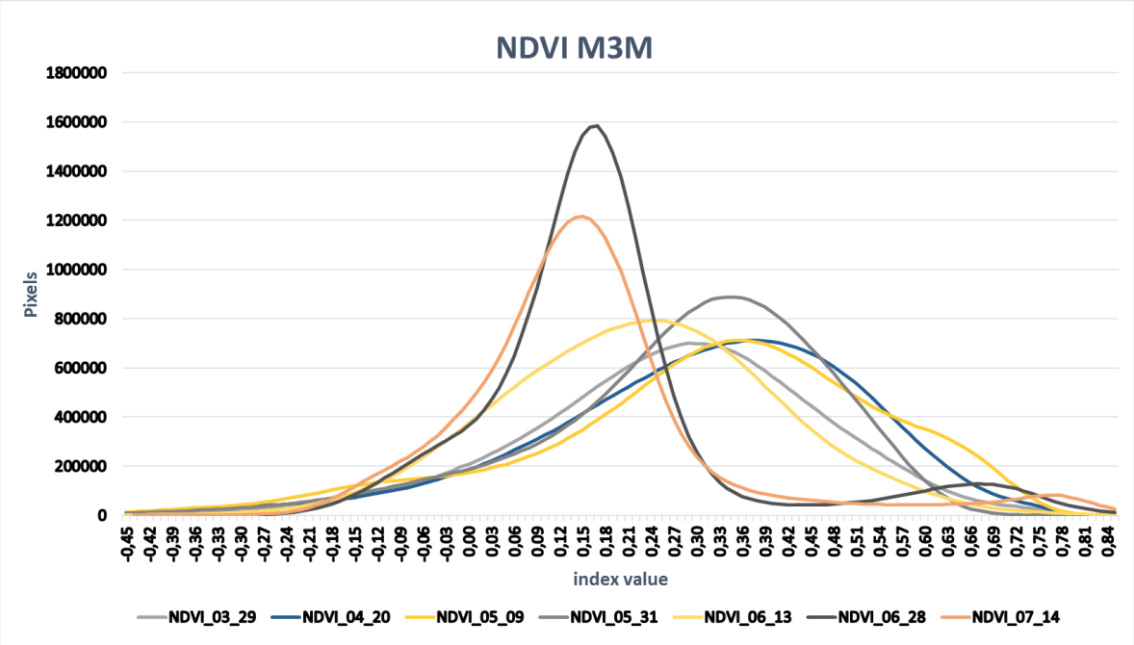


Figure 3. NDVI curves of the discrete system Mavic 3M, during the vegetation period

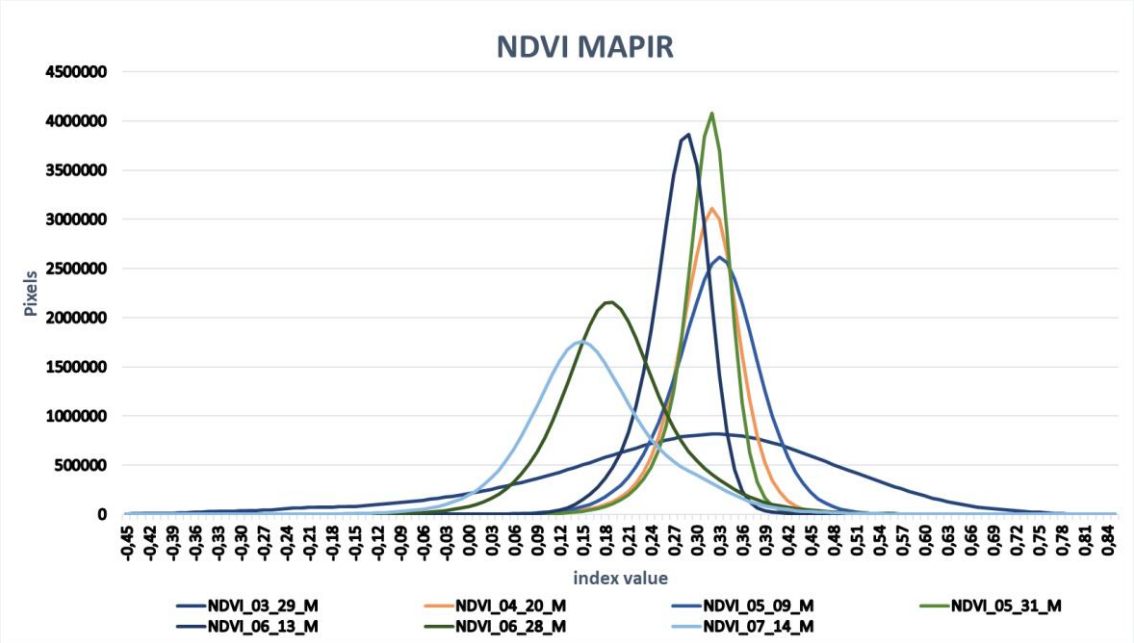
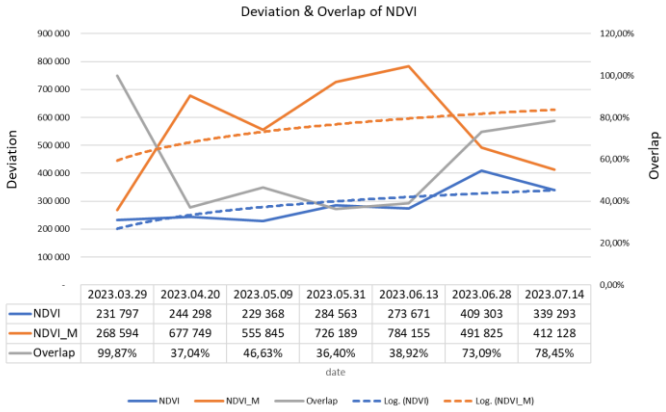


Figure 4. NDVI curves of the non-discrete system MAPIR Survey 3 RGN during the vegetation period

To measure the relation between the two dataset a Deviation and Overlap values were compared, it shows a high rate of fluctuation, data of Mavic 3M shown as NDVI, and MAPIR system is marked with NDVI_M (Figure 5).



	2023.03.29	2023.04.20	2023.05.09	2023.05.31	2023.06.13	2023.06.28	2023.07.14
NDVI	231 797	244 298	229 368	284 563	273 671	409 303	339 293
NDVI_M	268 594	677 749	555 845	726 189	784 155	491 825	412 128
Overlap	99,87%	37,04%	46,63%	36,40%	38,92%	73,09%	78,45%

Figure 5. NDVI value Deviation & Overlap between the two systems during the vegetation period

The weakness of the non-discrete band system is clearly shown here, in the middle of the vegetation period, which can be paralleled by the overlap of the area under the curves. The standard deviation is large, the overlap also decreases significantly in this case.
The first alternative, the data provided by the MAPIR Survey 3 RGN non-discrete system, can be useful to a farmer in the case of NDVI indices at the beginning and end of the vegetation season (~80% overlap), in the middle of the growing season (~40% overlap) he can only get approximate data, if he choose is a low-budget solution.

3.2 GNDVI discrete and GNDVI non-discrete comparison

The GNDVI, Green Normalized Difference Vegetation Index comparison of the two systems shows very low relation between the acquired data, maximum Overlap approx. 6% (Figure 6).

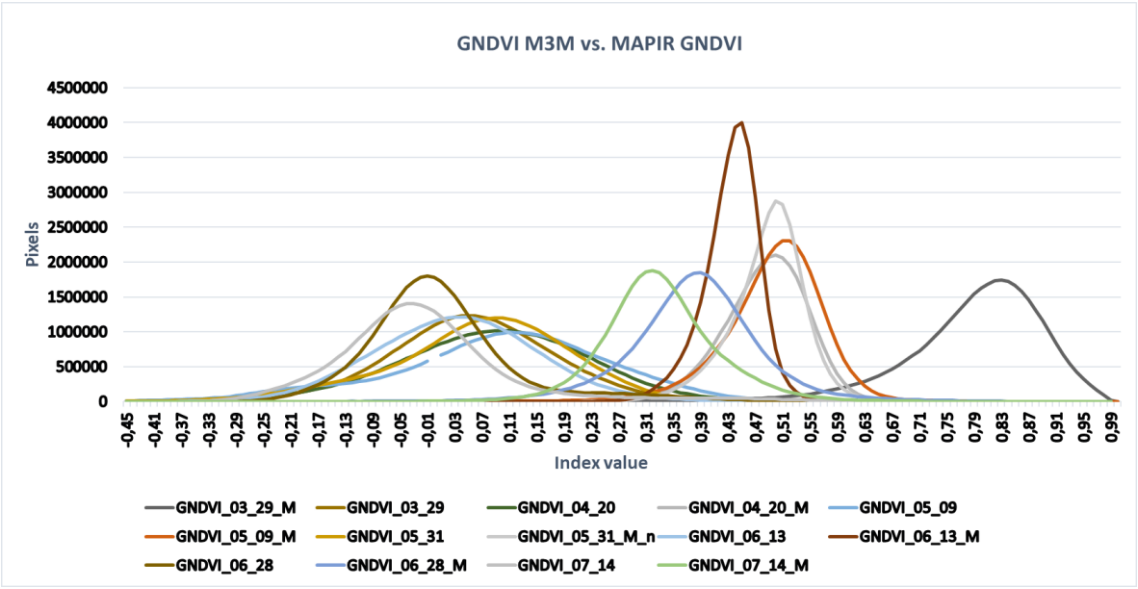


Figure 6. GNDVI curves of the discrete and non-discrete camera systems during the vegetation period

3.3 GNDVI discrete and VDVI non-discrete comparison

By examining the relationship between the discrete-band GNDVI index and the non-discrete-band VDVI index, which were recorded by the drone's RGB camera a surprise appeared, there was a correlation, since they are in the same range and the overlap of the areas under the curves were over 80% in the entire range of the vegetation period. This is much higher than in the case of the NDVI indices when examining the non-discrete and discrete bands (Figure 7,8).

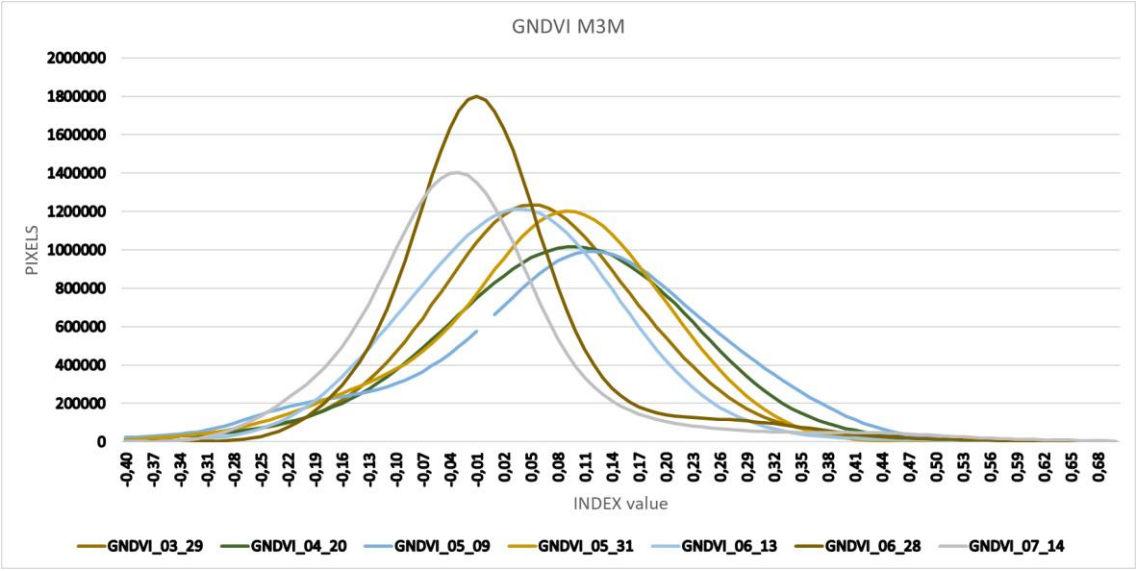


Figure 7. GNDVI curves of the discrete system Mavic 3M, during the vegetation period

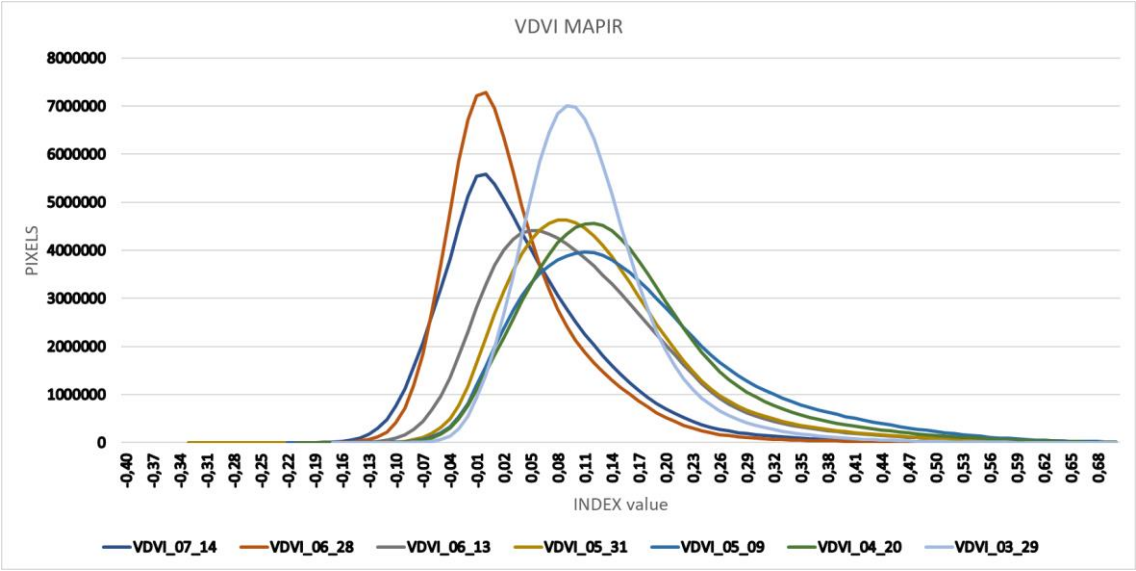
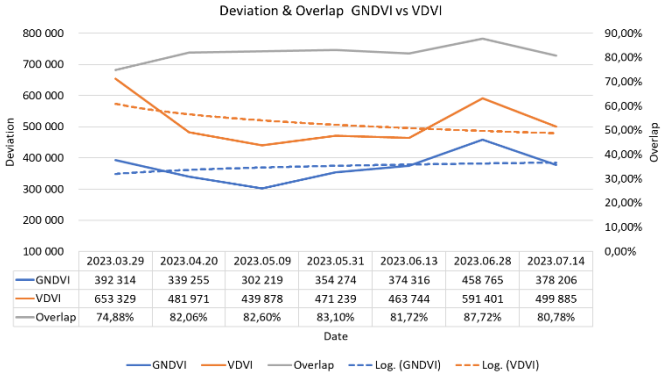


Figure 8. VDVI curves other non-discrete system MAPIR Survey 3 RGN during the vegetation period

The Deviation and Overlap values examination were compared, it shows a high rate of correlation, data of Mavic 3M shown as GNDVI, and MAPIR system is marked with VDVI (Figure 9).



	2023.03.29	2023.04.20	2023.05.09	2023.05.31	2023.06.13	2023.06.28	2023.07.14
GNDVI	392 314	339 255	302 219	354 274	374 316	458 765	378 206
VDVI	653 329	481 971	439 878	471 239	463 744	591 401	499 885
Overlap	74,88%	82,06%	82,60%	83,10%	81,72%	87,72%	80,78%

Figure 9. GNDVI vs VDVI value deviation and overlap between the two systems during the vegetation period

The course of the curves of the standard deviation values is similar, and their trend lines are somewhat coherent. The real surprise is that the overlap area of curves is almost always over 80%! In one case, it is close to 90%.

4 Conclusion

By the NDVI indices the conclusion can be drawn from the data provided by the MAPIR Survey 3 RGN non-discrete system, can be used by the farmers at the beginning and end of the growing season with ~80%reilability, in the middle of the growing season already relatively low ~40% reliability. Here only approximate data can be extracted with is a low-budget solution.
The GNDVI indices, the results shows that the discrete and non-discrete bands are in a completely different range. Here, the common area under the curves generally does not reach 6%, so the non-discrete band system are NOT suitable for GNDVI indices.
The VDVI indices based on results, although the processing time and amount of data is much more in the case of the VDVI index, it nevertheless shows more than 80% similarity with the data of the discrete band system, therefore, considering the data from this survey, it can be concluded that the VDVI index may be suitable to replace the GNDVI index.

5 Acknowledgment

Project no. TKP2021-NVA-05 has been implemented with the support provided by the Ministry of Innovation and Technology of Hungary from the National Research, Development and Innovation Fund, financed under the TKP 2021 funding scheme.

6 References

[1] Berke J. , Báldoghi T. , Major K. , Kozma-Bognár V. (2017): Képalkotó algoritmusok NDVI indexre gyakorolt hatása. VIII. Térinformatikai Konferencia és Szakkiállítás, Debrecen, Volume 8., pp. 51-56.
[2] Berke J. , Enyedi A. , Vastag V. , Óbermayer T. , Kozma-Bognár V. (2018): Képalkotó algoritmusok vizsgálata idősoros NDVI felvételeken. IX. Térinformatikai Konferencia és Szakkiállítás, Debrecen.
[3] Enyedi A. , Ocskai Zs. , Berke D. , Báldoghi T. , Óbermajer T. , Major K. , Berke J. (2018): Bayer-alapú érzékelők képalkotó algoritmusainak adatfeldolgozásra gyakorolt hatása. IX. Magyar Számítógépes Grafika és Geometriai Konferencia, Budapest, ISBN 978-963-313-282-1, pp. 75-85.
[4] Kurbanov R. K., Zakharova N. I. (2020): Primenenie vegetatsionnykh indeksov dlya otsenki sostoyaniya sel'skokhozyaystvennykh kul'tur [Application of vegetation indexes to assess the condition of crops]. Sel'skokhozyaystvennye mashiny i tekhnologii., Vol. 14. N2. 4-11 (In English), DOI 10.22314/2073-7599-2020-14-4-4-11.
[5] Wang X. , Wang M. , Wang S. and Wu Y. (2015): Extraction of vegetation information from visible unmanned aerial vehicle images, Nongye Gongcheng Xuebao/Transactions of the Chinese Society of Agricultural Engineering, vol. 31, no. 5, pp. 152–159, DOI:10.3969/j.issn.1002-6819.2015.05.022