

RESEARCH ON VEGETATION INDICATORS IN *Primula officinalis* Hill. SPECIES USING FIELDSCOUT CM 1000 NDVI METER

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Abstract

Studies were carried out during the growing season of Primula officinalis Hill., to obtain information on the health status of the plants and the influence of the measurement date on NDVI values. The FIELDSCOUT® CM1000 NDVI Meter measures the NDVI differentially in the presence of light at 660 nm and 840 nm wavelengths. Three determinations in dynamics were made. Three plants were analysed for each variant/repeat/row, with each plant having three readings on three different leaves, resulting in a total of 729 readings and 243 plants analysed in each determination. The study of the influence of the measurement date on the NDVI values in leaves of Primula officinalis Hill. in 2018 shows a slight increase in the values measured on 03.05.2018 by 0.08 units, which is distinctly significant compared to the first measurement, considered as a control. The results on the interaction of the two factors on NDVI values in 2019 showed that on 20.05.2019 all planting variants had distinctly significant and highly significant values relative to the control.

Key words: measurements, NDVI, *Primula officinalis* Hill., vegetation index.

INTRODUCTION

Medicinal and aromatic herbs are an essential part of our lives, from birth till oldness, they accompany us both in joy and sorrow. Almost each of us uses medicinal herbs in the form of teas when we relax or struggle with health issues. Just like the human beings, plants go through different stages of evolution; from emergence, maturity, to senescence.

Therefore, it's highly recommended to use the applied technologies in the organic farming system, the use of free hormones inputs, GMOs, pesticides, antibiotics and other synthetic substances and all of these allow the preservation of the bio-availability of the active compounds during processing and the elimination of toxicological risks in final food products (Săvescu & Popescu 2022).

Calculation of the Normalized Difference Vegetation Index (NDVI) is often used around the world to monitor drought, forecast agricultural production, assist in forecasting fire zones, and desert offensive maps. Farming apps, like Crop Monitoring, integrate NDVI to

facilitate crop scouting and irrigation, among other field treatment activities, at specific growth stages (<https://eos.com/make-an-analysis/ndvi/>).

NDVI is calculated in accordance with the formula:

$$NDVI = \frac{NIR - RED}{NIR + RED}$$

NIR - reflection in the near-infrared spectrum;
RED - reflection in the red range of the spectrum.

According to this formula, the density of vegetation (NDVI) at a certain point of the image is equal to the difference in the intensities of reflected light in the red and infrared range divided by the sum of these intensities (<https://eos.com/make-an-analysis/ndvi/>).

Reflectance is the ratio of energy that is reflected from an object to the energy incident on the object. The spectral reflectance of a crop differs considerably in the near-infrared region ($\lambda = 700-1300$ nm) and in the visible red range ($\lambda = 550-700$ nm) of the electromagnetic spectrum (Kumar & Silva, 1973).

Chlorophyll is a plant's health indicator, strongly absorbs visible light, and the cellular structure of the leaves strongly reflects near-infrared light. When the plant becomes dehydrated, sick, afflicted with disease, etc., the spongy layer deteriorates, and the plant absorbs more of the near-infrared light, rather than reflecting it. Thus, observing how NIR changes compared to red light provides an accurate indication of the presence of chlorophyll, which correlates with plant health

(<https://eos.com/make-an-analysis/ndvi/>).

Researches' results concerning the dynamics of the normalized difference vegetation index (NDVI) showed vast opportunities to use these non-invasive measures to monitor the health status of different crops.

Piekkielek & Fox, 1992; Chapman & Barreto, 1997; Evans, 1989, discovered that the NDVI is successful in predicting photosynthetic activity, because this vegetation index includes both near-infrared and red light. Plant photosynthetic activity is determined by chlorophyll content and activity. The relationship between leaf N and leaf chlorophyll has been demonstrated for maize.

Verhulst, & Govaerts, 2010 consider that the underlying factor for variability in a typical vegetation index cannot be blindly linked to a management input without some knowledge of the primary factor that limits growth. For example, in a field where N is the limiting factor to growth, the NDVI may show a strong correlation with the N availability in the soil; however, in another field, where water is the limiting factor, the NDVI may be just as strongly correlated with plant-available soil moisture

(<https://earthobservatory.nasa.gov/features>).

Field experiments were conducted in many countries, such as those from Southern Greece to assess the Normalized Difference Vegetation Index (NDVI) in estimating Camelina's crop growth and yield parameters under different tillage systems (conventional and minimum tillage) and organic fertilization types (compost, vermicompost and untreated control) Angelopoulou et al., 2020.

Zhang, et al., 2014 showed that crop condition assessment in the early growing stage is essential for crop monitoring and crop yield prediction. A normalized difference vegetation

index (NDVI)-based method is employed to evaluate crop condition by inter-annual comparisons of both spatial variabilities (using NDVI images) and seasonal dynamics (based on crop condition profiles).

The past two decades have seen an increasing demand for timely, transparent, and accurate information on global agricultural monitoring for enhancing food security at global, national, and sub-national scales. Information about the condition of crops in early crop-growing stages (before harvest) can help indicate potential food surpluses and shortages and support related decision-making (Meng, 2008).

The image classification method, which first made a supervised or unsupervised classification on the remote sensing data, then labels each category as a certain increase level with the observed data on the state of growth of the seedling that has spatial and temporal attributes (Liu, 1999).

MATERIALS AND METHODS

The research was carried out at The National Institute of Research and Development for Potato and Sugar Beet Braşov, Technology and Good Practices in Agriculture Department, Laboratory of Medicinal and Aromatic Plants.

The research was carried out for gathering information about the plant's health status through a non-invasive evaluation, in unirrigated field conditions, following at the same time the measurement date's influence, on the NDVI values.

The study took place during the years of 2018-2019. Analyses were made, using the FIELDSCOUT® CM1000 NDVI Chlorophyll Meter. Three determinations in dynamics were made, measurements that indicate the difference in vegetation index in the presence of light, for estimating a plant's health status. At each variant/repetition/row, three plants were examined, and at each plant three readings were on three different leaves, resulting in a total number of 729 readings and 243 analysed plants on each determination.

The biological material, on which the researches were made, was brought in the spring of 2016 from the spontaneous flora of Braşov County, this study focused on aspects of biology and technology regarding the

introduction into the culture of the species *Primula officinalis* Hill.

The experiment was bifactorial, set according to the model of randomized blocks, in three repetitions, being established by seedling in the fall of 2016, with the aim of determining the optimal nutrition space for the *Primula officinalis* Hill. species.

Factor A - the distance between rows with the following graduations: 25 cm, 50 cm, 75 cm;

Factor B - the distance between plants per row, with the following graduations: 10 cm, 25 cm, 50 cm;

Interaction with 10/25 density is considered the variant control of this research (Nițu (Năstase) et al., 2021).

Normalized difference vegetation index measurements using the NDVI Meter.

The FIELDSCOUT® CM1000 NDVI (Normalized Difference Vegetation Index) Meter (Figure 1) senses light at wavelengths of 660 nm and 840 nm to estimate plant health. The ambient and reflected light at each wavelength is measured. Chlorophyll absorbs 660 nm light and, as a result, the reflection of that wavelength from the leaf is reduced compared to the reflected 840 nm light. Light having a wavelength of 840 nm is unaffected by leaf chlorophyll content and serves as an indication of how much light is reflected due to leaf physical characteristics such as the presence of a waxy or hairy leaf surface.



Figure 1. NDVI measuring device (source: Original photo, Sorina Nițu)

RESULTS AND DISCUSSIONS

From the influence of measurement date upon NDVI values of the *Primula officinalis* Hill. leaves, there can be observed a slight increase in the values measured on 03.05.2018 by 0.08 units, this being distinctly significant compared

to the first measurement, considered as a control; measurements made on 11.05.2018 indicate an average value of 0.75 units, insignificant compared to the control variant. Measurements taken, indicate a good health status of the *Primula officinalis* Hill. plants (Table 1).

Table 1. The influence of the measurement date on the NDVI values in *Primula officinalis* Hill. leaves 2018

No.	Date of measurement	Average NDVI	Relative value (%)	Difference	Sig.
1	25.04.2018	0.72	100.0	0.00	Mt
2	03.05.2018	0.79	110.5	0.07	**
3	11.05.2018	0.75	104.2	0.03	-
DL (p 5%)				0.04	
DL (p 1%)				0.06	
DL (p 0.1%)				0.12	

The vegetation status of *Primula officinalis* plants, indicated by the NDVI measurements, was different during 2019, with deviations from the first measurement date, considered control, being distinctly significant and very significant (Table 2).

Table 2. The influence of the measurement date on the NDVI values in *Primula officinalis* Hill. leaves 2019

No.	Date of measurement	Average NDVI	Relative Value (%)	Difference	Sig.
1	25.04.2019	0.77	100.0	0.00	Mt.
2	13.05.2019	0.80	104.5	0.03	**
3	20.05.2019	0.84	108.5	0.07	***
DL (p 5%)				0.02	
DL (p 1%)				0.03	
DL (p 0.1%)				0.06	

The influence of planting distance on NDVI values in *Primula officinalis* Hill. leaves increases at the variants with a 50 cm distance between rows, with more significant values than the control variants, and those planted at a 75 cm distance between rows had the same values as the control, planted at a 25 cm distance between rows (Table 3).

Table 3. The influence of planting distance on NDVI values in *Primula officinalis* Hill leaves 2018

No.	Distance between rows	Average NDVI	Relative value (%)	Difference	Sig.
1	25	0.72	100.0	0.00	Mt
2	50	0.81	112.3	0.09	***
3	75	0.72	100.0	0.00	Mt
DL (p 5%)				0.02	
DL (p 1%)				0.02	
DL (p 0.1%)				0.03	

NDVI values, registered in the year of 2019 were insignificant at the 50 cm distance between rows and distinctly negatively significant at the 75 distance between rows (Table 4).

Table 4. The influence of planting distance on NDVI values in *Primula officinalis* Hill leaves 2019

No.	Distance between rows	Average NDVI	Relative Value (%)	Difference	Sig.
1	25	0.82	100.0	0.00	Mt.
2	50	0.80	98.5	-0.01	-
3	75	0.79	96.6	-0.03	00
DL (p 5%)				0.02	
DL (p 1%)				0.02	
DL (p 0.1%)				0.03	

The interactions between planting distance and the date of NDVI measurements (Table 5) have shown that on 25.04.2018, planted variants at 50 cm between rows had the highest values, with significant differences.

The variants planted at 75 cm between rows, at this date, have very significant negative values compared to the control. On 03.05.2018, the NDVI values of the variants planted at 50 cm between rows increase very significantly, the other variants having values close to the control.

Table 5. Interaction between planting distance and NDVI measurement data on *Primula officinalis* Hill. species 2018

No	Planting distance (cm/cm)	Date of measurement 2018	Average values NDVI	Relative value (%)	Diff.	Sig.
1	25	25.04.	0.73	100.0	0.00	Mt
2	50		0.77	105.5	0.04	*
3	75		0.66	90.4	-0.07	000
4	25	03.05.	0.77	100.0	0.00	Mt
5	50		0.84	109.6	0.07	***
6	75		0.78	101.7	0.01	-
7	25	11.05.	0.68	100.0	0.00	Mt
8	50		0.83	122.7	0.15	***
9	75		0.74	108.4	0.06	**
DL (p 5%)				0.03		
DL (p 1%)				0.04		
DL (p 0.1%)				0.06		

When performing the last analysis, the variants planted at 50 cm register very positive values, and those planted at 75 cm have distinctly significant values compared to the control.

In 2019, the NDVI values analyzed at the experience regarding the interaction between the planting distance and the measurement date were insignificant, close to the control variants (Table 6).

Table 6. Interaction between planting distance and NDVI measurement data on *Primula officinalis* Hill. species 2019

No.	Planting distance (cm/cm)	Date of measurement 2019	Average values NDVI	Relative value (%)	Diff.	Sig
1	25	25.04.	0.79	100.0	0.00	Mt
2	50		0.77	97.5	-0.02	-
3	75		0.75	94.9	-0.04	00
4	25	13.05.	0.81	100.0	0.00	Mt
5	50		0.81	100.4	0.00	-
6	75		0.79	97.5	-0.02	-
7	25	20.05.	0.85	100.0	0.00	Mt
8	50		0.83	97.6	-0.02	-
9	75		0.83	97.3	-0.02	-
DL (p 5%)				0.03		
DL (p 1%)				0.04		
DL (p 0.1%)				0.06		

The interaction between the NDVI measurement date and the planting distance shows distinctly significant differences in the case of variants planted at 75 cm between rows and significant in the case of those planted at 50 cm between rows, in both analyzed data. The variants with graduations of 25 cm between rows present insignificant values on 03.05.2018, with a slightly significant decrease on 11.05.2018 (Table 7).

Table 7. Comparisons of the interaction between the NDVI measurement date and the planting distance at *Primula officinalis* Hill. Species 2018

No	Date of measurement	Distance between rows	Average values NDVI	Relative value (%)	Diff	Sig
1	25.04.2018	25cm	0.73	100.0	0.00	Mt
2	03.05.2018		0.77	105.0	0.04	-
3	11.05.2018		0.68	93.1	-0.05	0
4	25.04.2018	50cm	0.77	100.0	0.00	Mt
5	03.05.2018		0.84	109.1	0.07	*
6	11.05.2018		0.83	108.3	0.06	*
7	25.04.2018	75cm	0.66	100.0	0.00	Mt
8	03.05.2018		0.78	118.3	0.12	**
9	11.05.2018		0.74	111.7	0.08	**
DL (p 5%)				0.05		
DL (p 1%)				0.07		
DL (p 0.1%)				0.12		

The normalized difference vegetation index in the presence of light estimates a very good state of plant health at a nutrition space of 50 cm between rows in very favorable years for the growing season, such as 2018. In less favorable years (2019), NDVI differences become insignificant between cultivation methods in the first phases of vegetation and with distinct and very significant values in full plant development (20.05).

The analysis of the results regarding the interaction of the two factors on the NDVI values in 2019 showed that on 20.05.2019, all three planting distances had distinctly

significant and very significant values compared to the control (Table 8).

Table 8. Comparisons of the interaction between the NDVI measurement date and the planting distance at *Primula officinalis* Hill. Species 2019

No.	Date of measurement	Distance between rows	Average values NDVI	Relative value (%)	Diff.	Sig.
1	25.04.2019	25cm	0.79	100.0	0.00	Mt
2	13.05.2019		0.81	102.5	0.02	-
3	20.05.2019		0.85	107.6	0.06	**
4	25.04.2019	50cm	0.77	100.0	0.00	Mt
5	13.05.2019		0.81	105.6	0.04	*
6	20.05.2019		0.83	107.8	0.06	**
7	25.04.2019	75cm	0.75	100.0	0.00	Mt
8	13.05.2019		0.79	105.3	0.04	*
9	20.05.2019		0.83	110.2	0.08	***
DL (p 5%)				0.03		
DL (p 1%)				0.05		
DL (p 0.1%)				0.07		

CONCLUSIONS

The influence of the measurement date upon NDVI values on the leaves of *Primula officinalis* Hill., notices, in 2018, a slight increase of the values measured on 03.05.2018 by 0.08 units, this being distinctly significant compared to the first measurement considered control; the measurements made on 11.05.2018 indicate an average value of 0.75 units, this being insignificant compared to the control.

The health status of the *Primula officinalis* Hill. plants, indicated by the NDVI measurements, were different during 2019, the deviations from the first measurement date, considered as a control, being distinctly significant and very significant. The measured NDVI values indicate good plant's health.

The influence of the planting distance upon NDVI values at *Primula officinalis* Hill. values, increases at the variants with 50 cm between rows, with very significant values compared to the control variants, and the 75 cm between rows variants had values close to those of the control variants, planted at a distance of 25 cm between rows.

NDVI (Normalized Difference Vegetation Index) analysis at the *Primula officinalis* Hill. species, is the first of this kind, made in Romania with this device on medicinal plants, opening, in this way, new research boundaries in the field of medicinal plants, which can determine the plant's health status, from emergence till senescence.

The use of normalized difference vegetation index can also help to establish the harvest season, correlated with an optimal accumulation of active substances in plants.

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