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Evaluation of Bacterial Leaf Spot on Sweet Pepper with Visual Assessment and Multispectral Sensor Device

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Summary: Plant diseases represent one of the main biotic stressors that, depending on the time of occurrence and intensity, lead to a reduction or complete yield losses. Phytopathogenic bacteria *Xanthomonas euvesicatoria,* a major causal agent of bacterial leaf spot disease (BLS) in sweet peppers causes lesions on the leaves, stems, and fruits. The aim of this study was to select spectral reflectance indices that correlate to the highest extent with the results of the visual assessment of BLS. The appearance of disease symptoms was assessed on two tolerant and two susceptible sweet pepper lines, by visual scoring according to the Horsfall–Barratt (HB) scale and by using an active, portable multispectral optical device (Plant-O-Meter), in the field under natural infection. The results indicated that vegetation indices (VIs) showed different significance depending upon the particular stage of visual assessments (V.A.). Indices, such as EVI, WDRVI, GRDVI, PNDVI were found to be the most suitable for early disease detection since they showed significant correlation at third V.A. The largest number of vegetation indices showed the highest significant correlation at 4 V.A. and 5 V.A. which indicated that they can serve in later stages of disease detection. This study provides valuable insights into the use of an active sensor device for sweet pepper bacterial leaf spot detection, monitoring, and evaluation, potentially enabling more timely and targeted interventions. Further research could explore the practical implementation of these findings in field settings and evaluate their effectiveness in large-scale disease management strategies.
Keywords: *Capsicum annuum*, pepper, sensor, *Xanthomonas euvesicatoria*

Introduction

Sweet pepper (*Capsicum annuum* L.) is a very important vegetable with a world-harvested area of more than 2 million hectares (FAOSTAT, 2024), but its yield is affected by numerous limiting factors. Bacterial leaf spot (BLS) caused by *Xanthomonas euvesicatoria* is considered to be one of the most devastating diseases of sweet pepper. This pathogenic bacteria is on the quarantine A2 list (EPPO/OEPP, 2013) and it has been reported in many European countries, as well as in the USA, South America, Australia, and several Asian countries. The disease may occur at any stage of sweet pepper development, but it is most harmful if the infection occurs at an early growth stage (Potnis et al., 2015). BLS symptoms begin as small, yellow-green water-soaked lesions on leaves (Fig. 1). Along with the disease progression, these lesions turn into large necrotic areas, which can lead to premature defoliation of infected plants (Vallad et al., 2010; Hassan et al., 2017), while their fruits are often damaged from the sunscald and therefore have a low market value (Ritchie, 2000). Severely affected crops under favourable environmental conditions can lead to total yield loss (Ritchie, 2000; Potnis et al., 2019).

Figure 1. Pepper plant infected with Bacterial spot *(Xanthomonas euvesicatoria)* (Rimski Šančevi, 2020)

Frequent precipitation, high air humidity and high temperatures provide ideal conditions for BLS development (Diab et al., 1982; Vallejos et al., 2010). The pathogen could survive on seed, in the infected plant debris and season on volunteer plants (Potnis et al., 2015; Stall et al., 2009). The spreading of the pathogen is favoured by rain and overhead irrigation, while it could also be transmitted mechanically, through farm equipment.

Despite the application of various integrated measures over the past several decades, bacterial leaf spot of peppers has been difficult to manage (Obradović et al., 2008). This problem has led to the use of genetically controlled resistances as an alternative method of disease control (Vallejos et al., 2010). However, among the recommended methods for the suppression of BLS of pepper, the use of resistant cultivars is one of the most efficient, highly desirable and very useful method of plant disease control (Leach et al., 2014). Resistant cultivars represent a low cost to the farmers and, due to reduced application of chemical substances, increase the product's final quality while decreasing environmental pollution (Riva-Souza et al., 2007). However, genetic resistance may be ineffective because of the shifts in the bacterial populations that emerge even before resistant cultivars are deployed (Gassmann et al., 2000). These race shifts may impact the durability of plant resistance. Six dominant R genes have been identified in pepper: BsT, Bs1, Bs2, Bs3, Bs4, and Bs7 (Stall et al., 2009). The creation of resistant varieties is hampered by the existence of a large number of races of this pathogen. Four physiological races of the pathogen (P1, P3, P7, P8) have been identified so far, with P8 being the most widespread in Serbia (Ignjatov et al., 2012).

The development of new pepper varieties tolerant to bacterial spot in the Institute of Field and Vegetable Crops (IFVC) started in 2013. The program was initiated in response to increasing market demands for pathogen control (Danojević et al., 2016). Parent with Bs2 gene was used to transfer into offspring.

The noninvasive, highly accurate and cost-effective methods for detecting and monitoring plant diseases and pests over a large area, which have been used in recent years, might considerably enhance plant protection. In this regard, many sensor technologies have been developed for identifying and monitoring plant diseases and pests (Zhang et al., 2019) and due to their accurate measurement reduce the application of pesticides (Orji et al., 2025). Many active and passive sensors have been commercially available and developed to assess better the condition of plants, such as growth stage, optimum nutrition, irrigation, as well as harvest time and optimal time for pest control. To make disease evaluation more objective, timely and efficient, it is very important to test the new sensor device for BLS evaluation. In this study, a new active multispectral optical device named Plant-O-Meter was tested in real field conditions. The device consists of an integrated multispectral source that includes lighting sources of the four most indicative wavelengths (850, 630, 535, and 465 nm), providing simultaneous illumination of the whole plant. Continuous illumination and sensing enable fast reflection measurements that are essential which are instantly transmitted via Bluetooth connection to Android-powered devices for data processing and storage (Kitić et al., 2019). Since that sensor records the reflectance for each band separately providing the ability to calculate more than 30 different vegetation indices (Ljubičić et al., 2020). Therefore, the objective of this study was to select the most suitable spectral reflectance indices for the evaluation of BLS symptoms by using the sensor device Plant-O-Meter, which correlates to the highest extent with the results of the visual assessment.

Material and methods

Four sweet pepper lines, from the collection of IFVC, were used in this study. Two lines are susceptible to BLS (Bell Susceptible-BS, Kapia Susceptible-KS) and two are tolerant (Bell Tolerant-BT, Kapia Tolerant-KT) from previous field evaluation. Seeds were sown on 31 March 2020 in a plastic greenhouse. The field trial was conducted at the experimental field of the IFVC, at Rimski Šančevi, near Novi Sad, Serbia, (Fig. 2). Pepper plants were transplanted on 27 May in three replicates (rows) with 10 plants in each row. The density of plants was 70 x 25 cm. Pepper plants were fertilized on 2 July with Amonium-nitrate (190 kg/ha), and 29 July with Ferticare 14:11:25 (200 kg/ha). Irrigation was done throughout the growing season with sprinklers in the morning period to minimize the wetness of plants. Weeds were removed two times (first manually, and second time with rotary cultivator).

Figure 2. Pepper plants in the field trial (Rimski Šančevi, 2020)

The disease was evaluated according to the Horsfall–Barratt (HB) scale in the condition of natural infection (Horsfall & Barratt, 1945). Every pepper plant was evaluated individually, which means 30 plants per line. Namely, three researchers participated in the visual assessment, with each providing their independent evaluation score, and then the average score for each plant was determined by the consensus. Since this experiment was not extensive in terms of space and did not take up much time, the researchers were able to dedicate sufficient attention to the disease evaluation. Chemical treatments were not applied in the trial against BLS. The first evaluation was done on 1 July when the first symptoms were observed and the last one was on 9 October. In total, there were seven visual assessments (Tab.1).

Table 1. Number and date of visual assessment of BLS symptoms of four sweet pepper lines during the field trial (Rimski Šančevi, 2020)

Visual assessment (V.A.)	1	2	3	4	5	6	7
Date	01.07.	15.07.	31.07.	13.08.	02.09.	17.09.	09.10.

The field trial plots were performed in conditions of moderately continental climate of Vojvodina with seasonal variation in precipitation and temperature. During the investigation, weather conditions and meteorological data, such as temperature and precipitation amounts were found to be favourable for most crops. The growing season for pepper in 2020 (June - October) was slightly warmer and humid related to average conditions (Tab. 2). The months with the highest precipitation were June and August (RHMZ, 2023).

Table 2. Average decade temperatures and precipitation during the field trial (Rimski Šančevi, 2020)

Month	June			July			August			September			October
Decade	I	II	III	I	II	III	I	II	III	I	II	III	I
Temperature (°C)	20	20	23	23	20	25	24	24	24	20	21	18	18
Precipitation (mm)	22	90	50	6	70	0	84	28	26	5	0	27	31
Σ Precipitation (mm)		162			76			138			32		31

After each V.A., plant evaluation with Plant-O-Meter sensor was done on the same day. Measurements with Plant-O-Meter sensor were made close to noon, on sunny and cloud-free days, between 10:00 am and 2:00 pm. Measurements were recorded by passing the sensor over the plant rows at a height of approximately 0.60 m above the top of the pepper plants (Fig. 3). Jay et al (2020) found that ground-based RGB imaging proved to be more effective than aerial RGB imaging in sugar beat leaf spot.

Plant-O-Meter is an active hand-held sensor device, which emits light and measures the reflectance at four indicative wavelengths, 465 nm (Blue), 535 nm (Green), 630 nm (Red) and 850 nm Near-infrared (NIR). Based on those spectral wavebands the following vegetation indices were calculated: Normalised difference vegetation index (NDVI), Red normalised difference vegetation index (RDVI), **Green normalised difference vegetation index (NDVIg)**, Blue normalised difference vegetation index (NDVIb), Simple ratio (SR), Modified simple ratio (MSR), Infrared Percentage Vegetation Index (IPVI), Structure Insensitive Pigment Index (SIPI), Green Atmospherically Resistant Index (GARI), Soil Adjusted Vegetation Index (SAVI), **Green Soil**

Adjusted Vegetation Index (GSAVI), Green Optimized Soil Adjusted Vegetation Index (GOSAVI), Normalized Pigment Chlorophyll Ratio Index (NPCI), Green Chlorophyll Index (GCI), Green Ratio Vegetation Index (GRVI), Plant Senescence Reflectance Index (PSRI), Non-Linear Index (NLI), Transformed Difference Vegetation Index (TDVI), Visible Atmospherically Resistant Index (VARI), **Wide Dynamic Range Vegetation Index (WDRVI), Green Re-normalized Difference Vegetation Index (GRDVI),** Green-Blue NDVI (GBNDVI), Red-Blue NDVI (RBNDVI), **Pan NDVI (PNDVI)**, Inversion of the simple ratio (ISR), **Normalised difference water index (NDWI),** Green leaf index (GLI) and Triangular Greenness Index (TGI). Calculation and selection of spectral reflectance indices were done according to the mathematical formulae described within the Index database for remote sensing indices (IDB, 2024).

Figure 3. BLS evaluation of four sweet pepper lines with Plant-O-Meter (Rimski Šančevi, 2020)

The nonparametric Kruskal-Wallis test was used for statistical analysis since values from the visual assessment were not normally distributed. Average values of three replications per index were used. Spearman correlation coefficients were used to evaluate the relationship between vegetation indices and V.A. All statistical analyses were carried out using the statistical software STATISTICA, version 13.2 (Statistica, 2016).

Results and discussion

According to the Horsfall–Barratt scale (HB) and Kruskall Wallis test, tolerant pepper genotypes (BT and KT) showed significantly lower disease scores than KS in the first V.A. (Fig. 4). In the second V.A. BT and KT had a lower disease score than BS and KS. During the third and the fourth V.A., a significant difference was noted between all genotypes except between KT and KS. At the same V.A., genotype BT had the lowest disease score, while the BS had the highest. In the fifth V.A., there were significant differences between genotypes, except between KT and KS and between BS and KS.

There was a significant difference between all genotypes in the sixth V.A. except between KT and KS. In the seventh V.A., only BS had a higher disease score than other genotypes. At the end of the evaluation (7 V.A.), 3 out of 4 genotypes showed decreasing disease scores. That was registered probably because of severe leaf dropping at the end of September.

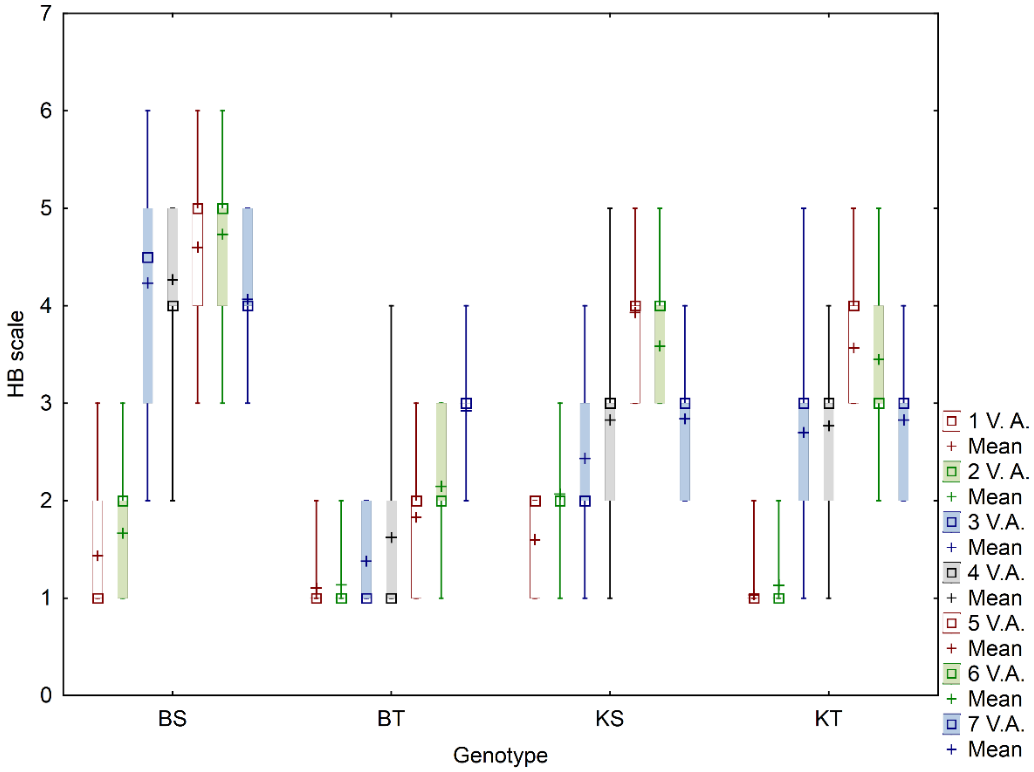

Figure 4. Median, mean, percentiles, minimum and maximum values of four evaluated pepper lines in the field trial. HB-Horsfall–Barratt scale, V.A.-visual assessment, BS-Bell Susceptible, BT-Bell Tolerant, KS-Kapia Susceptible, KT Kapia Tolerant

A strong correlation between two variables can be considered when the correlation index values are between 0.7 and 1.0. Values between 0.3 and 0.7 indicate a moderate linear relationship. In our research there was no significant correlation between indices and disease scores during the first, second and seventh visual assessments (V.A), (Tab. 3).

During the third V.A., it was observed a significant negative relationship between disease score and vegetation indices EVI (r = 0.58*), WDRVI (r = - 0.63*), GRDVI (r = - 0.61*) and PNDVI (r = - 0.61*). During the fourth and fifth evaluations, 16 and 24 indices were correlated with disease scores (respectively). During the fourth V.A. it was observed a significant negative relationship between disease score and vegetation indices was noticed for NDVI (r = - 0.66*), IPVI (r = - 0.66*), SAVI (r = -0.66*), TDVI (r = -0.65*), GBNDVI (r = -0.68*), RBNDVI (r = -0.66*), and ISR (r = 0.65*). Highly significant negative relationship during the fourth V.A. between disease score and vegetation indices was observed for NDVIg (r = - 0.78**), GARI (r = - 0.72**), GSAVI (r = - 0.78**), GOSAVI (r = - 0.78**), WDRVI (r = -0.72**), GRDVI (r = - 0.83**), and PNDVI (r = - 0.79**).

On the other side, a highly significant positive relationship between disease score and vegetation indices was observed for MSR (r = 0.64*), ISR (r= 0.65*) and NDWI (r = 0.78**). During the fifth V.A. it was observed the highly significant negative relationship between disease score and vegetation indices for NDVI (r = - 0.83**), NDVIg (r = - 0.93**), NDVIb (r = -0.74**), IPVI (r = - 0.83**), EVI (r = -0.76**), GARI (r = -0.89**), SAVI (r = -0.83**), GSAVI (r = -0.91**), GOSAVI (r=-0.93**), GCI (r= -0.79**), NLI (r= -0.80**), TDVI (r= -0.83**), WDRVI (r= -0.83**), GRDVI (r= - 0.92**), GBNDVI (r= -0.90**), RBNDVI (r=-0.85**) and PNDVI (r= -0.87**). A significant negative relationship during the five V.A. between disease score and vegetation indices was observed for CVI (r= -0.59*).

A highly significant positive relationship during the fifth V.A. between disease score and vegetation indices was noticed for NPCI (r= 0.86**), ISR (r= 0.83**), NDWI (r = 0.93**), and a significant positive relationship SIPI (r = 0.68*). During the sixth V.A., it was noticed a significant negative relationship between disease score and vegetation indices for NDVIg (r = - 0.63*), GSAVI (r = - 0.63*), GOSAVI (r = - 0.63*), while NDWI showed significant positive relation (r = 0.63*). Vegetation indices that showed the greatest correlation (during three V. A.) with disease scores were: NDVIg, GSAVI and GOSAVI as they showed persistent correlation in 4 V.A., 5 V.A., and 6 V.A. Contrary to these results NDWI indicated a positive relationship with 4 V.A., 5 V.A., 6 V.A. Similar results were found for ISR index which showed significant positive relation in 4 V. A. and 5 V.A. Other indices such as EVI, WDRVI, GRDVI, and PNDVI were found more appropriate for earlier stages of V.A. assessments as exposed high negative correlation in 3 V.A., 4 V.A., and 5 V.A. From these indices, only NDWI was positively correlated while others were in negative correlation (Tab. 3). Zhao et al (2020), studying several VIs, including NDVI, EVI, and SAVI, on diseased cotton plants, found that the EVI showed the best results.

Table 3. Spearman correlations of disease score in 7 visual assessments (V. A.) and vegetation indices measured with Plant-O-Meter. V.A.-visual assessment, Normalised difference vegetation index (NDVI), Red normalised difference vegetation index (RDVI), Green normalised difference vegetation index (NDVIg), Blue normalised difference vegetation index (NDVIb), Simple ratio (SR), Modified simple ratio (MSR), Infrared Percentage Vegetation Index (IPVI), Structure Insensitive Pigment Index (SIPI), Green Atmospherically Resistant Index (GARI), Soil Adjusted Vegetation Index (SAVI), Green Soil Adjusted Vegetation Index (GSAVI), Green Optimized Soil Adjusted Vegetation Index (GOSAVI), Normalized Pigment Chlorophyll Ratio Index (NPCI), Green Chlorophyll Index (GCI), Green Ratio Vegetation Index (GRVI), Plant Senescence Reflectance Index (PSRI), Non-Linear Index (NLI), Transformed Difference Vegetation Index (TDVI), Visible Atmospherically Resistant Index (VARI), Wide Dynamic Range Vegetation Index (WDRVI), Green Re-normalized Difference Vegetation Index (GRDVI), Green-Blue NDVI (GBNDVI), Red-Blue NDVI (RBNDVI), Pan NDVI (PNDVI), Inversion of the simple ratio (ISR), Normalised difference water index (NDWI), Green leaf index (GLI) and Triangular Greenness Index (TGI).

Index	1 V. A.	2 V. A.	3 V. A.	4 V. A.	5 V. A.	6 V. A.	7 V. A.
NDVI	0.08	0.04	-0.56	**-0.66***	**-0.83****	-0.19	0.07
RDVI	0.33	0.42	-0.14	-0.08	**-0.79****	-0.50	-0.08
NDVIg	0.13	0.01	-0.52	**-0.78****	**-0.93****	**-0.63***	-0.10
NDVIb	-0.05	0.19	-0.27	-0.55	**-0.74****	0.21	0.07
SR	0.07	0.01	-0.15	-0.30	**-0.83****	0.04	0.30
MSR	-0.20	0.12	0.55	**0.64***	0.27	-0.36	-0.04
IPVI	0.08	0.04	-0.56	**-0.66***	**-0.83****	-0.19	0.07
SIPI	-0.53	0.25	0.23	0.46	**0.68***	0.34	-0.31
EVI	0.32	0.07	**-0.58***	-0.44	**-0.76****	-0.31	-0.14
GARI	0.25	0.07	-0.07	**-0.72****	**-0.89****	-0.13	0.45
SAVI	0.08	0.04	-0.56	**-0.66***	**-0.83****	-0.19	0.07
GSAVI	0.13	0.01	-0.52	**-0.78****	**-0.91****	**-0.63***	-0.10
GOSAVI	0.13	0.01	-0.52	**-0.78****	**-0.93****	**-0.63***	-0.10
NPCI	-0.51	0.10	0.27	0.41	**0.86****	0.10	0.18
GCI	0.07	0.27	-0.29	-0.08	**-0.79****	-0.48	-0.03
GRVI	0.06	0.05	0.15	-0.12	0.00	0.18	0.07
PSRI	0.08	0.11	-0.03	-0.38	-0.38	-0.35	0.32

NLI	0.13	0.14	-0.43	-0.21	**-0.80****	-0.45	-0.01
TDVI	0.10	0.04	-0.56	**-0.65***	**-0.83****	-0.20	0.07
VARI	0.11	-0.01	0.08	-0.33	-0.21	0.17	0.12
WDRVI	0.08	0.04	**-0.63***	**-0.72****	**-0.83****	-0.05	0.07
GRDVI	0.10	0.10	**-0.61***	**-0.83****	**-0.92****	-0.52	0.02
GBNDVI	0.02	0.14	-0.53	**-0.68***	**-0.90****	-0.55	-0.09
RBNDVI	0.00	0.19	-0.55	**-0.66***	**-0.85****	-0.04	0.10
PNDVI	0.01	0.25	**-0.61***	**-0.79****	**-0.87****	-0.42	-0.09
ISR	-0.10	-0.04	0.56	**0.65***	**0.83****	0.20	-0.07
NDWI	-0.13	-0.01	0.52	**0.78****	**0.93****	**0.63***	0.10
TGI	-0.50	0.14	0.13	0.36	0.13	0.32	-0.10
GLI	-0.34	0.09	-0.08	0.07	0.31	0.57	0.18
CVI	0.14	0.40	-0.02	-0.04	**-0.59***	-0.48	-0.21

* and **are significant at p< .05000; p< .01000

Spectral reflectance indices were calculated in different stages of BLS development. Based on Spearman Correlations some indices showed to be more suitable for disease detection. The Green Re-normalized Difference Vegetation Index (GRDVI) is similar to NDVI except that it measures the green spectrum from 540 to 570 nm instead of the red spectrum. This index is more sensitive to chlorophyll concentration than NDVI (Yu et al., 2018). The lowest GRDVI was noted during the first V.A. GRDVI increased from the first to the third V.A. After that time GRDVI was almost the same or started to decrease in some genotypes (Fig. 5). During the 4th and 5th V.A., tolerant pepper genotypes (BT and KT) had a higher GRDVI value than susceptible ones.

Normalised difference water index (NDWI), was the highest at the beginning of the evaluation and decreased until 3rd V.A. (generally) (Fig. 6). According to Yu et al (2018), NDWI is more indicative of early infections compared to NDVI. Also, NDWI was the best index for detecting *Septoria tritici* Blotch disease of wheat. Our results show a higher difference between genotypes in 4th and 5th V.A. In that period tolerant genotypes had lower values of NDWI than susceptible. The lowest NDWI had BT in the 5th (-0.76) and 4th (-0.75) evaluations. The most effective indices for the detection of bacterial canker on tomato-infected plants were NDWI, SRWI and WI1180 (Cordon et al., 2022).

The Green Normalized Difference Vegetation Index (NDVIg) is similar to NDVI except that it measures the green spectrum from 540 to 570 nm instead of the red spectrum. This index is more sensitive to chlorophyll concentration than NDVI (Gitelson & Merzlyak, 1998).

The NDVIg was noted during the first V.A. NDVIg increased from the first to the third V.A. After that time, NDVIg was almost the same or started to decrease in some genotypes (Fig. 7). During the 4th and 5th V.A., susceptible pepper genotypes BS (Fig. 8) and KS had a lower NDVIg value than tolerant genotypes BT (Fig. 9) and KT. The higher correlation of NDVIg with disease infection than other NDVI indices was expected since NDVIg indicates the photosynthetic activity of the vegetation cover. It was primarily used to determine the moisture content and N concentration in plant leaves according to multispectral data, which do not have an extreme red channel. It had a higher sensitivity to chlorophyll congregation compared to the NDVI measure. NDVIg is used for evaluating ageing and depressed plants. On the contrary, NDVI based on NIR and the RED band presents a good descriptor of photosynthetic activity since the more red light absorbed by leaves, the higher the potential photosynthetic activity.

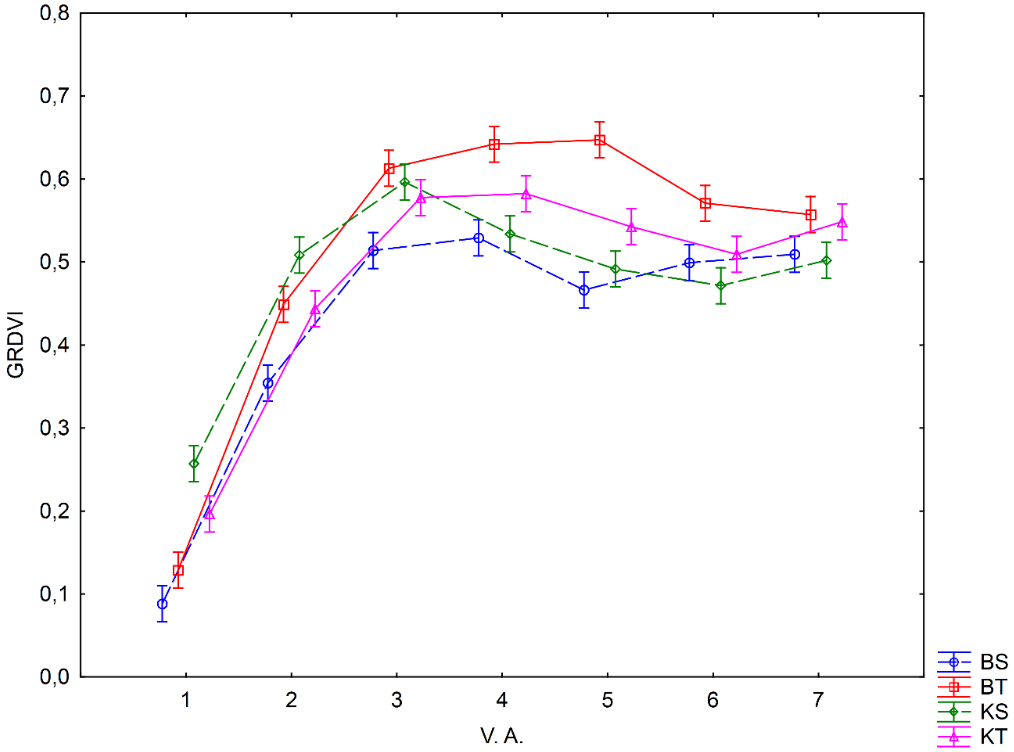

Figure 5. Green Re-normalized Difference Vegetation Index (GRDVI) in four pepper genotypes during seven visual assessments (V. A.)

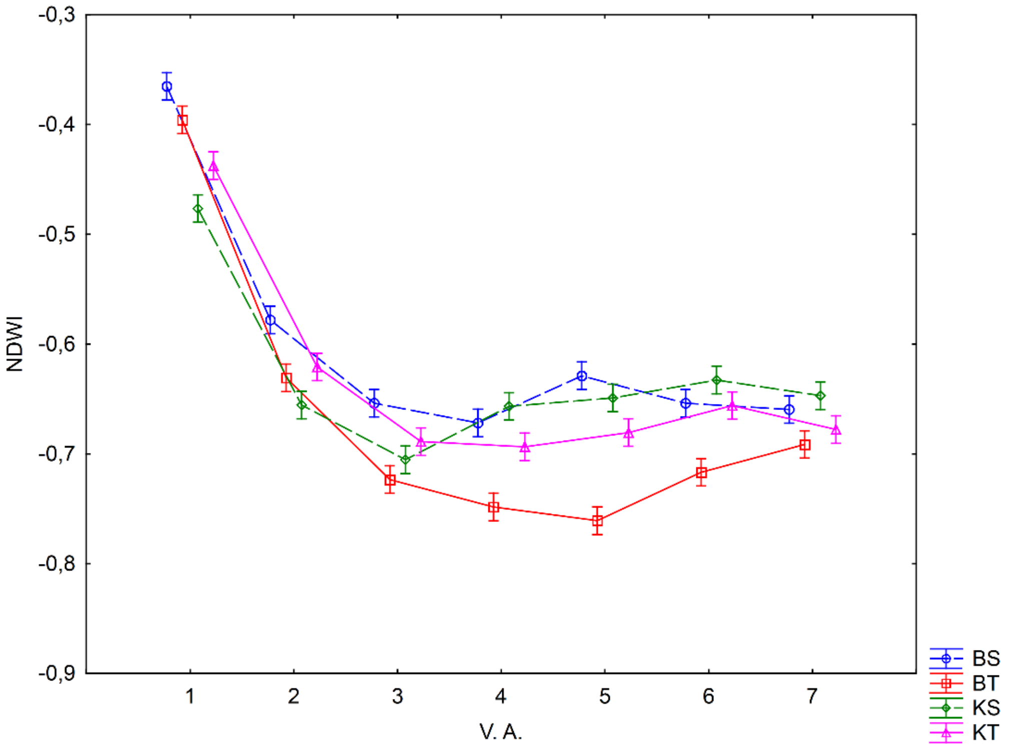

Figure 6. Normalised Difference Water Index (NDWI), in four pepper genotypes during seven visual assessments (V. A.)

NDVIb, which is based on the blue band, showed correlation only at 5th V.A. Previous results on maize showed, that NDVIb has a better capacity to describe leaf density because the blue band is known to be a good descriptor for distinguishing between vegetation and other background imagery (Ljubičić et al., 2023). In the case of BLS evaluation on pepper plants, this index was not highly correlated. According to Radočaj et al. (2023) EVI, GNDVI, and SAVI have the potential advantages over NDVI, but NDVI has a longer history in remote sensing, with well-documented performance. Thus, the growing focus on alternative vegetation indices from multispectral sensors could enhance better application of remote-sensing data for plant health assessment.

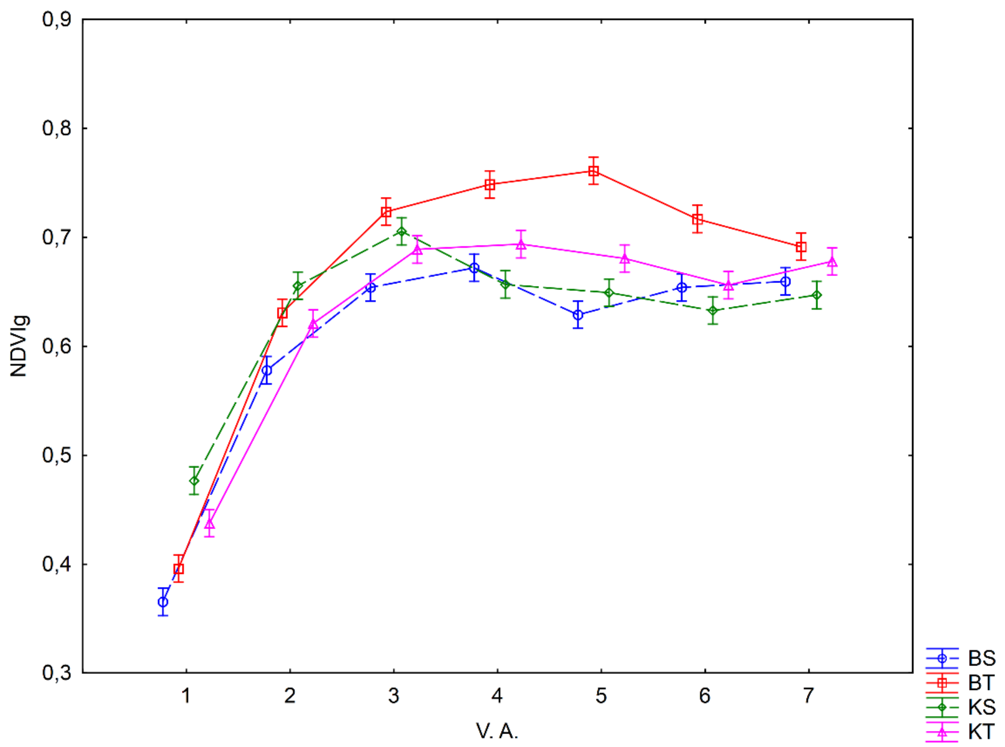

Figure 7. Green Normalised Difference Vegetation Index (NDVIg), in four pepper genotypes during seven visual assessments (V. A.)

Figure 8. Plants of Susceptible Bell Pepper Genotype (BS) 13.08.2020.

Figure 9. Plants of Tolerant Bell Pepper Genotype (BT) 13.08.2020.

Conclusion

The present findings showed that different vegetation indices exhibit different relations with with BLS symptoms depending on specific indices, including the stage of V.A. According to the present results of BLS evaluation on pepper plants, the indices, such as EVI, WDRVI, GRDVI and PNDVI could serve as early BLS detection since they showed significance at 3rd V.A. Additionally, the largest number of vegetation indices showed the highest significant correlation to disease symptoms at 4th V.A. and 5th V.A., such as NDVI, NDVIg, GSAVI, GOSAVI, WDRVI, GRDVI, PNDVI, and NDWI. Except for particular indices, such as NDWI, which were positively correlated at 4th V.A., 5th V.A. and 6th V.A., other indices obtained by Plant-O-Metre measurements showed highly significant negative correlation in the period with the highest BLS symptoms, indicating that they can be used for the late stage of BLS symptoms. This study offers valuable insights into employing remote sensing tool such as Plant-O-Metre for the detection, monitoring and evaluation of leaf spot caused by phytopathogenic bacteria *Xanthomonas euvesicatoria* on sweet peppers, which could facilitate timely and targeted interventions to reduce yield losses. Further studies could investigate the implementation of these findings in fields and assess their effectiveness within large-scale disease management strategies. To evaluate a great number of pepper genotypes on a significantly larger area, the estimate of plant disease with sensors would be of high importance for accelerating the process. Certainly, human oversight is still required to assess different biotic or abiotic stresses that can impact plants in both field and controlled environments.

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Procena bakterijske pegavosti paprike: vizuelno i multispektralnim senzorskim uređajem

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Sažetak: Biljne bolesti predstavljaju jedan od glavnih biotičkih stresora koji u zavisnosti od vremena i intenziteta pojave dovode do smanjenja ili potpunih gubitaka prinosa. Fitopatogena bakterija *Xanthomonas euvesicatoria*, prouzrokovač bakterijske pegavosti (BP) paprike, dovodi do pojave lezija na listovima, stabljikama i plodovima. Cilj ovog istraživanja bio je da se odaberu indeksi spektralne refleksije koji u najvećoj meri koreliraju sa rezultatima vizuelne procene BP. Pojava simptoma bolesti je procenjena na dve tolerantne i dve osetljive linije slatke paprike, vizuelnom ocenom prema Horsfall–Barratt (HB) skali i korišćenjem aktivnog, prenosivog multispektralnog optičkog uređaja (Plant-O-Meter), u polju u uslovima prirodne infekcije. Rezultati su pokazali da su vegetacijski indeksi (VI) pokazali različitu značajnost u zavisnosti od određene faze vizuelne procene (VP). Pokazalo se da su indeksi, kao što su EVI, WDRVI, GRDVI, PNDVI, najpogodniji za rano otkrivanje bolesti jer su pokazali značajnu korelaciju tokom treće VP. Najveći broj vegetacionih indeksa pokazao je značajnu korelaciju u 4. i 5. VP, što je ukazivalo da mogu poslužiti u kasnijim fazama praćenja BP. Ova studija pruža vredan uvid u upotrebu aktivnog senzorskog uređaja za otkrivanje, praćenje i ocenu bakterijske pegavosti paprike, potencijalno omogućavajući pravovremene i ciljane mere kontrole. Dalja istraživanja bi mogla biti usmerena na praktičnu primenu ovih nalaza na većim površinama kao i procenu efikasnosti u strategijama upravljanja ovom bolešću.

Ključne reči: *Capsicum annuum*, paprika, senzor, *Xanthomonas euvesicatoria*