International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

Disentangling the Relationship in Health of Zea Mays Crop using Photochemical Reflectance Index and Nitrogen Reflectance Index

Komal. D. Patil, K. V. Kale

Abstract*: Determining the spatial variation of different plant factors throughout growing season will help to resolve stress factors within a field in a timely basis. Whereas the spectral characterizes help to estimate the proper photosynthesis process. This research shows that the nitrogen reflectance index (NRI) help to predict the nitrogen level of healthy and diseased plants and photochemical reflectance index (PRI) affects the leaf spectral absorption. These indices are calibrated under the hyperspectral pushbroom camera Resonon PIKA-L (400-1000nm) which is non-destructive and less time consuming, it is available in RUSA lab in Dr. Babasaheb Ambedkar Marathawada University, Aurangabad, Maharashtra. The spectral bands considered for the calculation of NRI are 700nm, 670nm, 570nm and for PRI spectral bands considered were 531nm, 570nm. Statistical values for PRI were calculated like R-Square (0.727), RMSE (0.267), P-value (2.787), standard error (2.979) and the statistical values for NRI were R-Square (4.223), RMSE (0.512), P-value (0.968), standard error(2.648).Linear regression was calculated for finding the relation between the data.

Keywords: Disease Index, Hyperspectral Signature, Linear Regression, Maize, PIKA-L sensor

I. INTRODUCTION

In India, maize is the third largest staple crop following to rice and wheat. As per roughly calculation, its cultivation is probably 22.23 M tons in the year 2012-13 in the Kharif season, which consumed upto 80% of the cultivation area [1]. Literature indicates there is a strong correlation between intensity of nitrogen and the yield of maize, which implies that the proper nitrogen would increase maize yield. Nitrogen is not only responsible for yield but also important for the good quality of crop [2]. Due to which opting a proper nitrogen management practices is very essential.

Near infrared spectroscopy is used as an advanced tool to identify the concentration of nitrogen in a number of crops, like wheat, maize, rice, cotton, and various fruits [3,4].

Revised Manuscript Received on February 28, 2020.
***** Correspondence Author
Komal D. Patil*, Pursued Bachelor of Engineering, Computer Engineering, Pune University. Maharashtra, India.
Prof. K. V. K, Senior Member IEEE**,** Department of Computer Science and Information Technology, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license http://creativecommons.org/licenses/by-nc-nd/4.0/

Techniques for quantifying nitrogen in plant tissues present now-a -days includes Kjeldahl analysis using UV – vis spectroscopy. In NIR techniques, the quantity of the sample, strong acids release nitrogen which is a disadvantage [5].

Hyperspectral Imaging (HSI) is one of the most popular techniques for plant disease detection which make the use of various vegetation indices (VI).

The advantage of these vegetation indices is theta it reductions the dimensionality of the data and scale factor which affect the variations in the illuminations condition [6].

Photochemical Reflectance Index (PRI) is a normalized vegetation index used for estimating photosynthetic light use efficiency (LUE) and also helpful in monitoring crop stress. PRI can detect the Nitrogen stress or the water stress as it gives the high reflectance for the healthy crop as compared to diseased crop [7].

II. METHOD AND MATERIAL

A. Study area

Aurangabad's geographical position is 19.92712 Latitude and 75.35261 Longitude for maize. The research zone chosen as fields close the Aurangabad district urban area of Harsul Sawangi Naigaon area for this venture. 20 sample for disease leafs and 20 samples for healthy leafs were collected from the field.

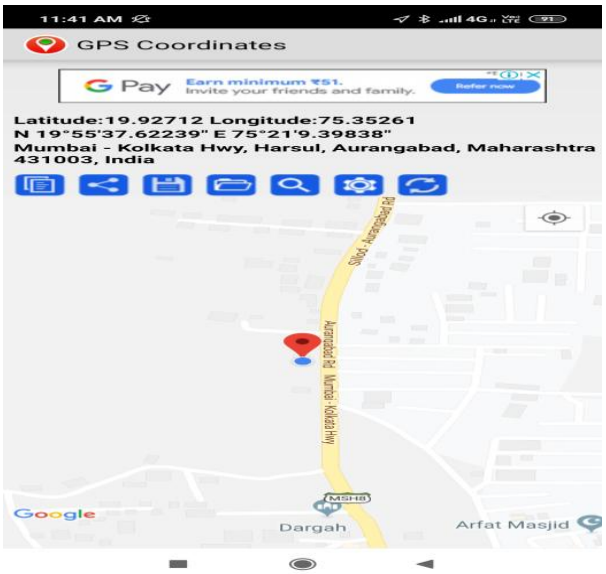

Fig.1. Study area cordinates

B. Experimental setup

C. PIKA-L hyperspectral sensor

The hyperspectral imaging PIKA-L sensor was used which as the spectral range from 400-1000 nm to capture the images of maize healthy and diseased leaves.

This Hyperspectral Imaging Sensor is present in the RUSA Laboratory at Dr. Babasaheb Ambedkar Marathawada University, Aurangabad, Maharashtra. It consists of 4 halogen lamps which were places approximately 100 cm above where the samples were places. The samples were placed on the black line scanner which had the size of 0.10m above the ground surface which moved in the camera field of view (FOV).

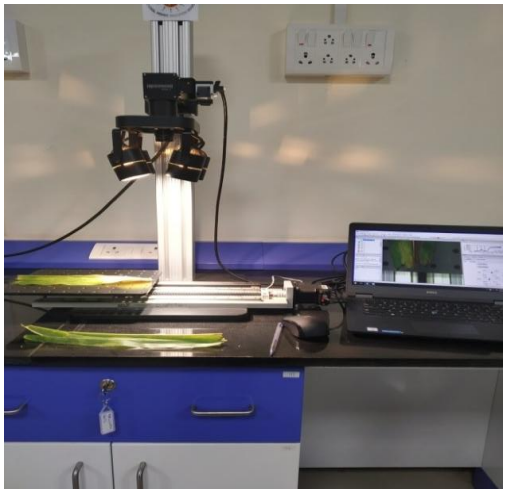

Fig.2. Post-processing of spectral signature

Pika-L is a hyperspectral imaging sensor which has license software known as Spectronon Software. The spectral signature file was converted into .text file which contain a reflectance and wavelength column.

D. Spectral Signature Analysis

The spectral signature of all 40 samples (healthy and diseased) is shown in the figure without any preprocessing. From the figure we can interpret that spectral signature shows certain variation in the visible region (350-680 nm). This high reflectance can be seen near 550 nm which contains chlorophyll. Then after the changes in the spectral reflectance are seen in the wavelength from near 750-1000 nm, these are the NIR region which contains various pigments and cellulose. These are the two regions mainly visible and the NIR regions which give use the more information about the plant health. In our study we have concreted on the wavelength from 400-1000.

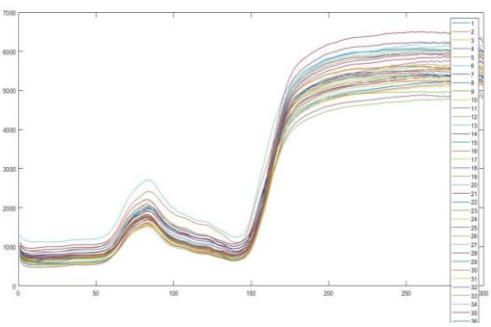

Fig.3. Spectral Signature of Maize

III. PROPOSED SYSTEM

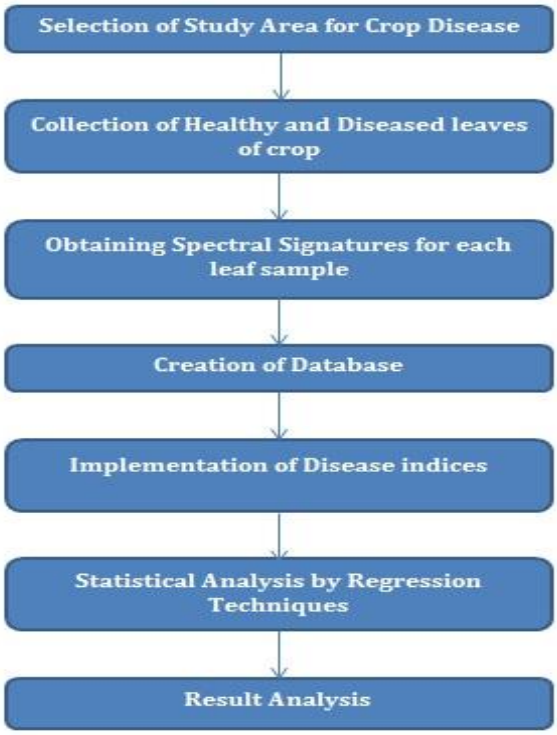

Fig.3. Proposed System

Field was selected for data sample collection of maize in Aurangabad region. The spectral signature was obtained using the Pika-L hyperspectral imaging sensor. This imaging sensor generates a .tiff file. The spectral signatures of this .tiff file were obtained using the resonance software. In the post-processing of this spectral signature this spectral signature were converted into the text file. Then after various disease indices were calculated for the maize plant**.** A machine learning linear regression algorithm was used for the correlation of the samples. Statistical values were calculated for each disease indices**.** In this manner, the advancement of the most generally utilized reflectance indexes and spectrum regions are associated with physiological analyses of the plants directly or indirectly.

IV. RESULT AND DISCUSSION

A. Nitrogen Reflectance Index

Nitrogen in plants is present in the mesophyll cell of plant leaf which is then used for the synthesis process in plant [8]. Healthy plant contain more amount of nitrogen then the diseased plant, which means that nitrogen content is directly proportional to chlorophyll content in plant. If the nitrogen content id reduced in the crop than the leaf turns yellow and less amount of radiations are used from spectrum. The nitrogen content can change according to the climatic conditions, season, etc.

$$NRI = (R_{700} - R_{670}) / (R_{570} + R_{670}) \quad (1)$$

Chlorophyll in leaf has High values in two different wavelengths in the spectrum which are Blue (400-500 nm) region and red (600-700) nm [9].

Many of the literature show that there is a strong relation among chlorophyll and crop reflectance at the wavelengths 525-630 nm, 640-660 nm, 705 nm,930 nm [10,11]

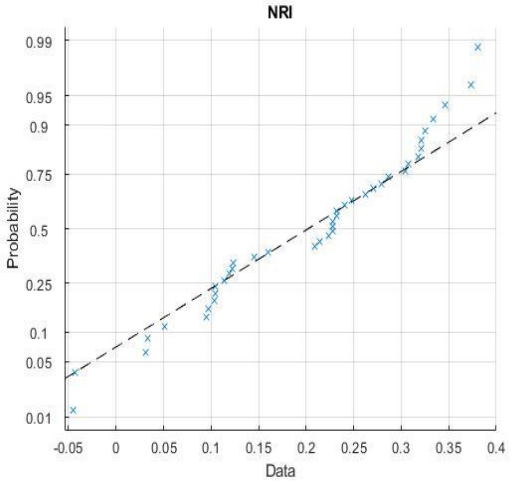

Fig.4. :Linear Regression Plot for NRI

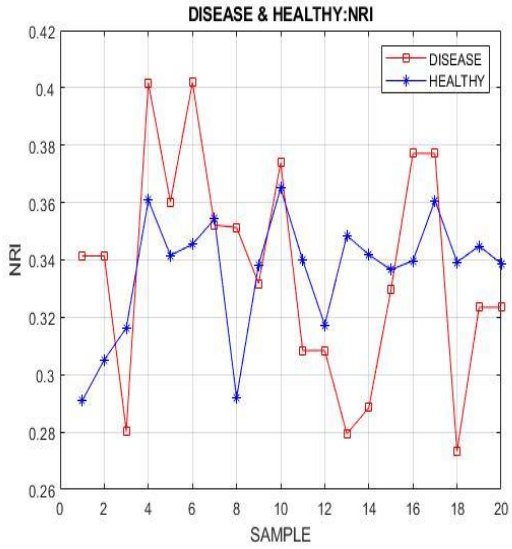

Fig.5. graphical representation of NRI

Table- I. PRI

PRI	
DISEASE	**HEALTHY**
0.341426253914174	0.290979290979291
0.341426253914174	0.305131506345411
0.280258163059023	0.316366087982471
0.401709936648219	0.360765739096112
0.360249598071492	0.341581117838028
0.401885260604001	0.345446487923776
0.352185715167649	0.354232585308864
0.351324407829926	0.291859695565850
0.331768095835223	0.338350365587720
0.373934466136233	0.364961700024710
0.308440975108129	0.339909217877095
0.308440975108129	0.317318566470382
0.279386188543769	0.348556215441327
0.288502463270790	0.341808524533066
0.329508674587379	0.336581677657832
0.377132021797113	0.339729461083020
0.377132021797113	0.360740908064152
0.273376829456366	0.339208570934854
0.323513658275308	0.344883405521285
0.323513658275308	0.338744126441692

B. Photochemical Reflectance Index

PRI is used in many of the literature [12] using 2 bands of the green wavelength spectrum. Following is the equation for PRI:

$$PRI = (R531 - R570)/(R531 + R570) \quad (2)$$

PRI changes affects the crops chlorophyll content and also leads to the water stress in the plant .

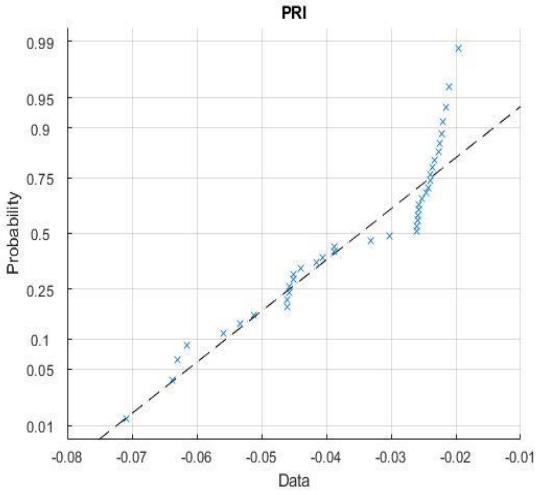

Fig.6. :Linear Regression Plot for PRI

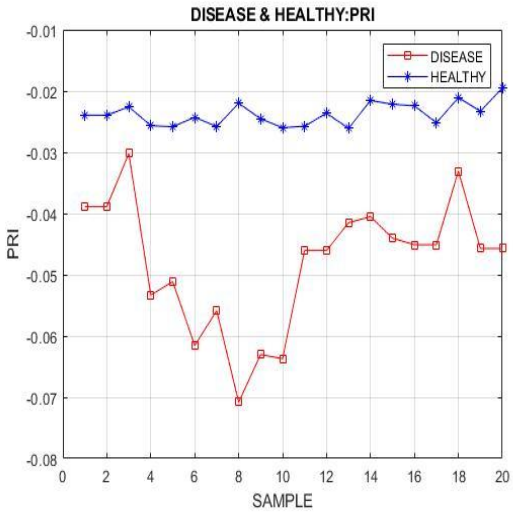

Fig.7. graphical representation of PRI

Table- II. NRI

NRI	
DISEASE	**HEALTHY**
-0.03886	-0.02394
-0.03886	-0.02395
-0.0302	-0.02259
-0.05332	-0.02566
-0.05114	-0.02583
-0.06156	-0.02429
-0.05586	-0.02581
-0.07081	-0.02199
-0.06303	-0.02455
-0.06371	-0.026
-0.04604	-0.02573
-0.04604	-0.02364
-0.04151	-0.0261
-0.04052	-0.02154
-0.04403	-0.02217
-0.04511	-0.02243
-0.04511	-0.02519
-0.03307	-0.02108
-0.0457	-0.0233
-0.0457	-0.01952

Table -III: Stastical values for SVI

SVI	R^2	RMSE	Standard Error	p-value
NRI	4.223	0.298	2.648	0.968
PRI	0.727	0.512	2.979	2.787

V. CONCLUSION

Hyperspectral imaging sensor was used for spectral data collection of maize healthy and diseased leaves 20 samples each. Nitrogen reflectance index and Photochemical reflectance index was calculated using the specific spectral reflectance bands. Linear Regression was applied on the data after the index calculation. Stastical values like r-squared, RMSE, Standard error, P-values were calculated using MATLAB 2018 tool

ACKNOWLEDGMENT

Authors would like to acknowledge technical supports under UGC SAP (II) DRS Phase-II, DST-FIST and RUSA to Department of Computer Science & IT, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra, India.

REFERENCES

1. https://farmer.gov.in/M_cropstaticsmaize.aspx [cited on 24-oct-2019]
2. Ullah, M.A., M. Anwar and A.S. Rana, 2010. Effect of nitrogen fertilization and harvesting intervals on the yield and forage quality of elephant grass (Pennisetum purpureumL.) under mesic climate of Pothowar plateau. Pak. J. Agri. Science, 47: 231-234.
3. Kusnierek, K., Korsaeth, A., 2015. Simultaneous identification of spring wheat nitrogen and water status using visible and near infrared spectra and powered partial least squares regression. Comput. Electron. Agric. 117, 200–213.
4. Li, F., Miao, Y., Feng, G., Yuan, F., Yue, S., Gao, X., Liu, Y., Liu, B., Ustin, S.L., Chen, X., 2014a. Improving estimation of summer maize nitrogen status with red edge-based spectral vegetation indices. Field Crops Res. 157, 111–123.
5. Sáez-Plaza, P., Navas, M.J., Wybraniec, S., Michałowski, T., Asuero, A.G., 2013. An overview of the Kjeldahl method of nitrogen determination. Part II. Sample preparation working scale instrumental finish and quality control. Crit. Rev. Anal. Chem. 43 (4), 224–272.
6. Jay, S., Gorretta, N., Morel, J., Maupas, F., Bendoula, R., Rabatel, G., Dutartre, D., Comar, A., Baret, F., 2017. Estimating leaf chlorophyll content in sugar beet canopies using millimeter-to centimeter-scale reflectance imagery. Remote Sens. Environ. 198, 173–186.
7. https://www.wur.nl/en/show/Photochemical_Reflectance_Index.htm
8. Ecarnotb, M., Rabatela, G., & Roumet, P. (2011). Potential of field hyperspectral imaging as a non-destructive method to assess leaf nitrogen content in wheat. Field Crops Research, 122(1), 25e31.
9. Eitel, J., Maguire, A., Boelman, N., Vierling, L. A., Griffin, K. L., Jensen, J., ... & Sonnentag, O. (2018, December). Evaluating the potential of fall trends in photochemical reflectance index (PRI) time-series to improve understanding of climate change effects at northern treeline. In AGU Fall Meeting Abstracts.
10. Basyouni, R., & Dunn, B. (2013). Use of reflectance sensors to monitor plant nitrogen status in horticultural plants. Oklahoma Cooperative Extension Service. HLA-6719 (pp. 1e4).
11. Jain, N., Ray, S. S., Singh, J. P., & Panigrahy, S. (2007). Use of hyperspectral data to assess the effects of different nitrogen applications on a potato crop. Precision Agriculture, 8, 225e239.
12. Kohzuma, K., & Hikosaka, K. (2018). Physiological validation of photochemical reflectance index (PRI) as a photosynthetic parameter using Arabidopsis thaliana mutants. Biochemical and biophysical research communications, 498(1), 52-57.

AUTHORS PROFILE

Komal D. Patil, Pursued Bachelor of Engineering degree in Computer Engineering from Pune University. Maharashtra, India in 2017 and, currently pursuing Master of Technology in Computer Science from Babasaheb Ambedkar Marathawada University, Aurangabad,Maharashtra, India.

Prof. K. V. K, M.Sc, M.C.A [Engg. and Tech.**],** B.Ed,Ph.D, FIETE, Senior Member IEEE**,** Department of Computer Science and Information Technology,
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, Maharashtra,