Original Research Article

Feasibility of multispectral observations for detecting nitrogen stress and yield potential in cotton (*Gossypium hirsutum* L.) through Remote Sensing

Abstract: The present investigation was conducted during *kharif* 2019-20 at Department of Agronomy farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The experiment was laid out in randomized block design with seven treatments and three replications. Treatments consisted of different nutrient management practices including FYM and nitrogen doses viz., Absolute Control (N_1), FYM @ 5 t ha^{-1} (N_2), N_2 + 30 kg N ha^{-1} (N_3), N_2 + 60 kg N ha^{-1} (N_4), N_2 + 90 kg N ha^{-1} (N_5), N_2 +120 kg N (N_6) and N_2 + 150 kg N ha^{-1} (N_7). Cotton crop was sown on 29th June 2019 and was harvested in four pickings. Among various spectral bands, significantly higher positive and negative correlation coefficient values (at 0.05 % level of significance) for plant chlorophyll content were noted with the simple ratio of NIR/G (r^2=0.829) and G/NIR(r^2=-0.826), respectively, being most efficient in detecting the nitrogen stress in cotton crop. Yield potential of cotton was established (at 0.05 % level of significance) with negative and positive (both) correlation coefficient of simple ratio of R/NIR (r^2=-0.815 and r^2=-0.869) and NIR/R (r^2=0.811and r^2=0.865) respectively at 180 DAS.

Keywords: Nitrogen levels, Remote Sensing, Spectral wavebands, Ground truth observation, Spectral reflectance values, Correlation.

1. Introduction

Cotton is the backbone of textile industry, which consumes 59% of the country's total fibre production. Cotton plant not only provides the fibre for making cloth to protect the human body with edible oil for consumption & also excellent cattle, poultry and fish feed. India remains the leading country in terms of area under cotton cultivation and raw cotton production in the world. As per CAB estimate, cotton production in India during 2017-18 was expected to produce 377 lakh bales of 170 kg from 122 lakh hectares with a productivity of 524 kg lint/ha.

For achieving highest yield, it becomes inevitable to early estimate the cotton yield, especially the nitrogen stress to avoid the further loss of crop yield. This can be made possible through remote sensing techniques. The sensor cameras can be carried away over the top of the canopy through various ground, aerial and space based platforms. Among aerial remote sensing platforms, drones are found very much suitable due to its ability to cover larger areas with higher spatial and temporal resolutions. Several vegetation indices had been developed for relating data obtained by remote sensing with the crop nitrogen content of numerous crops (Bagheri *et al.* 2013). Normalized Difference Vegetative Index (NDVI) estimated using remote sensing has been commonly used for monitoring of crop growth and prediction of crop yield (Bala and Islam 2009).

Cotton (*Gossypium hirsutum* L.) is one of the most important cash crops of Vidarbha but average yield per hectare is quite low. Among the nutritional factors, which are responsible for low yield of cotton, nitrogen stress is the important one. Nitrogen plays significant role in deciding the cotton yield since it markedly influences the growth and yield attributes. Cost of Production of cotton is very high due to costly inputs like nutrients, chemicals, etc. The precision farming can play an important role in the application of precise quantity of inputs without affecting productivity. For precise application of inputs across the entire field, the identification of the location and quantity of inputs is required to adjust the input on spatially variable basis.

Remote sensing techniques can be efficiently used in agriculture for prediction of yield, assessment of nutrient status, water status, effect of adverse weather on crop growth, detection of pest damage, weed mapping and weed control etc. with the help of remotely sensed parameters and models.

In contest of all the above points and with specific aim to identify the cause of stress in cotton crop based on the nitrogen management, present experiment was conducted with the objectives of

to investigate the feasibility of multispectral observations for detecting nitrogen stress in cotton with to establish effective wavebands for assessing nitrogen stress in cotton through discriminate analysis and to estimate the yield potential of cotton through various spectral vegetation indices.

2. Materials and Methods

2.1. Experimental details

The field experiment was conducted during *kharif* season of 2019-2020 at the Farm of Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS). The investigation was laid out in Randomized Block Design (RBD) with seven treatments replicated thrice. The allotment of the treatments to various plots was done randomly. Treatments consisted of different nutrient management practices including FYM and nitrogen doses viz., Absolute Control (N_1), FYM @ 5 t ha^{-1} (N_2), N_2 + 30 kg N ha^{-1} (N_3), N_2 + 60 kg N ha^{-1} (N_4), N_2 + 90 kg N ha^{-1} (N_5), N_2 +120 kg N (N_6) and N_2 + 150 kg N ha^{-1} (N_7). The soil of the experimental plot was clayey in texture with moderately alkaline in reaction (pH 8.12). The soil was low in available nitrogen (176 kg ha^{-1}), low in available phosphorus (15 kg ha^{-1}) and high in available potassium (360 kg ha^{-1}) while, low in organic carbon content (0.45 %). The gross and net plot size was 10.8 m x 9.00 m and 9.00 m x 7.8 m, respectively. A cotton variety named PKV-Hy-2-BG-II recommended by Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola was used. Cotton crop was sown on 29th June 2019 and was harvested in four pickings.

2.2.Spectral data collection

The Slant Range (USA make) 4P Series multispectral sensors having six high resolution bands (RGB, Red, Red Edge, NIR) with modular capability to support precision crop measurement and flexibility to work with most small UAVs with DJI SKYPORT integration was used for aerial scanning. The Slant Range (USA make) 4P Series multispectral sensors having six high resolution bands (RGB, Red, Red Edge, NIR) with modular capability to support precision crop measurement and flexibility to work with most small UAVs with DJI SKYPORT integration was used for aerial scanning. Spectral waveband reflectance values obtained at periodical interval of 120, 150 and 180 DAS.

2.3.Statistical analysis

The specific waveband reflectance values and their correlation with different plant characters, had correlated these values with those plants characters and tried to obtain the correlation coefficient for detecting N stress. The experimental data collected during the course of investigation was analyzed with Randomized Block Design by standard statistical techniques of analysis of variance . critical difference at p=0.05 level was calculated for comparison of treatment means. For correlation studies, the SPSS statistical analysis software was used.

3. Results

3.1. Nitrogen stress assessment

The specific waveband reflectance values were correlated to the total chlorophyll content and tried to obtain correlation coefficient for detecting N stress. The simple ratio of Green and Near Infra-Red (G/NIR) band recorded significantly higher negative correlation with total chlorophyll content (r^2=-0.826). Simple ratio of Near-Infra-Red and Green (NIR/G) band recorded significantly strong positive correlation with total chlorophyll content (r^2=0.829) (Table.2) similar strong correlation with various indices in relation to crop nitrogen and chlorophyll content was reported by Filella *et al*. (1995), Read *et al*. (2002) and Muharam *et al*. (2015).

Table 1: Correlation coefficient of ratios of Green spectral waveband with total Chlorophyll (mg/ml)

G/B	G/R	G/nRE	G/fRE	G/NIR
-0.264	0.018	0.129	0.004	-0.826*
0.063	-0.319	-0.285	-0.392	-0.373
0.284	0.275	-0.050	-0.129	-0.151

Table 2: Correlation coefficient of ratios of (Near Infra-Red) NIR spectral waveband with total Chlorophyll (mg/ml)

NIR/B	NIR/G	NIR/R	NIR/nRE	NIR/fRE
-0.071	0.829*	0.292	0.742	0.480
0.197	0.365	-0.050	-0.170	-0.229
0.423	0.160	0.456	O.138	-0.035

3.2. Yield potential

The specific waveband reflectance values were correlated to the seed cotton yield and correlated to obtain correlation coefficient for yield potential of cotton.The simple ratio of Red and Near Infra-Red (R/NIR) band observed significantly higher negative correlation in case of seed cotton yield (r^2=-0.815) and (r^2=-0.869). Similarly, the simple ratio of Near-Infra-Red and Red (NIR/R) was found significantly higher positive correlation in case of seed cotton yield (r^2=0.811) and (r^2=0.865) Similar strong correlation with various indices in relation to yield potential was reported by Huang *et al.* (2013).

Table 3: Correlation coefficient of ratios of Red spectral waveband with seed cotton yield

R/B	R/G	R/nRE	R/fRE	R/NIR
-0.449	0.245	0.169	0.031	-0.215
0.184	0.346	-0.273	-0.273	-0.815*

-0.057	-0.310	-0.451	-0.460	-0.869*

Table 4: Correlation coefficient of ratios of Near Infra-Red (NIR) spectral waveband with seed cotton yield

R/B	R/G	R/nRE	R/fRE	R/NIR
-0.330	0.651	0.284	0.658	0.374
0.129	0.298	0.811*	-0.296	-0.332
0.454	0.253	0.865*	0.126	-0.082

4. Conclusion

Correlation coefficient of simple ratios of G/NIR and NIR/G band was found significant correlation in case of total chlorophyll at the 5% level of significance. (P=0.05). Thus it is evident from these result that the nitrogen stress in cotton can be effectively detected by the G/NIR and NIR/G wave bands.Correlation coefficient of simple ratios of R/NIR and NIR/R band found significantly correlated in case of seed cotton yield at the level of significance of P=0.05).

Among various spectral bands, significantly higher positive and negative (both) correlation coefficient values (at 0.05 % level of significance) for plant chlorophyll content were noted with the simple ratio of NIR/G and G/NIR, respectively, being most efficient in detecting the nitrogen stress in cotton crop. Yield potential of cotton was established (at 0.05 % level of significance) with negative and positive (both) correlation coefficient of simple ratio of R/NIR and NIR/R, respectively.

5. References

Bagheri N., H. Ahmadi, S.K. Alavipanah and M. Omid. 2013. Multispectral remote sensing for site-specific nitrogen fertilizer management. Pesq. Agropec. Bras., Brasília, V.48,10: 1394-1401.

Bala S. K. and Islam A. S. 2009. Correlation between potato yield and MODIS‐derived vegetation indices. Int J. Remote Sensing Vol. 30(10): 2491-2507.

Filella I., L. Serrano, J. Serra and J. Penuelas. 1995. Evaluating wheat nitrogen status with canopy reflectance indices and discriminant analysis. Crop Sci 35(5): 1400-05.

Huang Y., R. Sui, S.J. Thomson and D.K. Fisher. 2013. Estimation of cotton yield with varied irrigation and nitrogen treatments using aerial multispectral imagery. Int J Agric & Biol Eng, 6(2): 37－41.

Muharam F.M., S.J. Maas, K.F. Bronson and T. Delahunty. 2015. Estimating Cotton Nitrogen Nutrition Status Using Leaf Greenness and Ground Cover Information. Remote Sens. 7: 7007-7028.

Read J.J., L. Tarpley, J. M. McKinion and K. R. Reddy. 2002. NarrowWaveband Reflectance Ratios for Remote Estimation of Nitrogen Status in Cotton. J. Environ. Qual.31:1442–1452.