INFLUENCE OF OPTICAL SENSOR-BASED NITROGEN MANAGEMENT PRACTICES ON MITIGATING LEAF REDDENING IN BT COTTON AND ITS SPECTRAL CHARACTERIZATION

ASHWINI, T. R.[1,2*] – POTDAR, M. P.[1] – ARAVIND KUMAR, B. N.[1] – PATIL, P. L.[3]

[1]*Department of Agronomy, University of Agricultural Sciences, Dharwad 580005, India*

[2]*Department of Agronomy, Vellore Institute of Technology, Vellore, Tamil Nadu 632014, India*

[3]*Directorate of Research, University of Agricultural Sciences, Dharwad 580005, India*

**Corresponding author*
e-mail: ashwini.tr@vit.ac.in

(Received 27th Dec 2022; accepted 27th Apr 2023)

Abstract. This study was undertaken for spectral characterization of red leaf and to mitigate leaf reddening in Bt cotton genotypes with different nitrogen management practices through proximal sensors. Field experimentation was carried during *Kharif* 2019 and 2020 with two genotypes in main plot and eight proximal sensor-based N management practices in sub plot. Spectral characterization of red leaves was recorded through GreenSeeker (NDVI) and SPAD meter (SPAD value) and quantitative estimation of degree of leaf reddening was visualized by intensity of red leaf color at 130 DAS. Genotypes show non-significant ($P > .005$) difference for NDVI and SPAD value and significant ($P < .005$) difference for red leaf index (1.03 and 1.59 with First Class and Ajeet 155, respectively). Proximal sensor-based N management practices significantly ($P < .0001$) influenced spectral values and red leaf index. N supplementation at 1.1–1.5 RI, 81–90% SI and RDF recorded comparable and significantly higher NDVI (0.78, 0.77 and 0.74, respectively) and SPAD value (31.70, 31.23 and 28.72, respectively) as compared to the rest of the treatments. Proximal sensor-based N management practices **(**1.1–1.5 RI and 81–90% SI) significantly reduced red leaf index (0.18 and 0.23) as compared to RDF (1.12) and N omission (2.23). Interactions were found non-significant. NDVI and SPAD value of red leaf, N content in leaf (%) and seed cotton yields were strongly and negatively correlated with red leaf index. The results showed that the nitrogen supplementation at 1.1–1.5 RI and 81–90% SI reduced the incidence of leaf reddening and also resulted in recording higher spectral values like NDVI and SPAD meter readings.
Keywords: *Bt cotton, proximal sensors, red leaf index, NDVI of red leaf, SPAD value of red leaf*

Introduction

Red leaf disease in cotton is commonly known as *lal patti* in India, copper top, phloem wilt and sudden wilt in the US and red leaf and red wilt in other countries. Atkinson (1892) first time observed red leaf syndrome and recognized yellow and red leaf blight as a physiological disorder and attributed it to mineral deficiency, although the exact element was not identified. Leaf reddening is more of a physiological disorder and outcome of the interaction of variety/hybrid, environmental factors and nitrogen deficiency including micronutrients. Symptoms of leaf reddening differ from region to region in India. In West Punjab and Maharashtra reddening is caused mainly by nitrogen deficiency, while in South-West Punjab and Eastern Rajasthan, it appears to be due to sudden drop in temperature. And in Southern states like Karnataka, Andhra Pradesh and Tamil Nadu magnesium deficiency leads to leaf reddening (Subba Rao, 1975). In Dharwad region, leaf reddening initiates at bud formation stage and continues

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

at an increasing rate. Initiation of leaf reddening is usually accompanied by sudden drop in temperature and high wind velocity, coupled with nutritional deficiency as observed by several scientists (Dastur, 1967 and Bhatt et al., 1982). Furthermore, it is also assumed that apart from external factors there might be other internal factors such as accumulation of photosynthates and formation of anthocyanin's, due to variation in the external factors. However, it is certain that mechanical injury and insect damage particularly jassids, cause the development of red pigments. It is also reported that the extent of reddening would also depend on the genotype of cotton grown at different regions (Dastur et al., 1952).

After introduction of Bt cotton leaf reddening has become a serious physiological problem. Due to rapid translocation of saccharides and nutrients from leaves alter source-sink relationship due to synchronized boll development (Wright, 1999; Hebbar et al., 2007). Leaf reddening in cotton causes due to non-synchronization of nutrients between source and sink. The red leaf syndrome is wide spread but its occurrence is not consistent. In American upland cotton occurrence of reddening at post flowering stage will not affect the yielding ability but when it occurs at flowering or vegetative stage yield will reduce drastically. The yield was reduced as the plant growth was arrested because of poor rate of photosynthesis in developing red leaves (Zade and Dhopte, 1987).

Leaf reddening is a complex phenomenon and there is no reason for why leaves turn red. Seed cotton yields can be reduced to the extent of 30–60% due to leaf reddening depending on variety and reddening intensity (Pagare, 2011). The main reason for leaf reddening is nitrogen and magnesium deficiencies coinciding by lower nutrient availability/crop uptake followed by lower temperatures. In early planting crop supply of nitrogen along with phosphorous and potassium to the leaf reduce formation of anthocyanin and achieve potential yield is critical (Basavaneppa et al., 2015; Honnali and Chittapur, 2017 and Sathyanarayanrao et al., 2014). Based on the survey on constraints of Bt cotton cultivation shown that 93% farmers are facing leaf reddening problem (Hosamani et al., 2017).

Number of remedial measures has been proposed from time to time by several workers to combat this problem. Some measures including early sowing to escape the cool night at boll development stage and present recommended practices of twice foliar application of urea @ 2% DAP and $MgSO_4$ @ 1.0% are in place as of now. But these measures have not been effective in reducing the leaf reddening. Since years much work has been carried to mitigate leaf reddening through supply of nitrogen, phosphorous and potassium in split applications and no work has been carried on time of application on real time basis. There is a need for developing new solutions based on modern technologies for the management of leaf reddening in cotton. The advanced technologies like use of sensors utilize the optical characteristics of plants and their associated vigor and health properties. Crop reflectance sensors provide an accurate and spatially-intensive method for diagnosing and applying the correct N rate (Scharf and Oliveira, 2008). Since years, many researchers observed higher degree of incidence of leaf reddening in *Hirsutum* and *Barbadens* than *Desi* types. Not much work has been carried to screen cultivars to leaf reddening. In the present investigation two Hirsutum genotypes Ajeet 155 and First Class were selected. Hosmath et al. (2012) also reported that 89% farmers experiencing leaf reddening problem from peak flowering to boll development stage. Hence the present investigation was undertaken for spectral characterization of red leaf and to mitigate leaf reddening in Bt cotton genotypes through real time nitrogen application using proximal sensors.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

Materials and methods

Experimental site, cultivar and index calculation

A field experiment was carried out at Main Agricultural Research Station, Dharwad, India during *Kharif* 2019-20 and 2020-21 to study the spectral characterization and mitigation of leaf reddening in Bt cotton genotypes through proximal sensor-based nitrogen management. Geographically experimental site lies between 15° 30’6” N latitude, 74°° 59’13.2” E longitude and at an altitude of 678 m above mean sea level. Highest amount of rainfall was received during early squaring to early blooming stage during both the years (492.0 and 357.4 mm received with 19 and 11 rainy days, respectively) followed by mid flowering to peak flowering/boll initiation stage (285.0 and 223.4 mm received with 9 rainy days, respectively). The highest mean monthly maximum temperature (29.2°C and 29.2°C, respectively) was observed during mid-flowering to peak flowering/boll initiation stage and boll development to 1st picking stage, respectively. The lowest mean monthly temperature (17.7°C and 16.1°C, respectively) was observed during the boll development to 1st picking stage, respectively. Mean monthly maximum relative humidity was 90.5% during early blooming to mid flowering stage at 2019 and 94.1% during early squaring to early blooming in 2020. Mean monthly minimum relative humidity values were 63.0 and 46.1% at boll development to harvest stage during 2019 and 2020, respectively (*Photo 1*).

Photo 1. *Aerial image of the experimental field*

Soil was neutral to slightly alkaline in reaction (7.65) with normal electrical conductivity (0.31 dSm^{-1}), low in organic carbon content (0.45%), medium in available nitrogen (278.30 kg ha^{-1}) and phosphorous (34.35 kg P_2O_5 ha^{-1}) and high in available potassium (357.65 kg K_2O ha^{-1}). The experiment was established in split plot design with

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

three replications and comprising of sixteen treatment combinations. Two genotypes Ajeet 155 (G1) and First Class (G2) in main plot and eight proximal sensor-based N management practices [N supplementation at 60–70, 71–80 and 81–90% Sufficiency Index (SI) (N_1–N_3), N supplementation at 1.1–1.5, 1.6–2.0 and 2.1–2.5 Response Index (RI) (N_4–N_6), RDF (150:75:75 N:P_2O_5:K_2O kg ha^{-1}) (N_7) and N omission (0:75:75 N:P_2O_5:K_2O kg ha^{-1}) (N_8)] in sub plot. Two nitrogen rich plots with application of 200% RDF and two absolute control plots were maintained for respective genotypes.

Sufficiency index was calculated from SPAD value recorded through SPAD 502 chlorophyll meter and response index from NDVI recorded through GreenSeeker (Trimble) proximal sensor. SPAD and GreenSeeker values were recorded at 7 days interval from early squaring up to mid bloom stage.

$$\text{Sufficiency Index (SI)} = \frac{\text{SPAD value of test plot}}{\text{SPAD value of N rich plot}} \times 100$$

$$\text{Response Index (RI)} = \frac{\text{NDVI value of N rich plot}}{\text{NDVI value of test plot}}$$

Land was ploughed by tractor drawn MB plough once and harrowed twice. Well decomposed FYM @ 10 t ha^{-1} was incorporated in to the soil three weeks prior to sowing. Bt cotton genotypes of Ajeet 155 and First Class were sown at a spacing of 90 cm × 60 cm on 21st June and 26th June of 2019 and 2020, respectively. Rest of the practices were done as per the package of practices of University of Agricultural Sciences, Dharwad. For all the treatments except N omission 50% of nitrogen fertilizer and full dose of phosphorous and potassium was applied at the time of sowing as basal dose. Whereas, in N omission plot full dose of phosphorous and potassium was supplied. In conventional nitrogen nutrition (RDF) plot the remaining 50% of nitrogen in the form of urea was applied in two splits at fixed growth stages of 30 and 60 DAS. In the rest of the treatments (N_1 to N_6) nitrogen top dressing was done at the rate of 30 kg ha^{-1} whenever SI and RI values fall in the set range (N_1, N_5 and N_6: No top dressing, N_2: one top dressing at 70 and 61 DAS during 1st and 2nd year, N_3: two top dressings (55 and 70 DAS during 1st year, 41 and 61 DAS during 2nd year); N_4: two top dressings (55 and 70 DAS during 1st year, 41 and 53 DAS during 2nd year) (*Table 1*).

Table 1. *The total amount of N fertilizer applied in different treatments*

Treatments	Basal dose		Top dressing				Total N (kg ha^{-1})	
	2019	2020	2019		2020		2019-20	2020-21
			1st	2nd	1st	2nd		
N_1	75	75	-	-	-	-	75	75
N_2	75	75	-	30 (70 DAS)	-	30(61 DAS)	105	105
N_3	75	75	30 (55 DAS)	30 (70 DAS)	30 (41 DAS)	30 (61 DAS)	135	135
N_4	75	75	30 (55 DAS)	30 (70 DAS)	30 (41 DAS)	30 (53 DAS)	135	135
N_5	75	75	-	-	-	-	75	75
N_6	75	75	-	-	-	-	75	75
N_7	75	75	37.5 (30 DAS)	37.5 (60DAS)	37.5 (30 DAS)	37.5 (60 DAS)	150	150
N_8	0	0	-	-	-	-	0	0
Reference plots								
N rich	150	150	75	75	75	75	300	300
Control	0	0	-	-	-	-	0	0

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

Spectral characterization of red cotton leaves

Spectral properties of prominent red cotton leaves were measured on-field using GreenSeeker and SPAD 502 m active proximal sensors. NDVI readings were recorded from a height of 0.75–1 m above cotton red leaf canopy using GreenSeeker on cloud free days between 9:00 am to 12:30 pm. SPAD meter reading were recorded from the red cotton leaves of ten randomly selected plants. Both NDVI and SPAD readings of cotton reddening were recorded at 130 DAS.

Red leaf index

Leaf reddening was recorded by visual observation. For quantitative estimation of degree of leaf reddening, observations were recorded at 130 DAS as outlined by Dastur et al. (1952). The number of leaves showing signs of reddening, partly or wholly were divided into five categories on the visual observations as shown below. Grade 'zero' - When all the leaves were green or less than three leaves showed signs of reddening, Grade 'one'- When three leaves showed reddening, Grade 'two'-When more than three leaves were showing signs of reddening but young leaves were green, Grade 'three'- When all the leaves were showing reddening in patches and Grade 'four'-When the whole plant turned red.

Statistical analysis

Statistical analysis of experimental data was carried out based on the mean value obtained. The level of significance used in 'F' and 'T' was P = .05. the treatment means were compared by Duncan's Multiple Range Test (DMRT) at 0.05 level of probability. Correlation matrix was worked out using R-Software.

Results and discussion

Nitrogen nutrition through graded levels, split applications and foliar applications is highly recommended for managing leaf reddening in cotton but it is not 100% successful. This is a first report on mitigating leaf reddening through nitrogen nutrition on real time basis through proximal sensors.

Spectral characterization of red leaf (130 DAS)

In the present study spectral characterization of red leaf was done through NDVI and SPAD value (*Figs. 1* and *2*; *Table 2*). Genotypes show non-significant ($P > .005$) difference for NDVI and SPAD value of red leaf (NDVI of 0.52 and 0.50, SPAD value of 15.47 and 14.58 with First Class and Ajeet 155, respectively). Since there were some green leaves at the top of the plant due to its indeterminate character might have affected spectral properties of red cotton leaf resulted in non-significant difference. Non-significant difference with respect to genotypes to spectral properties was also reported by Gowramma (2017). Considerably highest and comparable NDVI (0.78, 0.77 and 0.74, respectively) and SPAD value (31.70, 31.23 and 28.72, respectively) was recorded with N supplementation at 1.1–1.5 RI, 81–90% SI and RDF as compared to rest of the treatments. Even in individual year's also promising treatments has a higher spectral value with different treatments. Lowest NDVI and SPAD value was noticed with N omission (0.27 and 4.47) (*Table 2*). This may be due to non-availability of nitrogen might have

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

increased anthocyanin pigment accumulation and there by leaf reddening. N deficiency caused reduction in chlorophyll, increased the anthocyanin pigmentation and was directly associated with variation in color from dark green to light green and then to red. The interaction of genotypes and proximal sensor-based N management practices were incomparable with respect to NDVI and SPAD value of red leaf. When subjected to DMRT, proximal sensor-based N management practices of 1.1 - 1.5 RI and 81–90% SI of both the genotypes recorded significantly higher NDVI and SPAD value as compared to all other treatment combinations except for RDF (*Table 2*). The higher spectral properties at this stage might be due to lower red leaf index, higher leaf nitrogen; higher chlorophyll contents resulted in higher photosynthetic efficiency and resulted in higher plant biomass. These results are at parity with Satyanarayan and Santhosh (2017). The intensity of reddening between different treatments can be clearly seen in *Plate 1*.

Figure 1. *NDVI of red leaf as influenced by proximal sensor-based nitrogen management practices in Bt cotton (2019, 2020 and pooled)*

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

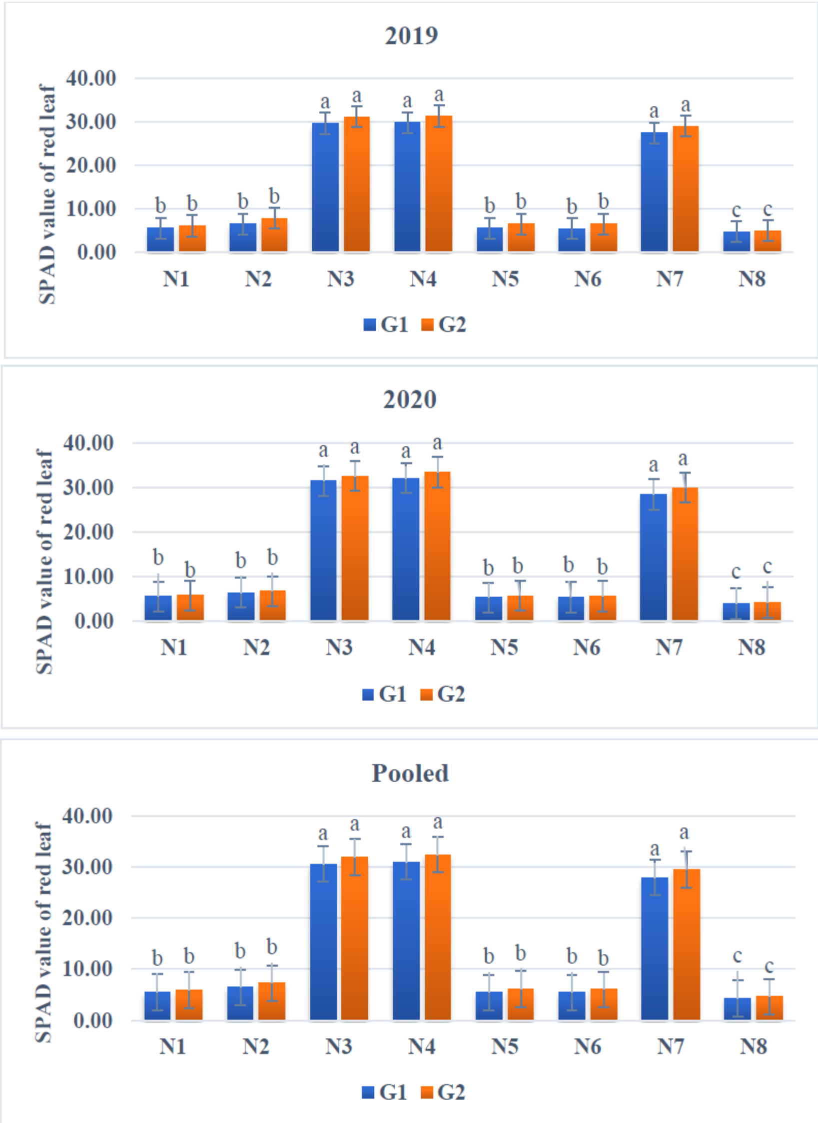


Figure 2. *SPAD value of red leaf as influenced by proximal sensor-based nitrogen management practices in Bt cotton (2019, 2020 and pooled)*

Red leaf index (130 DAS)

The data (pooled) pertaining to red leaf index at 130 DAS (*Fig. 3*) revealed that; genotypes exhibited a significant difference (P < .005). Among the tested genotypes First Class (1.03) recorded significantly lower red leaf index as compared to Ajeet 155 (1.59). This might be due to significantly higher chlorophyll a, b and total chlorophyll in First Class resulted in healthy cotton leaves as compared to Ajeet 155 where reduction in chlorophyll content in red leaf was more. These results are in conformity with findings of Pagare and Durge (2011) and Hosmath et al. (2012).

Red leaf index was significantly (P < .0001) influenced by different proximal sensor-based N management practices, N supplementation at 1.1–1.5 RI and 81–90% SI recorded significantly lower RLI (0.15 and 0.23, respectively) as compared to rest of the treatments, followed by RDF (1.12) (*Table 3*) and (*Fig. 3*). Significant reduction of RLI in proximal sensor-based N management practices might be due to synchrony of

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

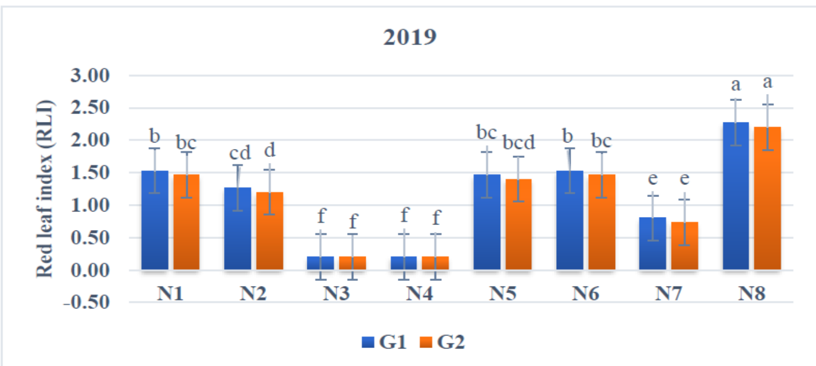
demand and supply of nitrogen to the crop as per crop needs. In cotton critical period for nutrient demand will be during pin head square stage and between early flowering to mid bloom stage and sensor-based treatments received top dressing at these stages. When moisture is not constraint, nitrogen supply coinciding with crop demand might have improved nitrogen uptake throughout growing period which enhanced photosynthetic rate and biomass aggregation. Because of this synchronization in demand and supply lower reddening was noticed. Whereas in conventional practice top dressing was done at fixed growth stages i.e. early squaring (30 DAS) and early flowering stage (60 DAS). Significantly higher RLI was observed with N omission (2.23). This might be due to deficiency of nitrogen created due to non-supply has increased anthocyanin pigmentation and reddening in leaf. These results were in conformity with Hallikeri et al. (2010).

Table 2. *Spectral characterization of red leaf of Bt cotton through NDVI and SPAD as influenced by optical sensor-based nitrogen management practices*

Treatments	NDVI									SPAD value								
	2019-20			2020-21			Pooled			2019-20			2020-21			Pooled		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
N_1	0.37^{cd}	0.40^{bc}	0.38^{c}	0.33^{cd}	0.34^{bcd}	0.34^{c}	0.35^{d}	0.37^{cd}	0.36^{c}	5.63^{b}	6.16^{b}	5.89^{b}	5.44^{b}	5.70^{b}	5.57^{b}	5.53^{b}	5.93^{b}	5.73^{b}
N_2	0.43^{bc}	0.45^{b}	0.44^{b}	0.41^{bc}	0.44^{b}	0.24^{b}	0.42^{bc}	0.43^{b}	0.43^{b}	6.50^{b}	7.90^{b}	7.20^{b}	6.36^{b}	6.64^{b}	6.50^{b}	6.43^{b}	7.27^{b}	6.85^{b}
N_3	0.77^{a}	0.78^{a}	0.77^{a}	0.77^{a}	0.77^{a}	0.77^{a}	0.77^{a}	0.77^{a}	0.77^{a}	29.66^{a}	31.13^{a}	30.40^{a}	31.50^{a}	32.63^{a}	32.06^{a}	30.58^{a}	31.88^{a}	31.23^{a}
N_4	0.78^{a}	0.78^{a}	0.78^{a}	0.77^{a}	0.77^{a}	0.77^{a}	0.78^{a}	0.78^{a}	0.78^{a}	29.83^{a}	31.30^{a}	30.56^{a}	32.13^{a}	33.53^{a}	32.83^{a}	30.98^{a}	32.42^{a}	31.70^{a}
N_5	0.35^{cd}	0.40^{bc}	0.38^{c}	0.34^{bcd}	0.34^{bcd}	0.34^{c}	0.35^{d}	0.37^{cd}	0.36^{c}	5.57^{b}	6.53^{b}	6.05^{b}	5.24^{b}	5.64^{b}	5.44^{b}	5.41^{b}	6.09^{b}	5.75^{b}
N_6	0.35^{cd}	0.39^{bc}	0.37^{c}	0.34^{bcd}	0.34^{bcd}	0.34^{c}	0.35^{d}	0.37^{cd}	0.36^{c}	5.53^{b}	6.58^{b}	6.06^{b}	5.31^{b}	5.50^{b}	5.40^{b}	5.42^{b}	6.04^{b}	5.73^{b}
N_7	0.73^{a}	0.75^{a}	0.74^{a}	0.74^{a}	0.74^{a}	0.74^{a}	0.74^{a}	0.74^{a}	0.74^{a}	27.40^{a}	29.00^{a}	28.20^{a}	28.50^{a}	30.00^{a}	29.25^{a}	27.95^{a}	29.50^{a}	28.72^{a}
N_8	0.28^{e}	0.29^{de}	0.28^{d}	0.25^{d}	0.26^{d}	0.25^{d}	0.27^{e}	0.27^{e}	0.27^{d}	4.82^{c}	5.06^{c}	4.94^{c}	3.84^{c}	4.16^{c}	4.00^{c}	4.33^{c}	4.61^{c}	4.47^{c}
Mean	0.51^{a}	0.53^{a}		0.49^{a}	0.50^{a}		0.50^{a}	0.52^{a}		14.37^{a}	15.46^{a}		14.79^{a}	15.47^{a}		14.58^{a}	15.47^{a}	

SV	S.Em ±	P value	S.Em ±	P value	S.Em ±	P value	S.Em ±	P value	S.Em ±	P value	S.Em ±	P value
G	0.010	0.2776	0.005	0.3925	0.004	0.1207	0.850	0.4598	0.401	0.3504	0.622	0.4190
N	0.018	0.0000	0..022	0.0000	0.015	0.0000	1.121	0.0000	1.106	0.0000	0.627	0.0000
G×N	0.029	0.9822	0.015	0.9995	0.011	0.9971	2.404	0.9998	1.135	0.9995	1.760	0.9928

DAS: days after sowing
*Reference plots not subjected to statistical analysis (N Rich: 200% RDF; Control: no fertilizer application)
Main plot: Bt cotton genotypes (G): G_1: Ajeet–155, G_2: First Class
Sub plot: Optical sensor-based N management (N): N_1: N supplementation at 60–70% Sufficiency Index, N_2: N supplementation at 71–80% Sufficiency Index, N_3: N supplementation at 81–90% Sufficiency Index, N_4: N supplementation at 1.1–1.5 Response Index, N_5: N supplementation at 1.6–2.0 Response Index, N_6: N supplementation at 2.1–2.5 Response Index, N_7: RDF (150:75:75 $N:P_2O_5:K_2O$ kg ha^{-1}), N_8: Absolute control (0:75:75 $N:P_2O_5:K_2O$ kg ha^{-1})



http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

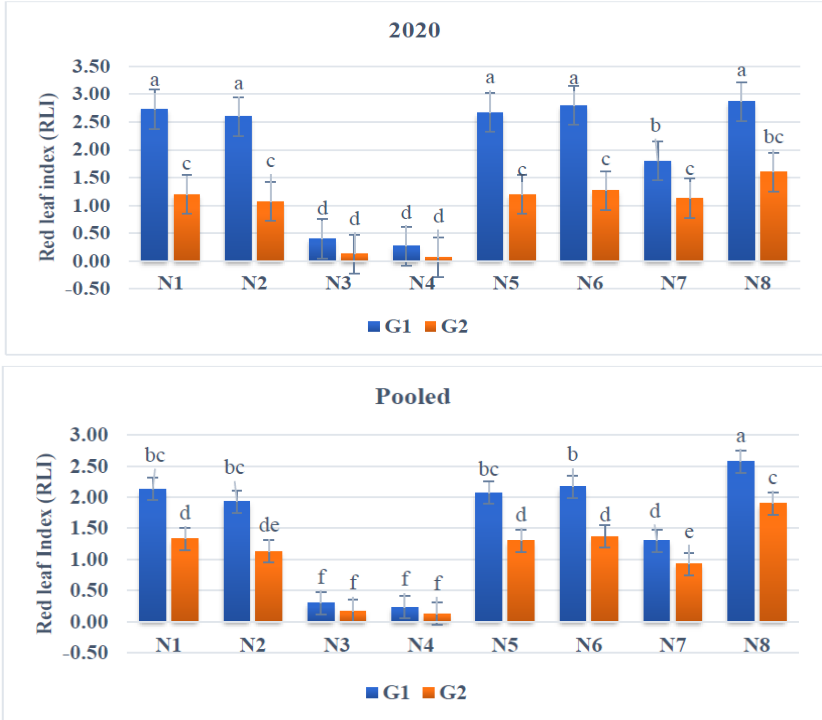


Figure 3. *Red leaf index (RLI) of Bt cotton as influenced by proximal sensor-based nitrogen management practices (2019, 2020 and pooled)*

Interaction of genotypes and proximal sensor-based N management practices significantly (P < .005) influenced red leaf index (*Table 3; Fig. 3*). First Class with N supplementation at 1.1–1.5 RI and 81–90% SI recorded significantly lower red leaf index (0.13 and 0.17, respectively) as compared to all other interaction treatments and found on par with Ajeet 155 with N supplementation at 1.1–1.5 RI and 81–90% SI (0.23 and 0.30, respectively). Significantly highest RLI observed with Ajeet 155 with N omission (2.57). This might be due to real time application of nitrogen at critical growth stages reduced the reddening in cotton. Brar et al. (2004) and Hallikeri et al. (2010) indicated that status of chlorophyll content in leaf was affected by nitrogen.

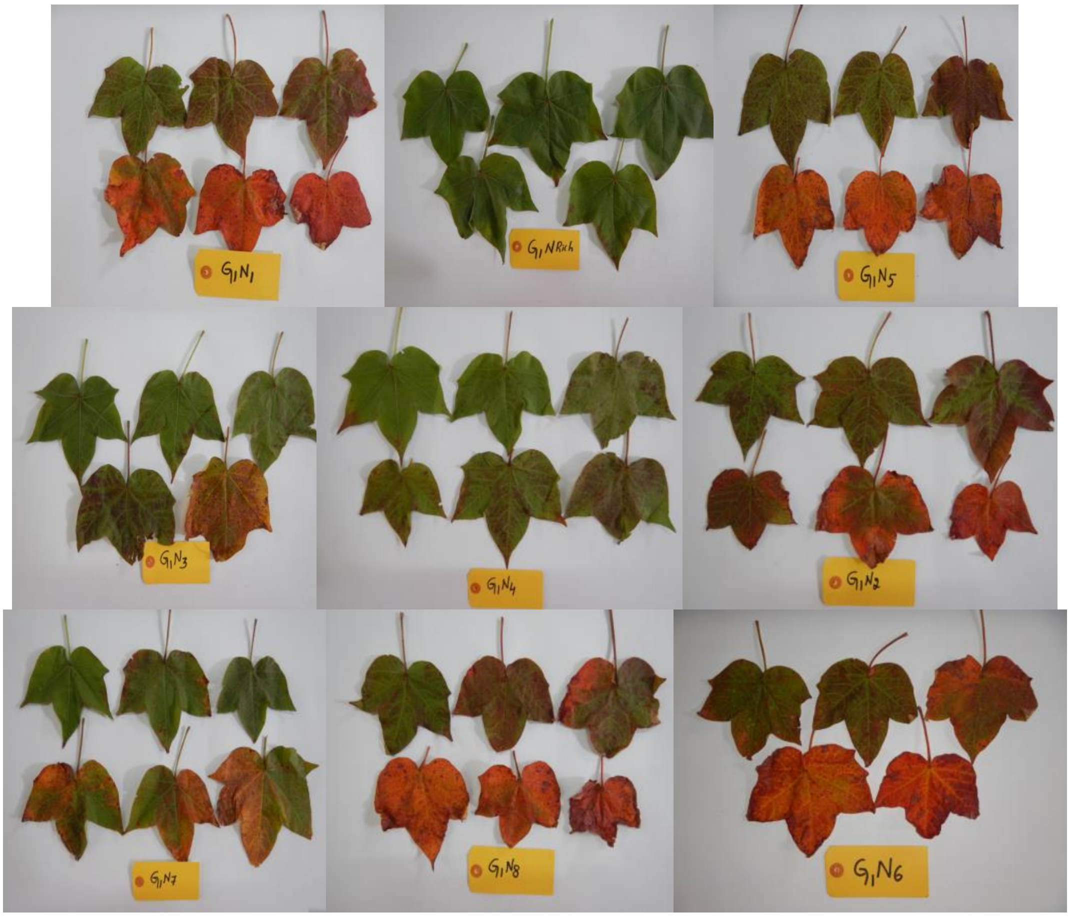
G1 N1

G1 N2

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

G1 N7

G1 N4 & N3



Treatment-wise leaf reddening in Ajeet 155 (G1)

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

Treatment-wise Leaf reddening in Ajeet 155 (G2)

Plate 1. *Treatment-wise intensity of leaf reddening in Ajeet 155 and First Class genotypes*

Table 3. *Red leaf index (RLI) of Bt cotton as influenced by optical sensor-based nitrogen management practices*

Treatments	Red leaf index								
	120 DAS								
	2019-20			2020-21			Pooled		
	G_1	G_2	Mean	G_1	G_2	Mean	G_1	G_2	Mean
N_1	1.53^{b}	1.47^{bc}	1.50^{b}	2.73^{a}	1.20^{c}	1.97^{ab}	2.13^{bc}	1.33^{d}	1.73^{b}
N_2	1.27^{cd}	1.20^{d}	1.23^{c}	2.60^{a}	1.07^{c}	1.83^{ab}	1.93^{bc}	1.13^{de}	1.53^{b}
N_3	0.20^{f}	0.20^{f}	0.20^{e}	0.40^{d}	0.13^{d}	0.27^{c}	0.30^{f}	0.17^{f}	0.23^{d}
N_4	0.20^{f}	0.20^{f}	0.20^{e}	0.27^{d}	0.07^{d}	0.17^{c}	0.23^{f}	0.13^{f}	0.18^{d}
N_5	1.47^{bc}	1.40^{bcd}	1.43^{bc}	2.67^{a}	1.20^{c}	1.93^{ab}	2.07^{bc}	1.30^{d}	1.68^{b}
N_6	1.53^{b}	1.47^{bc}	1.50^{b}	2.80^{a}	1.27^{c}	2.03^{a}	2.17^{b}	1.37^{d}	1.77^{b}
N_7	0.80^{e}	0.73^{e}	0.77^{d}	1.80^{b}	1.13^{c}	1.47^{b}	1.30^{d}	0.93^{e}	1.12^{c}
N_8	2.27^{a}	2.20^{a}	2.23^{a}	2.87^{a}	1.60^{bc}	2.23^{a}	2.57^{a}	1.90^{c}	2.23^{a}
Mean	1.16^{a}	1.11^{a}		2.02^{a}	0.96^{b}		1.59^{a}	1.03^{b}	
*N Rich	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
*Control	2.30	2.24	2.27	2.92	1.65	2.29	2.61	1.95	2.28

SV	S.Em ±	P value	S.Em ±	P value	S.Em ±	P value
G	0.062	0.6265	0.104	0.0189	0.021	0.0029
N	0.050	0.0000	0.116	0.0000	0.057	0.0000
G×N	0.176	0.9982	0.295	0.0002	0.060	0.0000

DAS: days after sowing
*Reference plots not subjected to statistical analysis (N Rich: 200% RDF; Control: no fertilizer application)
Main plot: Bt cotton genotypes (G): G_1: Ajeet–155, G_2: First Class
Sub plot: Optical sensor-based N management (N): N_1: N supplementation at 60–70% Sufficiency Index, N_2: N supplementation at 71–80% Sufficiency Index, N_3: N supplementation at 81–90% Sufficiency Index, N_4: N supplementation at 1.1–1.5 Response Index, N_5: N supplementation at 1.6–2.0 Response Index, N_6: N supplementation at 2.1–2.5 Response Index, N_7: RDF (150:75:75 N:P_2O_5:K_2O kg ha^{-1}), N_8: Absolute control (0:75:75 N:P_2O_5:K_2O kg ha^{-1})

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

Correlation of spectral values, N content in leaf, SCY with RLI

The correlation matrix (*Fig. 4*) indicates the association between NDVI, SPAD value, N content in leaf, SCY with red leaf index and found a perfect linear negative association. Strong negative association was observed between red leaf index v/s NDVI (-0.87), SPAD value (-0.85), N content in leaf (-0.85), seed cotton yield (-0.87).

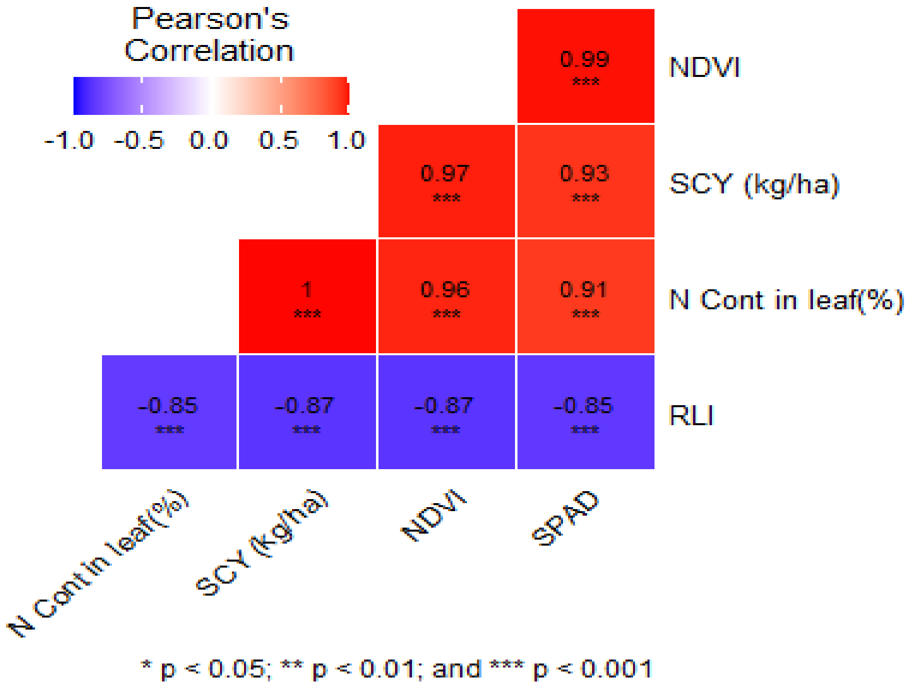


Figure 4. *Correlation of spectral values, N content in leaf, seed cotton yield (SCY) with RLI (red leaf index) as influenced by proximal sensor-based nitrogen management practices in Bt cotton*

Conclusion

Proximal sensor-based nitrogen management i.e. top dressing between pin head square and mid flowering window through GreenSeeker (N supplementation at 1.1–1.5 RI) and SPAD meter (N supplementation at 81–90% SI) significantly reduced the red leaf index in Bt cotton as compared to RDF with saving of 15 kg N ha^{-1} (10% of recommended dose of nitrogen). Spectral characterization of red leaf through NDVI and SPAD value might be useful tool in predicting Bt cotton yields.

Developing proximal sensing technology to predict the incidence of leaf reddening based on plant, soil and climatic parameters would be strongly recommended for future study.

REFERENCES

[1] Atkinson, C. F. (1892): Some diseases of cotton. – Frenching Bulletin of Albama Agricultural Experimental Station, pp. 19-29. http://hdl.handle.net/11200/2696.

[2] Basavanneppa, M. A., Ajaykumar, M. Y., Nidagundi, J. M., Biradar, D. P. (2015): Response of Bt cotton to foliar application of potassium nitrate in Tungh Bhadra project area. – Journal of Cotton Research and Development 29(2): 242-245.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245

[3] Bhatt, J. G., Rao, M. R. K., Appukuttan, E., Nathan, A. R. S. (1982): Leaf reddening in hybrids of cotton. – Communications in Soil Science and Plant Analysis 13: 151-156.

[4] Brar, M. S., Gill, M. S., Sekhan, K. S., Sidhu, B. S., Sharma, P., Singh, A. (2009): Effect of soil and foliar application of nutrients on yield and nutrient concentration in Bt cotton. – Agricultural Research Journal 45(3&4): 126-131.

[5] Dastur, R. H. (1967): Red Leaf Disease in American Cottons (*Gossypium hirsutum*). – In: Physiological Studies on the Cotton Crop and Their Practical Applications. I.C.A.R. Pub. New Delhi, pp. 20-29.

[6] Dastur, R. H., Singh, K., Kanwar, S. R. (1952): Investigation on the red leaf in American Cottons in Malwa and Bombay Karnataka. – Indian Cotton Growing Review 6: 193-204.

[7] Gowramma, M. D. (2017): Precision nutrient management in Bt cotton to achieve target yields. – M.Sc. Agri. Thesis, Univ. Agric. Sci., Dharwad, Karnataka.

[8] Hallikeri, S. S., Halemani, H. L., Patil, V. C., Palled, Y. B., Katageri, I. S. (2010): Effect of nitrogen levels, split application of nitrogen and detopping on seed cotton yield and fibre quality in Bt-cotton. – Karnataka Journal of Agricultural Sciences 23(3): 418-422.

[9] Hebbar, K. B., Rao, R. K., Khadi, B. M. (2007): Synchronized boll development of Bt cotton hybrids and their physiological consequences. – Current Science 93: 693-695.

[10] Honnali, S. N., Chittapur, B. M. (2017): Higher productivity and sustainability in cotton (*Gossypium hirsutum*) through management of leaf reddening by foliar nutrition. – Journal of Cotton Research and Development 30(2): 21-32.

[11] Hosamani, V., Chittapur, B. M., Hosamani, V., Hiremath, R. (2017): Leaf reddening Enigma in Bt cotton: a review. – International Journal of Current Microbiology and Applied Sciences 6(11): 3764-3772.

[12] Hosmath, J. A., Biradar, D. P., Patil, V. C., Palled, Y. B., Malligawad, L. H., Patil, S. S., Alagawadi, Vastrad, A. S. (2012): Performance of Bt and non Bt cotton genotypes under leaf reddening malady situation. – Karnataka Journal of Agricultural Sciences 25: 36-38.

[13] Pagare, G. A. (2011): Effect of leaf reddening on yield and yield attributes of cotton. – Bionfolet 8(1): 25-30.

[14] Pagare, G. A., Durge, D. V. (2011): Pigment analysis studies with reference to leaf reddening in Bt cotton. – International Journal of Plant Science 6(1): 42-44.

[15] Sathyanarayanarao, Gante, V. K., Chittapur, B. M., Ajaykumar, M. Y., Honnali, S. N. (2014): Management of leaf reddening in Bt-Cotton. – Proceedings of ZREAC and ZREFC Meet, held at UAS Raichur, 2-4 June 2014.

[16] Satyanarayan, R., Santhosh, U. N. (2017): Management of leaf reddening through soil and foliar nutrition in irrigated Bt cotton (*Gossypium hirsutum* L.). – Karnataka Journal of Agricultural Sciences 31(2): 244-248.

[17] Scharf, P., Oliveira, L. F. (2008): Managing nitrogen with sensors: some practical issues. – Paper presented at Beltwide Cotton Conf., Nashville, Tennessee, January, 8-11, pp. 1585-1587.

[18] Subba Rao, I. V. (1975): Nutritional disorders of crops in Andhra Pradesh. – Andhra Pradesh Agricultural University, Hyderabad, Technical Bull., pp. 42-43.

[19] Wright, P. R. (1999): Premature senescence of cotton (*Gossypium hirsutum* L.)-Predominantly a potassium disorder caused by an imbalance of source and sink. – Plant and Soil 211: 231-239.

[20] Zade, V. R., Dhopte, A. M. (1987): Anatomy and pigment analysis of red leaf in cotton. – PKV Research Journal 11(2): 107-111.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2106_52335245