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RESEARCH PAPER

Relationship between decision support tools, petiole nitrogen based fertilizer management and yield of irrigated cotton (*Gossypium hirsutum*)

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Abstract: A field experiment was conducted to study the relationship among SPAD(Soil Plant Analysis Development-502 chlorophyll meter, Minolta Camera Co. Ltd., Japan) meter, Green Seeker (Portable NDVI Analyzer, Trimble Co., US) and petiole Nitrogen (N) content and cotton yield using the decision support tools for N management in irrigated cotton in Vertisol during 2017-18 at Raichur, Karnataka. Treatments consisted of N supplementation at SPAD thresholds of ≤ 40, ≤ 60 throughout, ≤ 40 up to 60 DAS- later ≤ 50, and ≤ 50 up to 60 DAS- later ≤ 40, Green Seeker (GS) thresholds of ≤ 0.6 and ≤ 0.8; petiole N of ≤ 2 and ≤ 3% throughout along with regional recommended fertilizers. It was found that spectral properties of leaves can be used to precisely establish need based fertilizer N management strategy using SPAD meter and Green Seeker during boll opening and peak flowering stages, respectively. Strong relationship existed between SPAD readings and petiole N concentration (r^2= 0.66 to 0.8) and seed cotton yield (r^2= 0.45 to 0.69). Green Seeker-NDVI based N management is a new practice and requires further study.

Key words: Chlorophyll, Green Seeker, Petiole, Precision nutrition

Introduction

Cotton (*Gossypium hirsutum*) is a major fibre crop of global significance providing 85% of total raw material needs of textile industry in the country. Nitrogen (N) is the most used fertilizer nutrient in cotton and its consumption increased substantially in the last two decades. Farmers generally use leaf colour as a visual and subjective indicator of the crop N status.Overall, the present practice suffers from low use efficiency and consequently wastage of this costly input. One of the causes of low N use efficiency is the application of fertilizer N in excess of the crop requirement and at times when it is not required. For instance, in Tunga Bhadra Project (TBP)irrigation command area, the blanket fertilizer N recommendation consists of applying 180 kg N ha^{-1} for Bt hybrids at fixed growth stages of the crop without any consideration for spatial and temporal variability in soil N supply as well as crop need. Farmers' application often exceeds 250 kg N ha^{-1} leading to lot of wastage. Therefore, for economic N management a field experiment was conducted using two decision support systems (DSS) besides petiole N content as synchronization between real-time demand of N by cotton and supply from the available sources including fertilizers is very much necessary. The innovative tools like chlorophyll meter (SPAD) and Green Seeker help to measure different spectral properties of leaves and guide need based fertilizer N management in different crops (Chittapur *et al*., 2015; Vikram *et al*., 2015; Mallikarjun Swamy *et al*., 2016). Green Seeker emits brief bursts of red and infrared light, and then measures the amount of each type of light that is reflected back from the plant, and the sensor continues to sample the scanned area as long as the trigger remains engaged and displays the measured value in terms of Normalized difference vegetative index (NDVI) reading. The strength of the detected light is a direct indicator of the health of the crop, the higher the reading, the healthier the plant. The field experiment also aimedto optimize threshold levels of precision tools for nutrient management in the crop.

Material and methods

A field experiment was conducted at the Main Agricultural Research Station Raichur, University of Agricultural Sciences, Raichur (16.21' N and 77.3'E), Karnataka during *kharif* 2017-18. The soil of the experimental site was sandy loam with pH 7.8. There were 10 treatments *viz*., T_1 - N supplementation for SPAD thresholds of ≤ 40 throughout, T_2 - N supplementation for SPAD thresholds of ≤ 60 throughout, T_3 - N supplementation for SPAD thresholds of ≤ 40 up to 60 DAS- later ≤ 50, T_4 - N supplementation for SPAD thresholds of d" 50 up to 60 DAS-later ≤ 40, T_5 - N supplementation for Green Seeker (GS) thresholds of ≤ 0.6 throughout, T_6 - N supplementation for Green Seeker thresholds of ≤ 0.8 throughout,T_7 - N supplementation forpetiole N concentration of ≤ 2%, and T_8- N supplementation for petiole N concentration of ≤ 3% throughout, besides recommended (180:90:90 kg ha^{-1} NPK) nutrition (T_9) and unfertilized control (T_{10}) laid out in Randomized Complete Block Design (RCBD) with three replications. Sowing was done by hand dibbling and 25 % of recommended N, entire dose of P and half dose of K in the form of urea, diammonium phosphate and muriate of potash respectively were band placed 4-5 cm deep and 5 cm away from the seed as per the treatments. Remaining half dose of K fertilizer was top dressed at 50 DAS.

Hand held Green Seeker (Green Seeker, Handheld crop sensor,Trimble Inc. USA) was used to estimate NDVI values. SPAD and Green Seeker readings were recorded at 7-10 days interval separately and subsequent N applications were done

to maintain respective threshold levels as per treatments. N in the form of urea was top dressed whenever the decision aids *viz*., SPAD, Green Seeker and petiole N content had the readings below the threshold level at 30, 45, 60, 75, 90, 105 days after sowing. The amount of N for supplementation was fixed at the rate of 30 kg ha^{-1} per dressing. The spectral data of SPAD, NDVI and petiole N content were collected and used to find out correlationat different stages, if any, and the extent of correlation, besides seed cotton yield per ha. The data was statistically analyzed as per Fisher's method of analysis of variance and interpretated. The level of significance used in 'F' test was at p =0.05.

Results and discussion

Correlations between SPAD, NDVI and petiole N readings at different growth stages

Relationships among Green Seeker (NDVI), SPAD readings and petiole N concentration revealed significant and positive correlations between SPAD and NDVI readings at squaring, mid flowering and boll formation stages, and between SPAD readings and petiole N concentration at squaring, mid flowering and boll opening stages. Incase of NDVI and petiole N significant and negative correlations occurred at peak flowering stage (Table 1). In all, the correlation coefficient was lower between NDVI and petiole Nbut it was high between SPAD and petiole N when growth advanced from squaring to peak bloom. At mid flowering 'r' values were similar for NDVI valuesand SPAD reading, than with petiole N. Significant and positive correlations (0.65, 0.25 and 0.70, respectively) at squaring, mid flowering and boll opening stages were observed between SPAD readings and petiole N concentration (Fig 1). Poljak *et al*. (2008) also observed high positive correlation between SPAD reading and petiole sap NO_3^-N. Whereas, Wang *et al*. (2012) found high correlation ($r^2 = 0.97$) between NDVI and SPAD readings in geranium. Further, Sexton and Carroll (2002) reported that SPAD reading was well correlated

Table 1. Correlation between growth and yield attributes of cotton and Green Seeker values, SPAD readings and petiole nitrogen contents of cotton

Stage/Days after sowing	GS v/s PN	SPAD v/s PN	SPAD v/s GS
Node formation (20 DAS)			0.05
First squaring (30 DAS)			-0.14
Squaring (45 DAS)	0.07	0.65**	0.57**
Mid flowering (60 DAS)	0.28	0.25**	0.25
Peak flowering (75 DAS)	-0.63*	0.53	0.04
Boll formation (90 DAS)	0.55	0.28	0.69**
Boll development (105 DAS)	-0.17	0.37	0.08
Boll opening stage (120 DAS)	0.13	0.69**	0.34
Maturity (135 DAS)	0.31	0.15	-0.30

GS – Green seeker (NDVI), SPAD- SPAD mere readings, PN – Petiole nitrogen, and DAS – Days after sowing

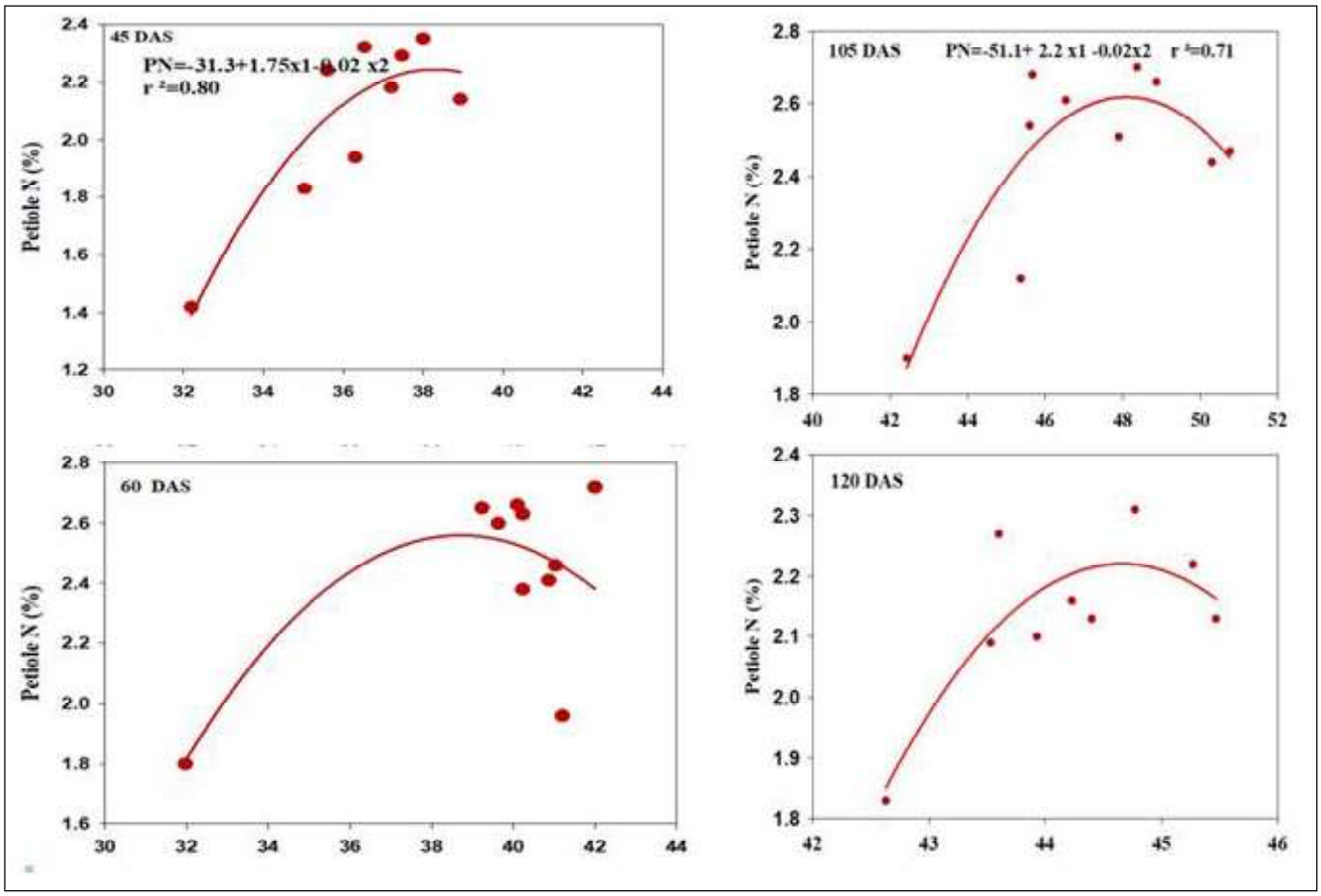

Fig 1.Relationship of Petiole nitrogen and SPAD readings at 45, 60, 105 and 120 days after sowing (DAS)

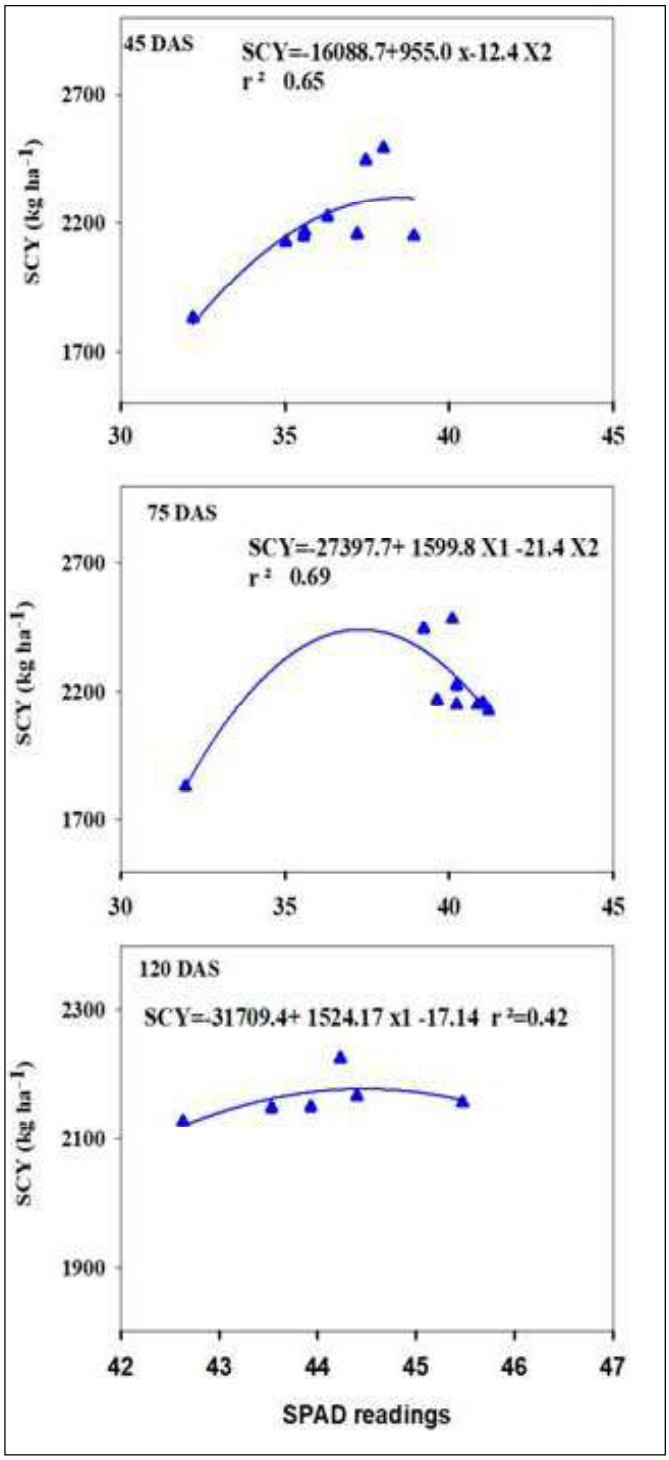

Fig 2. Relationship between seed cotton yield (SCY) and SPAD readings at 45, 75 and 120 DAS.

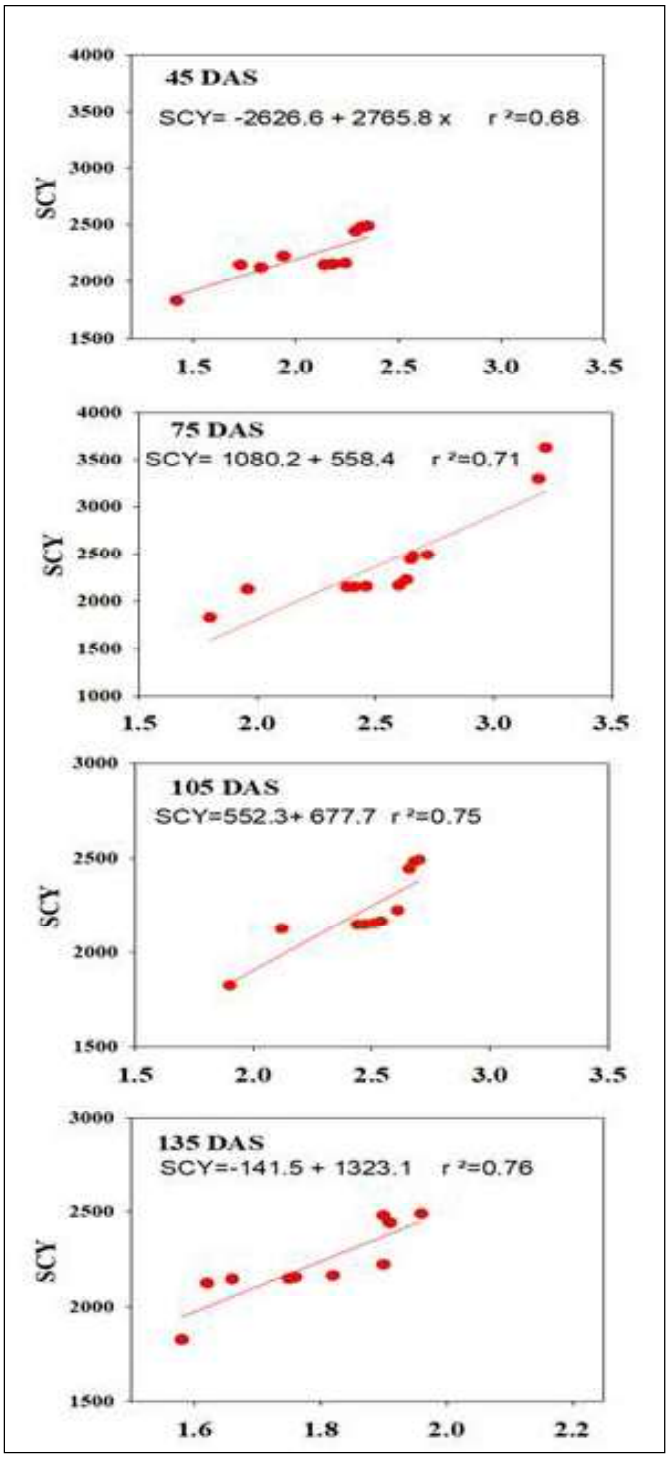

Fig 3. Relationship between seed cotton yield (SCY) and petiole N concentration (PN) at 45 (a), 75 (b), 120 DAS (c)

with petiole nitrate concentration in sugarbeet within 10,000 mg NO_3^-–N kg^{-1}, but beyond this petiole NO_3^--N level, SPAD reading did not correlate with petiole nitrate. Overall, the positive correlation among NDVI and SPAD readings except at first squaring and 135 DAS, and NDVI and petiole N concentration at peak flowering and boll development stages were observed in the present study.

Correlations between SPAD, NDVI, petiole N and seed cotton yield

Seed cotton yield was positively correlated with NDVI, SPAD reading and petiole N concentration and the attributes revealed significant correlation with NDVI at peak flowering, SPAD meter at boll opening stage and petiole N concentration from squaring stage to boll opening period (Fig. 2 and 3).

Table 2. Correlation between seed cotton yield and Green Seeker values, SPAD readings and petiole nitrogen contents of cotton

Stage/Days after sowing	SPAD v/s SCY	GS v/s SCY	PN v/s SCY
Node formation (20 DAS)	-0.25	0.19	
First squaring (30 DAS)	-0.00	-0.45	
Squaring (45 DAS)	0.07	-0.23	0.65
Mid flowering (60 DAS)	0.57	0.09	0.74*
Peak flowering (75 DAS)	0.35	-0.76	0.88*
Boll formation (90 DAS)	0.12	0.32	0.82*
Boll development (105 DAS)	-0.08	0.07	0.69*
Boll opening stage (120 DAS)	0.64**	0.00	0.77*
Maturity (135 DAS)	0.20	0.27	0.22

GS–SCY– seed cotton yield, Green seeker (GS) (NDVI), SPAD- SPAD meter readings, PN – Petiole nitrogen, DAS – Days after sowing

Similarly, Bronson *et al*. (2005) reported poor correlations at early squaring NDVI with cotton yield. Findings are also in line with Guteirrez *et al*. (2012) who observed that the correlation of cotton yield with NDVI was not significant at pinhead square, mid-bloom, or cut out (R^2 = 0.00–0.02) but was significant at early bloom and peak bloom (r^2 = 0.46–0.69).While, Bronson *et al*. (2011) observed that yield was significantly correlated with amber and red NDVI at early bloom and at mid-bloom. Lower significance in the relationship between yield and NDVI at later growth stages was attributed to canopy closure that influences the field of view of the optical sensor (Teal *et al*., 2006 and Ali *et al*., 2014).Correlation in petiole N concentration is in line with Wood *et al*. (1992) who reported that seed cotton yield is well correlated with petiole N at first square, first bloom and mid blooming stages (Table 2).

Conclusion

Significant correlations observed in the study indicated that spectral properties of leaves can be used to precisely establish need based fertilizer N management strategy using SPAD meter and Green Seeker optical sensor during boll opening and peak flowering stages, respectively in cotton. Further it also revealed that petiole N can also be used to assess in-season plant N need in cotton throughout crop growth. However, it is imperative that NDVI based N management being a new practice, requires further study.

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