International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 1397-1400

Received: 13-07-2019
Accepted: 15-08-2019

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Study on leaf nutrient status and spectral characteristics of *Bt* cotton in Jewargi Taluka, Kalaburagi district

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Abstract
A study was undertaken in *Bt* cotton growing soils of Jewargi taluka of Kalaburagi district in 2017-18 to study the leaf nutrient status and spectral characteristics of *Bt* cotton the results revealed that the leaf petiole nitrogen concentration of *Bt* cotton was low to high (1.27 to 4.15%), phosphorus was low to sufficient (0.10 to 0.41%) and potassium was sufficient (0.30 to 4.03%) in all samples. The leaf petiole calcium (0.29 to 0.97%) and magnesium (0.12 and 0.96%) concentration was found to be sufficient to high and leaf petiole sulphur concentration (0.14 and 0.49%) was found to be sufficient. The leaf petiole micronutrients (Fe, Mn, Cu and Zn,) were present well within the sufficient ranges. The NDVI and SPAD meter values of *Bt* cotton crop canopy were in the range of 0.59 to 0.94 and 27.70 to 51.30, respectively.

Keywords: Micronutrients, plant biomass, chlorophyll, NDVI and SPAD

Introduction
Cotton (*Gossypium* spp.) the ‘king of fibers’ also popularly known as the ‘white gold’ enjoys a pre-eminent position amongst cash crops in the world and in India as well. It is the nature’s most precious gift to the mankind, contributed by the genus *Gossypium*. Globally, cotton is cultivated in 70 countries with a total coverage of 32.3 million ha (Anonymous, 2016) [1].
Monitoring nutrient status of plant has advantages that plant integrates nutrient supply over a period of time, and hence can reflect nutrient supply as affected by weather, soil processing and fertilization. The farmers generally use leaf colour as a visual and subjective indicator of the need for N fertilizer. Since farmers generally prefer to keep leaves of the crop dark green, it leads to over application of fertilizers resulting in low recovery efficiency. Thus, the spectral properties of leaves should be used in a more rational manner to guide need-based fertilizer applications. Green seeker and SPAD meter can quickly measure greenness of leaf N status. These tools provided an excellent opportunity in terms of developing real time nutrient management, but these tools do not make into account photosynthetic rates or the biomass production and expected yields for working out nutrient requirements. So for determination of these factors, optical sensors are used based on the reflectance in red and near infrared spectrum. Li *et al.* (2001) [2] reported that NDVI values and red vegetative index were positively correlated with cotton biomass, N accumulation and lint yield. The application of optical sensing technology, as a quick, non destructive, high-resolution and large scale measurement of plant canopy radiation reflection can be used to monitor nutrition status, plant growth and crop yield. Leaf reflectance is an important indicator of water, nutrient, disease and pest stresses of crop. However, it changes depending on genotypes, nutrient content and environmental factors. Differences in Leaf Area Index (LAI) are useful for spectrally differentiating healthy crop from unhealthy crop canopies. Similarly, spectral parameters have been used to estimate important crop canopy variables such as LAI, chlorophyll content and biomass of crop species by NDVI. Nutrient stress is one of the important growth and yield limiting factor which affects plant metabolic processes particularly chlorophyll synthesis and LAI in nutrient deficient crop due to low chlorophyll content. Hence the present study was undertaken to study leaf nutrient status and spectral characteristics of *Bt* cotton in Jewargi taluka, Kalaburagi district

Materials and methods

A study was undertaken in *Bt* cotton growing soils of Jewargi taluka of Kalaburagi district in 2017-18 to study the leaf nutrient status and spectral characteristics of *Bt* cotton. The surveyed area was *Bt* cotton growing farmers fields in Jewargi taluka is located between 16^0 54' 14.5" and 17^0 02' 12.9" N latitude and between 76^0 46' 18.4" and 76^0 77' 39.5" E longitude and at an altitude on an average of 393 m above mean sea level of North Eastern Dry Zone of Karnataka.

One hundred *Bt* cotton petiole samples were collected from the farmer's field in different villages of Jewargi taluka. The samples were collected at flowering stage. Collected plant samples were thoroughly washed with distilled water and dried in hot air oven at 65°C for 8 hrs. Dried samples were powdered in a mixer grinder to a considerable fineness before storing them in butter paper bags for further analysis. Analysis were done using standard procedures

Estimation of chlorophyll content

Chlorophyll content was measured the observation fields by using SPAD meter (MINOLTA). Five fully opened leaves from the top were randomly selected and average value was recorded.

Spectral observations

Spectral observations were recorded from a height of 1 m using portable green seeker (Trimble) during flowering stage of cotton crop on cloud free days between 10.30 to 12.30 hrs. The observations were made in all the hundred fields that were chosen for tissue and soils nutrient analysis. Normalized difference vegetative index (NDVI) an indicator of total biomass and greenness of leaves is computed with the following equation:

$$NDVI = (NIR_{ref} - RED_{ref}) / (NIR_{ref} + RED_{ref})$$

Where, NIR_{ref} or Red_{ref} represents reflectance in the near infrared and red bands.

Results and Discussions

Results

The results of the investigations carried out to identify the nutrient content in *Bt* cotton leaf petiole grown in Jewargi taluka of Kalaburagi district were presented below.

Major and secondary nutrients concentration in leaf petiole of *Bt* cotton

Nitrogen content in *Bt* cotton leaf petiole varied from 1.27 to 4.15 per cent with an average of 2.59 per cent. The standard deviation was of 0.62 per cent nitrogen. Coefficient of variation was 24.16 per cent. Phosphorus content in the *Bt* cotton leaf petiole varied between 0.10 and 0.41 per cent with an average of 0.27 per cent. The standard deviation was of 0.06 per cent phosphorus while, coefficient of variation was 20.92 per cent. The leaf petiole potassium content in *Bt* cotton ranged between 0.30 and 4.03 per cent. The mean and standard deviation were 2.69 per cent and 0.56 per cent, respectively. Coefficient of variation was 20.70 per cent. Sulphur content in *Bt* cotton leaf petiole ranged between 0.14 and 0.49 per cent with an average value of 0.33 per cent. The standard deviation was 0.09 per cent sulphur content. Coefficient of variation was 27.52 per cent, data represented in table 1.

Bt cotton leaf petiole had calcium content in the range of 0.29 to 0.97 per cent with an average content of 0.52 per cent. The standard deviation was of 0.15 per cent calcium. The coefficient of variation was 28.15 per cent. Calcium content in studied crop samples was above the critical limit, data represented in table 1. Magnesium content in *Bt* cotton leaf petiole ranged between 0.12 to 0.96 per cent. The mean and the standard deviation were 0.30 per cent and 0.11 per cent, respectively. The coefficient of variation was 35.17 per cent. Entire lot of samples revealed, above the critical limit.

Micronutrients content in *Bt* cotton leaf petiole

Micronutrients like Iron, Manganese, copper and zinc content in *Bt* leaf petiole remained in the range of 219.48 to 284.03, 61.28 to 85.26, 18.30 to 28.40 and 18.40 and 42.10 mg kg^{-1}, respectively with an average range of 210.29, 74.30, 22.36 and 30.50 mg kg^{-1}, respectively. The standard deviation was 35.78, 15.28, 4.69 and 6.87 mg kg^{-1}, respectively and co-efficient of variation was 17.01, 20.57, 21.00 and 22.52 percent, respectively. Data represented in Table 2. All micronutrients content in studied samples showed that all most all samples are in optimum range.

Leaf chlorophyll content

SPAD meter value

The SPAD meter value of *Bt* cotton leaves in the study area ranged from 27.70 to 51.30. The mean and standard deviation were 39.48 and 4.06, respectively. The co-efficient of variation was 10.29 per cent. Data represented in Table 2.

Study of Spectral characteristics

Normalized difference vegetation index (NDVI)

The spectral observations were recorded during the peak flowering stage with the help of normalized difference vegetation index (NDVI). From spectral reflectance data under different spectral bands of NDVI was calculated. The NDVI values of *Bt* cotton crop canopy were in the range of 0.59 to 0.94. The mean and standard deviation were 0.76 and 0.09, respectively. The coefficient of variation was 11.22 per cent in the studied area. Data represented in Table 2.

Table 1: Major and secondary nutrients concentration in leaf petiole of *Bt* cotton

Sl. No.	Parameters	Range	Mean	SD	CV (%)
1	Nitrogen (%)	1.27-4.15	2.59	0.62	24.16
2	Phosphorus (%)	0.10-0.41	0.27	0.06	20.92
3	Potassium (%)	0.30-4.03	2.69	0.56	20.70
4	Sulphur (%)	0.14-0.49	0.33	0.09	27.52
5	Calcium (%)	0.29-0.97	0.52	0.15	28.15
6	Magnesium (%)	0.12-0.96	0.30	0.11	35.17

Table 2: Micronutrients concentration and Spectral indice value of leaf petiole of *Bt* cotton

Sl. No.	Parameters	Range	Mean	SD	CV (%)
1	Zinc (mg kg^{-1})	18.40-42.10	30.50	6.87	22.52
2	Iron (mg kg^{-1})	219.48-284.03	210.29	35.78	17.01
3	Copper (mg kg^{-1})	18.30-28.40	22.36	4.69	21.00
4	Manganese (mg kg^{-1})	61.28-85.26	74.30	15.28	20.57
5	NDVI	0.59-0.94	0.76	0.09	11.22
6	SPAD	27.70-51.30	39.48	4.06	10.29

Discussions

Major nutrient content in leaf petiole

Nitrogen content in *Bt* cotton leaf petiole varied from 1.27 to 4.15 per cent and recorded average of 2.59 per cent N. This nitrogen content in leaf petiole may be due to nitrogenous fertilizer application and organic matter status in these soils that led to slow breakdown of nitrogenous compounds making steady supply of N throughout the growth period. Chavan *et* *al*. (1997) [3] reported that higher N uptake was recorded in those soils, which were having sufficient organic matter status. Variation in N uptake by plants in different soils is attributed to variation in N status along with moisture and organic matter content of the soil. Increased uptake may also be accounted for synergistic effect between N and P. Similar to N content, Phosphorus content in the *Bt* cotton leaf petiole varied between 0.10 and 0.41 per cent with an average of 0.27 per cent. Most of the plant samples showed the sufficiency level of P. This may be due to the sufficient quantity of available P soil. Variation in P concentration in *Bt* cotton plants of different fields was attributed to variation in soil depth, available moisture, available P status and organic matter content. Further, cultivation practices particularly the quantum of fertilizers and manures applied by the farmers also influenced the P uptake. Bidari (2000) [4] reported that uptake of P varied with location, cultivation practices followed by farmers particularly the quantum of fertilizers and manures applied.

Potassium content in *Bt* cotton leaf petiole ranged between 0.30 and 4.03 per cent. The almost all samples had sufficient K content in leaf petiole. The soils of sampled fields were medium to high in available K status. Higher potassium uptake by *Bt* cotton crop might be due to sufficient K from the native and applied fertilizers. The results of major nutrient concentration (N, P and K) in leaf petiole are in accordance with Subbarao (1975) [5], he reported 4.3 to 5.5, 0.31 to 0.45, and 0.50 to 1.25 (%) as optimum range for N, P and K respectively in cotton leaf. Similar results were reported by Srinivas *et al.*, (1998) [6] in cotton grown soils of Guntur district and Ramesh Kumar (1992) [7] in Prakasam district of Andhra Pradesh.

Secondary nutrient content

The content of Ca and Mg ranged from 0.29 to 0.97 per cent and 0.12 and 0.96 per cent respectively. Calcium and Magnesium content in entire studied crop samples were in sufficiency range. This might be due to higher mean exchangeable Ca and Mg content and calcareous nature of soil. This is attributed to better root growth and root branching that favored the uptake of Ca and Mg by plants. Sulphur content in *Bt* cotton leaf petiole ranged between 0.14 and 0.49 per cent with an average value of 0.33 per cent. Eighty two samples were in sufficiency range (0.25-1.0%) and eighteen samples were below the critical range (<0.25). The sulphur content of the leaf petiole became nearly double from square formation stage to flowering stage which was in contrast to the findings of Zhao and Oosterhuis (1999). The reason for accumulation of sulphur was due to basal application of single super phosphate during the square formation stage and also requires for oil production in cotton seed. Similar trends were observed by Srinivas *et al*., (1998) [6] and Ramesh Kumar (1992) [7] in black cotton soils.

Micronutrient Concentration

The content of iron in *Bt* cotton leaves ranged between 219.48 to 284.43 mg kg^{-1} with an average range of 210.29 mg kg^{-1}. In the present study, Iron content in studied samples showed that all most all the samples had Fe content above the optimum range (50-250 mg kg^{-1}). Leaf petiole analysis showed that *Bt* cotton crop was not suffering from iron deficiency. There was greater accumulation of iron during the flowering part of growth of cotton crop. Foliar application of micronutrients may be the reason for sufficiency. This is attributed to high organic matter that forms stable complex with native Fe and make more soluble and available (Bidari 2000) [4]. Similar results were observed by Srinivas *et al*., (1998) [6] noticed a range of 118 to 272 with a mean value of 195 of leaf Fe concentration in black cotton soils.

The manganese content in *Bt* cotton leaf petiole ranged from 61.28 to 85.26 mg kg^{-1}. The mean value of 74.30 mg kg^{-1}. The sufficiency range of Mn for cotton leaf was given as 20-300 by Venkateswarlu (1978) [9]. Accordingly, none of the leaf samples were rated as deficient in leaf Mn. This might be due to medium and higher organic matter content of soils. Soil organic matter increases the availability of native manganese by mobilization through chelation. Thus, increasing the available manganese status in soil for growing crop resulted in its increased tissue content as well as uptake by the plant.

The mean copper (22.36 mg kg^{-1}) content in *Bt* cotton petiole was higher and no deficiency symptoms were observed. Generally, uptake of Cu increases significantly with the advancement in age of the crop. An increased Cu uptake in later stage was attributed to its role in relation of flowering in plants. Hence, there might be higher uptake of Cu has been happened during my study time. Higher organic matter content in soils had enhanced availability of native micronutrient cations through the transformation of precipitations to soluble metal complexes. Further, the extensive root system enhanced the copper uptake. Bidari (2000) [4] reported higher Cu uptake by plants grown on soils with high organic matter content. The results are agreed with the Venkateswarlu (1978) [9] and Srinivas *et al.*, (1998) [6], reported that the leaf Cu concentration of cotton ranged from 12 to 16 with a mean value 13.00 and also confirmed the non-existence of Cu deficiency.

The content of zinc in *Bt* cotton leaf petiole ranged between 18.40 to 42.10 mg kg^{-1}. 09 per cent of the samples were below the critical level (< 20 mg kg^{-1}) and 91 per cent were above critical range (>20 mg kg^{-1}). The mean zinc content in crop (30.50 mg kg^{-1}) was above the critical level. The increased in uptake of zinc was also due to mobility and possible chelation with decomposed organic matter which might have enhanced the supply of zinc in the entire growth period of the crop (Singh *et al.*, 2004) [10]. The synergetic effect of Zn and Fe in plant might be the reason for the higher uptake of zinc. Ramaprasad *et al.* (2011) [11] revealed that the increased zinc uptake could also be attributed to the sulphur and zinc application at higher level through zinc sulphate by most of the farmers.

Leaf chlorophyll content

SPAD meter value

In the present investigation, the SPAD meter values were significant and positive correlation with the leaf petiole N content and values ranged from 27.70 to 51.30. The chlorophyll content increased in the fields with higher organic matter content and nutrient status of soils. Adequate supply of soil N might have contributed to vigorous vegetative growth leading to increased in chlorophyll content in the leaves. In most of *Bt* cotton, leaf content of N was sufficient. Results are in accordance with Buscaglia and Varco (2002) [12], they observed linear relationship between SPAD readings and leaf N content. Paliwal *et al.* (2004) [13] opined that iron serves as catalyst in the formation of chlorophyll. Importance of zinc and iron in increasing chlorophyll content in leaves was reported by Wu and Xiao (1995) and Wood *et al* (1992) [14, 15].

Conclusions
Measurement of spectral properties of leaves may be very interesting for early, easy, and inexpensive determination of nutrient deficiencies and other stress conditions.Nutrient sufficiency samples had relatively high NDVI than nutrient deficiency. Reflectance measurements are powerful non-destructive tool to decide nutrient deficiency, fertilizer application and timely correction of nutrient deficiencies; also the results have shown that NIR and red bands could be used to estimate nutrient concentration.

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