International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 1876-1880

Received: 22-07-2019
Accepted: 24-08-2019

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Influence of foliar nutrition on leaf reddening of *Bt* cotton under rainfed condition

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Abstract
A field experiment was conducted on farmers field at Kautha, Tq. Kandhar. Dist. Nanded during *Kharif* 2018-19 on Vertisol to find out the effect of foliar nutrition on leaf reddening of *Bt* cotton under rainfed condition. The experiment was laid out in Randomized Block Design with eight treatments and replicated thrice. The result revealed that application of 100 per cent RDF (100:50:50 kg NPK ha^{-1}) in combination with foliar spray of DAP@ 2% + KNO_3 @ 1% + $MgSO_4$@ 1% and micronutrient Grade II @ 0.5% at flowering, boll formation and boll development stage recorded the maximum leaf nutrient content and total chlorophyll content and helpful in minimize the anthocyanin content and leaf reddening index in *Bt* cotton under rainfed condition.

Keywords: *Bt* cotton, foliar nutrition and leaf reddening

Introduction
Cotton is an important cash crop of India grown in tropical and sub-tropical areas. It is a base for textile industries and popularly known as 'Kind of Fibre' and 'White gold'. India is one of the important grower of cotton on global scale and cotton play vital role in Indian economy. Cotton is grown mainly for fibre production and seed yield is considered to be secondary importance. India is the largest producer of cotton and rank first in the world produce 6,205 thousand metric tons and china rank second produce 5,987 thousand metric tons of cotton. (Statista 2019).

Area under cotton has been increased distinctly over the past decade but average yield is less than potential yield. Cotton under rainfed condition normally suffers either due to lack of proper distribution of rains or heavy rains and moisture stress. Exposure of the crop to repeated cycles of low and excess moisture stress during growth periods has adversely effects on growth and development of cotton. The maximum yield potential of *Bt* cotton has been not achieved due to several reason like low fertility status of soil, imbalanced nutrition, water stress or uneven distribution of rainfall, climatic condition and leaf reddening.

Among the several production constraints leaf reddening has become one of the major cause which leads to reduction in yield of cotton up to 50 per cent depending upon the intensity of reddening. The extent of leaf reddening varies with genotype (Subbarao *et al.* 1975) [14]. Leaf reddening is also termed as 'Red leaf of American cotton', 'Red leaf blight', 'Lal patti', 'Bronze wilt', 'Sudden wilt', 'Phloem wilt' and 'Lalya' in Maharashtra. Reduction in moisture content and N in leaves due to nitrogen deficiency, water logging or water stress and growth in temperature below 21° C caused reddening. Dramatic biochemical changes occurred in reddened leaves *viz.* strong accumulation of anthocyanin and drop of chlorophyll content.

Foliar feeding is often effective when roots are unable to absorb sufficient nutrients from the soil due to moisture stress or higher degree of fixation. In this context the present investigation was carried out to study the influence of foliar nutrition on leaf reddening of *Bt* cotton under rainfed condition.

Materials and Methods
A field experiment was conducted to study the influence of foliar nutrition on leaf reddening of *Bt* cotton under rainfed condition on farmers field at Kautha, Tq, Kandhar, Dist. Nanded, Maharashtra during 2018-19. The geographical position of the experimental site was 18^0 48' 45" N Latitude and 77^0 21' 11" E Longitude. The soil of experimental plot was montomorillonitic calcic haplusterts, deep black were pH- 7.9, Electrical conductivity (EC) 0.30 ds m^{-1}, Organic carbon (OC) 0.60%, $CaCO_3$ 9.5%, Available nutrients (Kg ha^{-1})

N- 175.61, P- 13.44, K- 427.84. The experiment was laid out in Randomized Block Design with three replications. Cotton variety Ajeet-155 was used as test crop. Recommended dose of fertilizer (100:50:50 NPK ha^{-1}) were supplied through Urea, SSP, and Muriate of potash respectively. Twenty per cent nitrogen and full P, K were applied at the time of sowing as basal dose the remaining eighty per cent N was applied through urea in two equal split dosage.

The composite soil sample before sowing was taken for their initial values. The soil pH and EC were analyzed using 1:2.5 (soil: water) suspension, organic carbon by Walkley and Black (1934) method, available N by alkaline $KMnO_4$ method as described by Subbiah and Asija (1956) [15], available P by Olsen *et al*. (1954) [10] and available K by flame photometer as described by Jackson (1967) [7]. Foliar application of multi-nutrients were carried out at three different growth stages of cotton at flowering, boll formation and boll development stage *viz.*70, 90 and 120 DAS respectively. The treatments were T_1- Control (N_{100} P_{50} K_{50}), T_2 – 100% RDF + water spray, T_3- 100% RDF + Urea @ 2% foliar spray, T_4- 100% RDF + 19:19:19 @ 1% foliar spray, T_5- 100% RDF + KNO_3 @ 2% foliar spray, T_6- 100% RDF + $MgSO_4$ @ 1% foliar spray, T_7- 100% RDF + foliar spray of DAP @ 1% +KNO_3 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5%, T_8 – 100% RDF + Foliar spray of 19:19:19 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5%. The leaf samples with petiole collected at flowering, boll formation and boll development stages of cotton, samples were decontaminated by using 2% teepol solution and 0.1 N HCL followed by dipping in distilled water and dried at 70^0 C in hot air oven and dry samples were grind in grinder. Plant extract was prepared and analyzed for total N by modified Kjeldahl method by using keplus digestion and distillation unit, total P determined spectrophotometrically by Vandomolybdate phosphoric acid yellow colour method by di-acid extract described by (Jackson, 1967) [7], total K determined on flame photometer, chlorophyll pigment was estimated by using the DMSO method (Swain and Hilllis, 1959) [16] and anthocyanin pigment in cotton leaves was estimated spectrophotometrically using standard procedure.

Leaf reddening index was worked out by method outlined by Dastur *et al.* (1952) [3]. The basis of this method is the number of leaves showing the sign of reddening at given time. Leaves turned red partly or wholly, where divided into five categories as followes-

Grade zero- when all the leaves were green or less than three leaves shows sign of reddening.

Grade one- when three leaves shows sign of reddening.

Grade two- where more than three leaves show sign of reddening but young leaves were green.

Grade three- when all the leaves show reddening in patches

Grade four- when the whole plant turned red.

Results and Discussion

Nitrogen content of leaves (%)

It was evident from the result that the leaf nitrogen concentration was influenced due to various foliar application of multi nutrients along with RDF at critical growth stages of crop (Table 1). Maximum concentration of nitrogen in leaves of cotton recorded with treatment T_7- 100% RDF + foliar spray of DAP @ 1% +KNO_3 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5% at flowering (2.56%), boll formation (2.74) and boll development stage (2.95%) and it was found at par with treatment T_8 and T_5 at flowering, with T_8, T_3 at boll formation stage and further at boll development stage treatment T_7 found at par with treatment T_8. The leaf nitrogen content increased significantly by the different treatments over control. Treatment T_1- (100% RDF) recorded the lowest nitrogen content 1.59, 1.35, 1.07 per cent at flowering, boll formation and boll development stage of cotton respectively. This was similar to the results o*bt*ained by by Malode and Tamgadge (2016) [9] they revealed that treatment containing urea @ 2% and DAP @ 2% recorded maximum nitrogen content (1.61 and 1.61%) at flowering and boll development stage respectively.

Table 1: Effect of foliar nutrition on leaf nitrogen content (%) at different growth stages of cotton

Treatment	Nitrogen concentration (%)		
	At flowering stage	At boll formation stage	At boll development stage
T_1- Control (100% RDF)	1.59	1.35	1.07
T_2 – 100% RDF + Water spray	1.62	1.46	1.22
T_3 – 100% RDF + 2% urea	2.39	2.54	2.73
T_4 -100% RDF + 1% 19:19:19	2.28	2.28	2.35
T_5 – 100% RDF + 2% KNO_3	2.43	2.5	2.59
T_6 - 100% RDF + 1% $MgSO_4$	2.38	2.49	2.7
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.56	2.74	2.95
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.51	2.65	2.87
CD at 5%	0.122	0.192	0.201

Phosphorus content of leaves (%)

The leaf phosphorus concentration was decreased with the advanced stage of crop and varied due to different foliar treatments along with RDF (Table 2). Maximum P concentration was found due to treatment T_7- 100% RDF + foliar spray of DAP @ 1% +KNO_3 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5% at flowering (0.67%), boll formation (0.60%) and at boll development stage (0.49%) of cotton. The treatment T_7 found at par with treatment T_8, T_5, T_6, and T_4 at flowering and with treatment T_8, T_6 and T_4, at boll formation stage whereas, treatment T_7 also found at par with treatment T_8 at boll development stage. The lower P concentration recorded with treatment T_1- (100% RDF) at flowering, boll formation and boll development stage *viz.* 0.32, 0.23, 0.14 per cent respectively.

Table 2: Effect of foliar nutrition on leaf phosphorus content (%) at different growth stages of cotton

Treatment	Phosphorus concentration (%)		
	At flowering stage	At boll formation stage	At boll development stage
T_1- Control (100% RDF)	0.32	0.23	0.14
T_2 – 100% RDF + Water spray	0.38	0.27	0.16
T_3 – 100% RDF + 2% urea	0.56	0.53	0.38
T_4 -100% RDF + 1% 19:19:19	0.61	0.56	0.41
T_5 – 100% RDF + 2% KNO_3	0.62	0.54	0.45
T_6 - 100% RDF + 1% $MgSO_4$	0.61	0.56	0.45
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	0.67	0.60	0.49
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	0.63	0.57	0.46
CD at 5%	0.062	0.037	0.027

Potassium content of leaves (%)

Total potassium concentration in leaf sample at flowering, boll formation and boll development stage (Table 3.) and varied with treatments and it was ranged from 1.34 to 2.41 per cent, 1.16 to 2.58 per cent and 1.02 to 2.65 per cent at flowering, boll formation and boll development stage of cotton respectively. The maximum K content in leaf sample of cotton was noticed in treatment T_7 100% RDF + foliar spray of DAP @ 1% +KNO_3 @ 1% + $MgSO_4$ @ 1% + Micronutrient grade II @ 0.5% and found significantly superior over rest of the treatment at flowering and found at par with treatment T_8 at boll formation and boll development stage. Minimum K content found in treatment T_1 (100% RDF) 1.34, 1.16 and 1.02 per cent at flowering, boll formation and boll development stage of cotton. This might be due to additional foliar application of macro and micronutrients. Deshpande *et al.* (2015) [4].

Anthocyanin content of leaves

The data pertaining the effect of different foliar application of macro and micronutrients on anthocyanin content of cotton leaves were found to be in range of 2.83 to 3.02 mg g^{-1} at flowering, 2.63 to 3.35 mg g^{-1} at boll formation and 2.74 to 3.84 mg g^{-1} at boll development stage in (table 4). Highest anthocyanin content 3.84 mg g^{-1} with treatment T_1(RDF) observed at boll development stage and it was decreased up to 2.74 mg^{-1} due to treatment T_7 containing RDF + DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% + micronutrient grade II @ 0.5%. Anthocyanin pigment in

Table 3: Effect of foliar nutrition on leaf potassium content (%) at different growth statges of cotton

Treatment	Potassium concentration (%)		
	At flowering stage	At boll formation stage	At boll development stage
T_1- Control (100% RDF)	1.34	1.16	1.02
T_2 – 100% RDF + Water spray	1.34	1.2	1.08
T_3 – 100% RDF + 2% urea	1.64	1.6	1.6
T_4 -100% RDF + 1% 19:19:19	2.03	1.95	2.05
T_5 – 100% RDF + 2% KNO_3	2.29	2.4	2.49
T_6 - 100% RDF + 1% $MgSO_4$	1.9	2.08	2.2
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.41	2.58	2.65
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.26	2.46	2.59
CD at 5%	0.110	0.197	0.125

Table 4: Effect of foliar nutrition on leaf anthocyanin pigment (mg g^{-1}) different growth stages of cotton

Treatment	Anthocyanin pigment (mg g^{-1})		
	At flowering stage	At boll formation stage	At boll development stage
T_1- Control (100% RDF)	3.00	3.32	3.84
T_2 – 100% RDF + Water spray	3.02	3.35	3.73
T_3 – 100% RDF + 2% urea	2.90	3.00	2.95
T_4 -100% RDF + 1% 19:19:19	2.94	3.09	3.01
T_5 – 100% RDF + 2% KNO_3	2.91	3.05	2.95
T_6 - 100% RDF + 1% $MgSO_4$	2.85	2.92	2.85
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.83	2.63	2.74
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	2.85	2.69	2.77
CD at 5%	0.085	0.292	0.187

Cotton leaves were found to be increased with maturity of crop. Result indicated that foliar application of nutrients found to be beneficial for minimizing the anthocyanin pigment because during boll development stage leaf nutrients translocated toward bolls and deficiency of nutrients occur which reduces the chlorophyll and enhance the anthocyanin accumulation in leaf. Reduction in anthocyanin content might be due to foliar application of macro and micronutrients at specific growth stages of cotton which increased the supply of nitrogen and magnesium to leaf and reduce the formation of anthocyanin at the cost of chlorophyll because nitrogen, magnesium are the main constituent of chlorophyll molecule. Above result are in line with Byale *et al.* (2014) [1] they observed that application of primary nutrients along with magnesium, sulfur, zinc, boron (spray) found to be effective for controlling anthocyanin accumulation.

Total chlorophyll content of leaves

Data on effect of foliar nutrition on chlorophyll content of cotton at different growth stages tabulated in (table 5) from the data it was observed that chlorophyll – 'a', chlorophyll – 'b' and total chlorophyll found in range of 0.62 to 2.19, 0.53 to 1.88 and 0.86 to 2.90 mg g^{-1} at boll development stage of cotton. The data showed that application of Treatment T_7 contained RDF + foliar spray of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% + micronutrient grade II @ 0.5% showed maximum chlorophyll content followed by treatment T_8 over control (RDF) at flowering, boll formation and boll development stages of cotton and Chlorophyll -'a' content was higher than chlorophyll -'b'. Treatment T_7 found at par with treatment T_8 at flowering, boll formation and boll development stage and superior over rest of the treatment. This indicated that the foliar application of macro and micronutrients at critical growth stages of cotton increases the chlorophyll content in plant. Increase in chlorophyll content in cotton leaf might be due to supply of nitrogen, magnesium, phosphorus, zinc, sulfur and other micronutrients by foliar application because magnesium and nitrogen are main constituent of chlorophyll and other nutrients like Fe, Zn and S play an important role in synthesis of chlorophyll although they are not constituent of chlorophyll. Similar results were observed by Jadhao *et al.* (2004) [8] reported that the spray of 0.3% $MgSO_4$ was found to be the best for chlorophyll content in leaves and spray of 1% urea and 1.5% urea statistically superior over control. Above results are in line with Patel *et al.* (2011) [11] revealed that the total chlorophyll content was significantly higher with recommended dose of fertilizer based on soil test value with 10 t FYM ha^{-1} with one spray of each of 1 per cent and 2 per cent of urea and 1 per cent $MgSO_4$ during flowering and boll development stage.

Leaf reddening index

The result regarding effect of foliar nutrition on leaf reddening index of cotton at flowering, boll formation and boll development stage presented in (table 6). Data indicated that leaf reddening index were found to be maximum due to flowering stage.

Table 6: Effect of foliar nutrition on leaf reddening index at different growth statges of cotton.

Treatment	Leaf reddening index		
	At flowering stage	At boll formation stage	At boll development stage
T_1- Control (100% RDF)	0.80	1.06	1.26
T_2 – 100% RDF + Water spray	0.83	1.00	1.16
T_3 – 100% RDF + 2% urea	0.73	0.80	0.82
T_4 -100% RDF + 1% 19:19:19	0.73	0.87	0.82
T_5 – 100% RDF + 2% KNO_3	0.80	0.86	0.73
T_6 - 100% RDF + 1% $MgSO_4$	0.73	0.86	0.82
T_7- 100% RDF + 1% DAP + 1% KNO_3 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	0.60	0.73	0.69
T_8- 100% RDF + 1% 19:19:19 + 1% $MgSO_4$ + 0.5% Micronutrient grade II	0.66	0.81	0.70
CD at 5%	0.194	0.234	0.167

Maximum leaf reddening index at boll development stage found in 100% RDF (T_1) (1.26). This clearly indicated that due to lack of moisture in root zone and high amount of calcium carbonate induce the stress of macro and micronutrients in plant which resulted the leaf reddening (Ghode, 2016 and Ingole, 2018) [5, 6]. Minimum leaf reddening index with treatment T_7 followed by treatment T_8. It is indicated that foliar application of macro and micronutrients at critical growth stages of cotton reduce the intensity of leaf reddening. Foliar spray of DAP + KNO_3 + $MgSO_4$ and micronutrients along with RDF might be attributed to the development of optimum canopy as a result of lower leaf reddening index which was attributed due to higher leaf nitrogen, magnesium and chlorophyll contents thus leading to higher photosynthetic efficiency. Similar finding was also reported by Santhosh *et al.* (2015) [13]. Ali (2011) reported that use of potassic fertilizer and foliar spray of micronutrient especially zinc, boron and copper with RDF at specific growth stages reduce the intensity of reddening. Similar finding was also reported by Deshpande *et al.* (2015) [4] application of 100% RDF along with three foliar spray of 1% KNO_3 or 1% $MgSO_4$ or 2% DAP was found minimum intensity of reddening of leaves.

Conclusions

It is concluded that application of 100 per cent RDF along with foliar spray of DAP @ 1% + KNO_3 @ 1% + $MgSO_4$ @ 1% and micronutrient Grade II @ 0.5% followed by application of 100 per cent RDF + foliar spray of 19:19:19 @ 1% +$MgSO_4$ @ 1% + micronutrient grade II @ 0.5% at flowering, boll formation and boll development stage found to be beneficial for increase leaf nutrient content, chlorophyll content and control the stress of nutrients in cotton besides decrease in anthocyanin accumulation of leaves and reduced the leaf reddening index in cotton under rainfed condition.

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