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Leaf reddening of short duration rainfed *Bt* cotton hybrid-A review

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ABSTRACT: Leaf reddening is the predominant problem at the boll development stage of short duration *Bt* cotton hybrids (90%) under rainfed condition in shallow soils. Integrated approach of choosing sucking pest / multiple disease resistant *Bt* cotton hybrids and seed treatment with bio inoculants, GA_3 etc helps in ameliorating leaf reddening. Seed treatment and foliar (0.2%) application twice with humic acid and chelated micronutrients before flower initiation can improve root activity and delays leaf reddening by a month. Delayed square initiation with GA_3 and improved boll setting with 6 BA, TIBA can also reduce leaf reddening by improving the root length and its activity besides onset of timely cut out. In medium deep soils rain water conservation by opening of furrows from 2nd interculture onwards delays leaf reddening. In shallow red or calcareous soils peak flowering and early boll development stage two supplemental irrigations from dugout farm ponds in a year when rainfall was less than 25 percentage of water requirement *i.e.* 650 mm. Balanced nutrition by timely soil application of available organic manures/ press mud/ silt and macro-micro nutrient fertilizers can delay leaf reddening. Management of leafhoppers; foliar applications of broad spectrum fungicides/ antibiotics against leaf spot diseases and foliar correction of nutrient deficiencies in early reproductive stage proved best management tool for delay of leaf reddening.

Key words : *Bt* hybrid cotton, deficit irrigation, leaf reddening, short duration

Earliest report of leaf reddening was reported by NGOs as early as 2003-2004, however, it went unheard by public and private sectors, later it was confirmed by many authors about increase in management costs of sucking pests and foliar diseases besides decline in yield (Raju and Thakare, 2012; Better crops, 2014). Seed cotton yield reduction due to leaf reddening was estimated and reported by different authors around 15-20 percentage was further aggravated by foliar diseases and unfavourable rainfall distribution reaching an yield reduction upto 50 percentage (Raju and Thakare, 2012). Reddening of leaves is a physiological disorder only in early *Bt* hybrid cotton genotypes except medium and late duration hybrids (Raju, 2017). Induced by different biotic, abiotic and nutritional stresses at peak boll development stage, with strong accumulation of anthocyanins and drop of chlorophyll content, increase in proline content and peroxidase activity (Kumar and Swamy, 2014; Prakash *et al.,* 2014).

RESEARCH REVIEW

Forgotten Better Management Practices (BMPs): Surveys conducted by the investigator found no or rare application of animal manures, tank silt, animal penning, press mud, rain water conservation and supplemental irrigations in shallow soils etc due to the higher cost or short of supply. Commercial cultivation of *Bt* hybrid cotton soybean-gram / wheat system under imbalanced nutrition in the absence of P, K, S, Mg, Mn, Zn, Fe and B application resulted in permanent replacement of soybean due to viral disease (YMV) and partial replacement of *Bt* hybrid cotton by leaf reddening.

Farmer's returns were still compensated upto 40 percentage from strip cropped cotton+ pigeon pea (6-8:1/2) system. BMPs remained on paper itself as the gulf between technology developers and users was widened (Raju, 2017).

Role of *Bt* cotton hybrids: Leaf reddening incidence was more pronounced in early *Bt* hybrid cotton genotypes than medium and late duration or stay green hybrids like RCH 135, Vithal, Green Gold, GK 202, Mallika etc *vis a vis* non *Bt* hybrid cotton genotypes. The reduction of chlorophyll content in reddening affected leaf was maximum in *Bt* hybrid cotton MRC 6301. Anthocyanin content was increased in reddening affected leaves upto 5 per cent at square formation stage (Pagare and Durge, 2011). Long duration BG II *Bt* hybrid cotton Neeraja produced lowest red leaves and maximum of 25 percentage in short duration Bunny NCS 145 (Hosmath *et al.,* 2012). Long duration BG II Sigma *Bt* hybrid cotton recorded more seed cotton yield/ha with high anthocyanin pigment indicating starvation of required nutrients which were forced to translocate to sink (Khadangle *et al.,* 2011). Bunny NCS 145 BG II was susceptible genotype and long duration Bindaas BG II 7213-2 considered as tolerant to leaf reddening (Janagouder, 2015). Visual observations recorded at 108 DAS indicated BG II hybrids Ankur 216, Ankur 3042, Ankur Jai, Atal, Express, MRC 7301, Paras Krishna, Uttam, VICH 303 and VICH 304 were unaffected by leaf reddening (Nagarale *et al.,* 2014. Anthocyanin content in reddening affected leaves of *Kanak* (MRC 6301) was maximum compared to reddening affected leaves of NCS 145 BG II hybrid and both were out of market within 2-3 years (Pagare and Durge, 2010). Medium duration Jackpot, MRC 7347, Marvel and MRC 7351 were found tolerant to sucking pests and reddening symptoms. *Bt* cotton hybrids such as RCH 2, RCH 530, Brahma, Arya and Bunny were highly sensitive to insect-induced reddening (Ghante *et al.,* 2015).

Role of soil moisture: Soil moisture conservation practices were not at all practiced by the shallow red soils in eastern Vidarbha, Maharashtra state tribal farmers. Seed cotton yield were doubled with 1 or 2 life saving irrigations and improved six times under fertigation in the same soils (Raju, 2017). Supplemental irrigations significantly reduced leaf redness (Raju *et al.,* 2011). Tank silt and animal manure @ 0.2 t/ha/year soil application in calcareous improved seed cotton yields of Ajit 155, (20 q/ha) which was very profitable to that of medium deep soils (Raju, 2017).

Role of harmones and PGR on root activity: Seed treatment with PSB, foliar and soil application of humic acid alongwith fertilizer mixture improved seed cotton yields and delayed leaf reddening by chelating and harmonal action (Raju, 2017). Seed treatment with super gels, foliar application of cyto kinins, root activating harmones like IBA, humic acid can overcome short duration droughts and other bio stimulants for enhanced root activity must be explored for reducing the leaf reddening (Annie and Manikandan, 2012).

Role of shoot activity: Humic acid foliar spray (0.2%) at peak flowering and boll development stages extended shoot and leaf growth with its harmonal action and delayed boll bursting and senescence. Growth retardant CCC foliar application twice reduced plant height and leaf growth further delayed leaf reddening by one month in Hy 6 *Bt* hybrid cotton (Raju, 2017).

Role of sink / boll load: Early and concentrated boll retention and high fruiting efficiency in *Bt* hybrid cotton resulted in lower rate and quantity of dry matter/plant with shallow roots. Higher sink in *Bt* hybrid cotton leads to lower source to sink ratio, faster senescence and crop maturity. Sometimes, the increased assimilate demand of early and higher fruit retention reduces the resources for continued root growth, leading to early maturity and reduced yields.

Role of sucking pests: Seventy per cent leaf reddening in July and August months was due to leafhopper attack and 10 per cent was by thrips in early maturing Bunny *Bt* hybrid (Raju and Thakre 2012). BG II *Bt* hybrids MRC 7301, Atal, Classic , Krish, Ryan, SP 504, Namaskar, Madhura, VICH 312 registered lower population levels of sucking pest, and also lesser leaf reddening and higher yield levels (Nagarare *et al.,* 2014).

Role of diseases: Leaf spot diseases like *Alternaria, Myrothecium, Xanthomonas malvacearum* and grey mildew also produces leaf spots, necrosis and bronzing symptoms in 20-30 per cent of the leaf area in the absence of any plant protection measures (Santosh, 2014). One or two sprays of propiconazole (0.1%) was very effective against all the foliar diseases in *Bt* hybrid cotton (Janagouder, 2015, Raju, 2017).

Role of major nutrients: Mobile elements measured in the index leaves were often misleading to that of nitrogen content of affected leaves in *Bt* hybrid cotton due to their mobility (Raju and Thakre, 2012). Carbohydrates were 0.99 to 1.05 per cent was maximum in reddening affected leaves as compared to healthy leaves indicates disruption in carbohydrate metabolism (Pagare and Durge 2010). Leaf reddening significantly reduced with 125 per cent RDF of NPK fertilizers but non significant response was observed in Bunny *Bt* hybrid cotton (Raju and Thakare, 2012). The extent of reduction in leaf reddening was 125 and 150 per cent RDF was 15 and 30 per cent, respectively. Leaf reddening was 2.5 per cent with 100 per cent RDF (Santosh *et al.,* 2014). Redness of leaves was also caused by potassium starvation is a major problem in *Bt* hybrid cotton due to the absence of complex potash containing fertilizers (Raju, 2017). Leaf redness symptom in cotton, interfere with photosynthesis from time to time. K uptake in calcareous soils is difficult, therefore, it should be ensured to be within the critical limits prescribed for in the cotton leaf (Santosh, 2014).

Role of secondary nutrients: Excess of exchangeable Ca in calcareous soils leads to magnesium (Mg) and K deficiency resulting in leaf reddening. Leaf Mg was reduced in reddening affected leaves (Pagare and Durge 2010). Nutrient supply through foliar spray showed that if 2 per cent Urea + 0.2 per cent $MgSO_4$+ 0.1 per cent $ZnSO_4$ sprayed twice enhance high level of chlorophylls which kept under check the accumulation of anthocaynin content of Sigma *Bt* hybrid cotton leaf (Khadangle *et al.,* 2011). Reddening affected leaves Mg level was slightly lowered than that of healthy leaves (Pagare and Durge, 2010). Leaf reddening significantly reduced with foliar sprays of $MgSO_4$ + KNO_3, $MgSO_4$ + 19:19:19 and $MgSO_4$ thrice @1 per cent combined with initial soil application of $MgSO_4$ @ 25 kg/ha. Leaf reddening 18.7 and 16.2 per cent with three foliar sprays of $MgSO_4$ + KNO_3 and $MgSO_4$ +19:19:19, respectively, alongwith soil application of $MgSO_4$ @ 25 kg/ha (Santosh *et al.,*

2014). Minimum intensity of reddening in *Bt* hybrid cotton was observed in 100 per cent RDF + foliar sprays with 1percentage KNO_3, which suggest that at boll development stage the application of nitrogen and potassium were helpful for controlling the leaf reddening in *Bt* hybrid cotton. However, the application of 100 per cent RDF + 1 per cent $MgSO_4$ spray was found to be the best for highest content of chlorophyll as well as yield of *Bt* hybrid cotton (Masram *et al.,* 2015). Foliar spray of $MgSO_4$ 1 per cent is often recommended as a corrective measure needs to be verified in farmer's fields. Field experiments were conducted at Faridkot and Bathinda indicated highest seed cotton yield (3064 kg/ha) with application of $MgSO_4$@1.5 per cent thrice due to reduction in leaf reddening (8%) when leaf Mg content was below critical limits (Singh, *et al.,* 2015). In *"Mera Gaon Mera Gaurav"* programme both calcareous and non calcareous soils 850 demonstrations in the farmers fields were conducted with non significant improvement in seed cotton yield and leaf reddening by any of the soil and foliar application of N, P, K, Zn, Mg, B and humic acid except change in leaf colour quality and delayed onset of leaf reddening by one month probably due to fresh growth of new leaves. Once leaf reddening established leaf redness is irreversible and therefore curative measures are futile than preventive measures (Raju, 2017).

Role of micronutrients: Maximum reduction of red leaves were with the soil application of @ 120-70-40 NPK in combination with Zn and B @ 4 and 1.5 kg/ha, respectively (Gandahi *et al.,* 2016). However, the direct effect on leaf reddening major from and micronutrients could not be verified in farmer's fields but helped only in puttingup more fresh leaf growth, thereby reduces percent red leaves on *Bt* hybrid cotton plant (Raju and Thakare, 2012). Wide spread Zn, Mg, B deficiencies were observed in farmer's fields in Nagpur (M.S) preventive measures can improve productivity and profitability besides change in leaf colour and quality due to Mg application (Raju, 2017).

Role of growth regulators : Plant growth regulators GA_3, IAA amino acids and 6 BA, TIBA application to modify early and mid season growth respectively are very essential in the management of leaf reddening through increase in root growth for continued uptake throughout the boll development and reduction in the shoot biomass inviting timely cut out on further topical growth. There is potential to influence present seed cotton yield levels of 560 kg/ha lint with optimum adoption. Plant growth regulators have the potential to promote square and boll retention, higher nutrient uptake, and keeping vegetative and reproductive growth in harmony to improve lint yield and quality. Gibberellins are associated with increase in root activity and 6 BA with fruit retention in *Bt* hybrid cotton (Raju, 2017).

Role of cytokinins: Cytokinins can also delay aging of leaves, allowing longer photosynthetic activity with reduction in fruit abscission and also can promote cell division and enlargement of stems, leaves and fruit. PGR IV may be options for growers who want to pursue high yields through a more intensive management approach. It would be advisable to apply the materials early in the growing season to promote early growth, such as in furrow (PGR IV) or match head square treatments, then use Pix or Mepichlor after bloom to slow vegetative growth and force a timely cut out. Over an 8 year period, PGR IV on cotton if applied 2 to 4 ounces/ ac beginning at match head square and applying

weekly for a total of four applications has produced 115 pound lint yield from foliar applications. Cytokinin may be most beneficial under stressed conditions to maintain proper boll set and retention promote earliness and develop a better root system. Growth chamber studies revealed that the in-furrow applications of PGR IV @ 1.13 ìL/plant dramatically increased root length (+47%), root dry weight (+29%), lateral roots/ plant (+75%), and nutrient uptake one week after planting. These differences were still apparent five weeks later at pinhead square but to a lesser degree. Positive effect of PGR •-IV on root growth and accelerated early-season growth could have very substantial benefits in reducing the leaf reddening in *Bt* hybrid cotton production (Raju,2017).

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