EVALUATION OF BT COTTON GENOTYPES AND NUTRIENT MANAGEMENT TO CONTROL LEAF REDDENING

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1. INTRODUCTION

Cotton (*Gossypium* spp.), the king of fibers and popularly known as the white gold, enjoys a predominant position amongst cash crops in India and world as well. Cotton is the nature's most precious gift to the mankind, contributed by the genus "*Gossypium*" to cloth the people all over the world. Four out of the 50 recognized *Gossypium* species in the world are cultivated *viz., Gossypium arboreum, Gossypium herbaceum, Gossypium hirsutum* and *Gossypium barbadense.* India is the only country in the world where all the four cultivated species and some of their hybrid combinations are commercially grown. The diversity of cotton cultivars and cotton agroclimatic zones in India are considerably larger when compared to other major cotton growing countries in the world.

In India, cotton is grown under diverse agro-climatic conditions and contributes nearly 65 per cent of total raw material needs of textile industry. Cotton plays a major role in India's economy, both in terms of providing employment directly or indirectly to about 60 million people and earning foreign exchange for the country to the tune of Rs. 60,000 crores (Anon., 2011a).

Cotton is cultivated in 70 countries with a total coverage of 32.3 million ha (Anon., 2011b). Area wise, India ranks first in global scenario (about 33% of the world cotton area). However, in production it ranks second next to China. In India, cotton was cultivated in an area of 11.16 m ha with a production of 31.20 million bales of seed cotton during 2010-11. Average productivity of cotton in India is 494 kg lint/ha, which is low when compared to the world average of 725 kg lint/ha (Anon., 2011a). Maharashtra, Gujarat, Andhra Pradesh, Madhya Pradesh, Punjab, Haryana, Karnataka, Rajasthan and Tamil Nadu are the important cotton growing states in India.

Since the introduction of transgenic crops in 1996, there has been a substantial increase in their area from 1.7 m ha in 1996 to 148 m ha in 2010. This is an unprecedented 87-fold increase, making transgenic cotton the fastest adopted crop technology in the history of modern agriculture on account of multiple benefits that transgenics offered over the last 15 years. It is noteworthy that in 2010, the number of countries planting transgenic crops reached 29 from 6 in 1996, the first year of commercialization, 18 in 2003 and 25 in 2008. Of the 148 m ha in 2010, 73.3 m ha was under soybean, 46 m ha under maize, 31.2 m ha under cotton (with India being No. 1), 7 m ha under canola, 0.5 m ha under sugarbeet and 0.1 m ha under alfalfa (Anon., 2010).

The major countries growing Bt-cotton, either with Bt trait alone or stacked with herbicide tolerance, and the area occupied in 2010 are as follows with the year of introduction indicated in parenthesis: Argentina (1998) - 244,500 ha; Australia (1996) - 190,000 ha; Brazil (2005) – 0.25 m ha; Burkina Faso (2009) - 115,000 ha; China (1997) - 3.70 m ha; Colombia (2002) - 23,000 ha; Costa Rica (2009) - 1,500 ha; India (2002) - 11.16 m ha; Mexico (1996) - 56,000 ha; South Africa (1998) - 6,225 ha and USA (1996) - 3.90 m ha (Manjunath, 2011).

In India, Bt cotton since its release in 2002 by Genetic Engineering Approval Committee (GEAC) replaced more and more conventional cotton area. There was an exponential increase in Bt cotton area from 29,000 hectares in 2002 to 11.16 m ha in 2010 accounting for a staggering 92% of the total cotton area in India. It is estimated that Bt cotton would cover an area of 15.0 m ha by 2015 (Manjunath, 2011). The production increased from a meager 2.79 million bales (170 kg lint/bale) in 1947-48 to an all time record of 31.20 million bales during 2010-11 (Anon., 2010). The major states growing Bt cotton in 2010 in order of hectarage, were Maharashtra (3.39 m ha) representing almost half, or 40%, of all Bt cotton in India in 2009, followed by Gujarat (1.68 m ha or 20%), Andhra Pradesh (1.04 m ha or 16%), Northern Zone (1.24 m ha or 15%), Madhya Pradesh (621,000 ha or 8%), and the balance in Karnataka, Tamil Nadu and other states (Choudhary and Gaur, 2010).

In Karnataka, the present cotton growing situation is showing improvement after release of Bt cotton. In Karnataka, cotton is grown on an area of 3.95 lakh hectare with a total production of 9.0 lakh bales of seed cotton with a productivity of 387 kg lint/ha. The increase in productivity from 229 kg lint/ha in 1996 to 387 lint/ha in 2010 was mainly due to cultivation of Bt cotton (Anon., 2011a).

The most important reason for the adoption of Bt cotton is its resistance to pest, particularly boll worms which has been a devastating production constraint. Gandhi and Namboodiri (2006) have reported that Bt cotton offers good resistance to bollworms as well as several other pests from a study which covered the important cotton growing states of Gujarat, Maharashtra, Andra Pradesh and Tamil Nadu. The incidence of these pests is reported to be considerably lower in Bt cotton versus-non-Bt cotton. The Bt cotton area was found to be higher and the yield increase was statistically significant in all the states under irrigated and rainfed conditions. Subjective assessment indicates that farmers find advantages in pest incidence, pesticide cost, cotton yield, quality and profit.

Eventhough the performance of Bt cotton has been projected to be satisfactory in some circles, there is great discontent in different quarters with the variety. Some indicate that the variety is susceptible to the boll worm and the yield is below par (Venkateshwaralu, 2002). Other reports indicated that initially Bt cotton showed resistance to boll worms but as soon as the formation of bolls started, the worms started attacking them (Anon., 2002). Reports on Bt cotton cultivation in Andhra Pradesh indicated that there was high incidence of sucking pests like aphids, jassids, whitefly and disease like black arm and leaf spot (Anon., 2006). Parawilt has been noticed in Bt cotton hybrids again in certain areas. Practice of illegal/spurious Bt cotton hybrid seeds including F_2 seeds for planting still poses problems in respect to yield realization, susceptibility of pests/diseases besides adverse impact on fiber quality has been reported from Maharashtra and Gujarat (Hebbar and Mayee, 2011). Minor pests like mealy bugs becoming major threat in intense cotton growing tracts in central and south zone. Mirid bugs in certain locations, problems of pink bollworms in many areas, thrips and diseases like cotton leaf curl virus in north zone and grey mildew in central and south zone (Anon., 2009). Majority of Bt cotton growers in India have expressed that in the recent past, Bt cotton is very much prone to leaf reddening malady. The red colour becomes apparent when the green chlorophyll decomposes with the approach of winter (Anon., 2007). Intense light and low temperatures favour the development of anthocyanin pigments. Leaf reddening was found to reduce the seed cotton yield to the extent of 30-60 per cent depending on variety and reddening intensity (Pagare, 2011).

Synchronized boll development and better retention of bolls due to better boll worm control in Bt plants altered the source-sink relationship due to rapid translocation of saccharides and nutrients from leaves to the developing bolls. Scientists (Hebbar *et al.,* 2007b; Wright, 1999) opined that these adversities would develop some physiological disorders such as leaf reddening or premature senescence, square and boll shedding, parawilt or sudden wilt, bad opening of bolls etc, and early crop maturity. Poor performance of the transgenic traits during boll development period and varied performance between different regions has been reported (Poongothai *et al.,* 2010; Dong *et al.,* 2005). The efficacy is associated with reduction in insecticidal protein and production of toxins induce loss of chlorophyll, ribonucleic acid (RNA), decrease in nutrient ions and stimulation or inhibition of enzyme finally leads to senescence.

Leaf reddening malady in cotton is not a new problem and it was reported long back (Balls, 1908). Leaf reddening malady in cotton is called in different names across the world as red-leaf-disease, bronze wilt, copper top, early foliar decline, sudden wilt, phloem wilt, red leaf, red wilt and anthocyanosis (Ikisan, 2004). The red leaf syndrome in cotton was reported in various parts of the world like America (Burt and Haider, 1919); New guinea (Evans, 1926); Nigeria (Jones and Mason, 1926) Netherland, Uganda, South Africa (Combrink, 1988) and India (Butler, 1908). Jones and Mason (1926) considered leaf reddening to be a physiological disorder and Butler (1908) also opined the same reason for premature leaf reddening in American Cotton. However, Burt and Haider (1919) opined that it is due to an attack of aphids. Kottur (1920) considered that the jassids might be carrying the disease. Mali (1978) opined that red leaf disease is transmitted by aphids from diseased to healthy plants. This was assumed to be the cotton anthocyanic disease known to occur in Brazil.

Tracing the history of causes for leaf reddening in cotton, it is clear that this malady was much pronounced in *Hirsutum* (Mclendon 1912; Thadanki, 1921; Ware 1927 and 1929; Carver 1929) and *Barbadens* (Balls, 1908) Leaxe, 1911; Stroman and Mahoney, 1925, Alston, 1959) than *desi* types.

The scientists (Horlachewr and Killough 1931; Harland, 1932; Chimmad, 1989, Shanmugham, 1992) observed the cotton plants from inter and intraspecific crosses between *Hirsutum* and *Barbadenses* with partially deficient in chlorophyll. In the recent past this disorder is much reported in the Bt version (intra-*hirsutum*) cotton hybrids (Hebbar *et al*., 2007a; Hebbar and Mayee, 2011; Qaim and Zilberman, 2003; Singh *et al.,* 2003).

Several investigations have been carried out on leaf reddening malady to find out factors involved and control measures. The findings have indicated that the nutrient deficiencies and low temperatures play role in aggravating the leaf reddening malady. The research findings till 1990`s (Prabhakar 1981; Bhatt *et al*.1982; Chimmad 1989; Shanmugham 1992) indicated that deficiency of N, P, Mg was responsible for leaf reddening. From 2000`s onwards it is being attached to that the deficiency of K (Wright 1999; Singh 2004; Dong *et al.,* 2006; Velikova *et al*.2002). Drop in day temperature below 21 ^{0}C and sudden fall in night temperature below 15^{0}C stimulate the formation of anthocyanin pigment during winter causing the leaf reddening in non-Bt cotton hybrids (Shanmugham 1992; Nakajima *et al*., 2001)**.**

In the recent past leaf reddening has been a major problem in Bt cotton growing areas of northern Karnataka. Cotton cultivators have been approaching scientists and extension agencies for efficient control measures of leaf reddening. In this context, the present investigation was planned and executed during *kharif* seasons of 2007 and 2008 with the following objectives.

1. To document the constraints encountered by farmers during Bt cotton cultivation in major cotton growing districts of northern Karnataka.
2. To compare biochemical variations among Bt vis-à-vis non-Bt cotton genotypes and across their agronomic performance.
3. To study the effect of nutrient applications (*i.e* macro and micro) and other practices (*i.e* cytokinin, polyethylene mulching) on growth, yield, nutrient uptake, biochemical variations and economics of Bt cotton.

2. REVIEW OF LITERATURE

In the present study investigations were made to evaluate different genotypes and to develop remedial measures for management of leaf reddening malady in Bt-cotton. Literatures and results of the previous investigations carried out on leaf reddening malady in Bt version cotton hybrids only are very limited. Hence, work done on non-Bt cotton is also especially for leaf reddening management is also reported here under. The research is based on vast review out of which selected references are quoted in the present chapter. For the sake of convenience, the chapter has been divided in to following six sections as:

2.1 Field performance of Bt cotton hybrids

2.2 Causes of leaf reddening in cotton

2.3 Biochemical and anatomical changes in relation to leaf reddening

2.4 Remedial measures tried

2.5 Growth hormone effect on nutrient use efficiency

2.6 Polyethylene mulching for soil temperature regulation

2.1 Field performance of Bt cotton hybrids

The cry genes responsible for crystalline □-endotoxin production in soil bacterium, *Bacillus thuringiensis* var. *kurstaki* Berliner were transferred to cotton via. *Agrobacterium* with Ca MV 35 S promoter through advanced biotechnological tools. Transgenic Bt-cotton plants inturn expressed insect control protein to the extent of 0.05 to 0.10 per cent of total soluble protein thereby provided effective square and boll protection (70 to 87%) under high *Helicoverpa zea* (Boddie) pest pressure (Umbeck *et al.*, 1987). Bt □-endotoxin produced in transgenic plants when enters into the gut system of lepidopteron pests (having alkaline condition), the toxin gets activated into protoxin and binds to the specific receptor sites of the gut. The toxin ruptures the gut wall and later causes paralysis and death. In this way, cry protein produced in transgenic cotton was found to be toxic to bollworms (Tabashnik, 1994). Wilson *et al.* (1994) reported that expression of insecticidal protein caused no general reduction in lint yield, primary or secondary yield components or fibre properties. Six of nine transgenic lines yield significantly more lint than control, four had longer fibre, eight had stronger fibre, and two had higher staple length and did not differ significantly in micronaire when compared with control genotype.

Benedict *et al.* (1996) reported the field performance of transgenic cotton carrying a *Cry 1Ab* gene (Mon 65 and Mon 81) and *Cry 1Ac gene* (MON 247 and MON 249) against naturally occurring bollworm. The bollworm eggs were significantly higher in two non-transgenic cotton genotype lines (Cok-312 and Stoneville 453) in one season and two *Cry 1Ab* lines in the other season compared to others. Significantly lower number of larvae were recorded in Bt cotton lines carrying either *Cry 1A*c or *Cry 1 Ab* (<0.55/60 plants) when compared to non-Bt cotton lines (>198 larvae/60 plants). Similarly, significantly lower flower bud and square injury was recorded in Bt cotton lines carrying either Cry 1Ac or Cry 1Ab gene (<4.07 and <1.04%, respectively) when compared to non-Bt cotton lines (>20.60 and 11.77% respectively). An average yield of 1460 kg/ha was recorded in all the Bt cotton lines compared to Coker 312 (1050 kg/ha).

Wu *et al.* (2000) evaluated cotton cultivars in China against cotton bollworm, *H. armigera* in Hebei and Henan provinces of China and found that transgenic cultivars were highly resistant to cotton bollworm throughout the growing season. The control efficiency of two transgenic lines GK-2 and GK-12 to the second, third and fourth generation cotton bollworms were upto 88.7 to 95.4 per cent, 92.7 to 97.6 per cent, and 93.3 per cent, respectively. Bt cotton cultivars recorded the damage rate of 6.5 per cent to cotton squares and yield increase of 97.0 to 393.8 per cent.

Kerby (1996) in a 75 field comparison of three Bt cotton varieties and their non-Bt near-isogenic parents, reported a lint yield increase in Bt cotton varieties to the extent of 207.2 kg per ha which represented a 20 per cent improvement in yield compared to non Bt genotypes.

Benedict and Altman (2001) showed a yield increase of approximately 14 per cent (174.8 kg/ha) with Bt cotton. Qaim and Zilberman (2002) reported that Bt cotton containing *Cry 1Ac gene* provides a fairly high degree of resistance to the American bollworm (*H. armigera*), spotted bollworm (*Earias vittella*) and pink bollworm (*P. gossypiella*), all of which are major insects pests in India.

Udikeri *et al.* (2003a) found that under unprotected conditions, Bt cotton hybrids recorded lower *H. armigera* larvae compared to the check and non-Bt versions, with least being in MECH-184 Bt (0.91/plant). Spotted bollworms were significantly lower in Bt hybrids (0.06 to 0.08/plant) compared to non-Bt hybrids. Damage to fruiting bodies was significantly lower in MECH-184 Bt (4.04%) followed by MECH-162 Bt (5.02%) and MECH-12 Bt (6.84%). Highest seed cotton yield was recorded in MECH-184 Bt followed by MECH-162 Bt (8.44 q/ha) and MECH-12 Bt (6.71 q/ha)

Venugopal *et al.* (2002) showed that Bt cotton hybrids namely MECH-184 Bt, MECH-162 Bt and MECH-12 Bt recorded significantly lower population of bollworms especially, *Helicoverpa* compared to non-Bt and check hybrids. Among the Bt hybrids, MECH-184 Bt and MECH-12 Bt recorded significantly lower boll damage compared to non-Bt and check hybrids. Among the Bt hybrids, MECH-162 Bt was superior in central zone (13.3 q/ha) and MECH-184 Bt in south zone (20.09/ha).

Udikeri *et al.* (2003b) found that among the MECH Bt hybrids, *Helicoverpa* larvae were least in MECH-184 Bt (0.45/plant). Damage to the fruiting bodies was also lowest in MECH- 184 Bt (3.63%) followed by MECH-162 Bt (4.36%) and MECH-12 Bt (5.66%). Highest seed cotton yield of 21.75 q per ha was recorded in MECH-184 Bt which was on par with MECH- 162 Bt and MECH-12 Bt.

Vennila *et al.* (2004) showed that Bt cotton hybrids recorded significantly lower square, green boll, open boll and locule damage than the conventional and commercial Bt cotton hybrids. Among the cotton hybrids, RCH-20, RCH-134, RCH-138 and RCH-144 Bt hybrids recorded significantly lower damage levels. However, among Bt cotton hybrids significant differences in yield were not observed.

Hegde *et al.* (2004) reported that irrigated conditions recorded significantly lower damage to fruiting bodies in MECH-162 Bt compared to non-Bt cotton hybrids. The per cent damage in MECH-162 Bt (15.2%) was at par with non-Bt conventional hybrids (PCH-115, PCH-225, DHH-11 and NHH-44). Among the Bt hybrids, MECH-162 Bt recorded higher yield (1972 kg/ha). Further, boll damage was significantly lower in MECH-162 Bt (15.67%) and it was at par with MECH-184 Bt (19.12%) and MECH-12 Bt (20.18%) and significantly lower than the rest of the hybrids tested. MECH-184 Bt recorded significantly higher yield (782 kg/ha) than NHH-44, MECH-12 Bt and MECH-162 Bt.

Bhosle *et al.* (2004a) reported that the damage due to bollworms was 14 to 17 per cent in Bt cotton hybrids which was significantly lower compared to non-Bt and check hybrids (25 to 35%). MECH-184 Bt recorded the highest seed cotton yield of 2100 kg/ha followed by MECH-162 Bt (1631 kg/ha) and these were significantly superior over rest of the hybrids.

Bhosle *et al.* (2004b) found that the percentage of boll damage in Bt cultivars ranged between 14.6 to 17.2 per cent. MECH-184 Bt recorded the lowest damage in open boll of 14.6 per cent in comparison to non-Bt version (35.54%). Among the hybrids tested, MECH-184 Bt recorded the highest seed cotton yield of 1651 kg per ha with the lowest cost of plant protection.

Surulivelu *et al.* (2004) evaluated Bt cotton hybrids and found that, RCH-2 Bt and RCH-20 Bt were significantly superior in reducing the *H. armigera* incidence. Boll damage reduction in Bt entries was to the extent of 73.8 and 72.9 per cent over their non-Bt counterparts. RCH-2 Bt and RCH-20 Bt recorded significantly higher yield of 19.3 and 20.5 per cent, respectively over their non-Bt counter parts and 33.3 and 55.9 per cent, respectively over Savita.

An experiment was conducted at Agricultural Research Station, Dharwad Farm, Dharwad during 2001-02 to evaluate the Bt cotton hybrids. All the Bt cotton hybrids under the study (MECH-184 Bt, MECH-162 Bt and MECH-12 Bt) produced significantly superior yield over local checks (DHH-11 and NHH-44) as well as their non-Bt hybrids. Performance of Bt cotton hybrids was exceedingly superior and they produced 69 to 93 and 71 to 95 per cent more yield than DHH-11 (1130 kg/ha) and NHH-44 (1117 kg/ha) check hybrids, respectively (Hallikeri *et al.* 2004). Further, seed cotton yields of Bt hybrids were (1912 to 2183 kg/ha) 78 to 205 per cent greater than their non-Bt hybrids (634 to 1077 kg/ha). Among the Bt hybrids, MECH-184 Bt was the highest yielder (2183 kg/ha) and it reported 1468 and 1053 kg per ha more yield than MECH-184 non-Bt (715 kg/ha) and DHH-11 check hybrid (1130 kg/ha), respectively

Davis *et al.* (1995) evaluated the performance of Bt cotton DPL-5415 against bollworm complex and compared it with insecticide treated non-Bt cotton (DPL-5690). The results showed that non-Bt cotton received an average of 5.5 insecticide treatments for the bollworm complex. The Bt cotton had an average reduction of $77.96 in control costs and an average of 198 lb per acre more lint yield than the insecticide treated non-Bt cotton. In USA, Bt cotton growers produced 11.4 per cent higher yield than conventional cotton growers. In addition, Bt cotton plots required 72 per cent less insecticides and resulted in 155 per cent higher return on the seed investment (Carlson *et al.,* 1998).

Layton *et al.* (2000) reported that Bt cotton fields in Mississippi of USA suffered significantly less boll damage of 1.48 per cent compared to 3.44 per cent in non-Bt fields. Bt cotton fields, received fewer foliar insecticide treatments of 0.44 compared to 2.47 treatments in non-Bt cotton fields for the control of bollworm complex.

Fitt and Roush (2003) assessed the impact of transgenic Bt cotton (Ingard) in Australia over a period of six years. They revealed a significant increase in yield potential in Bt cotton (6.83 to 9.21 bales/ha) compared to conventional cotton was noticed. Economic benefit from Bt cotton was similar to conventional cotton initially. In the last two years net economic returns from Ingard® Bt cotton varieties have been considerably higher at over $300 per ha due to better performance of variety and better management experience.

Five years survey of Bt cotton growers in yellow river cotton growing region in China by Pray *et al.* (2002) indicated an increase in yields of Bt cotton. Yield of Bt cotton during 1999, 2000 and 2001 was 3371, 2941 and 3481 kg per ha, respectively against 3186, 1901 and 3138 kg per ha in non-Bt cotton varieties.

Ryssell (2003) showed that in the mixed cropping systems of China, apart from reduction in pesticides and increased yield the other benefits like saved labour, increased the total farm income to the extent of 12 per cent from the average of cotton farm of 0.25 ha.

Venugopal *et al.* (2002) reported that Bt cotton (MECH-184 Bt, MECH-162 Bt and MECH-12 Bt) required only one or two insecticidal sprays, thus, saving plant protection cost to the extent of Rs. 1500 per ha. The total economic benefit from Bt cotton hybrids, MECH-184 Bt and MECH-162 Bt was around Rs. 10,000 per ha.

Udikeri *et al.* (2003a) reported that Bt cotton hybrids (MECH-184 Bt, MECH-162 Bt and MECH-12 Bt) required one spray against bollworms when compared to three sprays for non-Bt versions and check hybrids.

Patil *et al.* (2004) studied the performance and economics of Bt cultivation in irrigated ecosystem at Regional Agricultural Research Station, Raichur and in farmer’s field. MECH-162 Bt and it’s non-Bt during 2002-03 and MECH-184 and it’s non-Bt during 2003-04 and local popular hybrids (NHH-44 and NCS-145) were cultivated and compared. Incidence of bollworms in MECH-162 Bt and MECH-184 Bt cotton hybrids was negligible. During 2002-03, MECH-162 Bt recorded significantly higher yield of 25.58 q per ha with a net profit of Rs. 33,802 in the farmer’s field than non-Bt and local hybrid. Similarly, during 2003-04, MECH-184 Bt recorded cotton yield of 24.38 q per ha with a net profit of Rs. 41,332 in research station and 24.65 q per ha with a net profit of Rs. 40,090 in the farmer’s field. Bt cotton hybrids recorded 35-45 per cent increase in net profit over local popular hybrids making it commercially viable and profitable under irrigated ecosystem.

Jackson *et al.* (2004) observed effects of genotype and insecticidal regime for the number of damaged bolls. Averaged across insecticidal regime, damaged boll numbers neared 250,000 per ha. in the conventional variety. Bollgard and Bollgard II cotton exhibited a reduction in number of damaged bolls of 61 and 95%, respectively compared with the conventional variety. The Bollgard II genotype sustained 80% less boll damage than the Bollgard when averaged across insecticide regime.

Investigations on performance of Rasi Bt-cotton hybrids carried out at Agricultural Research Station, Dharwad during 2002-2003. Results of experiment indicated that all Rasi Bt-cotton hybrids produced significantly higher yield (2585-2857 kg/ha) than their non-Bt cotton hybrids (1431-2100 kg/ha) and local check non-Bt hybrid DHH-11 (2103 kg/ha). Among the Bt-cotton hybrids RCH-2Bt (2857 kg/ha) was top yielder followed by RCH-144Bt (2794 kg/ha), RCH-20Bt (2585 kg/ha) and MECH-184Bt (2575 kg/ha) (Halemani *et al.,* 2004).

Hosmath *et al*. (2004) studied the effect of organic amendments on performance of Bt and non-Bt cotton. Study revealed that among different sources of nutrients significant higher cotton yield (kg/ha) was obtained in RDF+FYM (1169.33 kg/ha) and FYM (1168.8 kg/ha) compared to RDF (937.8 kg/ha), vermicompost (854.4 kg/ha), vermicompost + RDF (829.4 kg/ha), RDF + green manure (785.4 kg/ha) and green manure (712.5 kg/ha). Similar trend was observed in growth and yield attributing characters. Soil properties and nutrient content were not significantly influenced in Bt and non-Bt crop.

Farmer's participatory field trial was conducted in rainfed cotton growing region in Nanded district of central zone of Maharashtra to evaluate performance of Bt cotton hybrid MECH-162 under integrated pest management (IPM). In Bt MECH-162, 11.5% less fruiting bodies were damaged compared to conventional cotton. Seed cotton yield (12.49 q/ha), and net return (Rs 16231q/ha) were highest for Bt MECH-162 whereas conventional cotton under IPM recorded a yield of 7.1 q/ha and net return of 10507 Rs/ha (Bambawale *et al.,* 2004).

Yenagi (2006) reported that among the different Bt and non-Bt cotton genotypes, RCH-20 Bt recorded significantly higher seed cotton yield than RCH-144 Bt, MECH-162 Bt, DHH-11 and Sahana. The extent of increase in RCH-20 Bt was 8.0, 13.0, 26.0, 31.0, 48.0, 92.0 and 151 per cent over MECH-184 Bt, RCH-2 Bt, MECH-12 Bt, RCH-144 Bt, MECH-162 Bt, DHH-11 and Sahana, respectively.

Joshi (2007) reported that genotype JK-CH 99 Bt recorded significantly higher yield (3323 kg/ha) which is on par with JK- Durga Bt (3302 kg/ha), MRC-6322 Bt (3230 kg/ha) and NCS-207 Bt (2927 kg/ha). The two non-Bt cotton hybrids DHH-11 and DCH-32 recorded 2335 and 2122 kg per ha of seed cotton yield, respectively. The highest profit interms of B:C ratio was found with JK-CH 99 Bt (4.04) followed by JK-Durga Bt (4.02), MRC-6322 Bt (3.91) and NCS-207 Bt (3.50).

Rekha (2007) reported that among the Bt hybrids Bunny Bt produced significantly higher seed cotton yield 2672 kg/ha) and among non-Bt hybrids NHH-44 non-Bt (2090 kg/ha). The Bt hybrids recorded 30.96% more seed cotton yield, 15, 39% more number of bolls per plant and 9.02% more boll weight than the non-Bt cotton hybrids. This was mainly attributed to its close association with number of bolls per plant (r=0.53). While Bt hybrids recorded 6.95% less plant height, 10.81% less LAI than non-Bt hybrids.

Mehta *et al.* (2009) conducted frontline demonstrations at farmers' field during 2005-2006, 2006-2007 and 2007-2008 have proved that Bt cotton performed better than non-Bt cotton. The results indicated that pooled average of seed cotton yield of three years was to the extent of 24.06 q/ha in Bt cotton against 18.09 q/ha in non- Bt cotton. The Bt cotton has reduced the cost of plant protection by Rs. 2109/ha as compared to non-Bt cotton. An average enhancement of seed cotton yield from Bt cotton was 24.81% over non-Bt cotton. The average additional net returns from Bt over non-Bt cotton were Rs. 8959/ha. The results clearly indicated that Bt cotton technology was economically viable. As a result of this, the area under Bt cotton increased from 2.5% in 2005-2006 to 69.5% in 2008-2009 over a period of four years.

2.2 Causes of leaf reddening in cotton

Dastur and Bhatt (1956) observed that there was an accumulation of carbohydrates in the leaves when cotton plant had nearly reached the stage of senescence. Das and Leopold (1964) reported that the photosynthetic rate was reduced at senescence.

Moore and Lovell (1936) found that in senescent leaves, the leaf chlorophyll content was approximately linearly related to the estimated area of yellow tissue.

Burt and Haider (1919) reported this phenomenon in Cawnpore American cotton in United Provinces. They suggested that the red leaf disease was due to an attack of Aphids. Kottur (1920) suggested that the jassid might be the vector in carrying the red leaf disease and claimed success in warding off the disease by dusting with sulphur. Evans (1926) reported that the phosphate and potash deficiency in soil and hopper jassids caused the red leaf disease in cotton at New Guinea.

Sawhney (1932) observed that the red leaf blight of *Buri* cotton has been known in Hyderabad. The red pigment in leaves was reported to be developed as a result of injury caused by jassid. The injury caused death of leaf tissue and the red pigment was subsequently developed. Ramiah and Nath (1945) found that the red colour in *Gossypium hirsutum* leaves occurred uniformally over the whole upper surface. They suggested that it may also occur in patches on both surfaces due to an attack of jassids.

Since 1908 many research workers observed reddening malady was much pronounced in *Hirsutum* and *Barbadens* than *Desi* types (Alston, 1959 and Shanmugham, 1992). Deficiencies in the amount of chlorophyll in the cotton plant have been reported.

Balls (1908) made a cross between an upland cotton with light green leaves and a dark green Egyptian cotton. He states that in the F_2 generation, plants with light green leaves and plants with dark green leaves appeared in a 3 : 1 ratio.

The occurrence and inheritance of anthocyanin pigments in the cotton plant have been studied by several investigators. There are two general types of distribution of this pigment. The first type is the red plant color which is produced by the anthocyanin and distributed throughout the stem and leaves making the entire plant red. This type has been described in *G. hirsutum* by Mclendon (1912), Thadanki (1921), Ware (1927, 1929), Carver (1929) and Coury (1954).

It has also been described by Leaxe (1911) in *Gossypium arboreum.* It is usually called red leaf cotton. The second type is the red leaf spot which is confined to the leaf pulvinus. This spot is due to the development of anthocyanin in the epidermal and sub-epidermal cells of the petiole at the point where it divides into the leaf-veins. This type has been described by Balls (1908) in *Gossypium barbadense.* This red spot on the leaf is characteristic of all the so-called green varieties of *Gossypium hirsutum,* and of many other species of *Gossypium.*

The red plant color produced by the complete distribution of anthocyanin throughout the plant has been found to be a simple dominant to green plant color by each of the investigators mentioned. Balls (1908) reported that the red leaf spot is also a simple dominant to green. The anthocyanin pigment in red leaf cotton is distributed over the entire plant, but develops in greater quantities in those parts which are directly exposed to the rays of the sun. Less anthocyanin develops on the under sides of the branches, petioles, and leaves than on the upper sides. When these surfaces are turned over and held in position so that the sun's rays strike these under surfaces directly, they also develop as much red color as is normally characteristic of the upper surfaces. The effect of light on the development of anthocyanin pigment is further shown by the fact that plants of the red leaf strain grown in the greenhouse during the winter develop very small amounts of red pigment, giving to the plants only a slightly reddish cast on a green background, whereas plants of the same genotype grown in the field in the summer are solid red in appearance, except for the greenish under parts noted above.

The red colour becomes apparent when the green chlorophyll decomposes with the approach of winter. Intense light and low temperature favour the development of anthocyanin pigments (Anon., 2007).

Dastur (1967) reported that high wind velocity causing desiccation injury and low night temperature during November / December reported to be the cause of red leaf in cotton.

Prabhakar (1981) at Dharwad observed that leaf reddening was not noticed in October and it was started in November and increased in December and January.

Chimmad (1989) reported that all the genotypes showed an increasing trend for red leaf index from II fortnight of October (boll development stage) to maturity. Correlations indicated that anthocyanin accumulation was significantly negative with N, P, K, Ca and Mg contents of leaf. The chlorophyll content decreased, anthocyanin content increased as the crop attained maturity. This malady has been found to cause serious losses in the high yielding cultivars of *Hirsutum* and *Barbadenses.*

The red colour becomes apparent when the green chlorophyll decomposes with the approach of winter and intense light and low temperatures favour the development of anthocyanin pigments (Anon., 2007).

Shanmugham (1992) reported that drop in temperature below 21°C stimulate the formation of anthocyanin pigment. Sudden fall in night temperature below 15°C stimulate the formation of anthocyanin pigment. The reddened leaves show low chlorophyll content with high anthocyanin pigment. This malady has been found to cause serious losses in the high yielding cultivars of *hirsutum* and *barbadenses.* The critical N requirement of leaf is 2.0-2.6% if it falls below this reddening of leaf starts.

Garner (1934) reported that nitrogen deficiency causes frenching disease with light green colour of foliage, yellowing and firing of lower leaves of tobacco plant. Dabral (1938) found that the red leaf disease was caused by deficiency of nitrogen and this was cured by the application of various fertilizers containing nitrogen.

Dastur and Ahad (1941) found that the mineral composition of *desi* cotton was same except that there was less of K_2O as compared to American cotton. The mineral content of bolls of *desi* cotton was higher than the American cottons. The concentration of nitrogen in the bolls and leaves in these varieties was found nearly the same. Serry and Wad (1958) observed that the nitrogen deficiency in sand culture was associated with decrease in percentage of P_2O_5 and ash and in the quantities of Ca, Mg, and K absorbed by American cotton.

Dastur and Singh (1947) reported that the red leaf was caused by a deficiency of nitrogen in the leaves of plant growing on light sandy soil. The leaves of plant showed this type of reddening during the fruiting phase and contained significantly less nitrogen than the leaves of plant which were green in colour. Bhatt *et al*. (1982) also found reddening of cotton leaves associated with low leaf N concentrations and reduced amino acid levels of prematurely reddened cotton leaves.

Wright (1999) found that cotton plants with severe reddening symptoms had 55–66% heavier total bollmass and their leaves had only about half the potassium (K) and three-quarters the phosphorus (P) concentration of unaffected plants. Hence, affected plants had less leaf K and P to meet the demand of a bigger boll load

Velikova *et al*. (2002) observed the damage of photosynthetic activity upon reddening may be caused by oxidative stress due to K shortage and corresponding accumulation of Na ions. The oxidative stress in cotton may be partly counteracted by the strong accumulation of anthocyanins having protective antioxidants and antiradical functions.

Pettigrew (2002) observed that remobilization of leaf N to reproductive growth appears to be the principal component causing cutout and photosynthetic decline.

Howard (2003) suggested from the studies conducted at The West Tennessee that starter solutions containing either 11-37-0 or calcium Ca $(NO_3)_2$ nitrate boosted no-till (NT) cotton yields. In furrow applications of 2 to 8 gal/A of Ca $(NO_3)_2$ increased yields when compared with the check. Ammonium toxicity has been reported to result from a temporary calcium deficiency. Therefore, in furrow, starters for cotton production should contain nitrate N. Broadcasting the primary plant nutrients NPK was effective for increased no till yields.

Roberts *et al.* (1997) reported that foliar applied potassium (K) for cotton was profitable in Tennessee studies on low K soil with fast-fruiting, high yielding cultivars. K deficiencies can be corrected by foliar KNO_3 and found that lint yields responded to the K in foliar KNO_3 rather than the N.

Abaye (1996) reported that the traditional K deficiency which was first described in the 1960`s was a yellowish-white mottling of the older foliage that changes the leaf colour to light yellowish green. Yellowish spots begin to appear between the veins, then the center of these spots die and numerous brown specks occur at the leaf tips, around margins and between veins. The tips and margins break down first and begin to curl. These symptoms occur at the bottom of the plant on the lower, older or mature leaves. As the physiological breakdown progresses, the whole leaf becomes reddish-brown, dries, and finally becomes rust colored and brittle. Many leaves are prematurely shed, bolls fail to develop properly and may fail to open or partially open, and the fiber is of poor quality.

Maples *et al*. (1988) observed another type of K deficiency usually occurs in young leaves of top canopy and spread from the top to the bottom during boll development stage, differing from the traditional K deficiency occurring mostly in late season and spreading from the bottom to the top.

Wright (1999) observed that a typical K deficiency in top canopy led to potassium related premature senescence in Australia. Similar observations were made by Oosterhuis (1990 and 2001) in USA and Zheng and Dai (2000) in China.

Bednarz and Oosterhuis, (1996) observed that the first visible sign of premature senescence led to yellowing of the veins of the youngest leaf. The third or fourth leaf from the terminal turns yellow then rapidly red or bronze while the underside of the leaf remains green. The bronzing then spreads down the plant and the upper leaves fall from the plant. In severe cases, bronzing occurs in the middle canopy. As the season progresses, premature senescence symptoms can spread and the crop is defoliated. This potassium related premature senescence was initially found in Arkansas in the 1960s and in Alabama in the 1980s (Abaye, 1996), then it was reported from other countries including Australia (Wright, 1999) and China (Zheng and Dai, 2000). Studies conducted in Australia (Wright, 1999; Mott, 2003) have indicated that not all fields showed these symptoms and each field had varying degrees of the symptoms. The symptoms show up more in certain areas in some field and not all plants in these areas show symptoms.

Wright (1999) opined that transgenic cotton varieties with Bt gene seem to be more susceptible than the conventional varieties because of their higher retention of early fruit. These transgenic cotton varieties hold a smaller source and a large sink for assimilates than non-Bt cotton, which results in an unbalanced source and sink.

Ikram-ul-Haq and Zafar (2004) observed in cotton that when either NH_3^+ or NO_3^- was lacking, cell growth decreased leading to anthocyanin development. When NO_3^- was lacking, cell growth increased slightly and anthocyanin contents become relatively low. It was thought that NO_3^- affected cell growth while NH_4^+ affected anthocyanin production. Anthocyanin accumulation begins when there was no multiplication of cells, and when cell multiplication starts, anthocyanin accumulation diminishes. There is some indication that in addition to the importance of $NO_3^{\,-}$ in the enhancement of the cell growth and somatic embryo induction percentage, K^+ may also play a key role in these processes. When KNO_3 (1.90 g/l) was added to the embryo induction medium, both cell growth and embryo induction rate were high, but anthocyanin production was low. Meanwhile KNO_3 may be more helpful in somatic embryo maturation rather than somatic embryo induction.

Hebbar *et al*. (2007a) reported that synchronized boll development in Bt plants altered the source–sink relationship due to rapid translocation of saccharides and nutrients from leaves to the developing bolls.

Dong *et al*. (2004) reported that in modern cotton variety particularly Bt transgenic cotton (early-maturing, fast-fruiting, and heavy boll loading or high-yielding cotton) and environmental stress are major contributors to potassium deficiency.

Kaur *et al.* (2007) also observed the similar findings. Adoption of modern cotton varieties is another important factor for K deficiency, since sensitivity of cotton to potassium varies with genotypes. Many reports have indicated that modern cotton varieties with fast fruiting, high yielding or heavy boll load and early maturity seem to be more susceptible to K limitation than traditional varieties.

Edmisten *et al*. (2003) observed that soils “fix” potassium in non-available forms and mild to moderate drought stress following heavy fruit set, led to the relative inefficiency of cotton in absorbing K from the soils compared to other crop species.

Cassman *et al.* (1989) reported that important factors inducing potassium deficiency under field conditions by a combination of numerous factors, such as K susceptible variety, low K supply or uptake, and environmental stresses.

Oosterhuis (1990, 2001) indicated that planting cotton on soils having low K availability and inefficient K absorption by early maturing, high-yielding, fast fruiting cultivars, reduced root growth and ion uptake during reproductive development, and depressed available soil K levels might be the major contributors to K deficiency.

Biswas and Chaudhari (1976) reported that copper was more efficient retardant of leaf senescence than calcium and magnesium in rice. They observed that the deficiency of these elements brought yellowing of normal green tissue.

2.3 Biochemical and anatomical changes in relation to leaf reddening

Dastur (1936) found that the accumulation of starch in the mesophyll cells gives rise to crimping, curling and thickening of the leaves and the cells become fillcd with yellowish deposits which gives reaction of tannins, fat and proteins. Development of anthocyanin occurs in epidermal causing reddening of leaves.

Iyengar and Iyengar (1958) observed that the anthocyanin pigment was usually confined to the epidermal cells. The upper epidermis had more pigment than lower. This colour was found to spread from the epidermal to the adjacent parenchymatous cells and the secretary cavities were also very frequently pigmented.

Zade and Dhopte (1987) reported degeneration of pallisade, mesophyll and chlorenchymatous tissue with loss of turgidity and structure in partly red leaves . It was associated with weakening of vascular bundles. Anthocyanin pigments were first seen in upper epidermis and then spread downwards. Red leaf showed positive histochemical test for starch. Vascular bundles were found to contain anthocyanin pigments possibly blocking the translocation on *Hirsutum* cotton cv. L-147 and B-1007.

Sandhu *et al*. (1987) observed the TS of red pigmented leaf and indicated that upper one layered epidermis synthesised anthocyanin and therefore it appears red but pallisade and mesophyll cells were green with packed green plastids. Lower epidermis did not however show presence of anthoyanin in the cell. Thus, though leaf appears red, it is green inside. In hirsutum cotton TS of a green leaf examination showed few cells containing red pigments and gradually it spreads from lamina to base of the leaf. The veins (main and lateral) were prominently turned red after yellowing. In green veins also, the reddening was apparent and TS of the vein indicated the presence of red pigments in vascular bundles. The anthocyanin is reported to be monogeneic character.

Zhao *et al.* (2007) observed under a light microscope, leaves of K-deficient and control cotton plants have about the same thickness and proportion of palisade cells and spongy mesophyll cells. However, the K deficient leaf has less intercellular air space and fewer chloroplasts in mesophyll cells than the control plants. There exist more obvious differences in chloroplast ultrastructure between the control and K-deficient cotton leaves under a transmission electron microscope. The chloroplasts of control plant leaves have more well-defined grana stacks and extensive stroma lamellae with very small amounts of starch granules. The chloroplasts in leaves of K-deficient plants are filled with large starch granules, and contain markedly more and greater plastoglobuli and fewer grana. This result further supports the statement that the K-deficiency decreases translocation of saccharides from cotton leaves to fruit. The poor chloroplast ultrastructure, including starch granule accumulation, low chlorophyll content, fewer grana, disorientation of grana and thylakoids that occurred as they were pushed towards the periphery of the chloroplast, might be one of the causes of low photosynthetic rate in K deficient cotton.

Reddy *et al.* (2000) indicated that leaf growth was the most sensitive physiological process to K deficient conditions. They observed that plants grown in a growth chamber and watered with nutritional solution showed reduced rate in leaf area expansion by K deficiency. Leaf growth rates were 14% lower in plants that had only 1.9% K in the leaves compared to fully fertilized plants with 3% K in the leaves. Leaf expansion rates declined even more as K concentration decreased and were only 59% as great in plants that had approximately 1% leaf K. The rates at which main stem leaves and nodes were added were less in plants with lower K concentrations. Leaves were added to the main stem only 90% as fast in plants whose sampled leaves contained 1.9% K compared with plants with higher K concentrations.

Pettigrew (1999) conducted several studies on leaf and canopy photosynthesis of cotton associated with K-fertilization have been taken for the past several decades. Results from these studies are completely consistent that moderately K-deficiency significantly reduces the photosynthesis (Pn) rate of a single leaf.

Kerby and Adams (1985) studied the factors related to K deficiency, although insufficient soil K is implicated as a main contributing factor of K-deficiency in cotton, the relationship between the amount of K in the soil and the occurrence of K deficiency is not straight forward. While it appears to be connected with the supply of K, the reasons for it are not simple, and it can occur on soils with high or low K levels.

Robinson and Robinson (1939) observed transformation of leuco- anthocyanins into coloring matters of flavylium type and isolated and characterized two dihydro - anthocyanidines, namely, cyanomaclurin and peltogynol, and; these are stabilized by the possession of a glucose like oxide ring, however the related anthocyanidins were not found in the form of naturally occurring anthocyanins.

Alston (1959) observed that that decreased chlorophyll may expose anthocyanins , and reduced translocation of sugar provide for increased anthocyanin synthesis in the leaves.

Combrink (1988) reported that the red color has been identified as anthocyanin which is unmasked by chlorophyll breakdown.

Chalker-Scott (1999) reported that anthocyanins were water-soluble pigments derived from flavonoid precursors via the shikimic acid pathway.

Elizabeth *et al*. (2007) studied the possible enzymes responsible for anthocyanin pigmentation in *Plantago lanceolata,* seventeen anthocyanines derived from both cyanidin and delphinidin branches of the anthocyanin biosynthetic pathway, were detected. Most of these significantly increased in abundance under cool conditions.

Nakajima *et al*. (2001) remarked that the precise biochemical reaction mechanism from leucoanthocyanidin to anthocyanidin has not been clarified to date. The conversion from colorless leucoanthocyanidin to colored anthocyanidin 3-glucoside, at least two enzymes, anthocyanidin synthase (ANS) and UDP-glucose: flavonoid 3-O-glucosyltransferase (3-GT) are postulated to be involved.

Three possible mechanisms have been postulated

1) In the first postulation, anthocyanidin synthase(ANS) catalyzes a desaturation at the C-2 and C-3 positions of (2R,3S, 4S)-leucoanthocyanidin (15, 16) in the presence of 2-oxoglutarate and molecular oxygen, yielding 2-flaven- 3,4-diol, with concomitant release of CO_2, succinate and H_2O.
2) In the second postulation, after isomerization of the 2,3-double bond to the 3,4-position of 2- flaven-3,4-diol – by removal of the hydroxyl group at C-4, double bond migration and insertion of a hydroxyl group at C-2 – 3-flaven-2,3-diol is formed. Alternatively, ANS may catalyze a hydroxylation at the C-2 position of leucoanthocyanidin, followed by 3,4-dehydration.
3) In the third postulation, 3,4-dehydration occurs as the first step, followed by a hydroxylation at C-2 (1). The last two assumptions (pathway B and C) imply that the formation of 3-flaven-2,3-diol may require not only ANS but also a specific dehydratase catalyzing 3,4- dehydration. Alternatively, ANS may catalyze the dehydration of the reaction.

The (heterocyclic compound) flavylium cation is the parent material of the anthocyanidines, substances that are combined with sugars to form the anthocyanin pigments, the common red and blue colouring matters of flowers and fruits (Anon., 2007).

2.4 Remedial measures tried

At Dharwad, Prabhakar (1981) found that foliar application of 2% urea +1% SSP four times at 15 days interval during November and December helps to control the leaf reddening.

Singh (2004) observed that foliar application of urea (2-4%) with 15-20 ppm chlormequate chloride) and 0.1% citric acid, 2-3 times at weekly intervals resulted in 70-80% amelioration.

Application of $MgSO_4$ at 20-25 kg/ha to soil or as foliar spray with 5 per cent $MgSO_4$ and 1% urea as soon as the reddening symptoms appear in leaf reduces this disorder (Ikisan, 2004).

Application of 2% Urea or 2% DAP or 1% $MgSO_4$ at 90 & 110 DAS for control of leaf reddening has been recommended from the University of Agricultural Sciences, Dharwad (Anon., 2005).

Sharma and Singh (2007) in Bhanswara observed cotton response to 2% foliar application of potassium (K_2O @ 5 kg /ha) in potash deficient soils.

Brar *et al.,* (2008) from PAU, Ludhiana reported that foliar application of KNO_3 @ 2% increased the seed cotton yield (3380kg/ha) over soil application of K @ 60 kg/ha (2950 kg/ha). Kaur *et al.* (2007) also reported increased seed cotton yield with KNO_3 @ 2% foliar application.

2.5 Growth hormone effect on nutrient use efficiency

Cytokinin is synthesized largely in root tissue and then travels upward to the shoots; some production also occurs in developing leaves. Nutrients will move and accumulate in plant tissue where higher levels of cytokinin are expressed. In soybean, application of cytokinin increased the pod numbers, seed weight or seed yield but this will vary based on varietal sensitivity and correct application timing (Cho, 2002). Cytokinin is directly responsible for reprogramming apical meristem axes of cotton towards the multiplication of buds (Jorge *et al*., 1998). The cell enlargement in fully mature leaves was reported by Kuraishi and Okumura (1956) in presence of kinetin. Kinetin was found to induce pseudonodules on tobacco roots (Arora *et al.,* 1959). Similarly, kinetin was found to cause an enlargement of cortical cells of tobacco roots upto four times their normal size. Histological studies in pea demonstrated that the cytokinins cause the formation of vascular cannection which increased the water and solute supply for a renewed growth of the lateral buds (Sorokin and Thimann, 1964).

In studies with physiologicaly and anatomical aspects of histogenic differentiation in cultured tissue of *nicotiana,* Bornman (1971) reported that high auxin stimulates tracheid differentiation and high cytokinin increases the density of developing xylem. Similarly, the effect of kinetin was studied on cellular ultra structure in *Nicotiana glutinose* leaf discs by Purohit *et al.* (1977). It was reported that kinetin considerably delayed all degeneration changes as it inhibited the formation of crystaline bodies in the chloroplast. Kinetin was found to induce an increase in rough endoplasmic reticulum and free cytoplasmic ribosomes.

Artamonov (1975) reported that kinetin increased the formation of nodules in *Phaseolus vulgaris* and increased plant and nodule weight and pod yield. Similar results were also obtained with cv spite. Comparable result also obtained from Peas, *Vida faba* and *Trifolium pratense.* Kinetin increased potato tuber yields from 331 to 426 Kg/20 *m2* development of growth after moving. Inspite of these encouraging result, he suggested that further trials were necessary before kinetin application can be recommended. Gupta *et al.* (1978) studied the effect of decapitation (apex removal) of sugarbeet plant 70 days after decapitation on LAT and chlorophyll contents. DM production, growth rate, NAR, root and sugar yield and root sugar contents were described. GA increased root and sugar yields, but decreased sugar contents. Kinetin and chloromequat increased sugar yields mainly by increasing sugar contents.

2.6 Polyethylene mulching for soil temperature regulation

Plastic film mulch has been widely used all over the world (Chen, 1986). There are, however, lot of problems in an application of plastic film, such as soil pollution, high cost, which can make soil fertility decrease due to a long-term use, and be difficult to extend to close planting crop. The polyethylene mulch with (50 μm gauge) increased soil temperature by 4–5℃ throughout the groundnut crop growth (germination to maturity), which increased seedling emergence but was detrimental to pod setting and pod development (soil temperature exceeded 40℃). Thus, the benefit of polythene was only observed when it was retained up to podding stage, but not upto harvest. To minimize pollution of plastic film on field soil, biodegradable polyethylene film was used (Zhiyong Dong and Bingfa Qian, 2003). Biodegradable polyethylene films with 0.2 mm in thickness and 0.6 mm in width were used and it was observed that in the early days of mulch, biodegradable polyethylene film makes temperature increase in surface layer of soil. After irrigation or rain, however, the polyethylene makes soil temperature to decrease.

At Dharwad, Halemani *et al.* (2009) found that the seed cotton yield of with no mulching was 1708 kg per ha and it significantly increased with 75 micron (1989 kg/ha), 100 micron (1894 kg/ha) and 125 micron (2042 kg/ha) polyethylene mulch. Among the genotypes tried, RCH-Bt hybrid recorded the highest seed cotton yield (2784 g/ha).It was followed by DHH-11 (2158 kg/ha), Sahana variety (2032 kg/ha) and DHB-290 hybrid (1804 kg/ha). Significantly low yields were recorded with Jayadhar (1262 kg/ha) and DLSa-17 (1409 kg/ha).

3. MATERIALS AND METHODS

The materials used and the experimental techniques adopted during the course of investigations are presented in this chapter.

3.1 Survey of farmers field

In order to study the constraints/problems of Bt cotton cultivation, the sample (100) farmers were enquired about the various constraints faced by them in Bt cotton cultivation. Survey on farmer's field was undertaken during May 2007 to quantify the constraints in Belgaum and Haveri districts. About 100 farmers were interviewed with the help of questionnaire (Appendix I) comprising the improved Bt cotton cultivation technologies vis-à-vis farmers practice. The data was collected by scoring while interrogating the farmer about the constraints faced by them while cultivating Bt cotton in their area. The collected data was analyzed by adopting Garretts ranking technique (Garrett, 1952). Constrains were listed based on Garrett Scores (Table 3a and b).

Garrett's ranking technique

To know the constraints in cultivation of Bt cotton, Garrett's ranking technique was used. Basically it gives the change of order of constraints and advantages into numerical scores. The major advantage of this technique compared to simple frequency distribution is that the constraints and advantages are arranged based on their importance from the point of view of respondents.

Garrett's formula for converting ranks into per cent was given by

Per cent position=100*(Rij-0.5)/Nj

Where Rij= rank given for i^{th} factor by j^{th} individual

Nj= number of factors ranked by j^{th} individual

The per cent position of each rank was then converted into scores referring to the table given by Garrett and Woodsworth (1969). For each factor, the scores of individual respondents were added together and divided by the total number of the respondents for whom scores were added.

These mean scores for all the factors were arranged in descending order, ranks were given and most important factors were identified.

3.2 Experimental details

3.2.1 Experimental site

Two field experiments on Bt-cotton were conducted at Main Agricultural Research Station (MARS), University of Agricultural Sciences (UAS), Dharwad in 'E' block, plot No.131 during the years 2007-08 and 2008-09 (Plate 1). MARS is located in the northern transition zone of Karnataka situated at 15^0 26' N latitude, 75^0 07' E longitudes with an altitude of 678 m above the mean sea level.

3.2.2 Soil characteristics of the experimental site

The soil of the experimental site was black clayey in nature. A composite soil sample was drawn from the experimental area to a depth of 0-30 cm and was analyzed for physical and chemical properties and the values obtained are furnished in Table 2.

3.2.3 Climatic condition

3.2.3.1 Weather condition during experimental years

The data on rainfall, monthly maximum and minimum temperature and relative humidity for the years 2007-08 and 2008-09 and average of previous 56 years (1950-2006) as recorded at the Meteorological Observatory, UAS, Dharwad are presented in Table 1a and depicted in Fig.1a. The mean annual rainfall for the past 56 years at MARS, Dharwad was 759.5 mm and was well distributed from April to November. Maximum rainfall (150.9 mm) was received in the month of July followed by October (129.4 mm).

Table 1a: Monthly meteorological data for the experimental years (2007-08 and 2008-09) and the mean of past 56 years (1950-2006) as recorded at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)

Month	Rainfall (mm)				Temperature (°C)								Relative humidity (%)			
					Mean maximum				Mean minimum							
	*Mean	2007	2008	2009	*Mean	2007	2008	2009	*Mean	2007	2008	2009	*Mean	2007	2008	2009
January	0.1	Traces	0	0.8	29.6	30.4	29.7	29.8	14.6	14.0	19.8	13.3	63	72.0	65.9	66.6
February	1.1	0	0	0.4	32.5	31.9	31.2	33.2	16.3	15.7	21.3	16.7	51	67.0	65.9	57.5
March	0.2	12.8	111.0	29.8	36.4	35.3	32.4	35.0	19.6	19.7	22.4	19.9	56	49.0	70.2	73.1
April	49.3	86.4	28.8		37.4	36.7	34.7		19.9	21.4	20.4		76	55.0	80.4	
May	79.5	65.0	58.3		33.7	34.6	35.1		21.4	21.3	20.6		66	61.0	85.1	
June	110.6	220.1	101.6		28.9	29.7	28.7		21.5	21.3	21.1		81	80.0	91.8	
July	150.9	211.2	121.0		29.1	27.0	28.2		21.0	21.1	20.7		87	85.0	91.3	
August	96.9	176.0	213.2		27.0	27.1	26.9		20.3	20.5	20.1		86	85.0	91.5	
September	103.9	18.1	162.4		28.6	27.2	28.8		19.9	20.3	20.1		82	83.0	91.4	
October	129.4	74.8	60.4		30.0	29.7	30.3		18.4	19.4	18.9		76	68.0	83.5	
November	32.2	54.0	72.2		30.1	29.5	29.2		15.9	15.1	15.9		68	53.0	79.4	
December	5.4	Traces	0.0		29.4	29.0	28.6		12.5	14.6	13.9		63	65.0	75.4	
Total	759.5	1081.1	928.9													

* Mean of 56 years (1950-2006)

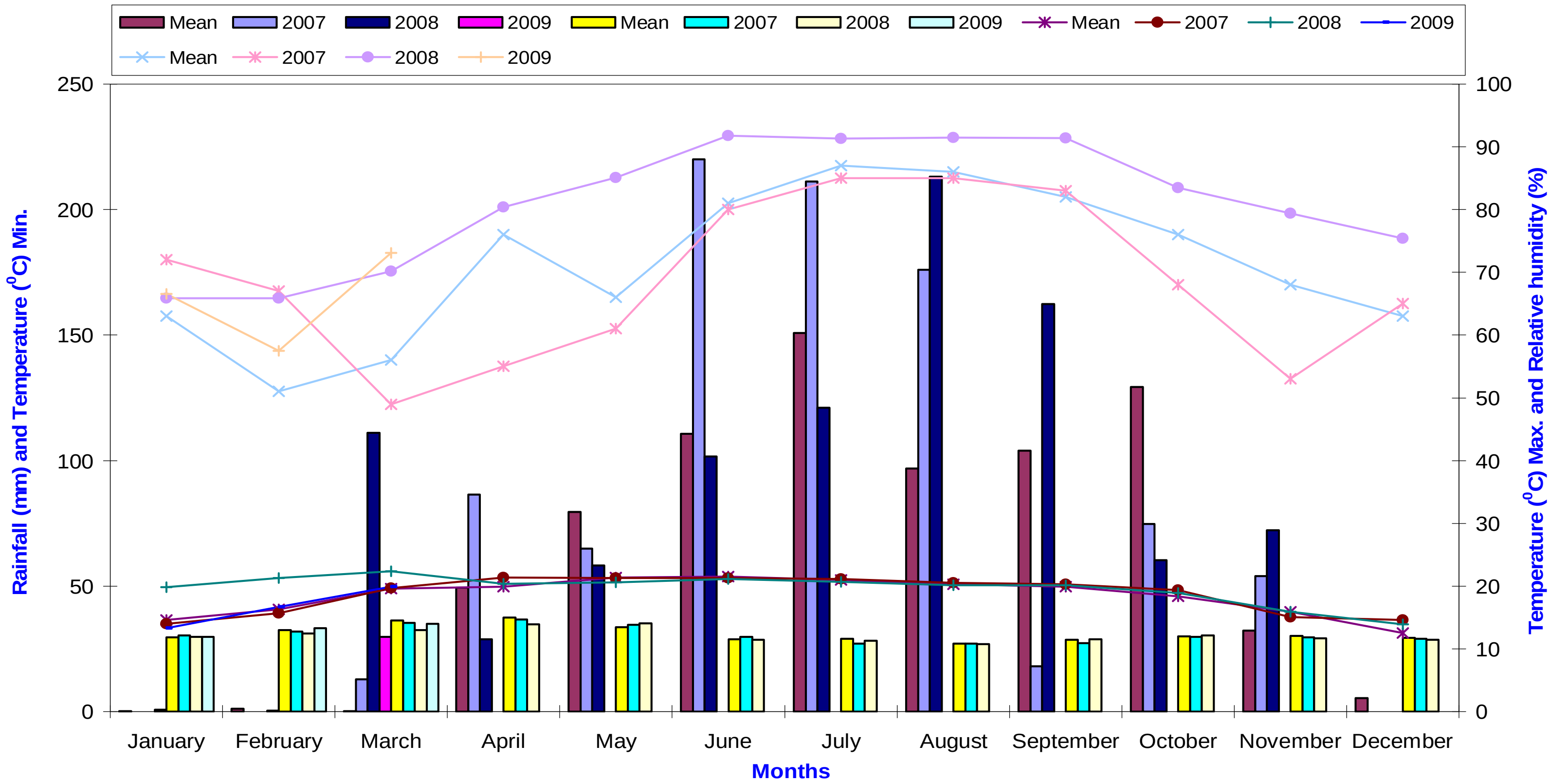


Fig. 1a: Monthly meteorological data for the experimental years (2007-08 and 2008-09) and the mean of past 56 years (1950-2006) as recorded at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)

Fig. 1a: Monthly meteorological data for the experimental years (2007-08 and 2008-09) and the mean of past 56 years (1950-2006) as recorded at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)

Maximum temperature varied from 27.0°C (August) to 37.4°C (April), whereas mean minimum temperature ranged from 12.5°C (December) to 21.5°C (June). Mean monthly maximum relative humidity of 87 per cent and mean monthly minimum humidity of 51 per cent was observed during the months of July and February, respectively. Due to delayed onset of monsoon at the time of sowing, irrigation was given for establishment of the crop during both the years of experimentation. The rainfall received during 2007-08 (April 2007 to March 2008) was 905.6 mm. The highest and lowest mean maximum temperatures recorded during the crop growth period of 2007 were 36.7°C during May and 27.1°C during August while, the highest and lowest mean minimum temperatures were recorded during June (21.3°C) and December (14.6°C), respectively. The mean relative humidity ranged from 49 per cent in March to 85 per cent in July and August of 2007. The rainfall received during 2008-09 (April 2008 to March 2009) was 848.9 mm. The highest and lowest mean maximum temperatures recorded during the crop growth period of 2008 were 35.1 °C during May and 28.2°C during July. While, the highest and lowest mean minimum temperatures were recorded during June (21.1°C) and December (13.9°C), respectively. The mean relative humidity ranged from 57.5 per cent in February to 91.8 per cent in July of 2008.

3.2.3.2 Weather condition during cropping period

In the first season (2007-08), the total rainfall received during the cropping period (1st June to last week of January) was 922 mm in 51 rainy days (Table 1b and Fig.1b). The crop experienced well distributed rainfall during its grand growth period i.e., 188.8 mm at 31.60 DAS in 9 rainy days, 104.8 mm at 61-90 DAS in 6 rainy days, 53.70 mm at 91-120 DAS in 2 rainy days. The average RH was 83.4 per cent during the cropping period. The maximum RH was provided at 31-60 DAS (92.2%) and decreased steadily at 61-90 DAS (79.2%) and at 91-120 DAS (79.2%) and at 91-120 DAS (71.4^{0}C).

The average mean maximum temperature prevailed during the cropping period was 28.5^{0}C. The mean maximum temperature 27.0^{0}C was prevailed at 0-30 DAS and it remained almost in the same range, 27.4^{0}C at 31-90 DAS, 29.4^{0}C at 91-120 DAS and 29.3^{0}C at 121 DAS-harvest. However, in comparison with mean maximum temperature, fluctuation in mean minimum temperature was prevailed. The average mean minimum temperature was 19.^{0}C. The mean minimum temperature prevailed during 1st June to sowing (21.^{0}C), 31-60 DAS (20.7^{0}C) and at 61-90 DAS (20.8^{0}C) remained almost same. There was sudden drop in mean minimum temperature to 16.4^{0}C at 91-120 DAS and 14.^{0}C at 121 DAS to harvest.

In the second season (2008-09) the total rainfall received during the cropping period (1st June to last week of January) was 730.8 mm in 46 rainy days. The crop experienced well distributed rainfall during its grand growth period i.e., 168.0 mm at 61 to 90 DAS in 13 rainy days, 60.4 mm at 91-120 DAS in 3 rainy days, 24.6 mm at 91-120 DAS in 2 rainy days and 47.6 mm at 120 DAS to lowest in 2 rainy days. The average RH was 85.3 per cent during the cropping period. The maximum RH was prevailed at 0 to 30 DAS (92.4%) and decreased steadily to 90 per cent at 31 to 60 DAS, 77.8 per cent at 91-120 DAS and 75.3 per cent at 121 DAS - harvest. The average mean maximum temperature 28.5^{0}C was prevailed at 1st June to sowing and it remained almost in the same range 26.2^{0}C at 0 to 30 DAS, 27.5^{0}C, at 31-60 DAS, 30.0 ^{0}C at 61 to 90 DAS and 91 to 120 DAS, 25.5^{0}C at 121 DAS to harvest. In 2008 also, there was sudden drop in mean minimum temperature 15.3^{0}C at 91-120 DAS and 13.8^{0}C at 121 DAS to harvest.

In both the season the mean minimum temperature dropped suddenly 91 to 120 DAS and 121 DAS to harvest. The RH also followed the similar trend.

3.2.4 Previous crop of the experimental area

Chilli crop was taken up during *kharif* 2006, while in *rabi* chickpea was raised.

3.2.5 Treatment details

Experiment No 1: Assessing leaf reddening malady in Bt cotton genotypes

Table 1b: Rainfall (mm), number of rainy days, relative humidity (%), mean maximum temperature (°C) and mean minimum temperatures (°C) during cropping period (kharif seasons of 2007 and 2008) as recorded at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad (Karnataka)

Crop growth stages of Cotton		Rainfall (mm)	Number of rainy days	Relative humidity (%)		Mean maximum temperature (°C)		Mean minimum temperature (°C)	
				Mean	Range	Mean	Range	Mean	Range
***Kharif* 2007**									
1	01-06-2007 to sowing	409.5	22	90.6	82.0-98.0	28.5	24.8-34.8	21.3	19.6-23.0
2	0 to 30 days after sowing	165.2	13	92.0	88.0-96.0	27.0	23.0-29.9	20.5	19.4-21.2
3	31 to 60 days after sowing	**188.8**	**9**	**92.2**	87.0-98.0	**27.4**	24.3-30.2	**20.7**	19.2-22.6
4	61 to 90 days after sowing	**104.8**	**5**	**79.2**	42.0-96.0	**29.4**	26.9-32.6	**20.8**	18.8-22.3
5	91 to 120 days after sowing	**53.7**	**2**	**71.4**	43.0-93.0	**29.4**	26.7-31.7	**16.4**	9.8-21.0
6	121 DAS to Harvest (175 days after sowing)	**0**	**0**	**75.1**	42.0-91.0	**29.3**	24.4-31.2	**14.0**	10.1-18.9
TOTAL /AVERAGE		**922.0**	**51.0**	**83.4**	64.0-95.3	**28.5**	25.0-31.7	**19.0**	16.2-21.5
Date of sowing :25-07-2007								**Date of total maturity period** : 20-01-2008	
***Kharif* 2008**									
1	01-06-2008 to sowing	184.6	13	91.1	82.0-96.0	28.8	24.0-33.0	20.8	19.5-21.8
2	0 to 30 days after sowing	245.6	13	92.4	82.0-100	26.2	21.8-30.3	20.2	18.6-21.0
3	31 to 60 days after sowing	168.0	13	90.0	85.0-96.0	27.5	24.2-30.4	20.3	18.8-21.3
4	61 to 90 days after sowing	60.4	3	85.1	46.0-95.0	30.0	26.2-31.6	19.5	13.1-23.1
5	91 to 120 days after sowing	24.6	2	77.8	58.0-86.0	30.0	26.2-31.8	15.3	12.5-19.3
6	121 DAS to Harvest (175days after sowing)	47.6	2	75.3	61.0-100	28.5	23.0-30.7	13.8	10.0-20.1
TOTAL /AVERAGE		**730.8**	**46**	**85.3**	69.0-95.5	**28.5**	24.2-31.3	**18.3**	15.4-21.1
Date of sowing : 27-07-2008								**Date of total maturity period** : 23-01-2009	

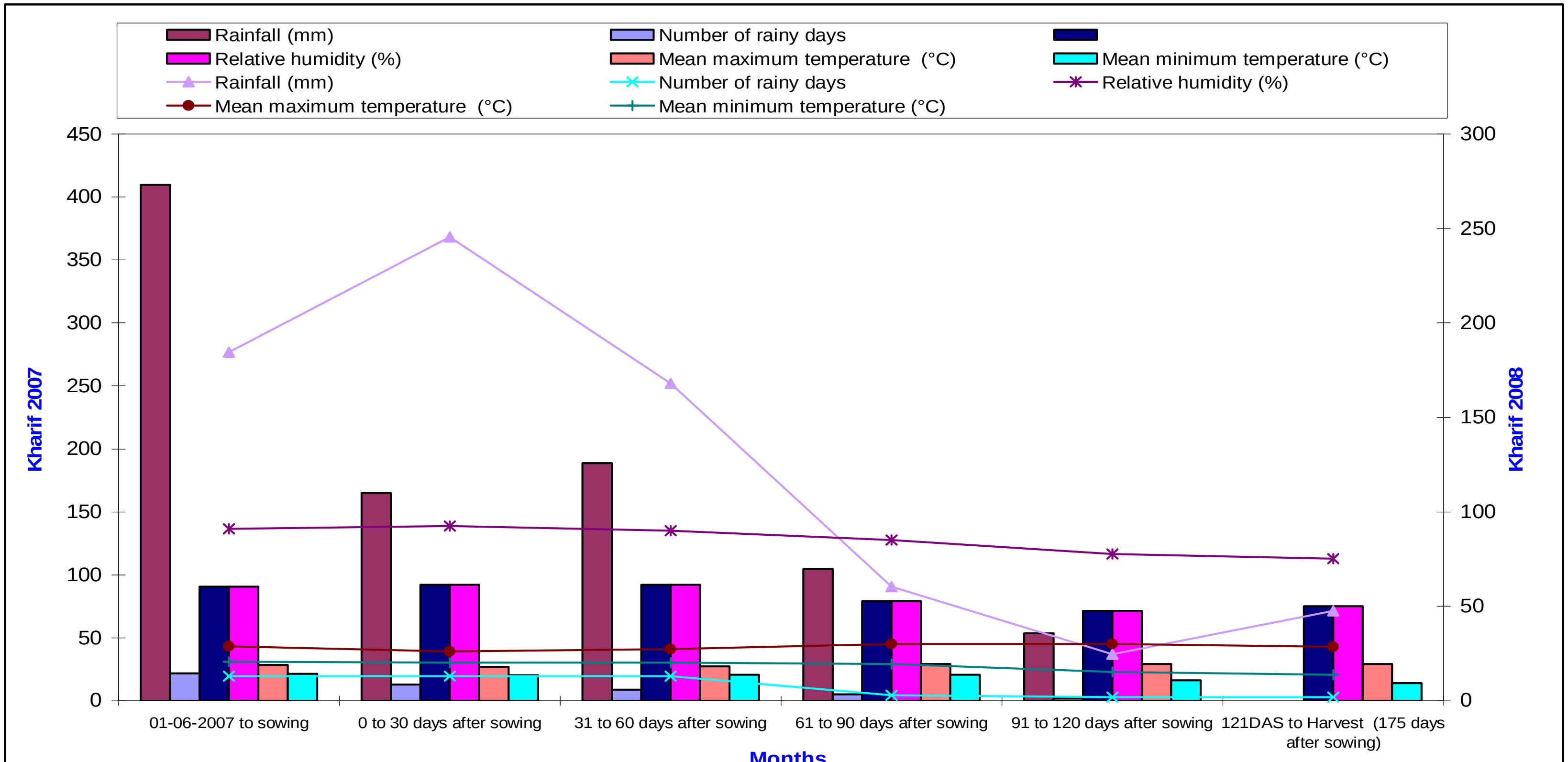


Fig. 1b: Rainfall (mm), number of rainy days, relative humidity (%), mean maximum temperature (^{0}C) and mean minimum temperature (^{0}C) during different crop growth stages of cotton during cropping period cropping period (2007-08 and 2008-09)

Fig. 1b: Rainfall (mm), number of rainy days, relative humidity (%), mean maximum temperature (0C) and mean minimum temperature (0C) during different crop growth stages of cotton during cropping period cropping period (2007-08 and 2008-09)

Table 2. Physical and chemical properties of the soil of experimental area

Sl.No.	Particulars	Value obtained	Rating	Method adopted
I	Physical properties			
1.	Textural composition			
	Coarse sand (%)	9.21	Clay texture	International pipette method (Piper, 1966)
	Fine sand (%)	16.41		
	Silt (%)	14.05		
	Clay (%)	60.40		
2.	Bulk density (Mg m^{-3})	1.30	Optimal	Core sampler method (Dastane, 1967)
II.	Chemical properties			
1.	Available nitrogen (kg ha^{-1}	206	Low	Modified Kjeldahl method (Jackson, 1967)
2.	Available phosphorus (P_2O_5) (kg ha^{-1})	18.4	Medium	Olsen's method (Jackson, 1967)
3.	Available potassium (K_2O) (kg ha^{-1})	462	High	Flamephotometer (Jackson, 1967)
4.	Soil pH (1:2.5 soil:water)	7.31	Neutral	pH meter (Piper, 1966)
5.	Organic carbon (%)	0.55	Medium	Wet oxidation method (Jackson, 1967)

The experiment consisted of ten treatments (cotton hybrids) as detailed below

Cotton hybrids	Source of supply
T_1-Bunny (BG I) Bt	M/s. Nuziveedu Seeds Ltd., Hyderabad (Andhra Pradesh)
T_2-Bunny non-Bt	
T_3-RCH-368 (BG I) Bt	M/s. Rasi Seeds Co. Ltd., Atur, (Tamil Nadu)
T_4-RCH-368 non-Bt	
T_5-JK Durga (BG I) Bt	M/s. JK Agri Genetics Ltd., Hyderabad (Andhra Pradesh)
T_6-JK Durga non-Bt	
T_7-Neeraja (BG II) Bt	M/s. Nuziveedu Seeds Ltd., Hyderabad (Andhra Pradesh)
T_8- Neeraja non-Bt	
T_9-Sahana (non-Bt variety check)	Agricultural Research Station, Hebballi Farm, Dharwad
T_{10}- DCH-32 (non-Bt hybrid check)	

Experiment No. 2: Studies on nutrient management to overcome leaf reddening in Bt cotton

The experiment consisted of twelve treatments (of different nutrient sources) as detailed below:

T_1- 120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal 6 splits)

T_2- T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN

T_3- T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN

T_4- T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN

T_5- T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN

T_6- T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN

T_7- T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN

T_8- T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN

T_9- T_1+ Soil application of $MgSO_4$ @ 25 kg/ha

T_{10}- T_9 + Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN

T_{11}- T_1+ Mulching of inter row space of 80 cm with polyethylene (100 □) during the period of October II FN to harvest

T_{12}-120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)

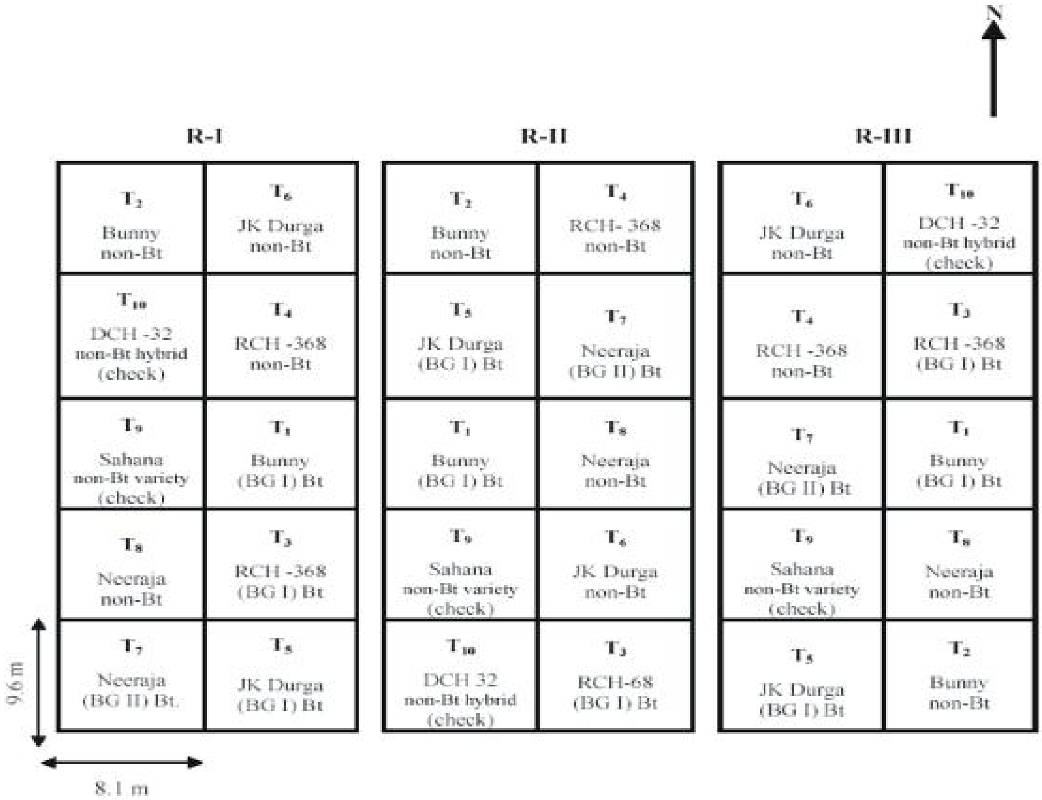


Fig 2. Plan of layout of Experiment I

Fig.2. Plan of layout of Experiment I

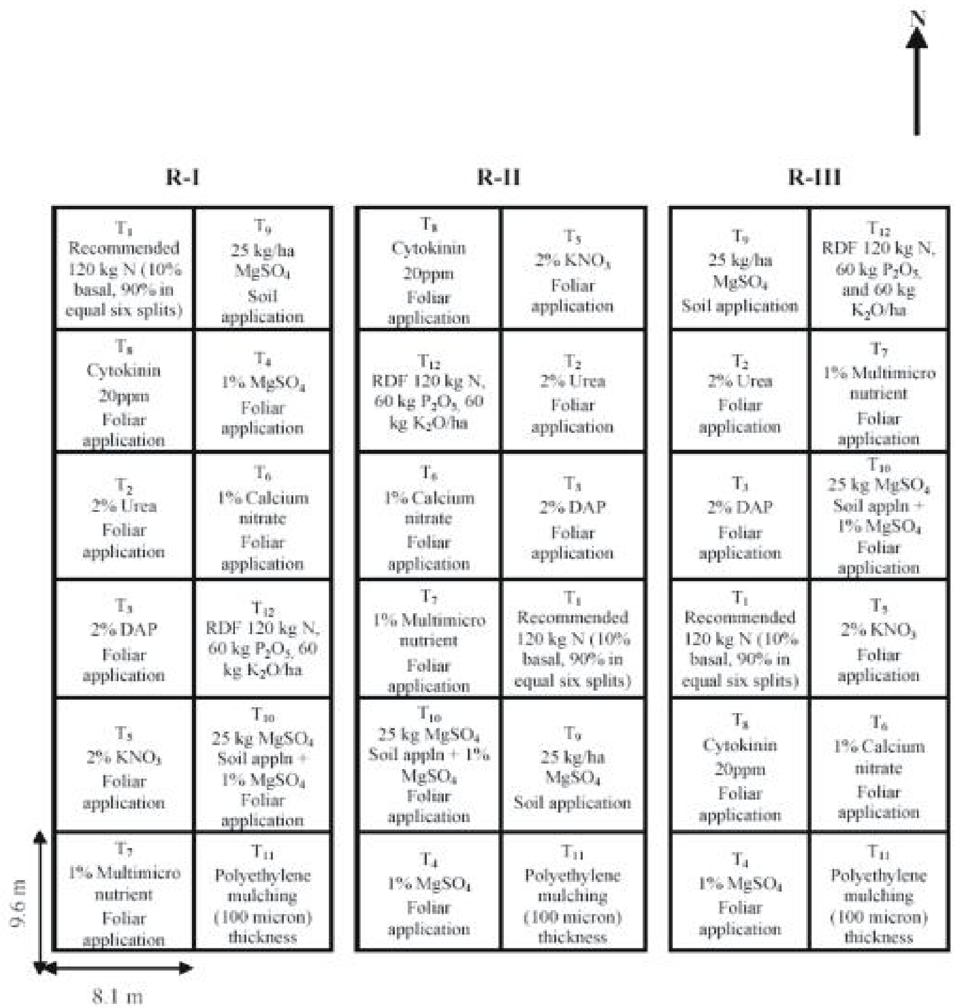


Fig 3. Plan of layout of Experiment II

Fig.3. Plan of layout of Experiment II

Plate 1. General view of experiment plots

3.2.6 Design and layout

The experiments (1 and 2) were laid out in a randomized complete block design with three replications. The plan of layout is given in Fig. 2 and 3 and Plate 1.

3.2.7 Plot size

Gross plot size: 8.1 m x 9.6 m

Net plot size: 6.3 m x 8.4 m

3.2.8 Cultural practices

3.2.8.1 Land preparation

Before the commencement of experiments, land was ploughed with tractor mounted mould board plough during summer followed by harrowing twice to prepare a fine seed bed during both the years.

3.2.8.2 Plant spacing and sowing

In experiment – 1, Bunny (BG I) Bt, Bunny non-Bt, RCH-368 (BG I) Bt, RCH-368 non-Bt, JK Durga (BG I) Bt, JK Durga non-Bt, Neeraja (BG II) Bt, Neeraja non-Bt, DCH-32 non-Bt hybrid and Sahana non-Bt variety were used. In experiment – 2, Bunny Bt (NCS-145) genotype was used. Sowing was done in both the experiments by adopting 90 x 60 cm spacing during first season on 25-07-2007 and for the second on 27-07-2008.

3.2.8.3 Fertilizer application

Experiment 1: The recommended fertilizer dose (120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1}) was applied to all the genotypes with entire dose of P_2O_5, K_2O and 50 per cent N as basal and the remaining 50 per cent N into three splits at 50, 80 and 110 DAS.

Experiment 2: The fertilizer was applied as per the treatment specifications. The recommended fertilizer dose to the conventional non-Bt cotton hybrid under transitional tract of Dharwad is 120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1}, the application is being advocated with entire dose of P_2O_5, K_2O and 50 percent N as basal and the remaining 50 per cent N into three splits at 50, 80 and 110 DAS. An attempt was made in fine tuning of the same recommended fertilizer dose with additional nutrients in Bt cotton cultivation with the objective of overcoming leaf reddening. The investigation focused on varying the nitrogen application rates into eight splits (N 10% as basal, 15% at 30 DAS, 15% at 60 DAS, 15% at 75 DAS, 15% at 90 DAS, 15% at 105 DAS and 15% at 120 DAS) along with the superimposed treatments comprising foliar nutrition, growth hormone (Cytokinin) and polyethylene mulching with entire dose of P_2O_5 and K_2O as basal. In this regard, treatments were imposed as soil application (120 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1}) of entire P_2O_5, K_2O along with nitrogen application into seven splits (10% as basal, 15% at 30 DAS, 15% at 60 DAS, 15% at 75 DAS, 15% at 90 DAS, 15% at 105 DAS and 15% at 120 DAS) to the T_1 - T_{10} and T_{12} treatments. Foliar spray of urea (2%), DAP (2%), $MgSO_4$ (1%), KNO_3 (2%), Calcium nitrate (1%), Multimicronutrient (1%) and Cytokinin (20 ppm) were superimposed, respectively to the treatments T_2, T_3, T_4, T_5, T_6, T_7 and T_8 on the October 15th, November 1st and November 15th. The treatment T_9 was superimposed with $MgSO_4$ @ 25 kg ha^{-1} with foliar application of $MgSO_4$ @ 1% on the October 15th, November 1st and November 15th. The treatment, T_{11} was superimposed with transparent polyethylene mulching (100 micron thickness) on the 15th October and was retained in the field till the harvest of the crop (Plate 2). To the check treatment T_{12}, the recommended dose of fertilizer (120:60:60 N, P_2O_5 and K_2O kg ha^{-1}) was applied (entire dose of P_2O_5, K_2O and 50 percent N as basal and the remaining 50 per cent N into three splits at 50, 80 and 110 DAS) and foliar application of $MgSO_4$ @ 1% at 90 DAS.

3.2.8.4 Plant protection schedule

The plant protection measures for sucking pests (leaf hoppers, thrips, aphids and white flies) were adopted commonly in all the treatments of experiment 1 and 2. The detailed plant protection schedule was undertaken during the investigation which is given in Appendix II and III.

Polyethylene mulching during onset of winter

Making slot with crow bar for Thermometer installation

Thermometer installation in non-polyethylene mulched soil

Thermometer installation In polyethylene mulched soil

Recording soil temperature

Plate 2: Methodology adopted for polyethylene mulching and recording soil temperature

3.2.8.5 Cultural operations

Two hand weedings at 25 and 45 DAS and two intercultivations at 45 and 65 DAS were carried out to keep the plots free from weeds and to close the cracks developed during the crop growth period to reduce evaporation losses in both the years and experiments.

3.2.8.6 Harvesting

Harvesting of seed cotton from the net plot area was taken up. Dates of pickings during both the years are given in Appendix V.

3.3 Observations recorded in experiment 1 and 2

3.3.1 Biometric observations

3.3.1.1 Monopodial branches per plant

The monopodial branches bearing minimum of one functional sympodial branches were counted separately in five tagged plants and average value was recorded at 120 DAS.

3.3.1.2 Sympodial branches per plant

Fruiting branches arising from the main stem were counted separately in the five tagged plants and average value was recorded at 120 DAS.

3.3.1.3 Number of bolls per plant

The number of good opened bolls (GOB) and bad opened bolls (BOB) per plant harvested from five tagged plants was counted at each picking. The total number of bolls (GOB + BOB) harvested in all the pickings was recorded.

3.3.1.4 Boll weight (g/boll)

Ten fully opened bolls were selected randomly from each plot and the mean boll weight of cotton was computed and expressed in g per boll at harvest.

3.3.1.5 Seed cotton yield (g) per plant

The total seed cotton yield from all the pickings from five tagged plants was recorded and the average was expressed as seed cotton yield per plant (g).

3.3.1.6 Seed cotton yield (kg/ha) per hectare

On the basis of seed cotton yield per net plot (6.3 m x 8.4 m), the seed cotton yield per hectare was computed and expressed as seed cotton yield in kg per hectare.

3.3.1.7 Fibre quality parameters

2.5 % span length

The mean fibre length of the total fibre present in a sample was determined by Ball's sorter method (Sundaram, 1979) and the value was expressed in mm at 2.5 per cent span.

Fibre fineness

Fibre fineness (fibre weight in mg per unit length of fibre) was assessed by using micronaire instrument following the procedure of Sundaram (1979) and values were expressed as micronaire value.

Bundle strength

Bundle strength (the ratio of breaking strength of a bundle of fibres to its weight) was determined following procedure described by Sundaram (1979) and expressed in g per tex.

3.3.2 Biochemical observations

The following biochemical characters were analyzed and recorded in experiment 1 and 2.

3.3.2.1 Chlorophyll ‘a’, Chlorophyll ‘b’ and Total chlorophyll content

Chlorophyll ‘a’, Chlorophyll ‘b’ and Total chlorophyll contents were determined in the leaves at 60, 90 and 120 DAS. Chlorophyll content in the leaves of different treatments was determined colorimetrically as per the DMSO (Di methyl sulfoxide) method (Shoaf and Lium, 1976). Fresh leaf tissue of 100 mg was cut into small pieces and incubated in 7.0 ml of DMSO at 65 ^{0}C for 30 minutes. At the end of incubation period, supernatant was decanted and leaf tissue was discarded. Volume was made to 10 ml with DMSO and absorbance of extract was read at 645, 652 and 663 nm using DMSO as blank. The Chlorophyll ‘a’, Chlorophyll ‘b’ and Total chlorophyll contents were calculated using the formula as follows.

$$\text{Chlorophyll 'a' content} = 12.7\,(A663) - 2.69\,(A645) \times \frac{V}{1000 \times W \times a}\ \text{(mg/g fr. wt)}$$

$$\text{Chlorophyll 'b' content} = 22.9\,(A645) - 4.68\,(A663) \times \frac{V}{1000 \times W \times a}\ \text{(mg/g fr. wt)}$$

$$\text{Total chlorophyll content} = 27.8\,(A652) \times \frac{V}{1000 \times W \times a}\ \text{(mg/g fr. wt)}$$

Where,

A = Absorbance at specific wave length (645 and 663 nm)

V = Final volume of the chlorophyll extract (ml)

W = Fresh weight of the sample (g)

a = Path length of light (1cm)

3.3.2.2 Anthocyanin content

Anthocyanin content was determined as per the standard method (Witham *et al*., 1986) in the leaves at 60, 90 and 120 DAS. One gram fresh plant sample was cut into small pieces and blended in 10 ml of methonal, the extract filtered through Whatman No.1 filter. The extract was boiled in hot water until the volume is reduced to 1-2 ml and made up the volume to 25 ml with distilled water and this is called as alcohol extraction. The extract was used with 3 ml of reagent methanolic-HCl (0.5 N HCl in 80-85% methonol) +1 ml of H_2O_2 + 1 ml of methanolic HCl (5:1 HCl in 80-85% methanol) the extract was incubated for 15-20 minutes and measured the absorbance of the solution at 525 nm. The Anthocyanin content was calculated using the following formula.

$$\text{Total absorbance (mg/g sample)} = \frac{\text{Absorbance at 525 nm} \times \text{Volume made up of the extract used for colour measurement} \times \text{Total volume}}{\text{ml of the extract used} \times \text{Weight of the sample}}$$

$$\text{Total absorbance (mg/g sample)} = \frac{A \times 6.0\ \text{ml} \times 25}{1.0\ \text{ml} \times 1.0\ \text{g}} = 150\ A$$

The molecular extinction co-efficient for 1% solution (i.e.10 µg/ml) at 525 nm is equivalent to 982 (standard) and therefore, the absorbance of solution containing 1µg is equal to 98.2.

$$\text{Total anthocyanin content (mg/g sample)} = \frac{150A}{98.2}$$

3.3.3 Other observations

3.3.3.1 Chlorophyll content in leaf (SPAD reading)

Chlorophyll content in leaf (SPAD reading) was recorded in experiment 1 and 2. Leaf chlorophyll content was estimated non-destructively by measuring leaf greenness using a portable SPAD (Soil Plant Analysis Development)-502 chlorophyll meter (Minolta Camera Co. Ltd., Japan). This meter operates by clamping the sensor head onto a leaf blade. A rubber boot seals out external light, and creates a closed chamber around the area to be measured. Two light emitting diodes are used to emit light through the leaf at two wavelengths, 650 nm (red) and 940 nm (infrared), when the chamber is closed. Light in the 650 nm range lies between the two primary wavelengths associated with chlorophyll activity (645 and 663 nm). SPAD meter operation is based on the inverse relationship between absorbed radiation in the 650nm region of the spectra, and that transmitted through the leaf. The 940 nm wavelength is not affected by leaf chlorophyll content and provides an internal meter calibration. A silicon photodiode receptor converts the transmitted light to analogue electrical signals, which are then converted into digital signals and used by the microprocessor to calculate the dimensionless SPAD unit value. Reading was taken from fully expanded leaf in between the leaf margin and the midrib. The average of five SPAD values was taken as the final value. The reading was recorded at 60, 90 and 120 DAS.

3.3.3.2 Red leaf index

Red leaf index was recorded in experiment 1 and 2 (Plate 3). For quantitative estimation of degree of leaf reddening, observations were recorded at 60, 90 and 120 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. At 60 DAS, Bt cotton plants were not showing the symptoms of leaf reddening, hence not recorded.

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

Grade 'four' – When the whole plant turned red

3.3.3.3 Spectral reflectance

Spectral reflectance was recorded in experiment 2 (Plate 3). Spectral reflectance measurements were made with the help of ground truth radiometer. Measurements were made in all the four bands viz., Band 1: Blue region, 450-520 nm, Band 2: Green region, 520-570 nm, Band 3: Red region, 620-680 nm, and Band 4: NIR region, 770-860 nm. Observation were recorded at a height of one meter above the crop canopy using 15^o field of view, Irradiation calibration was done using barium sulphate panel provided along with the instrument after every three observations. The readings were repeated two times for each field or ground truth site selected. The mean of the two repetitions was divided by the readings from barium sulphate reference panel to compute bi-directional reflectance. The reflectance panel observations were made under the same ambient conditions as the canopy observations. The reflectance percent values at different wavelengths corresponding to IRS P6 LISS III band 3(620-680 nm) and band 4 (770-860 nm) were used to calculate the vegetation index like NDVI (normalized difference vegetation index).

$$\text{Reflectance (\%) of the sample} = \frac{\text{Reflected radiation from sample material}}{\text{Reflected radiation from reference material}} \times 100$$

3.3.3.4 Normalized difference vegetation index (NDVI)

Normalized difference vegetation index (NDVI) was recorded in experiment No. 2 (Plate 3). NDVI proposed by Rouse *et al.* (1974) was used in this study. This index is sensitive to the presence of green vegetation. It permits the prediction of agricultural crops and precipitation in semi arid areas. NDVI can be defined by following equation.

$$NDVI = \frac{NIR-R}{NIR+R}$$

Where, NIR and R are the reflectance in the near infrared and red regions respectively. NDVI values were derived from both GTR and IRS P6 LISS III image using ERDAS IMAGINE modeler panel by running the NDVI model.

3.3.3.5 Canopy temperature

Canopy temperature was recorded in experiment No.2 (Plate 3). Infrared thermometer measures temperature using black body radiation (generally infrared) emitted from objects. By knowing the amount of infrared energy emitted by the object and its emissivity, the object's temperature can be determined. The basic design consists of a lens to focus the infrared energy on to a detector, which converts the energy to an electrical signal that can be displayed in units of temperature after being compensated for ambient temperature variation. This configuration facilitates temperature measurement from a distance without contact with the object to be measured. Infrared crop temperature meter (Model – 2956, Spectrum Technologies, Inc., USA) was used for measurement of canopy temperature. This equipment is having the operating temperature range of 0 to 50^0C. Canopy temperature of the Bt cotton plant was recorded at middle of the canopy with infrared thermometer at 9 AM, 1 PM and 5 PM at 60, 90 and 120 DAS.

3.3.3.6 Soil temperature

Soil temperature was recorded in experiment 2. Soil thermometer (model-0124) was used for measuring the temperature of inner layer of soil (Plate 2) The soil thermometer provided with brass body and cone having natural brass finish with size of 150 mm fitted with yellow back mercury, measures the temperature range -10 to 60°C. The soil temperature recording thermometers were installed in the polyethylene mulched and non-polyethylene mulched plots. In order to install the soil thermometer 40 cm depth slot was opened with crow bar. The soil thermometers were installed in the opened slot and covered with aluminum pan and retained in the field till the harvest of crop. Soil temperature in polythene mulched and non mulched plots was recorded daily at 9 AM, 1 PM and 5 PM from October 15^{th} to December 30^{th} during 2007 and 2008.

3.3.3.7 Correlation analysis

Correlation provides a measure of association between variables. The correlation coefficients were worked out between the seed cotton yield independent variables affecting the yield like SPAD chlorophyll content (SPAD reading), total chlorophyll content, anthocyanin content, red leaf index (RLI) in experiment 1 and 2. In addition to these parameters, in experiment 2, the correlation coefficients were worked out between the seed cotton yield independent variables like NDVI values, canopy temperature. The correlation was also worked out between RLI and chlorophyll content (SPAD reading) total chlorophyll content and anthocyanin content.

Recording canopy temperature with infrated Thermomter (Reytek model)

Chlorophyll meter observation (SPAD)

Recording spectral reflectance with a SKL 904 spectrosens-2, 4 channel display spectroradiometer

Red leaf index scoring

Plate 3: Methodology for recording canopy temperature, Chlorophyll, Spectral reflectance and Real leaf index (RLI)

3.3.4 Collection and preparation of plant samples

Collection and preparation of plant samples was carried out in experiment No. 2. Treatment-wise plant samples were collected at 60, 90 and 120 DAS by uprooting the entire plant carefully. The samples were dried in shade and then oven dried at 65^0C. Then the plant samples were powdered with the help of grinder and stored in butter paper bags. The samples were analyzed for nitrogen, phosphorus, potassium, calcium, magnesium and micronutrients content by following standard procedures.

3.3.4.1 Nitrogen

Nitrogen was determined by Kjeldahls method using digestion mixture consisting of $CuSO_4$, K_2SO_4, selenium powder and H_2SO_4. Half a gram plant sample was digested in a block digestion unit. After complete digestion, the samples were distilled. Using micro-Kjeldahl unit and the liberated ammonia was trapped in boric acid containing mixed indicator and titrated against 0.01 N H_2SO_4 (Jackson, 1973).

3.3.4.2 Wet ashing of plant samples for nutrient analysis

One gram plant sample was first pre-digested with 5 ml of nitric acid and then digested with triacid mixture consisting of sulphuric acid, nitric acid and prechloric acid (10:4:1). The clear digested material was made use for analyzing P, K, Ca, Mg and micronutrients (Jackson, 1967).

3.3.4.3 Phosphorus

The phosphorus in the plant sample was determined by vanadomolybdate yellow colour method in nitric acid medium. The intensity of colour was read at 420 nm wavelength using spectrophotometer (Jackson, 1967).

3.3.4.4 Potassium

Potassium in the plant sample was estimated by automizing the diluted plant extract in the flame photometer (Jackson, 1967).

3.3.4.5 Calcium and magnesium

Calcium and magnesium in plant digest were estimated by making use of chelating property of EDTA.

3.3.4.6 Micronutrients

Micronutrients in the plant extract were estimated by atomic absorption spectrophotometer (Jackson, 1973).

3.3.5 Soil analysis

Soil analysis was carried out in experiment 2.

3.3.5.1 Collection and preparation of soil samples

Composite soil samples (0 – 30 cm depth) were collected from the experimental site before sowing and treatment-wise at harvest during 2007-08 and 2008-09. Soil samples were prepared for further chemical analysis following the standard procedure (Jackson 1967).

3.3.5.2 Soil reaction (pH)

Soil pH was determined in 1:2.5 soil-water suspensions by potentiometric method (Jackson, 1967).

3.3.5.3 Electrical conductivity (EC)

Electrical conductivity was determined in 1:2.5 soil:water suspension using conductivity bridge and expressed as dS per m (Jackson, 1973).

3.3.5.4 Organic carbon (%)

The organic carbon content of a finely ground soil sample was determined by Walkely and Black wet oxidation method as described by Jackson (1967).

3.3.5.5 Available nitrogen (kg/ha)

Available nitrogen was estimated by alkaline $KMnO_4$ method where organic matter in the soil is oxidized with hot alkaline $KMnO_4$ solution. The ammonia (NH_3) evolved during oxidation was distilled and trapped in boric acid containing mixed indicator solution. The amount of NH_3 trapped was estimated by titration with standard acid (Subbaiah and Asija, 1956).

3.3.5.6 Available phosphorus (kg/ha)

Available phosphorus was extracted with sodium bicarbonate (0.5 M) at pH 8.5 (Olsen's reagent) and the amount of phosphorus was estimated by chlorostannous reduced phosphomolybdate blue colour method using spectrophotometer at wavelength of 660 nm (Jackson, 1973).

3.3.5.7 Available potassium (kg/ha)

Available potassium in soil was extracted by neutral ammonium acetate and subsequent estimation was by flame photometry (Jackson, 1973).

3.3.5.8 Exchangeable calcium & magnesium (me/100 g)

Exchangeable magnesium was determined by versenate titration method after extracting the soil with neutral normal ammonium acetate solution as described by Black (1965).

3.3.5.9 Micronutrients (ppm)

Available micronutrients (Zn, Fe, Mn and Cu) were determined by atomic absorption spectrophotometer (AAS) after extracting the soil with DTPA (Diethylene triamine penta acetic acid) as proposed by Lindsay and Norwell (1978).

3.4 Economics

Economics of each treatment was worked out considering the prevailing cost of seeds, fertilizers, plant protection chemicals and labour charges during the experimentation years (2007-08 and 2008-09) (Appendix VI). The economic analysis of each treatment was worked out considering the prevailing cost of seeds, fertilizers, plant protection chemicals and labour charges during 2010-11, is furnished in Appendix VII and Appendix VIII.

3.5 Statistical analysis

Data on various characters recorded from field experiments were subjected to Fischer's method of analysis of variance and interpretation as given by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was $P = 0.05$.

Frequencies and percentages were calculated in documentation of existing cultivation practices followed in Bt cotton growing by different farmers under two types of soils. The percentage analysis was done to make simple calculations. Percentages were used for standardization of size by calculating the number of individuals that would be in a given category if the total number of cases were 100.

4. EXPERIMENTAL RESULTS

4.1 Survey report on constraints of Bt cotton cultivation in Belgaum and Haveri districts of Karnataka

The data pertaining to the constraints faced by the Haveri and Belgaum district farmers presented in Table 3a and b. In Karnataka, the present cotton growing situation is showing improvement after release of Bt cotton. In this context a survey on farmer's field was undertaken during May 2007 to know the advantages and the constraints of Bt cotton cultivation in Belgaum and Haveri districts. About 100 sample farmers were enquired individually regarding the advantages and various constraints faced by them in Bt cotton cultivation with the help of questionnaire which comprised the improved Bt cotton cultivation technologies vis-à-vis farmers practice. The collected data was analyzed by adopting Garrets ranking technique. The survey analysis indicated that Bt cotton technology is accepted by the farmers of northern Karnataka on account of its higher yield (96% farmers opined) followed by lower pest attack (93% farmers opined), lower pesticide cost (90% farmers opined) and lower insecticidal sprays (2-3) (82% farmers opined) compared to non Bt version cotton (8-10). Regarding constraints of Bt cotton cultivation, 93 per cent farmers had faced the problem of leaf reddening, 92 per cent farmers expressed that the high seed cost, limiting its cultivation by the economically poor farmers. The survey analysis warrants that the research work has to be intensified on leaf reddening management in Bt cotton.

4.2 Experiment-1: Assessing leaf reddening malady in Bt cotton genotypes

4.2.1 Biometric observations

4.2.1.1 Seed cotton yield (kg/ha)

The yearwise and pooled data on seed cotton yield per hectare is presented in Table 4. Seed cotton yield differed significantly among the genotypes. Based on the pooled data Neeraja (BG II) Bt registered significantly higher seed cotton yield (2483 kg/ha) compared to Bt, other non-Bt and check genotypes. In individual years also, the same trend is observed. The next best Bt genotype was Bunny (BGI) Bt (2071 kg/ha) with same trend in both the years. Bt hybrids (BG I and BG II) were superior with respect to yield (1978 kg/ha) compared to their non Bt counterparts (1258 kg/ha). Among the tested genotypes (4 Bt and 4 non-Bt genotypes), Neeraja (BG II) Bt recoded 36 and 43 per cent higher yield over check DCH-32 non-Bt hybrid and check Sahana non-Bt variety, respectively. Between Bt and non-Bt cotton genotypes Bt cotton genotypes recorded significantly higher seed cotton yield (1865 kg/ha) compared to their corresponding non-Bt genotypes (1215 kg/ha) during 2007.

4.2.1.2 Boll weight (g/boll)

The pooled and yearwise data on boll weight (g/boll) are presented in Table 5. Boll weight (g/boll) differed significantly among the cotton genotypes. The pooled data indicated significantly higher boll weight (4.37 g/boll) with Bunny (BG I) Bt than RCH 368 and JK Durga Bt, non-Bt, JK Durga non-Bt and checks and it was on par with Neeraja (BG II) Bt (4.28 g/boll). Both of these genotypes also recorded higher boll weight during both the years. Between Bt and non-Bt cotton genotypes, Bt cotton genotypes recorded significantly higher boll weight (4.05 g/boll) compared to their corresponding non-Bt genotypes (3.47 g/boll). During 2007 and 2008 also Bt cotton genotypes recorded significantly higher boll weight. The lowest boll weight based on pooled data (2.31 g/boll) was recorded with check Sahana non-Bt variety.

4.2.1.3 Seed cotton yield (g) per plant

The pooled and yearwise data on seed cotton yield (g) per plant of different genotypes are presented in Table 6. There were significant differences in seed cotton yield among the cotton genotypes during both the years and also in pooled data. Significantly higher seed cotton yield per plant was obtained with Neeraja (BG II) Bt (142.95 g/plant) compared to other Bt, non-Bt and check genotypes.

Table 3: Advantages of Bt cotton technology as expressed by the sample farmers in Belgaum and Haveri districts (A survey analysis during May 2007)

Sl.No	Advantages of Bt cotton technology	Garrett`s score	Rank
1	Higher yielding ability	96.00	1
2	Lower pest attack	93.00	2
3	Lower pesticide cost	90.00	3
4	Lower insecticidal sprays (2-3) compared to non Bt version cotton (8-10)	81.00	4

Table 3a: Constraints of Bt cotton cultivation as expressed by the sample farmers in Belgaum and Haveri districts (A survey analysis during May 2007)

SL. No.	Problems	Garrets score	Rank
1.	Leaf reddening	93.00	1
2	High seed cost	92.00	2

Table 4: Seed cotton yield in different cotton genotypes

Seed cotton yield (kg ha^{-1}) during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	2044	Bunny (BG-I)	2044	1294	**1669**
G_2	Bunny Non Bt	1294				
G_3	RCH 368 Bt (BG-I)	1833	RCH 368(BG-I)	1525	1058	**1292**
G_4	RCH 368 Non Bt	1203				
G_5	JK Durga Bt (BG-I)	1886	JK Durga (BG-I)	1471	1189	**1330**
G_6	JK Durga Non Bt	1288				
G_7	Neeraja Bt (BG-II)	2545	Neeraja (BG-II)	2421	1319	**1885**
G_8	Neeraja Non Bt	1393				
G_9	Sahana (Non-Bt variety)	1671	**Mean**	**1865**	**1215**	**1542**
G_{10}	DCH 32 (Non-Bt Hybrid)	1748	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1690.50**				
S.Em±		86	Genotype (**G**)	73.77		211
LSD (p=0.05)		256	Type of genotype (**TG**)	104.32		299
CV (%)		8.82	**G** × **TG** Interaction	147.54		422
Seed cotton yield (kg ha^{-1}) during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	2097	Bunny (BG-I)	2097	1287	**1692**
G_2	Bunny Non Bt	1287				
G_3	RCH 368 Bt (BG-I)	1525	RCH 368(BG-I)	1833	1203	**1518**
G_4	RCH 368 Non Bt	1057				
G_5	JK Durga Bt (BG-I)	1471	JK Durga (BG-I)	1886	1288	**1587**
G_6	JK Durga Non Bt	1188				
G_7	Neeraja Bt (BG-II)	2421	Neeraja (BG-II)	2545	1393	**1968**
G_8	Neeraja Non Bt	1349				
G_9	Sahana (Non-Bt variety)	1151	**Mean**	**2090**	**1293**	**1691**
G_{10}	DCH 32 (Non-Bt Hybrid)	1434	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1498**				
S.Em±		150.69	Genotype (**G**)	49.02		147
LSD (p=0.05)		447.74	Type of genotype (**TG**)	69.32		208
CV (%)		17.42	**G** × **TG** Interaction	98.04		294
Seed cotton yield (kg ha^{-1}) (Pooled)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	2071	Bunny (BG-I)	2071	1291	**1680**
G_2	Bunny Non Bt	1291				
G_3	RCH 368 Bt (BG-I)	1679	RCH 368(BG-I)	1679	1131	**1405**
G_4	RCH 368 Non Bt	1131				
G_5	JK Durga Bt (BG-I)	1679	JK Durga (BG-I)	1679	1238	**1459**
G_6	JK Durga Non Bt	1238				
G_7	Neeraja Bt (BG-II)	2483	Neeraja (BG-II)	2483	1371	**1927**
G_8	Neeraja Non Bt	1371				
G_9	Sahana (Non-Bt variety)	1411	**Mean**	**1978**	**1258**	**1618**
G_{10}	DCH 32 (Non-Bt Hybrid)	1591	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1698**				
S.Em±		87.50	Genotype (**G**)	44.10		128
LSD (p=0.05)		251	Type of genotype (**TG**)	62.37		181
CV (%)		14.06	**G** × **TG** Interaction	88.20		255

Table 5: Boll weight (g/boll) in different cotton genotypes

Boll weight (g/boll) during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	4.57	Bunny (BG-I)	4.56	3.96	**4.26**
G_2	Bunny Non Bt	3.97				
G_3	RCH 368 Bt (BG-I)	4.32	RCH 368(BG-I)	4.32	3.85	**4.08**
G_4	RCH 368 Non Bt	3.85				
G_5	JK Durga Bt (BG-I)	4.32	JK Durga (BG-I)	4.31	3.90	**4.11**
G_6	JK Durga Non Bt	3.91				
G_7	Neeraj Bt (BG-II)	4.31	Neeraj (BG-II)	4.31	4.06	**4.19**
G_8	Neeraj Non Bt	4.07				
G_9	Sahana (Non-Bt variety)	2.54	**Mean**	**4.37**	**3.94**	**4.15**
G_{10}	DCH 32 (Non-Bt Hybrid)	3.01	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**3.88**				
S.Em±		0.14	Genotype (**G**)	0.07		0.21
LSD (p=0.05)		0.40	Type of genotype (**TG**)	0.10		0.30
CV (%)		6.07	**G** × **TG** Interaction	0.14		0.43

Boll weight (g/boll) during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	4.19	Bunny (BG-I)	4.19	3.01	**3.60**
G_2	Bunny Non Bt	3.01				
G_3	RCH 368 Bt (BG-I)	3.21	RCH 368(BG-I)	3.21	3.00	**3.10**
G_4	RCH 368 Non Bt	3.00				
G_5	JK Durga Bt (BG-I)	3.22	JK Durga (BG-I)	3.21	3.01	**3.11**
G_6	JK Durga Non Bt	3.01				
G_7	Neeraj Bt (BG-II)	4.26	Neeraj (BG-II)	4.26	3.00	**3.63**
G_8	Neeraj Non Bt	3.00				
G_9	Sahana (Non-Bt variety)	2.08	**Mean**	**3.72**	**3.00**	**3.36**
G_{10}	DCH 32 (Non-Bt Hybrid)	2.04	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**3.10**				
S.Em±		0.15	Genotype (**G**)	0.06		0.21
LSD (p=0.05)		0.44	Type of genotype (**TG**)	0.09		0.29
CV (%)		8.31	**G** × **TG** Interaction	0.13		0.41

Boll weight (g/boll) (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	4.37	Bunny (BG-I)	4.37	3.48	**3.93**
G_2	Bunny Non Bt	3.48				
G_3	RCH 368 Bt (BG-I)	3.76	RCH 368(BG-I)	3.76	3.42	**3.59**
G_4	RCH 368 Non Bt	3.42				
G_5	JK Durga Bt (BG-I)	3.76	JK Durga (BG-I)	3.76	3.46	**3.61**
G_6	JK Durga Non Bt	3.46				
G_7	Neeraj Bt (BG-II)	4.28	Neeraj (BG-II)	4.28	3.53	**3.91**
G_8	Neeraj Non Bt	3.53				
G_9	Sahana (Non-Bt variety)	2.31	**Mean**	**4.05**	**3.47**	**3.76**
G_{10}	DCH 32 (Non-Bt Hybrid)	2.52	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**3.48**				
S.Em±		0.09	Genotype (**G**)	0.05		0.15
LSD (p=0.05)		0.28	Type of genotype (**TG**)	0.07		0.21
CV (%)		6.89	**G** × **TG** Interaction	0.10		0.30

Table 6: Seed cotton yield (g) per plant in different cotton genotypes

Seed cotton yield (g) per plant during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G1	Bunny Bt (BG-I)	108.80	Bunny (BG-I)	108.80	84.80	**96.80**
G2	Bunny Non Bt	84.80				
G3	RCH 368 Bt (BG-I)	103.53	RCH 368(BG-I)	103.53	81.86	**92.70**
G4	RCH 368 Non Bt	81.87				
G5	JK Durga Bt (BG-I)	98.67	JK Durga (BG-I)	98.66	66.00	**82.33**
G6	JK Durga Non Bt	66.00				
G7	Neeraj Bt (BG-II)	145.47	Neeraj (BG-II)	145.46	69.20	**107.33**
G8	Neeraj Non Bt	69.20				
G9	Sahana (Non-Bt variety)	70.40	**Mean**	**114.11**	**75.46**	**94.78**
G10	DCH 32 (Non-Bt Hybrid)	76.07	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**90.48**				
S.Em±		4.34	Genotype (**G**)	2.24		6.74
LSD (p=0.05)		12.88	Type of genotype (**TG**)	3.17		9.53
CV (%)		8.30	**G** × **TG** Interaction	4.49		13.47
Seed cotton yield (g) per plant during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G1	Bunny Bt (BG-I)	111.26	Bunny (BG-I)	111.25	67.18	**89.22**
G2	Bunny Non Bt	67.19				
G3	RCH 368 Bt (BG-I)	83.81	RCH 368(BG-I)	83.80	64.16	**73.98**
G4	RCH 368 Non Bt	64.17				
G5	JK Durga Bt (BG-I)	86.79	JK Durga (BG-I)	86.78	49.47	**68.13**
G6	JK Durga Non Bt	49.47				
G7	Neeraj Bt (BG-II)	140.44	Neeraj (BG-II)	140.44	66.13	**103.28**
G8	Neeraj Non Bt	66.13				
G9	Sahana (Non-Bt variety)	65.71	**Mean**	**105.57**	**61.74**	**83.65**
G10	DCH 32 (Non-Bt Hybrid)	71.75	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**80.72**				
S.Em±		3.60	Genotype (**G**)	1.88		5.64
LSD (p=0.05)		10.70	Type of genotype (**TG**)	2.66		7.98
CV (%)		7.73	**G** × **TG** Interaction	3.76		11.29
Seed cotton yield (g) per plant (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G1	Bunny Bt (BG-I)	110.02	Bunny (BG-I)	110.02	75.93	**93.01**
G2	Bunny Non Bt	75.99				
G3	RCH 368 Bt (BG-I)	93.67	RCH 368(BG-I)	93.67	73.01	**83.34**
G4	RCH 368 Non Bt	73.01				
G5	JK Durga Bt (BG-I)	92.27	JK Durga (BG-I)	92.27	57.73	**75.23**
G6	JK Durga Non Bt	57.73				
G7	Neeraj Bt (BG-II)	142.95	Neeraj (BG-II)	142.95	67.66	**105.31**
G8	Neeraj Non Bt	67.66				
G9	Sahana (Non-Bt variety)	68.05	**Mean**	**109.84**	**68.60**	**89.22**
G10	DCH 32 (Non-Bt Hybrid)	73.90	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**85.52**				
S.Em±		2.75	Genotype (**G**)	1.49		0.49
LSD (p=0.05)		7.89	Type of genotype (**TG**)	2.11		6.36
CV (%)		7.89	**G** × **TG** Interaction	2.99		8.99

The next seed cotton yield was observed in Bunny (BG I) Bt (110.2 g/plant). Similar trend was noticed during both the years. Between Bt and non-Bt genotypes, Bt cotton had significantly higher seed cotton yield (109.84 g/plant) than non-Bt genotypes (68.60 g/plant). During 2007 and 2008 also Bt genotypes (114.11 and 105.57 g/plant) recorded higher seed cotton yield compared to non-Bt cultivars. The lowest seed cotton yield (67.66 g) per plant was recorded with Neeraja non-Bt.

4.2.1.4 Total number of bolls per plant

Total number of bolls per plant in different genotypes during 2007, 2008 and pooled data is presented in Table 7. Genotypes differed significantly with respect to total number of bolls per plant over means of two years. DCH-32 non- Bt hybrid produced significantly higher total number of bolls (54.25 than others and it was on par with Neeraja (BG II) Bt (53.21), JK Durga (BG I) Bt (52.06) and Bunny (BG I) Bt (51.92). The pooled analysis indicated that Bt genotypes recorded significantly higher total number of bolls (48.95) than non-Bt genotypes (35.18). Similar trend of higher number of bolls in Bt genotypes was observed in 2007 (50.26) and 2008 (47.64). The lowest number of total bolls per plant was recorded with RCH-368 non-Bt (28.23) during 2008.

4.2.1.5 Number of bad opened bolls per plant

The pooled data and yearwise data on number of bad opened bolls per plant in different genotypes is presented in Table 8. Genotypes differed significantly with respect to the number of bad opened bolls. Significantly lower number of bad opened bolls were recorded in Neeraja (BG II) Bt (1.68) followed by Bunny (BG I) Bt (2.16). The highest number of bad opened bolls was noticed in check genotype DCH-32 non- Bt hybrid (12.80). Between Bt and non-Bt genotypes, significantly lower number of bad opened bolls (2.48) was recorded with Bt genotypes over non-Bt genotypes (5.27). DCH-32 non- Bt hybrid produced significantly higher number of bad opened bolls (12.80).

4.2.1.6 Number of good opened bolls per plant

The pooled and yearwise data on number of good opened bolls per plant of different genotypes is presented in Table 9. Significant differences were observed among the genotypes with respect to the number of good opened bolls per plant. Neeraja (BG II) Bt produced significantly higher number of good opened bolls (51.53) than other genotypes and it was on par with Bunny (BG I) Bt (49.76). The pooled analysis indicated significantly higher number of good opened bolls (46.23) with Bt than with non-Bt cotton genotypes (29.82). Similar trend was seen in 2007 and 2008. The lowest number of good opened bolls (24.85) recorded with RCH-368 non-Bt.

4.2.1.7 Number of sympodial branches per plant

The pooled and yearwise data on the number of sympodial branches per plant of different genotypes is presented in Table10. The pooled and yearwise results indicated significant difference among the genotypes. DCH-32 non-Bt hybrid produced significantly higher number of sympodial branches (19.38) per plant and it was on par with Neeraja (BG II) Bt (18.60). Between Bt and non-Bt genotypes, Bt cotton genotypes produced significantly higher mean number of sympodial branches per plant (18.20) than non-Bt cotton genotypes (15.31). During 2007 and 2008, Bt genotypes recorded significantly higher number of sympodial branches per plant (19.03 and 17.38, respectively) compared to non-Bt genotypes (15.80 and 14.82, respectively). The lowest number of sympodial branches per plant recorded with Neeraja non-Bt (14.83).

4.2.1.8 Number of monopodial branches per plant

Data on the number of monopodial branches per plant of different cotton genotypes are presented in Table 11. The mean number of monopodial branches per plant in pooled and yearwise analysis differed significantly among the cotton genotypes. Sahana non-Bt variety produced significantly higher number of monopodial branches (3.85) than other genotypes. Non-significant differences were observed between Bt and non-Bt cotton genotypes with respect to monopodial branches per plant. The lowest monopodial branches per plant (2.56) observed with Neeraja non-Bt.

Table 7: Total number of bolls in different cotton genotypes

Total number of bolls/plant during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	52.46	Bunny (BG-I)	52.46	44.2	**49.60**
G_2	Bunny Non Bt	43.53				
G_3	RCH 368 Bt (BG-I)	40.93	RCH 368(BG-I)	42.26	29.8	**36.03**
G_4	RCH 368 Non Bt	29.80				
G_5	JK Durga Bt (BG-I)	53.20	JK Durga (BG-I)	55.20	40.93	**48.06**
G_6	JK Durga Non Bt	40.93				
G_7	Neeraja Bt (BG-II)	52.60	Neeraja (BG-II)	48.60	31.73	**40.16**
G_8	Neeraja Non Bt	31.73				
G_9	Sahana (Non-Bt variety)	39.93	**Mean**	**50.26**	**36.66**	**43.46**
G_{10}	DCH 32 (Non-Bt Hybrid)	54.33	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**43.94**				
S.Em±		2.70	Genotype (**G**)	1.19		3.59
LSD (p=0.05)		8.02	Type of genotype (**TG**)	1.69		5.08
CV (%)		10.57	**G** × **TG** Interaction	2.39		7.18
Total number of bolls/plant during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	51.40	Bunny (BG-I)	51.40	36.40	**43.90**
G_2	Bunny Non Bt	36.39				
G_3	RCH 368 Bt (BG-I)	34.39	RCH 368(BG-I)	34.40	28.23	**31.31**
G_4	RCH 368 Non Bt	28.23				
G_5	JK Durga Bt (BG-I)	50.93	JK Durga (BG-I)	50.93	34.76	**42.85**
G_6	JK Durga Non Bt	34.76				
G_7	Neeraja Bt (BG-II)	53.84	Neeraja (BG-II)	53.84	35.40	**42.98**
G_8	Neeraja Non Bt	35.40				
G_9	Sahana (Non-Bt variety)	34.00	**Mean**	**47.64**	**33.70**	**40.67**
G_{10}	DCH 32 (Non-Bt Hybrid)	54.20	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**41.35**				
S.Em±		1.98	Genotype (**G**)	0.99		2.98
LSD (p=0.05)		5.90	Type of genotype (**TG**)	1.40		3.12
CV (%)		8.31	**G** × **TG** Interaction	1.98		5.96
Total number of bolls/plant (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	51.92	Bunny (BG-I)	51.92	39.96	**47.56**
G_2	Bunny Non Bt	39.96				
G_3	RCH 368 Bt (BG-I)	37.66	RCH 368(BG-I)	37.66	29.01	**33.67**
G_4	RCH 368 Non Bt	29.01				
G_5	JK Durga Bt (BG-I)	52.06	JK Durga (BG-I)	52.06	37.84	**45.45**
G_6	JK Durga Non Bt	37.84				
G_7	Neeraja Bt (BG-II)	53.21	Neeraja (BG-II)	53.21	33.56	**41.57**
G_8	Neeraja Non Bt	33.56				
G_9	Sahana (Non-Bt variety)	36.97	**Mean**	**48.95**	**35.18**	**42.06**
G_{10}	DCH 32 (Non-Bt Hybrid)	54.25	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**42.64**				
S.Em±		1.66	Genotype (**G**)	0.75		2.26
LSD (p=0.05)		4.75	Type of genotype (**TG**)	0.06		3.20
CV (%)		9.50	**G** × **TG** Interaction	0.51		4.53

Table 8: Number of bad opened bolls per plant in different cotton genotypes

Number of bad opened bolls/plant during 2007

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	1.73	Bunny (BG-I)	1.73	7.00	**4.36**
G_2	Bunny Non Bt	7.00				
G_3	RCH 368 Bt (BG-I)	2.93	RCH 368(BG-I)	2.93	3.60	**4.26**
G_4	RCH 368 Non Bt	3.60				
G_5	JK Durga Bt (BG-I)	2.93	JK Durga (BG-I)	2.93	5.13	**4.03**
G_6	JK Durga Non Bt	5.13				
G_7	Neeraja Bt (BG-II)	1.60	Neeraja (BG-II)	1.60	7.00	**4.30**
G_8	Neeraja Non Bt	7.00				
G_9	Sahana (Non-Bt variety)	6.00	**Mean**	**2.30**	**5.68**	**3.99**
G_{10}	DCH 32 (Non-Bt Hybrid)	13.73	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**5.17**				
S.Em±		0.46	Genotype (**G**)	0.14		0.45
LSD (p=0.05)		1.37	Type of genotype (**TG**)	0.21		0.63
CV (%)		9.00	**G** × **TG** Interaction	0.29		0.89

Number of bad opened bolls/plant during 2008

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	2.60	Bunny (BG-I)	2.60	4.06	**3.33**
G_2	Bunny Non Bt	4.06				
G_3	RCH 368 Bt (BG-I)	3.26	RCH 368(BG-I)	3.26	4.73	**4.00**
G_4	RCH 368 Non Bt	4.73				
G_5	JK Durga Bt (BG-I)	3.06	JK Durga (BG-I)	3.06	4.83	**3.95**
G_6	JK Durga Non Bt	4.83				
G_7	Neeraja Bt (BG-II)	1.77	Neeraja (BG-II)	1.77	5.80	**3.78**
G_8	Neeraja Non Bt	5.80				
G_9	Sahana (Non-Bt variety)	6.47	**Mean**	**2.67**	**4.85**	**3.76**
G_{10}	DCH 32 (Non-Bt Hybrid)	11.87	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**4.84**				
S.Em±		0.29	Genotype (**G**)	0.12		0.39
LSD (p=0.05)		0.86	Type of genotype (**TG**)	0.18		0.55
CV (%)		10.39	**G** × **TG** Interaction	0.25		0.78

Number of bad opened bolls/plant (Pooled) (Mean of 2007 and 2008)

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	2.16	Bunny (BG-I)	2.16	5.53	**3.85**
G_2	Bunny Non Bt	5.53				
G_3	RCH 368 Bt (BG-I)	3.10	RCH 368(BG-I)	3.10	4.16	**3.63**
G_4	RCH 368 Non Bt	4.16				
G_5	JK Durga Bt (BG-I)	3.00	JK Durga (BG-I)	3.00	4.98	**3.99**
G_6	JK Durga Non Bt	4.98				
G_7	Neeraja Bt (BG-II)	1.68	Neeraja (BG-II)	1.68	6.40	**4.04**
G_8	Neeraja Non Bt	6.40				
G_9	Sahana (Non-Bt variety)	6.24	**Mean**	**2.48**	**5.27**	**3.87**
G_{10}	DCH 32 (Non-Bt Hybrid)	12.80	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**5.01**				
S.Em±		0.20	Genotype (**G**)	0.08		0.26
LSD (p=0.05)		0.56	Type of genotype (**TG**)	0.12		0.37
CV (%)		10.08	**G** × **TG** Interaction	0.17		0.52

Table 9: Number of good opened bolls per plant in different cotton genotypes

Number of good opened bolls/plant during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	50.73	Bunny (BG-I)	50.73	36.53	**43.63**
G_2	Bunny Non Bt	36.53				
G_3	RCH 368 Bt (BG-I)	38.00	RCH 368(BG-I)	38.00	26.20	**32.10**
G_4	RCH 368 Non Bt	26.20				
G_5	JK Durga Bt (BG-I)	50.27	JK Durga (BG-I)	50.26	35.80	**43.03**
G_6	JK Durga Non Bt	35.80				
G_7	Neeraja Bt (BG-II)	51.00	Neeraja (BG-II)	51.00	24.73	**37.87**
G_8	Neeraja Non Bt	24.73				
G_9	Sahana (Non-Bt variety)	33.93	**Mean**	**47.50**	**30.81**	**39.15**
G_{10}	DCH 32 (Non-Bt Hybrid)	40.60	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**38.77**				
S.Em±		1.71	Genotype (**G**)	0.97		2.91
LSD (p=0.05)		5.09	Type of genotype (**TG**)	1.37		4.11
CV (%)		7.65	**G** × **TG** Interaction	1.94		5.82

Number of good opened bolls/plant during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	48.80	Bunny (BG-I)	48.80	32.33	**40.57**
G_2	Bunny Non Bt	32.33				
G_3	RCH 368 Bt (BG-I)	31.13	RCH 368(BG-I)	31.13	23.50	**27.31**
G_4	RCH 368 Non Bt	23.50				
G_5	JK Durga Bt (BG-I)	47.87	JK Durga (BG-I)	47.86	29.93	**38.90**
G_6	JK Durga Non Bt	29.93				
G_7	Neeraja Bt (BG-II)	52.07	Neeraja (BG-II)	52.06	29.60	**40.83**
G_8	Neeraja Non Bt	29.60				
G_9	Sahana (Non-Bt variety)	27.53	**Mean**	**44.96**	**28.84**	
G_{10}	DCH 32 (Non-Bt Hybrid)	42.33	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**36.05**				
S.Em±		2.01	Genotype (**G**)	0.98		2.96
LSD (p=0.05)		5.96	Type of genotype (**TG**)	1.39		4.19
CV (%)		9.52	**G** × **TG** Interaction	1.97		5.93

Number of good opened bolls/plant (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	49.76	Bunny (BG-I)	49.76	34.43	**42.10**
G_2	Bunny Non Bt	34.43				
G_3	RCH 368 Bt (BG-I)	34.56	RCH 368(BG-I)	34.56	24.85	**29.70**
G_4	RCH 368 Non Bt	24.85				
G_5	JK Durga Bt (BG-I)	49.06	JK Durga (BG-I)	49.06	32.86	**40.96**
G_6	JK Durga Non Bt	32.86				
G_7	Neeraja Bt (BG-II)	51.53	Neeraja (BG-II)	51.53	27.16	**39.35**
G_8	Neeraja Non Bt	27.16				
G_9	Sahana (Non-Bt variety)	30.73	**Mean**	**46.23**	**29.82**	**38.02**
G_{10}	DCH 32 (Non-Bt Hybrid)	41.45	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**37.63**				
S.Em±		1.30	Genotype (**G**)	0.64		1.93
LSD (p=0.05)		3.71	Type of genotype (**TG**)	0.91		2.73
CV (%)		8.45	**G** × **TG** Interaction	1.28		3.86

4.2.2 Biochemical observations

4.2.2.1 Chlorophyll content in leaf (SPAD readings)

The pooled and yearwise data on SPAD observations at different growth stages are presented in Tables (12, 13 and 14). SPAD values differed significantly among different cotton genotypes.

At 60 DAS, the pooled analysis indicated that Neeraja non-Bt recorded significantly higher SPAD value (40.85) and was on par with Neeraja (BG II) Bt (39.20). Similar trend was noticed in 2007 and 2008 also (Table 12). At 90 DAS also Neeraja non-Bt recorded significantly higher SPAD value (42.30) than other genotypes (Table 13). Non-Bt cotton genotypes recorded significantly higher SPAD value at both 60 and 90 DAS than Bt cotton genotypes during both the years. The lowest SPAD value (33.98 at 60 DAS and 35.66 at 90 DAS) was recorded with JK Durga (BG I) Bt. Between Bt and non-Bt cotton genotypes, non-Bt cotton genotypes recorded significantly higher SPAD value (36.76 at 60 DAS and 38.40 at 90 DAS) than Bt genotypes (35.70 at 60 DAS and 37.17 at 90 DAS). At 120 DAS, Neeraja (BG II) Bt recorded significantly higher SPAD value (44.38). Between Bt and non-Bt cotton genotypes, non-Bt genotypes recorded significantly higher SPAD value (42.71) than Bt cotton genotypes (41.16). The lowest SPAD value (39.06) was observed with Sahana non-Bt variety (Table 14).

4.2.2.2 Chlorophyll content 'a' content (mg/g fresh weight)

The pooled data pertaining to chlorophyll 'a' content of different genotypes is presented in Tables (15, 16 and 17). Cotton genotypes differed significantly with respect to chlorophyll 'a' content at different growth stages.

At 60 DAS, significantly higher chlorophyll 'a' content (0.23 mg/g fresh weight) was recorded with check DCH-32 non-Bt hybrid than other genotypes. There was no significant difference between Bt and non-Bt cotton genotypes with respect to chlorophyll 'a' content at 60, 90 and 120 DAS. The pooled data indicate lowest chlorophyll 'a' content (0.18 mg/g fresh weight) was recorded with check genotype Sahana non-Bt variety. Similar trend observed during 2007 and 2008.

At 90 DAS, also DCH-32 non-Bt hybrid recorded significantly higher chlorophyll 'a' content (0.92 mg/g fresh weight) than other genotypes. Between Bt and non-Bt cotton genotypes, significantly higher chlorophyll 'a' content (0.78 mg/g fresh weight) was recorded with non-Bt cotton genotypes compared to Bt cotton genotypes (0.75 mg/g fresh weight). The lowest chlorophyll 'a' content (0.58 mg/g fresh weight) was recorded with RCH-368 (BG I) Bt and Sahana non-Bt variety.

At 120 DAS, Neeraja non-Bt recorded significantly higher chlorophyll 'a' content (1.05 mg/g fresh weight) than others and it was on par with Neeraja (BG II) Bt (1.02 mg/g fresh weight), Bunny (BG I) Bt (1.02 mg/g fresh weight) and DCH-32 non-Bt hybrid (1.01 mg/g fresh weight). There was no significant difference between Bt and non-Bt cotton genotypes with respect to chlorophyll 'a' content.

4.2.2.3 Chlorophyll 'b' content (mg/g fresh weight)

The pooled and yearwise data on chlorophyll 'b' content of different genotypes at different growth stages is presented in Tables (18, 19 and 20). Cotton genotypes differed significantly with respect to chlorophyll 'b' content.

At 60 DAS, DCH-32 non-Bt hybrid recorded significantly higher chlorophyll 'b' content (0.18 mg/g fresh weight) and it was on par with Neeraja non-Bt (0.17 mg/g fresh weight). There was no significant difference between Bt and non-Bt cotton genotypes with respect to chlorophyll 'b' content. JK Durga (BG I) Bt and Neeraja (BG II) Bt recorded the lowest chlorophyll 'b' content (0.13 mg/g fresh weight). Similar trends were observed in 2007 and 2008.

At 90 DAS, Bunny (BG I) Bt recorded significantly higher chlorophyll 'b' content (0.42 mg/g fresh weight) and it was on par with Neeraja non-Bt (0.40 mg/g fresh weight). No significant difference was observed between Bt and non-Bt cotton genotypes with respect to chlorophyll 'b' content. The lowest chlorophyll 'b' content (0.22 mg/g fresh weight) was recorded with Sahana non-Bt variety.

Table 10: Number of sympodial branches per plant in different cotton genotypes

Number of sympodial branches per plant during 2007

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	18.67	Bunny (BG-I)	18.66	16.60	**17.63**
G_2	Bunny Non Bt	16.60				
G_3	RCH 368 Bt (BG-I)	18.33	RCH 368(BG-I)	18.33	15.13	**16.73**
G_4	RCH 368 Non Bt	15.13				
G_5	JK Durga Bt (BG-I)	19.87	JK Durga (BG-I)	19.26	15.40	**17.33**
G_6	JK Durga Non Bt	15.40				
G_7	Neeraja Bt (BG-II)	19.26	Neeraja (BG-II)	19.86	16.06	**17.96**
G_8	Neeraja Non Bt	16.07				
G_9	Sahana (Non-Bt variety)	17.20	**Mean**	**19.03**	**15.80**	**17.41**
G_{10}	DCH 32 (Non-Bt Hybrid)	20.73	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**17.72**				
S.Em±		0.54	Genotype (**G**)	0.28		0.87
LSD (p=0.05)		1.61	Type of genotype (**TG**)	0.40		1.22
CV (%)		5.31	**G** × **TG** Interaction	0.57		1.73

Number of sympodial branches per plant during 2008

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	17.80	Bunny (BG-I)	17.80	15.36	**16.58**
G_2	Bunny Non Bt	15.37				
G_3	RCH 368 Bt (BG-I)	17.40	RCH 368(BG-I)	17.40	15.46	**16.43**
G_4	RCH 368 Non Bt	15.47				
G_5	JK Durga Bt (BG-I)	16.40	JK Durga (BG-I)	16.40	14.20	**15.30**
G_6	JK Durga Non Bt	14.20				
G_7	Neeraja Bt (BG-II)	17.93	Neeraja (BG-II)	17.93	14.26	**16.10**
G_8	Neeraja Non Bt	14.27				
G_9	Sahana (Non-Bt variety)	15.03	**Mean**	**17.38**	**14.82**	**16.10**
G_{10}	DCH 32 (Non-Bt Hybrid)	18.03	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**16.19**				
S.Em±		0.58	Genotype (**G**)	0.29		0.88
LSD (p=0.05)		1.71	Type of genotype (**TG**)	0.41		1.24
CV (%)		6.16	**G** × **TG** Interaction	0.58		1.75

Number of sympodial branches per plant (Pooled) (Mean of 2007 and 2008)

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	18.23	Bunny (BG-I)	18.23	15.98	**17.10**
G_2	Bunny Non Bt	15.98				
G_3	RCH 368 Bt (BG-I)	17.86	RCH 368(BG-I)	17.86	15.30	**16.58**
G_4	RCH 368 Non Bt	15.30				
G_5	JK Durga Bt (BG-I)	18.13	JK Durga (BG-I)	18.13	15.13	**16.63**
G_6	JK Durga Non Bt	15.13				
G_7	Neeraja Bt (BG-II)	18.60	Neeraja (BG-II)	18.60	14.83	**16.71**
G_8	Neeraja Non Bt	14.83				
G_9	Sahana (Non-Bt variety)	16.12	**Mean**	**18.20**	**15.31**	**16.75**
G_{10}	DCH 32 (Non-Bt Hybrid)	19.38	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**16.75**				
S.Em±		0.39	Genotype (**G**)	0.21		0.65
LSD (p=0.05)		1.11	Type of genotype (**TG**)	0.30		0.92
CV (%)		5.58	**G** × **TG** Interaction	0.43		1.29

Table 11: Number of monopodial branches per plant in different cotton genotypes

Number of monopodial branches plant during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	2.47	Bunny (BG-I)	2.46	2.66	**2.56**
G_2	Bunny Non Bt	2.67				
G_3	RCH 368 Bt (BG-I)	2.57	RCH 368(BG-I)	2.56	2.66	**2.61**
G_4	RCH 368 Non Bt	2.67				
G_5	JK Durga Bt (BG-I)	2.60	JK Durga (BG-I)	2.60	2.60	**2.60**
G_6	JK Durga Non Bt	2.60				
G_7	Neeraja Bt (BG-II)	2.93	Neeraja (BG-II)	2.93	2.46	**2.70**
G_8	Neeraja Non Bt	2.47				
G_9	Sahana (Non-Bt variety)	3.43	**Mean**	**2.64**	**2.60**	**2.62**
G_{10}	DCH 32 (Non-Bt Hybrid)	2.60	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**2.70**				
S.Em±		2.47	Genotype (**G**)	0.03		NS
LSD (p=0.05)		0.29	Type of genotype (**TG**)	0.05		NS
CV (%)		6.23	**G** × **TG** Interaction	0.07		NS
Number of monopodial branches plant during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	2.80	Bunny (BG-I)	2.80	2.66	**2.73**
G_2	Bunny Non Bt	2.67				
G_3	RCH 368 Bt (BG-I)	2.93	RCH 368(BG-I)	2.93	2.73	**2.83**
G_4	RCH 368 Non Bt	2.73				
G_5	JK Durga Bt (BG-I)	2.67	JK Durga (BG-I)	2.66	2.73	**2.70**
G_6	JK Durga Non Bt	2.73				
G_7	Neeraja Bt (BG-II)	2.67	Neeraja (BG-II)	2.66	2.66	**2.66**
G_8	Neeraja Non Bt	2.67				
G_9	Sahana (Non-Bt variety)	4.27	**Mean**	**2.76**	**2.70**	**2.73**
G_{10}	DCH 32 (Non-Bt Hybrid)	2.60	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**2.87**				
S.Em±		0.12	Genotype (**G**)	0.05		NS
LSD (p=0.05)		0.37	Type of genotype (**TG**)	0.07		NS
CV (%)		7.53	**G** × **TG** Interaction	0.11		NS
Number of monopodial branches plant (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	2.63	Bunny (BG-I)	2.63	2.66	**2.65**
G_2	Bunny Non Bt	2.66				
G_3	RCH 368 Bt (BG-I)	2.75	RCH 368(BG-I)	2.75	2.70	**2.72**
G_4	RCH 368 Non Bt	2.70				
G_5	JK Durga Bt (BG-I)	2.63	JK Durga (BG-I)	2.63	2.66	**2.65**
G_6	JK Durga Non Bt	2.66				
G_7	Neeraja Bt (BG-II)	2.80	Neeraja (BG-II)	2.80	2.56	**2.68**
G_8	Neeraja Non Bt	2.56				
G_9	Sahana (Non-Bt variety)	3.85	**Mean**	**2.70**	**2.65**	**2.67**
G_{10}	DCH 32 (Non-Bt Hybrid)	2.60	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**2.78**				
S.Em±		0.07	Genotype (**G**)	0.03		NS
LSD (p=0.05)		0.22	Type of genotype (**TG**)	0.04		NS
CV (%)		6.85	**G** × **TG** Interaction	0.06		NS

Table 12: Chlorophyll content in leaf (SPAD readings) at 60 DAS in different cotton genotypes

Chlorophyll content in leaf (SPAD readings) at 60 DAS during 2007

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	34.77	Bunny (BG-I)	34.77	34.66	**34.71**
G_2	Bunny Non Bt	34.67				
G_3	RCH 368 Bt (BG-I)	33.10	RCH 368(BG-I)	33.10	34.37	**33.73**
G_4	RCH 368 Non Bt	34.37				
G_5	JK Durga Bt (BG-I)	33.97	JK Durga (BG-I)	33.97	34.07	**34.01**
G_6	JK Durga Non Bt	34.07				
G_7	Neeraja Bt (BG-II)	38.07	Neeraja (BG-II)	38.67	39.60	**38.83**
G_8	Neeraja Non Bt	39.60				
G_9	Sahana (Non-Bt variety)	32.00	**Mean**	**34.97**	**35.67**	**35.32**
G_{10}	DCH 32 (Non-Bt Hybrid)	33.23	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**34.79**				
S.Em±		0.33	Genotype (**G**)	0.14		0.44
LSD (p=0.05)		0.97	Type of genotype (**TG**)	0.20		0.62
CV (%)		1.63	**G** × **TG** Interaction	0.29		0.87

Chlorophyll content in leaf (SPAD readings) at 60 DAS during 2008

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	36.37	Bunny (BG-I)	36.37	36.90	**36.64**
G_2	Bunny Non Bt	36.90				
G_3	RCH 368 Bt (BG-I)	35.07	RCH 368(BG-I)	35.07	36.47	**35.77**
G_4	RCH 368 Non Bt	36.47				
G_5	JK Durga Bt (BG-I)	34.00	JK Durga (BG-I)	34.00	35.97	**35.99**
G_6	JK Durga Non Bt	35.97				
G_7	Neeraja Bt (BG-II)	40.33	Neeraja (BG-II)	40.33	42.10	**41.23**
G_8	Neeraja Non Bt	42.10				
G_9	Sahana (Non-Bt variety)	38.23	**Mean**	**36.44**	**37.86**	**37.15**
G_{10}	DCH 32 (Non-Bt Hybrid)	38.83	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**37.42**				
S.Em±		0.74	Genotype (**G**)	0.17		0.52
LSD (p=0.05)		2.21	Type of genotype (**TG**)	0.19		0.57
CV (%)		3.45	**G** × **TG** Interaction	0.26		0.81

Chlorophyll content in leaf (SPAD readings) (Pooled) at 60 DAS (Mean of 2007 and 2008)

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	35.56	Bunny (BG-I)	35.56	35.78	**35.67**
G_2	Bunny Non Bt	35.78				
G_3	RCH 368 Bt (BG-I)	34.08	RCH 368(BG-I)	34.08	35.41	**34.75**
G_4	RCH 368 Non Bt	35.41				
G_5	JK Durga Bt (BG-I)	33.98	JK Durga (BG-I)	33.98	35.02	**34.50**
G_6	JK Durga Non Bt	35.01				
G_7	Neeraja Bt (BG-II)	39.20	Neeraja (BG-II)	39.20	40.85	**40.02**
G_8	Neeraja Non Bt	40.85				
G_9	Sahana (Non-Bt variety)	35.12	**Mean**	**35.70**	**36.76**	**36.23**
G_{10}	DCH 32 (Non-Bt Hybrid)	36.03	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**36.10**				
S.Em±		0.398	Genotype (**G**)	0.21		0.63
LSD (p=0.05)		1.14	Type of genotype (**TG**)	0.30		0.89
CV (%)		2.71	**G** × **TG** Interaction	0.43		1.26

Table 13: Chlorophyll content in leaf (SPAD readings) at 90 DAS in different cotton genotypes

Chlorophyll content in leaf (SPAD readings) at 90 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	36.00	Bunny (BG-I)	36.00	37.37	**36.80**
G_2	Bunny Non Bt	37.37				
G_3	RCH 368 Bt (BG-I)	36.07	RCH 368(BG-I)	36.06	37.03	**36.55**
G_4	RCH 368 Non Bt	37.03				
G_5	JK Durga Bt (BG-I)	36.23	JK Durga (BG-I)	36.23	37.97	**36.98**
G_6	JK Durga Non Bt	37.97				
G_7	Neeraja Bt (BG-II)	40.10	Neeraja (BG-II)	40.10	42.47	**41.28**
G_8	Neeraja Non Bt	42.47				
G_9	Sahana (Non-Bt variety)	37.17	**Mean**	**37.10**	**38.70**	**37.90**
G_{10}	DCH 32 (Non-Bt Hybrid)	38.77	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**37.91**				
S.Em±		0.49	Genotype (**G**)	0.25		0.77
LSD (p=0.05)		1.45	Type of genotype (**TG**)	0.36		1.09
CV (%)		2.23	**G** × **TG** Interaction	0.51		1.54

Chlorophyll content in leaf (SPAD readings) at 90 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	35.87	Bunny (BG-I)	35.87	35.70	**35.40**
G_2	Bunny Non Bt	35.70				
G_3	RCH 368 Bt (BG-I)	36.33	RCH 368(BG-I)	36.33	37.03	**36.68**
G_4	RCH 368 Non Bt	37.03				
G_5	JK Durga Bt (BG-I)	35.10	JK Durga (BG-I)	35.10	37.50	**36.69**
G_6	JK Durga Non Bt	37.50				
G_7	Neeraja Bt (BG-II)	41.73	Neeraja (BG-II)	41.73	42.13	**41.93**
G_8	Neeraja Non Bt	42.13				
G_9	Sahana (Non-Bt variety)	39.90	**Mean**	**37.23**	**37.97**	**39.68**
G_{10}	DCH 32 (Non-Bt Hybrid)	40.80	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**38.20**				
S.Em±		0.64	Genotype (**G**)	0.25		0.77
LSD (p=0.05)		1.90	Type of genotype (**TG**)	0.36		1.09
CV (%)		2.89	**G** × **TG** Interaction	0.51		1.54

Chlorophyll content in leaf (SPAD readings) (Pooled) at 90 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	35.93	Bunny (BG-I)	35.93	36.53	**36.10**
G_2	Bunny Non Bt	36.53				
G_3	RCH 368 Bt (BG-I)	36.20	RCH 368(BG-I)	36.20	37.03	**36.61**
G_4	RCH 368 Non Bt	37.03				
G_5	JK Durga Bt (BG-I)	35.66	JK Durga (BG-I)	35.66	37.73	**36.83**
G_6	JK Durga Non Bt	37.73				
G_7	Neeraja Bt (BG-II)	40.91	Neeraja (BG-II)	40.91	42.30	**41.60**
G_8	Neeraja Non Bt	42.30				
G_9	Sahana (Non-Bt variety)	38.53	**Mean**	**37.17**	**38.40**	**37.78**
G_{10}	DCH 32 (Non-Bt Hybrid)	39.78	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**38.06**				
S.Em±		0.40	Genotype (**G**)	0.20		0.58
LSD (p=0.05)		1.13	Type of genotype (**TG**)	0.28		0.82
CV (%)		2.55	**G** × **TG** Interaction	0.40		1.16

Table 14: Chlorophyll content in leaf (SPAD readings) at 120 DAS in different cotton genotypes

Chlorophyll content in leaf (SPAD readings) at 120 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	40.80	Bunny (BG-I)	40.80	41.96	**41.38**
G_2	Bunny Non Bt	41.97				
G_3	RCH 368 Bt (BG-I)	38.70	RCH 368(BG-I)	38.70	40.73	**39.71**
G_4	RCH 368 Non Bt	40.73				
G_5	JK Durga Bt (BG-I)	44.20	JK Durga (BG-I)	44.20	43.13	**43.66**
G_6	JK Durga Non Bt	43.13				
G_7	Neeraja Bt (BG-II)	42.57	Neeraja (BG-II)	42.56	43.33	**42.95**
G_8	Neeraja Non Bt	43.33				
G_9	Sahana (Non-Bt variety)	36.57	**Mean**	**41.56**	**42.29**	**41.92**
G_{10}	DCH 32 (Non-Bt Hybrid)	37.60	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**40.96**				
S.Em±		0.53	Genotype (**G**)	0.26		0.79
LSD (p=0.05)		1.57	Type of genotype (**TG**)	0.37		1.12
CV (%)		2.23	**G** × **TG** Interaction	0.52		1.58

Chlorophyll content in leaf (SPAD readings) at 120 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	39.30	Bunny (BG-I)	39.30	42.40	**40.85**
G_2	Bunny Non Bt	42.40				
G_3	RCH 368 Bt (BG-I)	38.57	RCH 368(BG-I)	38.57	41.87	**40.22**
G_4	RCH 368 Non Bt	41.87				
G_5	JK Durga Bt (BG-I)	41.77	JK Durga (BG-I)	41.77	42.83	**42.30**
G_6	JK Durga Non Bt	42.83				
G_7	Neeraja Bt (BG-II)	43.40	Neeraja (BG-II)	43.30	45.43	**44.34**
G_8	Neeraja Non Bt	45.43				
G_9	Sahana (Non-Bt variety)	41.57	**Mean**	**40.74**	**43.13**	**41.94**
G_{10}	DCH 32 (Non-Bt Hybrid)	41.00	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**41.81**				
S.Em±		0.84	Genotype (**G**)	0.20		0.62
LSD (p=0.05)		2.51	Type of genotype (**TG**)	0.39		1.19
CV (%)		3.49	**G** × **TG** Interaction	0.56		1.68

Chlorophyll content in leaf (SPAD readings) (Pooled) at 120 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	40.05	Bunny (BG-I)	40.05	42.18	**41.11**
G_2	Bunny Non Bt	42.18				
G_3	RCH 368 Bt (BG-I)	38.63	RCH 368(BG-I)	38.63	41.3	**39.96**
G_4	RCH 368 Non Bt	41.30				
G_5	JK Durga Bt (BG-I)	42.98	JK Durga (BG-I)	42.98	42.98	**42.98**
G_6	JK Durga Non Bt	42.98				
G_7	Neeraja Bt (BG-II)	42.98	Neeraja (BG-II)	42.98	44.38	**43.68**
G_8	Neeraja Non Bt	44.38				
G_9	Sahana (Non-Bt variety)	39.06	**Mean**	**41.16**	**42.71**	**41.93**
G_{10}	DCH 32 (Non-Bt Hybrid)	39.30	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**41.38**				
S.Em±		0.53	Genotype (**G**)	0.26		0.76
LSD (p=0.05)		1.53	Type of genotype (**TG**)	0.37		1.07
CV (%)		3.16	**G** × **TG** Interaction	0.52		1.52

Table 15: Chlorophyll 'a' content (mg/g fresh weight) at 60 DAS in different cotton genotypes

Chlorophyll 'a' content (mg/g fresh weight) at 60 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.19	Bunny (BG-I)	0.19	0.19	**0.19**
G_2	Bunny Non Bt	0.19				
G_3	RCH 368 Bt (BG-I)	0.19	RCH 368(BG-I)	0.19	0.20	**0.20**
G_4	RCH 368 Non Bt	0.21				
G_5	JK Durga Bt (BG-I)	0.20	JK Durga (BG-I)	0.20	0.20	**0.20**
G_6	JK Durga Non Bt	0.21				
G_7	Neeraja Bt (BG-II)	0.20	Neeraja (BG-II)	0.20	0.21	**0.20**
G_8	Neeraja Non Bt	0.21				
G_9	Sahana (Non-Bt variety)	0.16	**Mean**	**0.19**	**0.20**	**0.19**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.20	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.19**				
S.Em±		0.005	Genotype (**G**)	0.004		NS
LSD (p=0.05)		0.01	Type of genotype (**TG**)	0.005		NS
CV (%)		4.37	**G** × **TG** Interaction	0.007		NS

Chlorophyll 'a' content (mg/g fresh weight) at 60 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.22	Bunny (BG-I)	0.21	0.21	**0.21**
G_2	Bunny Non Bt	0.21				
G_3	RCH 368 Bt (BG-I)	0.23	RCH 368(BG-I)	0.23	0.22	**0.23**
G_4	RCH 368 Non Bt	0.22				
G_5	JK Durga Bt (BG-I)	0.22	JK Durga (BG-I)	0.22	0.20	**0.21**
G_6	JK Durga Non Bt	0.21				
G_7	Neeraja Bt (BG-II)	0.23	Neeraja (BG-II)	0.22	0.22	**0.22**
G_8	Neeraja Non Bt	0.22				
G_9	Sahana (Non-Bt variety)	0.19	**Mean**	**0.22**	**0.21**	**0.21**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.24	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.21**				
S.Em±		0.004	Genotype (**G**)	0.002		NS
LSD (p=0.05)		0.01	Type of genotype (**TG**)	0.003		NS
CV (%)		3.11	**G** × **TG** Interaction	0.004		NS

Chlorophyll 'a' content (mg/g fresh weight) (Pooled) at 60 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.20	Bunny (BG-I)	0.20	0.20	**0.20**
G_2	Bunny Non Bt	0.20				
G_3	RCH 368 Bt (BG-I)	0.21	RCH 368(BG-I)	0.21	0.21	**0.21**
G_4	RCH 368 Non Bt	0.21				
G_5	JK Durga Bt (BG-I)	0.21	JK Durga (BG-I)	0.21	0.20	**0.21**
G_6	JK Durga Non Bt	0.20				
G_7	Neeraja Bt (BG-II)	0.21	Neeraja (BG-II)	0.21	0.21	**0.21**
G_8	Neeraja Non Bt	0.21				
G_9	Sahana (Non-Bt variety)	0.18	**Mean**	**0.21**	**0.21**	**0.21**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.23	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.20**				
S.Em±		0.004	Genotype (**G**)	0.001		NS
LSD (p=0.05)		0.01	Type of genotype (**TG**)	0.002		NS
CV (%)		4.82	**G** × **TG** Interaction	0.003		NS

Table 16: Chlorophyll 'a' content (mg/g fresh weight) at 90 DAS in different cotton genotypes

Chlorophyll 'a' content (mg/g fresh weight) at 90 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.78	Bunny (BG-I)	0.78	0.74	**0.76**
G_2	Bunny Non Bt	0.74				
G_3	RCH 368 Bt (BG-I)	0.38	RCH 368(BG-I)	0.38	0.48	**0.43**
G_4	RCH 368 Non Bt	0.48				
G_5	JK Durga Bt (BG-I)	0.66	JK Durga (BG-I)	0.66	0.73	**0.70**
G_6	JK Durga Non Bt	0.72				
G_7	Neeraja Bt (BG-II)	0.80	Neeraja (BG-II)	0.81	0.85	**0.83**
G_8	Neeraja Non Bt	0.85				
G_9	Sahana (Non-Bt variety)	0.58	**Mean**	**0.66**	**0.70**	**0.68**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.87	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.68**				
S.Em±		0.01	Genotype (**G**)	0.004		0.01
LSD (p=0.05)		0.03	Type of genotype (**TG**)	0.006		0.02
CV (%)		2.72	**G** × **TG** Interaction	0.009		0.03
Chlorophyll 'a' content (mg/g fresh weight) at 90 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.90	Bunny (BG-I)	0.90	0.89	**0.89**
G_2	Bunny Non Bt	0.89				
G_3	RCH 368 Bt (BG-I)	0.79	RCH 368(BG-I)	0.79	0.81	**0.80**
G_4	RCH 368 Non Bt	0.81				
G_5	JK Durga Bt (BG-I)	0.79	JK Durga (BG-I)	0.79	0.80	**0.80**
G_6	JK Durga Non Bt	0.80				
G_7	Neeraja Bt (BG-II)	0.92	Neeraja (BG-II)	0.92	0.93	**0.93**
G_8	Neeraja Non Bt	0.93				
G_9	Sahana (Non-Bt variety)	0.59	**Mean**	**0.85**	**0.86**	**0.85**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.99	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.84**				
S.Em±		0.02	Genotype (**G**)	0.007		0.02
LSD (p=0.05)		0.05	Type of genotype (**TG**)	0.010		0.03
CV (%)		3.29	**G** × **TG** Interaction	0.014		0.04
Chlorophyll 'a' content (mg/g fresh weight) (Pooled) at 90 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.84	Bunny (BG-I)	0.84	0.81	**0.83**
G_2	Bunny Non Bt	0.81				
G_3	RCH 368 Bt (BG-I)	0.58	RCH 368(BG-I)	0.58	0.65	**0.62**
G_4	RCH 368 Non Bt	0.64				
G_5	JK Durga Bt (BG-I)	0.73	JK Durga (BG-I)	0.73	0.76	**0.75**
G_6	JK Durga Non Bt	0.76				
G_7	Neeraja Bt (BG-II)	0.87	Neeraja (BG-II)	0.87	0.89	**0.88**
G_8	Neeraja Non Bt	0.89				
G_9	Sahana (Non-Bt variety)	0.58	**Mean**	**0.75**	**0.78**	**0.76**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.92	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.76**				
S.Em±		0.10	Genotype (**G**)	0.004		0.01
LSD (p=0.05)		0.03	Type of genotype (**TG**)	0.006		0.02
CV (%)		3.20	**G** × **TG** Interaction	0.008		0.03

Table 17: Chlorophyll 'a' content (mg/g fresh weight) at 120 DAS in different cotton genotypes

Chlorophyll 'a' content (mg/g fresh weight) at 120 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.02	Bunny (BG-I)	1.02	0.92	**0.97**
G_2	Bunny Non Bt	0.92				
G_3	RCH 368 Bt (BG-I)	0.76	RCH 368(BG-I)	0.76	0.78	**0.77**
G_4	RCH 368 Non Bt	0.78				
G_5	JK Durga Bt (BG-I)	0.73	JK Durga (BG-I)	0.73	0.76	**0.75**
G_6	JK Durga Non Bt	0.76				
G_7	Neeraja Bt (BG-II)	1.01	Neeraja (BG-II)	1.01	1.04	**1.02**
G_8	Neeraja Non Bt	1.04				
G_9	Sahana (Non-Bt variety)	0.60	**Mean**	**0.88**	**0.87**	**0.87**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.01	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.86**				
S.Em±		0.02	Genotype (**G**)	0.006		0.02
LSD (p=0.05)		0.06	Type of genotype (**TG**)	0.009		0.03
CV (%)		3.92	**G** × **TG** Interaction	0.012		0.04
Chlorophyll 'a' content (mg/g fresh weight) at 120 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.03	Bunny (BG-I)	1.03	0.97	**1.00**
G_2	Bunny Non Bt	0.97				
G_3	RCH 368 Bt (BG-I)	0.87	RCH 368(BG-I)	0.87	0.89	**0.88**
G_4	RCH 368 Non Bt	0.89				
G_5	JK Durga Bt (BG-I)	0.89	JK Durga (BG-I)	0.89	0.91	**0.90**
G_6	JK Durga Non Bt	0.91				
G_7	Neeraja Bt (BG-II)	1.03	Neeraja (BG-II)	1.03	1.06	**1.05**
G_8	Neeraja Non Bt	1.06				
G_9	Sahana (Non-Bt variety)	0.74	**Mean**	**0.95**	**0.96**	**0.95**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.01	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.94**				
S.Em±		0.02	Genotype (**G**)	0.010		0.03
LSD (p=0.05)		0.07	Type of genotype (**TG**)	0.014		0.04
CV (%)		4.36	**G** × **TG** Interaction	0.020		0.06
Chlorophyll 'a' content (mg/g fresh weight) (Pooled) at 120 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.02	Bunny (BG-I)	1.02	0.95	**0.99**
G_2	Bunny Non Bt	0.95				
G_3	RCH 368 Bt (BG-I)	0.81	RCH 368(BG-I)	0.82	0.83	**0.83**
G_4	RCH 368 Non Bt	0.83				
G_5	JK Durga Bt (BG-I)	0.81	JK Durga (BG-I)	0.81	0.84	**0.83**
G_6	JK Durga Non Bt	0.83				
G_7	Neeraja Bt (BG-II)	1.02	Neeraja (BG-II)	1.02	1.05	**1.03**
G_8	Neeraja Non Bt	1.05				
G_9	Sahana (Non-Bt variety)	0.67	**Mean**	**0.92**	**0.92**	**0.92**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.01	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.90**				
S.Em±		0.15	Genotype (**G**)	0.006		NS
LSD (p=0.05)		0.04	Type of genotype (**TG**)	0.008		NS
CV (%)		4.28	**G** × **TG** Interaction	0.012		0.03

Table 18: Chlorophyll ‘b’ content (mg/g fresh weight) at 60 DAS in different cotton genotypes

Chlorophyll ‘b’ content (mg/g fresh weight) at 60 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.12	Bunny (BG-I)	0.12	0.12	**0.12**
G_2	Bunny Non Bt	0.12				
G_3	RCH 368 Bt (BG-I)	0.14	RCH 368(BG-I)	0.13	0.14	**0.14**
G_4	RCH 368 Non Bt	0.14				
G_5	JK Durga Bt (BG-I)	0.12	JK Durga (BG-I)	0.12	0.13	**0.12**
G_6	JK Durga Non Bt	0.13				
G_7	Neeraja Bt (BG-II)	0.14	Neeraja (BG-II)	0.13	0.18	**0.16**
G_8	Neeraja Non Bt	0.18				
G_9	Sahana (Non-Bt variety)	0.15	**Mean**	**0.13**	**0.14**	**0.13**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.18	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.14**				
S.Em±		0.04	Genotype (**G**)	0.001		NS
LSD (p=0.05)		0.01	Type of genotype (**TG**)	0.002		NS
CV (%)		5.01	**G** × **TG** Interaction	0.003		NS

Chlorophyll ‘b’ content (mg/g fresh weight) at 60 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.17	Bunny (BG-I)	0.17	0.17	**0.17**
G_2	Bunny Non Bt	0.17				
G_3	RCH 368 Bt (BG-I)	0.16	RCH 368(BG-I)	0.16	0.15	**0.15**
G_4	RCH 368 Non Bt	0.16				
G_5	JK Durga Bt (BG-I)	0.14	JK Durga (BG-I)	0.14	0.16	**0.15**
G_6	JK Durga Non Bt	0.16				
G_7	Neeraja Bt (BG-II)	0.14	Neeraja (BG-II)	0.14	0.16	**0.15**
G_8	Neeraja Non Bt	0.16				
G_9	Sahana (Non-Bt variety)	0.16	**Mean**	**0.15**	**0.15**	**0.15**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.17	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.16**				
S.Em±		0.004	Genotype (**G**)	0.001		NS
LSD (p=0.05)		0.01	Type of genotype (**TG**)	0.002		NS
CV (%)		3.95	**G** × **TG** Interaction	0.003		NS

Chlorophyll ‘b’ content (mg/g fresh weight) (Pooled) at 60 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.14	Bunny (BG-I)	0.14	0.14	**0.14**
G_2	Bunny Non Bt	0.14				
G_3	RCH 368 Bt (BG-I)	0.15	RCH 368(BG-I)	0.15	0.15	**0.15**
G_4	RCH 368 Non Bt	0.15				
G_5	JK Durga Bt (BG-I)	0.13	JK Durga (BG-I)	0.13	0.14	**0.13**
G_6	JK Durga Non Bt	0.14				
G_7	Neeraja Bt (BG-II)	0.13	Neeraja (BG-II)	0.13	0.17	**0.15**
G_8	Neeraja Non Bt	0.17				
G_9	Sahana (Non-Bt variety)	0.15	**Mean**	**0.14**	**0.15**	**0.14**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.18	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.14**				
S.Em±		0.003	Genotype (**G**)	0.0013		NS
LSD (p=0.05)		0.01	Type of genotype (**TG**)	0.0019		NS
CV (%)		4.30	**G** × **TG** Interaction	0.0026		NS

Table 19: Chlorophyll 'b' content (mg/g fresh weight) at 90 DAS in different cotton genotypes

Chlorophyll 'b' content (mg/g fresh weight) at 90 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.30	Bunny (BG-I)	0.30	0.22	**0.26**
G_2	Bunny Non Bt	0.23				
G_3	RCH 368 Bt (BG-I)	0.24	RCH 368(BG-I)	0.23	0.24	**0.23**
G_4	RCH 368 Non Bt	0.24				
G_5	JK Durga Bt (BG-I)	0.22	JK Durga (BG-I)	0.21	0.24	**0.22**
G_6	JK Durga Non Bt	0.24				
G_7	Neeraja Bt (BG-II)	0.28	Neeraja (BG-II)	0.28	0.27	**0.28**
G_8	Neeraja Non Bt	0.28				
G_9	Sahana (Non-Bt variety)	0.17	**Mean**	**0.25**	**0.24**	**0.24**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.25	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.24**				
S.Em±		0.01	Genotype (**G**)	0.003		0.01
LSD (p=0.05)		0.02	Type of genotype (**TG**)	0.005		0.01
CV (%)		4.86	**G** × **TG** Interaction	0.007		0.02
Chlorophyll 'b' content (mg/g fresh weight) at 90 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.55	Bunny (BG-I)	0.55	0.53	**0.54**
G_2	Bunny Non Bt	0.54				
G_3	RCH 368 Bt (BG-I)	0.25	RCH 368(BG-I)	0.25	0.31	**0.28**
G_4	RCH 368 Non Bt	0.31				
G_5	JK Durga Bt (BG-I)	0.47	JK Durga (BG-I)	0.47	0.50	**0.48**
G_6	JK Durga Non Bt	0.51				
G_7	Neeraja Bt (BG-II)	0.51	Neeraja (BG-II)	0.51	0.52	**0.51**
G_8	Neeraja Non Bt	0.52				
G_9	Sahana (Non-Bt variety)	0.27	**Mean**	**0.44**	**0.46**	**0.45**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.51	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.44**				
S.Em±		0.01	Genotype (**G**)	0.003		0.01
LSD (p=0.05)		0.02	Type of genotype (**TG**)	0.005		0.02
CV (%)		3.24	**G** × **TG** Interaction	0.007		0.02
Chlorophyll 'b' content (mg/g fresh weight) (Pooled) at 90 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.42	Bunny (BG-I)	0.42	0.38	**0.40**
G_2	Bunny Non Bt	0.38				
G_3	RCH 368 Bt (BG-I)	0.24	RCH 368(BG-I)	0.24	0.27	**0.26**
G_4	RCH 368 Non Bt	0.27				
G_5	JK Durga Bt (BG-I)	0.34	JK Durga (BG-I)	0.34	0.37	**0.35**
G_6	JK Durga Non Bt	0.37				
G_7	Neeraja Bt (BG-II)	0.39	Neeraja (BG-II)	0.39	0.40	**0.39**
G_8	Neeraja Non Bt	0.40				
G_9	Sahana (Non-Bt variety)	0.22	**Mean**	**0.35**	**0.36**	**0.36**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.37	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.34**				
S.Em±		0.005	Genotype (**G**)	0.002		0.01
LSD (p=0.05)		0.02	Type of genotype (**TG**)	0.003		0.01
CV (%)		3.76	**G** × **TG** Interaction	0.005		0.02

Table 20: Chlorophyll ‘b’ content (mg/g fresh weight) at 120 DAS in different cotton genotypes

Chlorophyll ‘b’ content (mg/g fresh weight) at 120 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.61	Bunny (BG-I)	0.61	0.61	**0.61**
G_2	Bunny Non Bt	0.61				
G_3	RCH 368 Bt (BG-I)	0.48	RCH 368(BG-I)	0.48	0.55	**0.51**
G_4	RCH 368 Non Bt	0.55				
G_5	JK Durga Bt (BG-I)	0.51	JK Durga (BG-I)	0.50	0.62	**0.56**
G_6	JK Durga Non Bt	0.62				
G_7	Neeraja Bt (BG-II)	0.54	Neeraja (BG-II)	0.54	0.56	**0.55**
G_8	Neeraja Non Bt	0.56				
G_9	Sahana (Non-Bt variety)	0.27	**Mean**	**0.53**	**0.58**	**0.55**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.49	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.52**				
S.Em±		0.01	Genotype (**G**)	0.003		0.11
LSD (p=0.05)		0.03	Type of genotype (**TG**)	0.005		0.02
CV (%)		2.97	**G** × **TG** Interaction	0.007		0.02
Chlorophyll ‘b’ content (mg/g fresh weight) at 120 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.61	Bunny (BG-I)	0.61	0.61	**0.61**
G_2	Bunny Non Bt	0.61				
G_3	RCH 368 Bt (BG-I)	0.47	RCH 368(BG-I)	0.46	0.54	**0.50**
G_4	RCH 368 Non Bt	0.55				
G_5	JK Durga Bt (BG-I)	0.50	JK Durga (BG-I)	0.50	0.62	**0.56**
G_6	JK Durga Non Bt	0.62				
G_7	Neeraja Bt (BG-II)	0.54	Neeraja (BG-II)	0.54	0.55	**0.55**
G_8	Neeraja Non Bt	0.55				
G_9	Sahana (Non-Bt variety)	0.44	**Mean**	**0.53**	**0.58**	**0.55**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.52	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.54**				
S.Em±		0.01	Genotype (**G**)	0.004		0.01
LSD (p=0.05)		0.03	Type of genotype (**TG**)	0.006		0.02
CV (%)		3.60	**G** × **TG** Interaction	0.009		0.03
Chlorophyll ‘b’ content (mg/g fresh weight) (Pooled) at 120 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.61	Bunny (BG-I)	0.61	0.61	**0.61**
G_2	Bunny Non Bt	0.61				
G_3	RCH 368 Bt (BG-I)	0.47	RCH 368(BG-I)	0.47	0.55	**0.51**
G_4	RCH 368 Non Bt	0.55				
G_5	JK Durga Bt (BG-I)	0.50	JK Durga (BG-I)	0.50	0.62	**0.56**
G_6	JK Durga Non Bt	0.62				
G_7	Neeraja Bt (BG-II)	0.54	Neeraja (BG-II)	0.54	0.55	**0.55**
G_8	Neeraja Non Bt	0.55				
G_9	Sahana (Non-Bt variety)	0.35	**Mean**	**0.53**	**0.58**	**0.55**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.50	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.53**				
S.Em±		0.007	Genotype (**G**)	0.003		NS
LSD (p=0.05)		0.02	Type of genotype (**TG**)	0.004		NS
CV (%)		3.28	**G** × **TG** Interaction	0.006		NS

At 120 DAS, pooled data indicate that JK Durga non-Bt recorded significantly higher chlorophyll ‘b’ content (0.62 mg/g fresh weight) and it was on par with Bunny (BG I) Bt and Bunny non-Bt (0.61 mg/g fresh weight). Significantly higher chlorophyll ‘b’ content (0.58 mg/g fresh weight) was recorded with non-Bt cotton genotypes compared to Bt cotton genotypes (0.53 mg/g fresh weight). The lowest chlorophyll ‘b’ content (0.35 mg/g fresh weight) was recorded with Sahana non-Bt variety.

4.2.2.4 Total chlorophyll content (mg/g fresh weight)

The pooled and yearwise data pertaining to total chlorophyll content (mg/g fresh weight) at different growth stages is presented in Tables (21, 22 and 23). Genotypes differed significantly with respect to total chlorophyll content at different growth stages.

At 60 DAS, DCH-32 non-Bt hybrid recorded significantly higher total chlorophyll content (0.39 mg/g fresh weight) than other genotypes. No significant difference was observed between Bt and non-Bt cotton genotypes with respect to total chlorophyll content. The lowest total chlorophyll content (0.33 mg/g fresh weight) was observed with Bunny (BG I) Bt.

At 90 DAS, too DCH-32 non-Bt hybrid recorded significantly higher total chlorophyll content (1.38 mg/g fresh weight) and it was on par with Neeraja non-Bt (1.35 mg/g fresh weight) and Bunny (BG I) Bt (1.33 mg/g fresh weight). The lowest chlorophyll content (0.82 mg/g fresh weight) was recorded with Sahana non-Bt variety.

At 120 DAS, Neeraja non-Bt recorded significantly higher total chlorophyll content (1.66 mg/g fresh weight) and it was on par with Bunny (BG I) Bt (1.60 mg/g fresh weight). Non-Bt cotton genotypes recorded significantly higher total chlorophyll content (1.47 mg/g fresh weight) than the Bt cotton (1.42 mg/g fresh weight). The lowest total chlorophyll content (1.04 mg/g fresh weight) was recorded with Sahana non-Bt variety.

4.2.2.5 Anthocyanin content (mg/g fresh weight)

The pooled and yearwise data on anthocyanin content in leaf (mg/g fresh weight) of different genotypes at various growth stages is presented in Tables (24, 25 and 26). At 60 DAS, there was no significant change observed in anthocyanin content among genotypes. Significant differences were observed in pooled and during 2007 and 2008 data among genotypes at 90 and 120 DAS.

At 90 DAS, anthocyanin content (0.21 mg/g fresh weight) significantly increased in Sahana non-Bt variety than other genotypes. The anthocyanin content was significantly higher in Bt cotton (0.104 mg/g fresh weight) compared to the non-Bt cotton genotypes (0.065 mg/g fresh weight). The lowest anthocyanin content (0.076 mg/g fresh weight) was recorded with Neeraja non-Bt. At 120 DAS, RCH 368 (BG I) Bt recorded significantly higher anthocyanin content (0.284 mg/g fresh weight) than other genotypes. Between Bt and non-Bt, Bt cotton genotypes recorded significantly higher anthocyanin content (0.237 mg/g fresh weight) compared to non-Bt cotton (0.156 mg/g fresh weight). The lowest anthocyanin content (0.093 mg/g fresh weight) was observed with Bunny non-Bt.

4.2.3 Red leaf index (RLI)

The pooled and yearwise data pertaining to red leaf index scored in different genotype at 90 and 120 DAS is presented in Tables (27, 28 and Plate 4, 5, 6, 7 and 8). At 60 DAS, there was no visual symptom of reddening on all the genotypes; hence, scoring was not carried out. At 90 and 120 DAS, genotypes differed significantly with respect to red leaf index.

At 90 DAS, significantly higher red leaf index (1.88) was recorded with Sahana non-Bt compared to other genotypes. Pooled data and yearwise data indicate that there was no significant difference between Bt and non-Bt cotton genotypes with respect to red leaf index. The lowest red leaf index (0.96) was observed with Neeraja non-Bt.

At 120 DAS also, Sahana non-Bt variety recorded significantly higher red leaf index (2.12) compared to other genotypes. Between Bt and non-Bt cotton genotypes, Bt cotton genotypes recorded significantly higher red leaf index (1.82) compared to non-Bt cotton genotypes. The lowest red leaf index (1.52) was recorded with Neeraja non-Bt. Similar trends are observed in 2007 and 2008.

Table 21: Total chlorophyll content (mg/g fresh weight) at 60 DAS in different cotton genotypes

Total chlorophyll content (mg/g fresh weight) at 60 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.31	Bunny (BG-I)	0.31	0.31	**0.31**
G_2	Bunny Non Bt	0.31				
G_3	RCH 368 Bt (BG-I)	0.33	RCH 368(BG-I)	0.33	0.35	**0.34**
G_4	RCH 368 Non Bt	0.36				
G_5	JK Durga Bt (BG-I)	0.32	JK Durga (BG-I)	0.32	0.33	**0.33**
G_6	JK Durga Non Bt	0.33				
G_7	Neeraja Bt (BG-II)	0.35	Neeraja (BG-II)	0.34	0.37	**0.36**
G_8	Neeraja Non Bt	0.38				
G_9	Sahana (Non-Bt variety)	0.33	**Mean**	**0.32**	**0.34**	**0.33**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.38	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.34**				
S.Em±		0.008	Genotype (**G**)	0.004		NS
LSD (p=0.05)		0.02	Type of genotype (**TG**)	0.006		NS
CV (%)		3.85	**G** × **TG** Interaction	0.008		NS

Total chlorophyll content (mg/g fresh weight) at 60 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.36	Bunny (BG-I)	0.36	0.39	**0.37**
G_2	Bunny Non Bt	0.39				
G_3	RCH 368 Bt (BG-I)	0.40	RCH 368(BG-I)	0.39	0.37	**0.38**
G_4	RCH 368 Non Bt	0.37				
G_5	JK Durga Bt (BG-I)	0.36	JK Durga (BG-I)	0.36	0.38	**0.37**
G_6	JK Durga Non Bt	0.38				
G_7	Neeraja Bt (BG-II)	0.36	Neeraja (BG-II)	0.36	0.36	**0.36**
G_8	Neeraja Non Bt	0.37				
G_9	Sahana (Non-Bt variety)	0.36	**Mean**	**0.37**	**0.37**	**0.37**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.41	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.37**				
S.Em±		0.009	Genotype (**G**)	0.004		NS
LSD (p=0.05)		0.03	Type of genotype (**TG**)	0.006		NS
CV (%)		4.26	**G** × **TG** Interaction	0.009		NS

Total chlorophyll content (mg/g fresh weight) (Pooled) at 60 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.33	Bunny (BG-I)	0.33	0.35	**0.34**
G_2	Bunny Non Bt	0.35				
G_3	RCH 368 Bt (BG-I)	0.36	RCH 368(BG-I)	0.36	0.36	**0.36**
G_4	RCH 368 Non Bt	0.36				
G_5	JK Durga Bt (BG-I)	0.34	JK Durga (BG-I)	0.34	0.35	**0.35**
G_6	JK Durga Non Bt	0.35				
G_7	Neeraja Bt (BG-II)	0.35	Neeraja (BG-II)	0.35	0.37	**0.36**
G_8	Neeraja Non Bt	0.37				
G_9	Sahana (Non-Bt variety)	0.34	**Mean**	**0.35**	**0.36**	**0.35**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.39	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.35**				
S.Em±		0.006	Genotype (**G**)	0.003		NS
LSD (p=0.05)		0.02	Type of genotype (**TG**)	0.004		NS
CV (%)		4.46	**G** × **TG** Interaction	0.006		NS

Table 22: Total chlorophyll content (mg/g fresh weight) at 90 DAS in different cotton genotypes

Total chlorophyll content (mg/g fresh weight) at 90 DAS during 2007						
Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	1.10	Bunny (BG-I)	1.09	0.86	**0.98**
G_2	Bunny Non Bt	0.86				
G_3	RCH 368 Bt (BG-I)	0.68	RCH 368(BG-I)	0.68	0.73	**0.70**
G_4	RCH 368 Non Bt	0.74				
G_5	JK Durga Bt (BG-I)	0.87	JK Durga (BG-I)	0.86	0.96	**0.91**
G_6	JK Durga Non Bt	0.96				
G_7	Neeraja Bt (BG-II)	1.07	Neeraja (BG-II)	1.06	1.12	**1.09**
G_8	Neeraja Non Bt	1.12				
G_9	Sahana (Non-Bt variety)	0.75	**Mean**	**0.92**	**0.91**	**0.91**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.25	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.94**				
S.Em±		0.02	Genotype (**G**)	0.009		0.03
LSD (p=0.05)		0.07	Type of genotype (**TG**)	0.013		0.04
CV (%)		4.23	**G** × **TG** Interaction	0.018		0.06

Total chlorophyll content (mg/g fresh weight) at 90 DAS during 2008						
Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	1.58	Bunny (BG-I)	1.57	1.51	**1.54**
G_2	Bunny Non Bt	1.51				
G_3	RCH 368 Bt (BG-I)	1.12	RCH 368(BG-I)	1.11	1.19	**1.15**
G_4	RCH 368 Non Bt	1.19				
G_5	JK Durga Bt (BG-I)	1.35	JK Durga (BG-I)	1.35	1.41	**1.38**
G_6	JK Durga Non Bt	1.42				
G_7	Neeraja Bt (BG-II)	1.53	Neeraja (BG-II)	1.53	1.58	**1.55**
G_8	Neeraja Non Bt	1.58				
G_9	Sahana (Non-Bt variety)	0.91	**Mean**	**1.39**	**1.42**	**1.04**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.51	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.37**				
S.Em±		0.03	Genotype (**G**)	0.010		0.03
LSD (p=0.05)		0.08	Type of genotype (**TG**)	0.144		0.05
CV (%)		3.44	**G** × **TG** Interaction	0.211		0.06

Total chlorophyll content (mg/g fresh weight) (Pooled) at 90 DAS (Mean of 2007 and 2008)						
Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	1.33	Bunny (BG-I)	1.33	1.18	**1.26**
G_2	Bunny Non Bt	1.18				
G_3	RCH 368 Bt (BG-I)	0.89	RCH 368(BG-I)	0.89	0.96	**0.93**
G_4	RCH 368 Non Bt	0.96				
G_5	JK Durga Bt (BG-I)	1.11	JK Durga (BG-I)	1.11	1.18	**1.14**
G_6	JK Durga Non Bt	1.18				
G_7	Neeraja Bt (BG-II)	1.29	Neeraja (BG-II)	1.29	1.35	**1.32**
G_8	Neeraja Non Bt	1.35				
G_9	Sahana (Non-Bt variety)	0.82	**Mean**	**1.16**	**1.17**	**1.16**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.38	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.14**				
S.Em±		0.017	Genotype (**G**)	0.006		0.02
LSD (p=0.05)		0.05	Type of genotype (**TG**)	0.009		0.03
CV (%)		3.77	**G** × **TG** Interaction	0.013		0.04

Table 23: Total chlorophyll content (mg/g fresh weight) at 120 DAS in different cotton genotypes

Total chlorophyll content (mg/g fresh weight) at 120 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.63	Bunny (BG-I)	1.63	1.53	**1.58**
G_2	Bunny Non Bt	1.53				
G_3	RCH 368 Bt (BG-I)	1.21	RCH 368(BG-I)	1.21	1.32	**1.27**
G_4	RCH 368 Non Bt	1.33				
G_5	JK Durga Bt (BG-I)	1.24	JK Durga (BG-I)	1.23	1.37	**1.30**
G_6	JK Durga Non Bt	1.38				
G_7	Neeraja Bt (BG-II)	1.56	Neeraja (BG-II)	1.55	1.59	**1.57**
G_8	Neeraja Non Bt	1.59				
G_9	Sahana (Non-Bt variety)	0.91	**Mean**	**1.40**	**1.45**	**1.42**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.50	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.38**				
S.Em±		0.03	Genotype (**G**)	0.008		0.03
LSD (p=0.05)		0.08	Type of genotype (**TG**)	0.011		0.04
CV (%)		3.28	**G** × **TG** Interaction	0.016		0.05

Total chlorophyll content (mg/g fresh weight) at 120 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.58	Bunny (BG-I)	1.57	1.59	**1.54**
G_2	Bunny Non Bt	1.51				
G_3	RCH 368 Bt (BG-I)	1.14	RCH 368(BG-I)	1.13	1.32	**1.18**
G_4	RCH 368 Non Bt	1.23				
G_5	JK Durga Bt (BG-I)	1.37	JK Durga (BG-I)	1.36	1.37	**1.41**
G_6	JK Durga Non Bt	1.46				
G_7	Neeraja Bt (BG-II)	1.63	Neeraja (BG-II)	1.63	1.53	**1.63**
G_8	Neeraja Non Bt	1.63				
G_9	Sahana (Non-Bt variety)	1.18	**Mean**	**1.42**	**1.45**	**1.43**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.62	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.43**				
S.Em±		0.02	Genotype (**G**)	0.010		0.03
LSD (p=0.05)		0.07	Type of genotype (**TG**)	0.014		0.04
CV (%)		2.74	**G** × **TG** Interaction	0.020		0.06

Total chlorophyll content (mg/g fresh weight) (Pooled) at 120 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.60	Bunny (BG-I)	1.60	1.52	**1.56**
G_2	Bunny Non Bt	1.52				
G_3	RCH 368 Bt (BG-I)	1.17	RCH 368(BG-I)	1.17	1.41	**1.22**
G_4	RCH 368 Non Bt	1.41				
G_5	JK Durga Bt (BG-I)	1.30	JK Durga (BG-I)	1.30	1.28	**1.36**
G_6	JK Durga Non Bt	1.28				
G_7	Neeraja Bt (BG-II)	1.61	Neeraja (BG-II)	1.61	1.66	**1.64**
G_8	Neeraja Non Bt	1.66				
G_9	Sahana (Non-Bt variety)	1.04	**Mean**	**1.42**	**1.47**	**1.45**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.56	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.45**				
S.Em±		0.017	Genotype (**G**)	0.006		0.02
LSD (p=0.05)		0.05	Type of genotype (**TG**)	0.008		0.03
CV (%)		2.95	**G** × **TG** Interaction	0.012		0.04

Table 24: Anthocyanin content (mg/g fresh weight) at 60 DAS in different cotton genotypes

Anthocyanin content (mg/g fresh weight) at 60 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.031	Bunny (BG-I)	0.032	0.030	**0.031**
G_2	Bunny Non Bt	0.030				
G_3	RCH 368 Bt (BG-I)	0.031	RCH 368(BG-I)	0.032	0.032	**0.032**
G_4	RCH 368 Non Bt	0.031				
G_5	JK Durga Bt (BG-I)	0.031	JK Durga (BG-I)	0.031	0.032	**0.031**
G_6	JK Durga Non Bt	0.031				
G_7	Neeraja Bt (BG-II)	0.031	Neeraja (BG-II)	0.032	0.032	**0.032**
G_8	Neeraja Non Bt	0.031				
G_9	Sahana (Non-Bt variety)	0.032	**Mean**	**0.031**	**0.031**	**0.031**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.031	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.031**				
S.Em±		0.001	Genotype (**G**)	0.0004		NS
LSD (p=0.05)		NS	Type of genotype (**TG**)	0.0006		NS
CV (%)		5.07	**G** × **TG** Interaction	0.0008		NS
Anthocyanin content (mg/g fresh weight) at 60 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.032	Bunny (BG-I)	0.032	0.030	**0.031**
G_2	Bunny Non Bt	0.030				
G_3	RCH 368 Bt (BG-I)	0.032	RCH 368(BG-I)	0.032	0.032	**0.032**
G_4	RCH 368 Non Bt	0.031				
G_5	JK Durga Bt (BG-I)	0.032	JK Durga (BG-I)	0.032	0.032	**0.032**
G_6	JK Durga Non Bt	0.031				
G_7	Neeraja Bt (BG-II)	0.031	Neeraja (BG-II)	0.032	0.032	**0.032**
G_8	Neeraja Non Bt	0.031				
G_9	Sahana (Non-Bt variety)	0.032	**Mean**	**0.032**	**0.031**	**0.031**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.031	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.031**				
S.Em±		0.001	Genotype (**G**)	0.0004		NS
LSD (p=0.05)		NS	Type of genotype (**TG**)	0.005		NS
CV (%)		4.61	**G** × **TG** Interaction	0.007		NS
Anthocyanin content (mg/g fresh weight) (Pooled) at 60 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.30	Bunny (BG-I)	0.032	0.030	**0.031**
G_2	Bunny Non Bt	0.30				
G_3	RCH 368 Bt (BG-I)	0.30	RCH 368(BG-I)	0.032	0.032	**0.032**
G_4	RCH 368 Non Bt	0.30				
G_5	JK Durga Bt (BG-I)	0.30	JK Durga (BG-I)	0.01	0.032	**0.032**
G_6	JK Durga Non Bt	0.30				
G_7	Neeraja Bt (BG-II)	0.30	Neeraja (BG-II)	0.032	0.032	**0.032**
G_8	Neeraja Non Bt	0.30				
G_9	Sahana (Non-Bt variety)	0.30	**Mean**	**0.032**	**0.031**	**0.031**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.30	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.30**				
S.Em±		0.00	Genotype (**G**)	0.0003		NS
LSD (p=0.05)		NS	Type of genotype (**TG**)	0.0004		NS
CV (%)		0.00	G × TG Interaction	0.0006		NS

Table 25: Anthocyanin content (mg/g fresh weight) at 90 DAS in different cotton genotypes

Anthocyanin content (mg/g fresh weight) at 90 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.088	Bunny (BG-I)	0.088	0.032	**0.060**
G_2	Bunny Non Bt	0.032				
G_3	RCH 368 Bt (BG-I)	0.097	RCH 368(BG-I)	0.098	0.080	**0.089**
G_4	RCH 368 Non Bt	0.080				
G_5	JK Durga Bt (BG-I)	0.156	JK Durga (BG-I)	0.156	0.108	**0.132**
G_6	JK Durga Non Bt	0.108				
G_7	Neeraja Bt (BG-II)	0.089	Neeraja (BG-II)	0.089	0.079	**0.084**
G_8	Neeraja Non Bt	0.079				
G_9	Sahana (Non-Bt variety)	0.205	**Mean**	**0.10**	**0.07**	**0.08**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.184	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.111**				
S.Em±		0.001	Genotype (**G**)	0.007		0.021
LSD (p=0.05)		0.004	Type of genotype (**TG**)	0.010		0.003
CV (%)		2.00	**G** × **TG** Interaction	0.0014		0.004
Anthocyanin content (mg/g fresh weight) at 90 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.090	Bunny (BG-I)	0.090	0.025	**0.058**
G_2	Bunny Non Bt	0.025				
G_3	RCH 368 Bt (BG-I)	0.096	RCH 368(BG-I)	0.096	0.027	**0.062**
G_4	RCH 368 Non Bt	0.027				
G_5	JK Durga Bt (BG-I)	0.123	JK Durga (BG-I)	0.123	0.098	**0.111**
G_6	JK Durga Non Bt	0.098				
G_7	Neeraja Bt (BG-II)	0.095	Neeraja (BG-II)	0.095	0.073	**0.084**
G_8	Neeraja Non Bt	0.073				
G_9	Sahana (Non-Bt variety)	0.213	**Mean**	**0.10**	**0.05**	**0.075**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.089	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.029**				
S.Em±		0.001	Genotype (**G**)	0.0006		0.018
LSD (p=0.05)		0.003	Type of genotype (**TG**)	0.008		0.024
CV (%)		2.13	**G** × **TG** Interaction	0.012		0.004
Anthocyanin content (mg/g fresh weight) (Pooled) at 90 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.089	Bunny (BG-I)	0.089	0.029	**0.059**
G_2	Bunny Non Bt	0.029				
G_3	RCH 368 Bt (BG-I)	0.097	RCH 368(BG-I)	0.097	0.053	**0.075**
G_4	RCH 368 Non Bt	0.053				
G_5	JK Durga Bt (BG-I)	0.140	JK Durga (BG-I)	0.140	0.103	**0.121**
G_6	JK Durga Non Bt	0.103				
G_7	Neeraja Bt (BG-II)	0.092	Neeraja (BG-II)	0.092	0.076	**0.084**
G_8	Neeraja Non Bt	0.076				
G_9	Sahana (Non-Bt variety)	0.210	**Mean**	**0.104**	**0.065**	**0.084**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.140	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.100**				
S.Em±		0.001	Genotype (**G**)	0.0005		0.001
LSD (p=0.05)		0.004	Type of genotype (**TG**)	0.0007		0.020
CV (%)		3.13	**G** × **TG** Interaction	0.0010		0.003

Table 26: Anthocyanin content (mg/g fresh weight) at 120 DAS in different cotton genotypes

Anthocyanin content (mg/g fresh weight) at 120 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.205	Bunny (BG-I)	0.205	0.133	**0.169**
G_2	Bunny Non Bt	0.133				
G_3	RCH 368 Bt (BG-I)	0.226	RCH 368(BG-I)	0.226	0.133	**0.180**
G_4	RCH 368 Non Bt	0.133				
G_5	JK Durga Bt (BG-I)	0.226	JK Durga (BG-I)	0.218	0.159	**0.188**
G_6	JK Durga Non Bt	0.159				
G_7	Neeraja Bt (BG-II)	0.211	Neeraja (BG-II)	0.211	0.104	**0.158**
G_8	Neeraja Non Bt	0.104				
G_9	Sahana (Non-Bt variety)	0.247	**Mean**	**0.210**	**0.130**	**0.170**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.216	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.186**				
S.Em±		0.004	Genotype (**G**)	0.002		0.006
LSD (p=0.05)		0.011	Type of genotype (**TG**)	0.002		0.008
CV (%)		1.64	**G** × **TG** Interaction	0.004		0.012
Anthocyanin content (mg/g fresh weight) at 120 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.200	Bunny (BG-I)	0.200	0.082	**0.141**
G_2	Bunny Non Bt	0.082				
G_3	RCH 368 Bt (BG-I)	0.325	RCH 368(BG-I)	0.325	0.233	**0.279**
G_4	RCH 368 Non Bt	0.233				
G_5	JK Durga Bt (BG-I)	0.350	JK Durga (BG-I)	0.350	0.266	**0.308**
G_6	JK Durga Non Bt	0.266				
G_7	Neeraja Bt (BG-II)	0.162	Neeraja (BG-II)	0.162	0.082	**0.122**
G_8	Neeraja Non Bt	0.141				
G_9	Sahana (Non-Bt variety)	0.225	**Mean**	**0.250**	**0.180**	**0.215**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.156	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.214**				
S.Em±		0.006	Genotype (**G**)	0.002		0.008
LSD (p=0.05)		0.018	Type of genotype (**TG**)	0.004		0.012
CV (%)		5.00	**G** × **TG** Interaction	0.005		0.017
Anthocyanin content (mg/g fresh weight) (Pooled) at 120 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	0.202	Bunny (BG-I)	0.202	0.093	**0.148**
G_2	Bunny Non Bt	0.093				
G_3	RCH 368 Bt (BG-I)	0.284	RCH 368(BG-I)	0.280	0.183	**0.212**
G_4	RCH 368 Non Bt	0.242				
G_5	JK Durga Bt (BG-I)	0.280	JK Durga (BG-I)	0.284	0.212	**0.248**
G_6	JK Durga Non Bt	0.187				
G_7	Neeraja Bt (BG-II)	0.187	Neeraja (BG-II)	0.187	0.137	**0.162**
G_8	Neeraja Non Bt	0.137				
G_9	Sahana (Non-Bt variety)	0.275	**Mean**	**0.237**	**0.156**	**0.196**
G_{10}	DCH 32 (Non-Bt Hybrid)	0.196	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**0.204**				
S.Em±		0.004	Genotype (**G**)	0.001		0.005
LSD (p=0.05)		0.010	Type of genotype (**TG**)	0.002		0.008
CV (%)		4.540	**G** × **TG** Interaction	0.003		0.010

4.2.3.1 Correlation coefficient

Correlation coefficient (r) was worked out between seed cotton yield, chlorophyll content (SPAD reading), total chlorophyll content, anthocyanin content, red leaf index (RLI) as influenced by different treatments.

The data on correlation coefficient (r) analyzed between seed cotton yield and chlorophyll content (SPAD readings), total chlorophyll content, anthocyanin content and red leaf index (RLI) is presented in Table 28a and RLI with anthocyanin content, total chlorophyll content, red leaf index in Table 28b. Positive correlation existed between seed cotton yield and chlorophyll content (SPAD reading) at 90 DAS (r = 0.14), total chlorophyll content (r = 0.36 at 90 DAS and r = 0.34 at 120 DAS). However, negative correlation existed between seed cotton yield and anthocyanin content (r = -0.10 at 90 DAS and r = -0.09 at 120 DAS) and red leaf index (r = -0.26 at 90 DAS and r = -0.03 at 120 DAS). The red leaf index was significantly and negatively correlated with chlorophyll content (SPAD reading) at 120 DAS (r= -0.80) and total chlorophyll content at 120 DAS (r = -0.64). However, the red leaf index was positively and significantly correlated with anthocyanin content at 90 DAS (r = 0.69) and 120 DAS (r = 0.68).

4.2.4 Fibre quality parameters

Pooled and yearwise data pertaining to fibre quality parameters in different genotypes are presented in Tables 29, 30 and 31.

2.5% span length (mm)

Cotton genotypes differed significantly with respect to 2.5 per cent span length. DCH-32 non-Bt hybrid recorded significantly higher 2.5 per cent span length (33.82 mm) over other genotypes. There was no significant difference between Bt and non-Bt cotton genotypes with respect to 2.5 per cent span length. The lowest 2.5 per cent span length (30.90 mm) was observed with Sahana non-Bt variety.

Fibre fineness (micronair value)

Cotton genotypes differed significantly with respect to fibre fineness. Neeraja (BG II) Bt recorded significantly higher fibre fineness (4.56 micronaire) over other genotypes and it was on par with Neeraja non-Bt (4.36 micronaire). No significant difference was observed between Bt and non-Bt cotton genotypes. The lowest fibre fineness (3.70 micronaire) was noticed with DCH-32 non-Bt hybrid.

Bundle strength (g/tex)

Cotton genotypes differed significantly with respect to bundle strength, Neeraja non-Bt recorded higher bundle strength (25.60 g/tex) and it was on par with JK Durga (BG I) Bt (25.52 g/tex), DCH-32 non-Bt hybrid (25.42 g/tex) and JK Durga non-Bt (25.12 g/tex). There was no significant difference between Bt and non-Bt cotton genotypes with respect to bundle strength. The lowest bundle strength (23.83 g/tex) was recorded with RCH-368 (BG I) Bt.

4.2.5 Economic analysis

The pooled and yearwise data on economics of cultivation of Bt cotton genotypes and non-Bt cotton hybrid/variety are presented in Tables 32, 33, 34 and 35.

4.2.5.1 Cost of cultivation

The cost of cultivation was higher in Bt cotton cultivation (Rs. 24917/ha) than Sahana non-Bt variety (Rs. 24082/ha) and DCH-32 non-Bt hybrid (Rs. 24513/ha) (Table 32).

4.2.5.2 Gross return (Rs./ha)

The gross return in the study were in the range of Rs. 24968/ha to 54895/ha. Neeraja (BG II) Bt recorded significantly higher gross return (Rs. 54895/ha) compared to other genotypes. Compared to check, Neeraja (BG II) Bt produced 36 and 43 per cent higher gross return over DCH-32 non-Bt hybrid and Sahana non-Bt variety, respectively. Next best genotype is Bunny (BG I) Bt, recoded Rs.45826/ha.

Table 27: Red leaf index at 90 DAS in different cotton genotypes

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
Red leaf index at 60 DAS during 2007						
G_1	Bunny Bt (BG-I)	1.46 (1.67)	Bunny (BG-I)	1.46 (1.67)	1.34 (1.33)	1.40 (1.50)
G_2	Bunny Non Bt	1.34 (1.33)				
G_3	RCH 368 Bt (BG-I)	1.46 (1.33)	RCH 368(BG-I)	1.46 (1.33)	1.17 (1.67)	1.31 (1.50)
G_4	RCH 368 Non Bt	1.17 (1.67)				
G_5	JK Durga Bt (BG-I)	1.56 (1.00)	JK Durga (BG-I)	1.55 (1.00)	1.46 (1.67)	1.50 (1.34)
G_6	JK Durga Non Bt	1.46 (1.67)				
G_7	Neeraja Bt (BG-II)	1.05 (0.67)	Neeraja (BG-II)	1.05 (0.67)	1.05 (0.67)	1.05 (0.67)
G_8	Neeraja Non Bt	1.05 (0.67)				
G_9	Sahana (Non-Bt variety)	2.08 (3.33)	**Mean**	**1.38**	**1.25**	**1.31**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.46 (1.67)	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.40**				
S.Em±		0.17	Genotype (G)	0.08		NS
LSD (p=0.05)		0.50	Type of genotype (TG)	0.11		NS
CV (%)		13.86	G × TG Interaction	0.16		NS
Red leaf index at 90 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.05 (1.00)	Bunny (BG-I)	1.05 (1.00)	1.22 (0.67)	1.13 (1.11)
G_2	Bunny Non Bt	1.22 (0.67)				
G_3	RCH 368 Bt (BG-I)	1.34 (1.33)	RCH 368(BG-I)	1.34 (1.33)	1.22 (1.00)	1.28 (1.17)
G_4	RCH 368 Non Bt	1.22 (1.00)				
G_5	JK Durga Bt (BG-I)	1.46 (1.00)	JK Durga (BG-I)	1.46 (1.00)	1.17 (0.69)	1.31 (0.84)
G_6	JK Durga Non Bt	1.17 (0.67)				
G_7	Neeraja Bt (BG-II)	1.05 (0.67)	Neeraja (BG-II)	1.05 (0.67)	0.88 (0.67)	0.96 (0.67)
G_8	Neeraja Non Bt	0.88 (0.67)				
G_9	Sahana (Non-Bt variety)	1.68 (2.00)	**Mean**	**1.18**	**1.16**	**1.17**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.46 (1.67)	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.25**				
S.Em±		0.12	Genotype (G)	0.07		NS
LSD (p=0.05)		0.43	Type of genotype (TG)	0.10		NS
CV (%)		14.44	G × TG Interaction	0.14		NS
Red leaf index (Pooled) at 120 DAS (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.25 (1.34)	Bunny (BG-I)	1.25 (1.34)	1.28 (1.00)	1.26 (1.17)
G_2	Bunny Non Bt	1.28 (1.00)				
G_3	RCH 368 Bt (BG-I)	1.40 (1.33)	RCH 368(BG-I)	1.40 (1.33)	1.19 (1.34)	1.29 (1.34)
G_4	RCH 368 Non Bt	1.19 (1.34)				
G_5	JK Durga Bt (BG-I)	1.50 (1.00)	JK Durga (BG-I)	1.50 (1.00)	1.31 (1.17)	1.41 (1.09)
G_6	JK Durga Non Bt	1.31 (1.17)				
G_7	Neeraja Bt (BG-II)	1.05 (0.67)	Neeraja (BG-II)	1.05 (0.67)	0.96 (0.67)	1.08 (0.67)
G_8	Neeraja Non Bt	0.96 (0.67)				
G_9	Sahana (Non-Bt variety)	1.88 (2.67)	**Mean**	**1.28**	**1.21**	**1.25**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.46 (1.67)	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.32**				
S.Em±		0.11	Genotype (G)	0.05		NS
LSD (p=0.05)		0.31	Type of genotype (TG)	0.07		NS
CV (%)		19.93	G × TG Interaction	0.10		NS

* Figures in the paranthesis indicate the original values and analysed data are Öx + 0.5 transformed values.

Table 28: Red leaf index at 120 DAS in different cotton genotypes

Red leaf index at 120 DAS during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.87 (3.00)	Bunny (BG-I)	1.87 (3.00)	1.67 (2.50)	**1.77**
G_2	Bunny Non Bt	1.67 (2.50)				
G_3	RCH 368 Bt (BG-I)	1.87 (3.00)	RCH 368(BG-I)	1.87 (3.00)	1.58 (2.00)	**1.73**
G_4	RCH 368 Non Bt	1.58 (2.00)				
G_5	JK Durga Bt (BG-I)	1.77 (2.67)	JK Durga (BG-I)	1.77 (2.67)	1.77 (2.67)	**1.77**
G_6	JK Durga Non Bt	1.77 (2.67)				
G_7	Neeraja Bt (BG-II)	1.58 (2.00)	Neeraja (BG-II)	1.58 (2.00)	1.58 (2.00)	**1.58**
G_8	Neeraja Non Bt	1.58 (2.00)				
G_9	Sahana (Non-Bt variety)	1.95 (2.50)	**Mean**	**1.77**	**1.65**	**1.71**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.77 ()	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.74**				
S.Em±		0.07	Genotype (**G**)	0.02		0.09
LSD (p=0.05)		0.20	Type of genotype (**TG**)	0.04		0.13
CV (%)		6.71	**G** × **TG** Interaction	0.05		0.18
Red leaf index at 120 DAS during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.77 (2.67)	Bunny (BG-I)	1.77 (2.67)	1.68 (1.67)	**1.73**
G_2	Bunny Non Bt	1.68 (1.67)				
G_3	RCH 368 Bt (BG-I)	2.08 (3.33)	RCH 368(BG-I)	2.08 (3.33)	1.68 (2.33)	**1.87**
G_4	RCH 368 Non Bt	1.68 (2.33)				
G_5	JK Durga Bt (BG-I)	2.08 (3.33)	JK Durga (BG-I)	2.08 (3.33)	1.68 (2.33)	**1.87**
G_6	JK Durga Non Bt	1.68 (2.33)				
G_7	Neeraja Bt (BG-II)	1.58 (2.00)	Neeraja (BG-II)	1.58 (2.00)	1.46 (2.33)	**1.51**
G_8	Neeraja Non Bt	1.46 (2.33)				
G_9	Sahana (Non-Bt variety)	2.29 (3.67)	**Mean**	**1.87**	**1.62**	**1.74**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.87 (3.00)	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.81**				
S.Em±		0.40	Genotype (**G**)	0.06		0.20
LSD (p=0.05)		0.55	Type of genotype (**TG**)	0.09		0.28
CV (%)		12.82	**G** × **TG** Interaction	0.13		0.40
Red leaf index (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	1.82 (2.84)	Bunny (BG-I)	1.82 (2.44)	1.67 (2.01)	**1.74**
G_2	Bunny Non Bt	1.67 (2.01)				
G_3	RCH 368 Bt (BG-I)	1.97 (3.12)	RCH 368(BG-I)	1.97 (3.12)	1.62 (2.17)	**1.78**
G_4	RCH 368 Non Bt	1.62 (2.17)				
G_5	JK Durga Bt (BG-I)	1.92 (2.56)	JK Durga (BG-I)	1.92 (2.56)	1.72 (2.50)	**1.82**
G_6	JK Durga Non Bt	1.72 (2.50)				
G_7	Neeraja Bt (BG-II)	1.58 (2.00)	Neeraja (BG-II)	1.58 (2.00)	1.52 (2.00)	**1.55**
G_8	Neeraja Non Bt	1.52 (2.17)				
G_9	Sahana (Non-Bt variety)	2.12 (3.09)	**Mean**	**1.82**	**1.63**	**1.72**
G_{10}	DCH 32 (Non-Bt Hybrid)	1.82 (2.75)	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**1.77**				
S.Em±		0.074	Genotype (**G**)	0.03		0.11
LSD (p=0.05)		0.21	Type of genotype (**TG**)	0.05		0.16
CV (%)		10.18	**G** × **TG** Interaction	0.07		0.22

Note: * Figures in the paranthesis indicate the original values and analysed data are Öx + 0.5 transformed values.

Table 28a: Correlation coefficient (r) between seed cotton yield and chlorophyll content in leaf (SPAD reading), total chlorophyll content, anthocyanin content and red leaf index in different cotton genotypes (mean of 2007-08 and 2008-09)

Variable	Growth stage	Correlation coefficient (r)
SPAD reading	90 DAS	0.14
	120 DAS	-0.04
Total chlorophyll content	90 DAS	0.36
	120 DAS	0.34
Anthocyanin content	90 DAS	-0.10
	120 DAS	-0.09
Red leaf index	90 DAS	-0.26
	120 DAS	-0.03

** - Significant at 1% * - Significant at 5%

Table 28b: Correlation coefficient (r) between red leaf index (RLI) at 120 DAS and chlorophyll content in leaf (SPAD reading), total chlorophyll content and anthocyanin content in different cotton genotypes (mean of 2007-08 and 2008-09)

Variable	Growth stage	Correlation coefficient (r)
SPAD reading	90 DAS	-0.35
	120 DAS	-0.80**
Total chlorophyll content	90 DAS	-0.43
	120 DAS	-0.64*
Anthocyanin content	90 DAS	0.69*
	120 DAS	0.68*

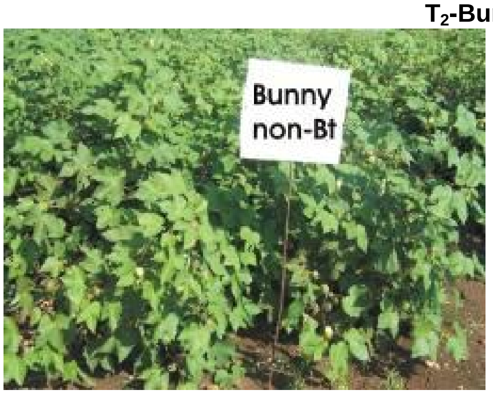
** - Significant at 1% * - Significant at 5%

T_1-Bunny (BG I) Bt

At 120 DAS

At harvest

T_2-Bunny non-Bt



At 120 DAS

At harvest

Plate 4: Photograph showing the treatment difference between Bunny (BG I) Bt and Bunny non-Bt cotton genotypes

T_3-RCH-368 (BG I) Bt

At 120 DAS

At harvest

T_4-RCH-368 non-Bt

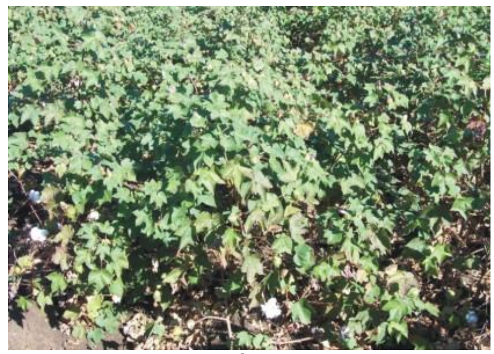
AT 120 DAS

At harvest

Plate 5: Photograph showing the treatment difference between RCH-368 Bt and RCH-368 non-Bt cotton genotypes

T_5-JK Durga (BG I) Bt

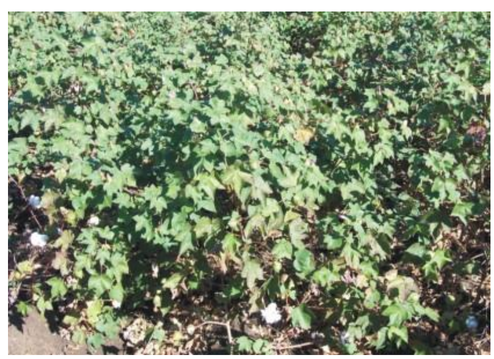
At 120 DAS



At harvest

T_6-JK Durga non-Bt

At 120 DAS



At harvest

Plate 6: Photograph showing the treatment difference between JK Durga Bt and JK Durga non-Bt cotton genotypes

T_7-Neeraja (BG II) Bt

At 120 DAS

At harvest

T_8-Neeraja non-Bt

At 120 DAS

At harvest

Plate 7: Photograph showing the treatment difference between Neeraja (BG II) Bt and Neeraja non-Bt cotton genotypes

T_9-Sahana (non-Bt variety check)

At 120 DAS

At harvest

T_{10}-DCH-32 (non-Bt hybrid check)

At 120 DAS

At harvest

Plate 8: Photograph showing the treatment difference between Sahana non-Bt variety and DCH-32 non-Bt hybrid cotton genotypes

Table 29: 2.5% span length (mm) in different cotton genotypes

2.5% span length (mm) during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	32.32	Bunny (BG-I)	32.32	32.30	**32.31**
G_2	Bunny Non Bt	32.30				
G_3	RCH 368 Bt (BG-I)	32.50	RCH 368(BG-I)	32.50	31.93	**32.22**
G_4	RCH 368 Non Bt	31.93				
G_5	JK Durga Bt (BG-I)	32.32	JK Durga (BG-I)	32.32	32.83	**32.58**
G_6	JK Durga Non Bt	32.83				
G_7	Neeraja Bt (BG-II)	32.78	Neeraja (BG-II)	32.78	32.03	**32.41**
G_8	Neeraja Non Bt	32.03				
G_9	Sahana (Non-Bt variety)	31.00	**Mean**	**32.48**	**32.28**	**32.38**
G_{10}	DCH 32 (Non-Bt Hybrid)	33.98	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**32.39**				
S.Em±		0.574	Genotype (**G**)	0.202		NS
LSD (p=0.05)		NS	Type of genotype (**TG**)	0.285		NS
CV (%)		3.07	**G** × **TG** Interaction	0.403		NS

2.5% span length (mm) during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	32.45	Bunny (BG-I)	32.45	32.10	**32.28**
G_2	Bunny Non Bt	32.10				
G_3	RCH 368 Bt (BG-I)	32.80	RCH 368(BG-I)	32.80	31.80	**32.30**
G_4	RCH 368 Non Bt	31.80				
G_5	JK Durga Bt (BG-I)	32.15	JK Durga (BG-I)	32.15	33.00	**32.58**
G_6	JK Durga Non Bt	33.00				
G_7	Neeraja Bt (BG-II)	32.45	Neeraja (BG-II)	32.45	31.80	**32.13**
G_8	Neeraja Non Bt	31.80				
G_9	Sahana (Non-Bt variety)	30.80	**Mean**	**32.46**	**32.18**	**32.32**
G_{10}	DCH 32 (Non-Bt Hybrid)	33.65	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**32.30**				
S.Em±		0.561	Genotype (**G**)	0.143		0.41
LSD (p=0.05)		NS	Type of genotype (**TG**)	0.202		NS
CV (%)		3.01	**G** × **TG** Interaction	0.285		0.83

2.5% span length (mm) (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	32.31	Bunny (BG-I)	32.31	32.28	**32.29**
G_2	Bunny Non Bt	32.28				
G_3	RCH 368 Bt (BG-I)	32.22	RCH 368(BG-I)	32.22	32.30	**32.26**
G_4	RCH 368 Non Bt	32.30				
G_5	JK Durga Bt (BG-I)	32.58	JK Durga (BG-I)	32.41	32.58	**32.49**
G_6	JK Durga Non Bt	32.41				
G_7	Neeraja Bt (BG-II)	32.58	Neeraja (BG-II)	32.58	32.13	**32.35**
G_8	Neeraja Non Bt	32.13				
G_9	Sahana (Non-Bt variety)	30.90	**Mean**	**32.47**	**32.23**	**32.35**
G_{10}	DCH 32 (Non-Bt Hybrid)	33.82	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**32.53**				
S.Em±		0.301	Genotype (**G**)	0.123		NS
LSD (p=0.05)		0.91	Type of genotype (**TG**)	0.175		NS
CV (%)		1.61	**G** × **TG** Interaction	0.247		NS

Table 30: Fibre fineness (micronair value) in different cotton genotypes

Fibre fineness (micronair value) during 2007

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	4.22	Bunny (BG-I)	4.22	3.95	**4.08**
G_2	Bunny Non Bt	3.94				
G_3	RCH 368 Bt (BG-I)	4.72	RCH 368(BG-I)	4.25	4.48	**4.37**
G_4	RCH 368 Non Bt	4.46				
G_5	JK Durga Bt (BG-I)	3.88	JK Durga (BG-I)	3.88	3.96	**3.92**
G_6	JK Durga Non Bt	3.96				
G_7	Neeraja Bt (BG-II)	4.25	Neeraja (BG-II)	4.72	4.46	**4.59**
G_8	Neeraja Non Bt	4.48				
G_9	Sahana (Non-Bt variety)	4.00	**Mean**	**4.27**	**4.21**	**4.24**
G_{10}	DCH 32 (Non-Bt Hybrid)	3.93	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**4.18**				
S.Em±		0.073	Genotype (**G**)	0.031		0.09
LSD (p=0.05)		0.218	Type of genotype (**TG**)	0.044		NS
CV (%)		3.04	**G** × **TG** Interaction	0.062		0.18

Fibre fineness (micronair value) during 2008

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	4.07	Bunny (BG-I)	4.07	4.05	**4.06**
G_2	Bunny Non Bt	4.05				
G_3	RCH 368 Bt (BG-I)	4.05	RCH 368(BG-I)	4.05	4.12	**4.09**
G_4	RCH 368 Non Bt	4.12				
G_5	JK Durga Bt (BG-I)	4.03	JK Durga (BG-I)	4.03	4.13	**4.08**
G_6	JK Durga Non Bt	4.13				
G_7	Neeraja Bt (BG-II)	4.40	Neeraja (BG-II)	4.40	4.25	**4.33**
G_8	Neeraja Non Bt	4.25				
G_9	Sahana (Non-Bt variety)	4.07	**Mean**	**4.14**	**4.14**	**4.14**
G_{10}	DCH 32 (Non-Bt Hybrid)	3.47	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**4.06**				
S.Em±		0.148	Genotype (**G**)	0.076		0.22
LSD (p=0.05)		0.439	Type of genotype (**TG**)	0.107		NS
CV (%)		6.30	**G** × **TG** Interaction	0.151		0.44

Fibre fineness (micronair value) (Pooled) (Mean of 2007 and 2008)

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	4.14	Bunny (BG-I)	4.14	4.00	**4.07**
G_2	Bunny Non Bt	4.00				
G_3	RCH 368 Bt (BG-I)	4.15	RCH 368(BG-I)	4.15	4.30	**4.23**
G_4	RCH 368 Non Bt	4.30				
G_5	JK Durga Bt (BG-I)	3.96	JK Durga (BG-I)	3.96	4.05	**4.00**
G_6	JK Durga Non Bt	4.05				
G_7	Neeraja Bt (BG-II)	4.56	Neeraja (BG-II)	4.56	4.36	**4.46**
G_8	Neeraja Non Bt	4.36				
G_9	Sahana (Non-Bt variety)	4.03	**Mean**	**4.20**	**4.18**	**4.19**
G_{10}	DCH 32 (Non-Bt Hybrid)	3.70	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**4.12**				
S.Em±		0.065	Genotype (**G**)	0.041		0.12
LSD (p=0.05)		0.194	Type of genotype (**TG**)	0.058		NS
CV (%)		2.74	**G** × **TG** Interaction	0.082		0.24

Table 31: Bundle strength (g/tex) in different cotton genotypes

Bundle strength (g/tex) during 2007

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	24.75	Bunny (BG-I)	24.75	24.55	**24.65**
G_2	Bunny Non Bt	24.55				
G_3	RCH 368 Bt (BG-I)	23.64	RCH 368(BG-I)	23.60	24.15	**23.90**
G_4	RCH 368 Non Bt	24.15				
G_5	JK Durga Bt (BG-I)	24.46	JK Durga (BG-I)	24.46	25.48	**24.97**
G_6	JK Durga Non Bt	25.48				
G_7	Neeraja Bt (BG-II)	25.95	Neeraja (BG-II)	25.95	25.30	**25.63**
G_8	Neeraja Non Bt	25.30				
G_9	Sahana (Non-Bt variety)	24.77	**Mean**	**24.70**	**24.81**	**24.75**
G_{10}	DCH 32 (Non-Bt Hybrid)	25.72	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**24.87**				
S.Em±		0.309	Genotype (**G**)	0.172		0.50
LSD (p=0.05)		0.918	Type of genotype (**TG**)	0.243		NS
CV (%)		2.15	**G** × **TG** Interaction	0.344		1.01

Bundle strength (g/tex) during 2008

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	24.13	Bunny (BG-I)	24.13	23.42	**23.77**
G_2	Bunny Non Bt	23.42				
G_3	RCH 368 Bt (BG-I)	24.03	RCH 368(BG-I)	24.03	24.36	**24.19**
G_4	RCH 368 Non Bt	24.36				
G_5	JK Durga Bt (BG-I)	25.09	JK Durga (BG-I)	25.09	24.76	**24.93**
G_6	JK Durga Non Bt	24.76				
G_7	Neeraja Bt (BG-II)	25.91	Neeraja (BG-II)	25.91	24.53	**25.22**
G_8	Neeraja Non Bt	24.53				
G_9	Sahana (Non-Bt variety)	24.50	**Mean**	**24.79**	**24.27**	**24.53**
G_{10}	DCH 32 (Non-Bt Hybrid)	25.13	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**24.58**				
S.Em±		0.276	Genotype (**G**)	0.151		0.44
LSD (p=0.05)		0.819	Type of genotype (**TG**)	0.214		NS
CV (%)		1.94	**G** × **TG** Interaction	0.303		0.88

Bundle strength (g/tex) (Pooled) (Mean of 2007 and 2008)

Cotton genotypes			Cotton genotypes	Bt	Non Bt	Mean
G_1	Bunny Bt (BG-I)	24.44	Bunny (BG-I)	24.44	23.98	**24.21**
G_2	Bunny Non Bt	23.98				
G_3	RCH 368 Bt (BG-I)	23.83	RCH 368(BG-I)	23.83	24.25	**24.04**
G_4	RCH 368 Non Bt	24.25				
G_5	JK Durga Bt (BG-I)	25.52	JK Durga (BG-I)	25.52	25.12	**25.32**
G_6	JK Durga Non Bt	25.12				
G_7	Neeraja Bt (BG-II)	24.49	Neeraja (BG-II)	25.60	24.49	**25.05**
G_8	Neeraja Non Bt	25.60				
G_9	Sahana (Non-Bt variety)	24.63	**Mean**	**24.84**	**24.46**	**24.65**
G_{10}	DCH 32 (Non-Bt Hybrid)	25.42	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**24.72**				
S.Em±		0.233	Genotype (**G**)	0.115		0.33
LSD (p=0.05)		0.74	Type of genotype (**TG**)	0.162		NS
CV (%)		1.64	**G** × **TG** Interaction	0.229		0.66

The lowest gross return (Rs. 24968/ha) was recoded with RCH-368 non-Bt cotton. Cultivation of Bt cotton genotypes given significantly higher gross return (Rs.43698/ha) compared to non-Bt cotton genotypes (Rs.27804/ha) (Table 33).

4.2.5.3 Net return (Rs./ha)

Cotton genotypes differed significantly with respect to net return. The net return in the study were in the range of Rs. 1950/ha to 28832/ha. Neeraja (BG II) Bt cotton cultivation recorded significantly higher net return (Rs. 28832/ha) than other genotypes. Neeraja (BG II) Bt produced 63 and 75 per cent higher net return over DCH-32 non-Bt hybrid and Sahana non-Bt variety. Significantly highest net return (Rs. 18780/ha) was recorded with Bt genotypes cultivation than non-Bt cotton genotypes cultivation (Rs. 4491/ha). The lowest net return (Rs. 1950/ha) was obtained with RCH 368 non-Bt cotton cultivation.

4.2.5.4 Benefit Cost (BC) ratio

Benefit cost ratio differed significantly among different cotton genotypes (Table 35). Benefit:Cost ratios were in the range of 1.09 to 2.11 rupee per rupee invested. Neeraja (BG II) Bt recorded significantly higher benefit:cost ratio (2.11) than the other cotton genotypes and was followed by Bunny (BGI) Bt (1.82). Neeraja (BG II) Bt recorded 32 and 39 per cent higher BC ratios over DCH 32 non-Bt hybrid and Sahana non-Bt variety, respectively. There was no significant difference observed between cultivation of Bt and non-Bt cotton genotypes with respect to benefit:cost ratio. The lowest benefit:cost ratio (1.09) was recorded with RCH-368 non-Bt.

4.3 Experiment-2: Studies on nutrient management to overcome leaf reddening in Bt cotton

4.3.1 Biometric observations

4.3.1.1 Seed cotton yield (kg/ha)

Pooled and yearwise data on seed cotton yield per hectare as influenced by different treatments is presented in Table 36. Significant differences were observed among the treatments. Based on the pooled and yearwise data, foliar application of KNO_3 @ 2% (T_5) recorded significantly higher seed cotton yield (2543 kg/ha) than other treatments and it was on par with T_{10} and T_9 treatments i.e., soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (2522 kg/ha) and soil application of $MgSO_4$ @ 25 kg/ha (2517 kg/ha). The yield levels obtained in T_5, T_{10} and T_9 were 25.0, 24.7 and 24.7 per cent higher compared to the RDF treatment (T_{12}). The lowest seed cotton yield (1383 kg/ha) was recorded with polyethylene mulching.

Split application of 90 per cent recommended nitrogen (10% basal) in six equal splits resulted in seed cotton yield advantage of per cent with 9 to 33 (T_1) over recommended nitrogen application (50% basal and remaining 50% in equal 3 splits) (T_3).

The same three treatments recorded similar trends of higher yields in 2007 but in 2008 little changes in their ranking was observed in these treatments. The lower yield in RDF treatment (T_{12}) was seen in both 2007 and 2008.

4.3.1.2 Boll weight (g/boll)

Data on boll weight (g/boll) as influenced by different treatments during 2007, 2008 and pooled are presented in Table 36. The boll weight differed significantly among the different treatments. The mean boll weight of two years (4.96 g/boll) increased significantly with the soil application of $MgSO_4$ @ 25 kg/ha along with $MgSO_4$ @1% foliar application (T_{10}) and it was on par with foliar application of KNO_3 @ 2% (T_5) which recorded 4.85 g/boll and soil application of $MgSO_4$ @ 25 kg/ha treatment (T_9) which had 4.81 g/boll. Compared to RDF these three treatments (T_{10}, T_5 and T_9) recorded 20.1, 18.0 and 17.7 per cent higher boll weight. The lowest boll weight (2.91 g/boll) was recorded with polyethylene mulching.

4.3.1.3 Seed cotton yield (g) per plant

Data on seed cotton yield (g) per plant is presented in Table 36. The seed cotton yield per plant differed significantly among the treatments.

Table 32: Cost of cultivation (Rs./ha) in different cotton genotypes

Cost of cultivation (Rs./ha) during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	24514	Bunny (BG-I)	24514	23016	**23765**
G_2	Bunny Non Bt	23016				
G_3	RCH 368 Bt (BG-I)	24094	RCH 368(BG-I)	24094	22834	**23464**
G_4	RCH 368 Non Bt	22834				
G_5	JK Durga Bt (BG-I)	24200	JK Durga (BG-I)	24200	23002	**23601**
G_6	JK Durga Non Bt	23002				
G_7	Neeraja Bt (BG-II)	25516	Neeraja (BG-II)	25516	23212	**24364**
G_8	Neeraja Non Bt	23212				
G_9	Sahana (Non-Bt variety)	24220	**Mean**	**24581**	**23016**	**23799**
G_{10}	DCH 32 (Non-Bt Hybrid)	24373	**Comparing the means** 24152	**S.Em±**		**LSD (p=0.05)**
Mean		**23898**				
S.Em±		-	Genotype (**G**)	-		
LSD (p=0.05)		-	Type of genotype (**TG**)	-		
CV (%)		-	**G** × **TG** Interaction	-		

Cost of cultivation (Rs./ha) during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	25800	Bunny (BG-I)	25800	23776	**24788**
G_2	Bunny Non Bt	23776				
G_3	RCH 368 Bt (BG-I)	24370	RCH 368(BG-I)	24370	23201	**23786**
G_4	RCH 368 Non Bt	23201				
G_5	JK Durga Bt (BG-I)	24235	JK Durga (BG-I)	24235	23529	**23882**
G_6	JK Durga Non Bt	23529				
G_7	Neeraja Bt (BG-II)	26610	Neeraja (BG-II)	26610	23931	**25271**
G_8	Neeraja Non Bt	23931				
G_9	Sahana (Non-Bt variety)	23945	**Mean**	**25254**	**23609**	**24432**
G_{10}	DCH 32 (Non-Bt Hybrid)	24653	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**24405**				
S.Em±		-	Genotype (**G**)	-		
LSD (p=0.05)		-	Type of genotype (**TG**)	-		
CV (%)		-	**G** × **TG** Interaction	-		

Cost of cultivation (Rs./ha) (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	25157	Bunny (BG-I)	25157	23396	**24276**
G_2	Bunny Non Bt	23396				
G_3	RCH 368 Bt (BG-I)	24232	RCH 368(BG-I)	24232	23018	**23625**
G_4	RCH 368 Non Bt	23018				
G_5	JK Durga Bt (BG-I)	24217	JK Durga (BG-I)	24217	23266	**23742**
G_6	JK Durga Non Bt	23266				
G_7	Neeraja Bt (BG-II)	26063	Neeraja (BG-II)	26063	23571	**24817**
G_8	Neeraja Non Bt	23571				
G_9	Sahana (Non-Bt variety)	24082	**Mean**	**24917**	**23299**	**24108**
G_{10}	DCH 32 (Non-Bt Hybrid)	24513	**Comparing the means** 24152	**S.Em±**		**LSD (p=0.05)**
Mean		**24298**				
S.Em±		-	Genotype (**G**)	-		
LSD (p=0.05)		-	Type of genotype (**TG**)	-		
CV (%)		-	**G** × **TG** Interaction	-		

Table 33: Gross return (Rs./ha) in different cotton genotypes

Gross return (Rs./ha) during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	43939	Bunny (BG-I)	43939	27828	**35884**
G_2	Bunny Non Bt	27828				
G_3	RCH 368 Bt (BG-I)	39417	RCH 368(BG-I)	39417	25872	**32644**
G_4	RCH 368 Non Bt	25872				
G_5	JK Durga Bt (BG-I)	40556	JK Durga (BG-I)	40556	27685	**34121**
G_6	JK Durga Non Bt	27685				
G_7	Neeraja Bt (BG-II)	54710	Neeraja (BG-II)	54710	29942	**42326**
G_8	Neeraja Non Bt	29942				
G_9	Sahana (Non-Bt variety)	35934	**Mean**	**44656**	**27832**	**36244**
G_{10}	DCH 32 (Non-Bt Hybrid)	37582	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**36346**				
S.Em±		1851	Genotype (**G**)	1018		2950
LSD (p=0.05)		5500	Type of genotype (**TG**)	1440		4173
CV (%)		8.82	**G** × **TG** Interaction	2037		5901
Gross return (Rs./ha during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	47713	Bunny (BG-I)	47713	29296	**38504**
G_2	Bunny Non Bt	29296				
G_3	RCH 368 Bt (BG-I)	34699	RCH 368(BG-I)	34699	24064	**29382**
G_4	RCH 368 Non Bt	24064				
G_5	JK Durga Bt (BG-I)	33466	JK Durga (BG-I)	33466	27045	**30256**
G_6	JK Durga Non Bt	27045				
G_7	Neeraja Bt (BG-II)	55080	Neeraja (BG-II)	55080	30700	**42890**
G_8	Neeraja Non Bt	30700				
G_9	Sahana (Non-Bt variety)	26185	**Mean**	**42740**	**27776**	**35258**
G_{10}	DCH 32 (Non-Bt Hybrid)	32635	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**34088**				
S.Em±		3428	Genotype (**G**)	1693		4904
LSD (p=0.05)		10186	Type of genotype (**TG**)	2394		6936
CV (%)		17.42	**G** × **TG** Interaction	3386		9809
Gross return (Rs./ha) (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	45826	Bunny (BG-I)	45826	28562	**37194**
G_2	Bunny Non Bt	28562				
G_3	RCH 368 Bt (BG-I)	37058	RCH 368(BG-I)	37058	24968	**31013**
G_4	RCH 368 Non Bt	24968				
G_5	JK Durga Bt (BG-I)	37011	JK Durga (BG-I)	37011	27365	**32188**
G_6	JK Durga Non Bt	27365				
G_7	Neeraja Bt (BG-II)	54895	Neeraja (BG-II)	54895	30321	**42608**
G_8	Neeraja Non Bt	30321				
G_9	Sahana (Non-Bt variety)	31060	**Mean**	**43698**	**27804**	**35751**
G_{10}	DCH 32 (Non-Bt Hybrid)	35109	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**35217**				
S.Em±		1872	Genotype (**G**)	988		2862
LSD (p=0.05)		5561	Type of genotype (**TG**)	1397		4047
CV (%)		9.20	**G** × **TG** Interaction	1976		5723

Table 34: Net return (Rs./ha) in different cotton genotypes

Net return (Rs./ha) during 2007						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	19425	Bunny (BG-I)	19425	4813	**12119**
G_2	Bunny Non Bt	4813				
G_3	RCH 368 Bt (BG-I)	15323	RCH 368(BG-I)	15323	3038	**9181**
G_4	RCH 368 Non Bt	3038				
G_5	JK Durga Bt (BG-I)	16357	JK Durga (BG-I)	16357	4682	**10520**
G_6	JK Durga Non Bt	4682				
G_7	Neeraja Bt (BG-II)	29194	Neeraja (BG-II)	29194	6730	**17962**
G_8	Neeraja Non Bt	6730				
G_9	Sahana (Non-Bt variety)	11714	**Mean**	**20075**	**4816**	**12445**
G_{10}	DCH 32 (Non-Bt Hybrid)	13209	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**12448**				
S.Em±		1851	Genotype (**G**)	1018		2950
LSD (p=0.05)		5500	Type of genotype (**TG**)	1440		4173
CV (%)		25.76	**G** × **TG** Interaction	2037		5901
Net return (Rs./ha) during 2008						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	21913	Bunny (BG-I)	21913	5519	**13716**
G_2	Bunny Non Bt	5519				
G_3	RCH 368 Bt (BG-I)	10329	RCH 368(BG-I)	10329	863	**5596**
G_4	RCH 368 Non Bt	863				
G_5	JK Durga Bt (BG-I)	9232	JK Durga (BG-I)	9232	3516	**6374**
G_6	JK Durga Non Bt	3516				
G_7	Neeraja Bt (BG-II)	28470	Neeraja (BG-II)	28470	6770	**17620**
G_8	Neeraja Non Bt	6770				
G_9	Sahana (Non-Bt variety)	2241	**Mean**	**17486**	**4167**	**10826**
G_{10}	DCH 32 (Non-Bt Hybrid)	7982	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**9683**				
S.Em±		3428	Genotype (**G**)	1693		4904
LSD (p=0.05)		10186	Type of genotype (**TG**)	2394		6936
CV (%)		61.32	**G** × **TG** Interaction	3386		9809
Net return (Rs./ha) (Pooled) (Mean of 2007 and 2008)						
Cotton genotypes			**Cotton genotypes**	**Bt**	**Non Bt**	**Mean**
G_1	Bunny Bt (BG-I)	20669	Bunny (BG-I)	20669	5166	**12917**
G_2	Bunny Non Bt	5166				
G_3	RCH 368 Bt (BG-I)	12826	RCH 368(BG-I)	12826	1950	**7388**
G_4	RCH 368 Non Bt	1950				
G_5	JK Durga Bt (BG-I)	12794	JK Durga (BG-I)	12794	4099	**8447**
G_6	JK Durga Non Bt	4099				
G_7	Neeraja Bt (BG-II)	28832	Neeraja (BG-II)	28832	6750	**17791**
G_8	Neeraja Non Bt	6750				
G_9	Sahana (Non-Bt variety)	6977	**Mean**	**18780**	**4491**	**11635**
G_{10}	DCH 32 (Non-Bt Hybrid)	10595	**Comparing the means**	**S.Em±**		**LSD (p=0.05)**
Mean		**11065**				
S.Em±		1872	Genotype (**G**)	988		2862
LSD (p=0.05)		5561	Type of genotype (**TG**)	1397		4047
CV (%)		29.29	**G** × **TG** Interaction	1976		5723

Table 35: BC ratio in different cotton genotypes

BC ratio during 2007

	Cotton genotypes	
G_1	Bunny Bt (BG-I)	1.79
G_2	Bunny Non Bt	1.21
G_3	RCH 368 Bt (BG-I)	1.64
G_4	RCH 368 Non Bt	1.13
G_5	JK Durga Bt (BG-I)	1.68
G_6	JK Durga Non Bt	1.20
G_7	Neeraja Bt (BG-II)	2.14
G_8	Neeraja Non Bt	1.29
G_9	Sahana (Non-Bt variety)	1.48
G_{10}	DCH 32 (Non-Bt Hybrid)	1.54
	Mean	**1.51**
	S.Em±	0.077
	LSD (p=0.05)	0.230
	CV (%)	8.88

Cotton genotypes	Bt	Non Bt	Mean
Bunny (BG-I)	1.79	1.21	**1.50**
RCH 368(BG-I)	1.64	1.13	**1.39**
JK Durga (BG-I)	1.68	1.21	**1.44**
Neeraja (BG-II)	2.15	1.29	**1.72**
Mean	**1.81**	**1.21**	**1.51**

Comparing the means	S.Em±	LSD (p=0.05)
Genotype (**G**)	0.043	0.12
Type of genotype (**TG**)	0.060	0.17
G × **TG** Interaction	0.085	0.25

BC ratio during 2008

	Cotton genotypes	
G_1	Bunny Bt (BG-I)	1.85
G_2	Bunny Non Bt	1.23
G_3	RCH 368 Bt (BG-I)	1.42
G_4	RCH 368 Non Bt	1.04
G_5	JK Durga Bt (BG-I)	1.38
G_6	JK Durga Non Bt	1.15
G_7	Neeraja Bt (BG-II)	2.07
G_8	Neeraja Non Bt	1.28
G_9	Sahana (Non-Bt variety)	1.09
G_{10}	DCH 32 (Non-Bt Hybrid)	1.32
	Mean	**1.38**
	S.Em±	0.142
	LSD (p=0.05)	0.421
	CV (%)	17.75

Cotton genotypes	Bt	Non Bt	Mean
Bunny (BG-I)	1.85	1.23	**1.54**
RCH 368(BG-I)	1.42	1.04	**1.23**
JK Durga (BG-I)	1.38	1.15	**1.26**
Neeraja (BG-II)	2.07	1.28	**1.68**
Mean	**1.68**	**1.18**	**1.43**

Comparing the means	S.Em±	LSD (p=0.05)
Genotype (**G**)	0.071	0.20
Type of genotype (**TG**)	0.099	0.29
G × **TG** Interaction	0.1397	0.41

BC ratio (Pooled) (Mean of 2007 and 2008)

	Cotton genotypes	
G_1	Bunny Bt (BG-I)	1.82
G_2	Bunny Non Bt	1.22
G_3	RCH 368 Bt (BG-I)	1.53
G_4	RCH 368 Non Bt	1.09
G_5	JK Durga Bt (BG-I)	1.53
G_6	JK Durga Non Bt	1.18
G_7	Neeraja Bt (BG-II)	2.11
G_8	Neeraja Non Bt	1.29
G_9	Sahana (Non-Bt variety)	1.29
G_{10}	DCH 32 (Non-Bt Hybrid)	1.43
	Mean	**1.44**
	S.Em±	0.078
	LSD (p=0.05)	0.232
	CV (%)	9.35

Cotton genotypes	Bt	Non Bt	Mean
Bunny (BG-I)	1.82	1.22	**1.52**
RCH 368(BG-I)	1.53	1.09	**1.31**
JK Durga (BG-I)	1.53	1.18	**1.35**
Neeraja (BG-II)	2.11	1.29	**1.70**
Mean	**1.75**	**1.19**	**1.47**

Comparing the means	S.Em±	LSD (p=0.05)
Genotype (**G**)	0.041	0.12
Type of genotype (**TG**)	0.058	1.67
G × **TG** Interaction	0.082	0.24

Table 36: Seed cotton yield and yield paramateres as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	Boll weight (g/boll)			Seed cotton yield (g) per plant			Seed cotton yield (kg/ha)		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	3.98	4.13	4.06	82.27	79.07	80.67	2109	2058	2084
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	4.12	4.01	4.07	83.73	80.47	82.10	2117	2080	2099
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	4.13	4.25	4.19	82.61	81.87	82.24	2142	2078	2110
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	4.09	4.18	4.13	83.31	81.93	82.62	2120	2090	2105
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	4.78	4.92	4.85	99.87	96.50	98.19	2555	2530	2543
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	4.03	4.05	4.04	92.73	80.83	86.78	2090	2092	2092
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	4.05	4.03	4.04	83.50	80.29	81.89	2150	2082	2116
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	4.00	4.03	4.01	80.16	77.48	78.82	2099	2085	2092
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	4.74	4.87	4.81	109.07	94.09	101.6	2500	2533	2517
T_{10}	T_9 + Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	4.82	5.10	4.96	111.53	92.05	101.8	2509	2536	2522
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	2.80	3.01	2.91	49.60	50.90	50.25	1438	1329	1383
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	3.86	4.07	3.96	79.88	76.05	78.63	1950	1862	1906
S.Em ±		**0.24**	**0.27**	**0.06**	**3.26**	**2.46**	**2.02**	**127**	**140**	**96**
LSD (p=0.05)		**0.72**	**0.78**	**0.18**	**9.56**	**7.20**	**5.75**	**374**	**412**	**272**
CV (%)		**10.29**	**10.90**	**3.61**	**6.52**	**5.25**	**5.91**	**10**	**12**	**11**

Soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) recorded significantly higher seed cotton yield per plant (101.8 g) and it was on par with T_9 i.e., soil application of $MgSO_4$ @ 25 kg/ha (101.6 g) and T_5 i.e., foliar application of KNO_3 @ 2% (98.19 g). Treatments with polyethylene mulching (T_{11}) resulted in lower seed cotton yield per plant (50.25 g).

4.3.1.4 Total number of bolls per plant

The data pertaining to total number of bolls per plant is presented in Table 37. Significant differences were observed in both the years as well as pooled data.

Total number of bolls per plant (51.93) increased significantly with the soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) and it was on par with T_5 i.e., foliar application of KNO_3 @ 2% (50.47) and T_9 soil application of $MgSO_4$ @ 25 kg/ha (50.33). Polyethylene mulching treatment (T_{11}) significantly reduced the total number of bolls per plant (43.57).

4.3.1.5 Number of good opened bolls per plant

Pooled and yearwise data on number of good opened bolls per plant is presented in Table 37. The results indicated significant differences among the treatments. Significantly higher number of good opened bolls (49.27) recorded with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) and it was on par with T_9 i.e., soil application of $MgSO_4$ @ 25 kg/ha (47.78) and T_5 i.e., foliar application of KNO_3 @ 2% (47.73). The lowest number of good opened bolls per plant (38.93) was recorded with polyethylene mulching treatment (T_{11}).

4.3.1.6 Number of bad opened bolls per plant

Pooled and yearwise data on number of bad opened bolls per plant are presented in Table 37. The number of bad opened bolls per plant differed significantly among the treatments.

Soil application of $MgSO_4$ @ 25 kg/ha (T_9) reduced the number of bad boll openings (2.55) than other treatments and it was on par with T_{10} i.e., soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @1% (2.67) and T_5 i.e., foliar application of KNO_3 @ 2% (2.73). Significantly higher number of bad opened bolls (4.63) was observed with polyethylene mulching treatment (T_{11}).

4.3.1.6 Number of sympodial branches per plant at harvest

Pooled and yearwise data on number of sympodial branches per plant at harvest is presented in Table 38. The results indicated significant differences among the treatments.

Significantly higher number of sympodial branches per plant (17.50) was recorded with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% T_{10} and it was on par with *viz.,* T_9, T_5 and T_4 application of $MgSO_4$ @ 25 kg/ha (17.13), foliar application of KNO_3 @ 2% (16.97) and foliar application of $MgSO_4$ @ 1% (16.60), respectively. The lowest number of sympodial branches (14.47) recorded with polyethylene mulching treatment (T_{11}).

4.3.1.7 Number of monopodial branches per plant at harvest

Pooled and yearwise data on number of monopodial branches per plant harvest is presented in Table 38. The number of monopodial branches per plant at harvest did not differ significantly among the treatments during both the years as well as in pooled. The number of monopodial branches was in the range of 2.57 to 2.73 based on pooled data.

4.3.2 Biochemical observations

4.3.2.1 Chlorophyll content in leaf (SPAD) readings

The pooled and yearwise data on SPAD observations at 60, 90 and 120 DAS is presented in Table 39. SPAD values differed significantly among the different treatments.

Table 37: Number of good opened bolls, bad opened bolls and total number of bolls per plant as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	No. of good opened bolls per plant			No. of bad opened bolls per plant			Total number of bolls per plant		
		2007	**2008**	**Pooled**	**2007**	**2008**	**Pooled**	**2007**	**2008**	**Pooled**
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	45.57	41.13	43.35	4.93	3.40	4.17	50.50	44.53	47.52
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	45.93	40.73	44.50	5.07	3.33	4.20	53.33	44.07	48.70
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	45.20	40.27	42.73	5.27	3.27	4.27	50.47	43.53	47.00
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	45.47	40.93	44.70	5.13	3.47	4.30	53.27	44.73	49.00
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	51.13	44.33	47.73	2.73	2.07	2.73	54.53	46.40	50.47
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	45.93	40.67	43.80	4.13	3.40	3.67	50.87	44.07	47.47
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	45.87	41.33	43.60	5.07	3.47	4.27	50.93	44.80	47.87
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	44.80	40.87	44.00	5.13	3.47	3.97	51.60	44.33	47.97
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	51.27	46.63	47.78	2.70	2.07	2.55	52.97	47.70	50.33
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	52.27	47.00	49.27	2.93	1.87	2.67	55.00	48.87	51.93
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	38.33	37.53	38.93	5.33	3.93	4.63	43.67	43.47	43.57
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	40.07	41.27	42.00	5.70	3.40	4.03	50.73	44.67	47.70
S.Em ±		**1.62**	**1.45**	**0.99**	**0.40**	**0.24**	**0.21**	**1.52**	**0.78**	**0.98**
LSD (p=0.05)		**4.74**	**4.26**	**2.89**	**1.17**	**0.72**	**0.61**	**4.44**	**2.29**	**2.78**
C V(%)		**6.08**	**6.01**	**5.29**	**15.37**	**13.67**	**13.9**	**5.10**	**3.00**	**4.96**

Table 38: Monopodial and sympodial branches per plant at harvest as influenced by different treatments in Bt cotton (Cv. NCS-145)

Sl. No.	Treatments	No. of monopodial branches per plant			No. of sympodial branches per plant		
		2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	2.67	2.67	2.67	17.40	14.93	16.17
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	2.67	2.60	2.63	17.83	15.07	15.90
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	2.67	2.80	2.73	18.00	14.60	16.30
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	2.67	2.67	2.67	18.07	14.80	16.60
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	2.67	2.73	2.70	18.60	15.33	16.97
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	2.60	2.53	2.57	17.53	14.60	16.07
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	2.73	2.60	2.67	17.87	14.47	16.17
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	2.60	2.67	2.63	17.67	14.53	16.10
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	2.47	2.67	2.57	18.53	17.07	17.13
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	2.80	2.53	2.67	18.77	17.00	17.50
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	2.73	2.60	2.67	14.33	14.60	14.47
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	2.67	2.67	2.67	15.97	14.40	15.63
S.Em ±		**0.11**	**0.10**	**0.071**	**0.77**	**0.48**	**0.32**
LSD (p=0.05)		**NS**	**NS**	**NS**	**2.25**	**1.40**	**0.94**
C V(%)		**6.88**	**6.27**	**6.53**	**7.57**	**5.49**	**3.40**

Table 39: Chlorophyll content in leaf (SPAD readings) as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	**2008**	**Pooled**	**2007**	**2008**	**Pooled**	**2007**	**2008**	**Pooled**
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	38.40	38.13	38.27	38.77	41.90	40.33	41.40	43.83	42.62
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	38.00	38.90	38.45	40.57	42.67	41.62	40.83	46.50	43.67
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	38.50	37.93	38.22	40.70	40.43	40.57	41.80	47.33	44.57
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	39.93	39.80	39.87	40.53	42.17	41.35	42.17	50.50	46.33
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	38.53	37.40	37.97	42.57	44.20	43.38	43.20	52.07	47.63
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	39.43	37.23	38.33	40.70	41.73	41.22	41.10	46.90	44.00
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	35.80	38.13	36.97	40.10	41.80	40.95	41.33	46.43	43.88
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	38.03	38.50	38.27	40.70	41.53	41.12	41.23	47.40	44.32
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	41.13	42.80	41.97	42.30	44.80	43.55	43.10	51.83	47.47
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	41.42	43.00	42.21	42.77	45.30	44.03	43.27	52.70	47.98
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	37.20	35.03	36.12	35.60	36.93	36.37	34.30	36.17	35.23
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	31.87	34.83	33.35	35.23	38.83	37.03	34.90	39.57	37.23
S.Em ±		**0.74**	**0.58**	**0.48**	**0.65**	**0.78**	**0.50**	**0.55**	**0.76**	**0.47**
LSD (p=0.05)		**2.18**	**1.69**	**1.35**	**1.89**	**2.29**	**1.43**	**1.61**	**2.23**	**1.35**
CV (%)		**3.38**	**2.59**	**3.04**	**2.79**	**3.24**	**3.01**	**2.34**	**2.81**	**2.65**

At 60 DAS, soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) recorded significantly higher SPAD value (42.21) and was found on par with T_9 i.e., soil application of $MgSO_4$ @ 25 kg/ha (41.97). The lowest SPAD value (33.35) was observed with recommended package of practice (T_{12}).

At 90 DAS also soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) recorded significantly higher SPAD value (44.03) and was on par with soil application of $MgSO_4$ @ 25 kg/ha (43.55) and foliar application of KNO_3 @ 2% (43.38) treatment (T_5). Polyethylene mulching treatment (T_{11}) recorded lowest SPAD value (36.37).

At 120 DAS, SPAD value increased compared to 60 and 90 DAS and the treatments followed the similar trend as that of 90 DAS.

4.3.2.2 Chlorophyll ‘a’ content (mg/g fresh weight)

The pooled and yearwise data pertaining to chlorophyll ‘a’ content at 60, 90 and 120 DAS is presented in Table 40. Chlorophyll ‘a’ content in leaf differed significantly at all the growth stages.

At 60 DAS, chlorophyll ‘a’ content was significantly increased with treatments T_9 and T_{10} *viz.,* soil application of $MgSO_4$ @ 25 kg/ha (0.22) and soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @1% (0.22) compared to other treatments. The lowest chlorophyll ‘a’ content was observed with T_3, T_6 and T_{12} *viz.,* foliar application of DAP @ 2% (0.19) calcium nitrate @ 1% (0.19) and polyethylene mulching (0.19).

At 90 DAS, treatment (T_{10}) recorded significantly higher chlorophyll ‘a’ content (0.82) and was on par with T_9 *viz.,* soil application of $MgSO_4$ @ 25 kg/ha (0.79). The lowest chlorophyll ‘a ‘content (0.47) was observed with polyethylene mulching treatment (T_{11}).

At 120 DAS, significantly higher chlorophyll ‘a’ content (1.08) was observed with soil application of $MgSO_4$ @ 25 kg/ha along with $MgSO_4$ @ 1% foliar application (T_{10}) and it was on par with T_9, T_5 and T_4 *viz.,* soil application of $MgSO_4$ @ 25 kg/ha (1.06), foliar application of KNO_3 @ 2% (1.05) and foliar application of $MgSO_4$ @ 1% (1.04), respectively. Significantly lower chlorophyll ‘a’ content (0.52) was observed with polyethylene mulching (T_{11}).

4.3.2.3 Chlorophyll ‘b’ content (mg/g fresh weight)

The pooled and yearwise data on chlorophyll content ‘b’ content at 60, 90 and 120 DAS is presented in Table 41. The chlorophyll ‘b’ content differed significantly among the treatments.

At 60 DAS, the chlorophyll ‘b’ content (0.14) was among T_9, T_{10} and T_5 were not different and were significantly superior to the rest. The lowest chlorophyll content (0.11) was observed with treatment T_1.

At 90 DAS similarly the chlorophyll ‘b’ content (0.23) remained same in the treatments T_9, T_{10} and T_5 and these treatments were superior to other treatments. The lower chlorophyll ‘b’ content (0.15) was observed with the recommended package of practices (T_{12}).

At 120 DAS, chlorophyll ‘b’ content (0.52) was increased significantly with the soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) and was on par with treatment T_5 i.e., foliar application of KNO_3 @ 2% (0.51). The lowest chlorophyll ‘b’ content (0.26) was recorded with polyethylene mulching (T_{11}).

4.3.2.4 Total chlorophyll content (mg/g fresh weight)

The pooled and yearwise data on total chlorophyll content at 60, 90 and 120 DAS is presented in Table 42. At 60 DAS, the total chlorophyll content (0.35) significantly increased with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) and it was on par with soil application of $MgSO_4$ @ 25 kg/ha (0.34) and T_5 i.e., foliar application of KNO_3 2% (0.34) over other treatments. The lowest total chlorophyll content (0.28) was observed with polyethylene mulching (T_{11}).

Similarly, at 90 DAS, total chlorophyll content (1.22) was increased significantly with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) and it was on par with T_9 i.e., soil application of $MgSO_4$ @ 25 kg/ha (1.19). The lowest total chlorophyll content (0.73) was observed with polyethylene mulching (T_{11}).

Table 40: Chlorophyll 'a' content (mg/g fresh weight) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	0.19	0.20	0.20	0.68	0.58	0.63	1.00	0.93	0.97
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	0.19	0.21	0.20	0.70	0.57	0.64	1.07	0.97	1.02
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	0.18	0.20	0.19	0.72	0.59	0.66	1.06	0.96	1.01
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.19	0.21	0.20	0.82	0.68	0.75	1.07	1.01	1.04
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.19	0.20	0.20	0.85	0.64	0.75	1.10	1.00	1.05
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	0.18	0.19	0.19	0.72	0.52	0.62	1.09	0.90	0.99
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	0.19	0.21	0.20	0.73	0.50	0.62	0.98	0.95	0.96
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	0.19	0.20	0.20	0.62	0.52	0.57	0.94	0.94	0.94
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.21	0.23	0.22	0.85	0.74	0.79	1.07	1.04	1.06
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.21	0.22	0.22	0.86	0.78	0.82	1.11	1.06	1.08
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	0.18	0.19	0.19	0.44	0.50	0.47	0.52	0.51	0.52
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	0.18	0.21	0.20	0.51	0.57	0.54	0.92	0.85	0.88
S.Em ±		**0.01**	**0.01**	**0.004**	**0.02**	**0.02**	**0.012**	**0.02**	**0.02**	**0.013**
LSD (p=0.05)		**0.02**	**0.02**	**0.01**	**0.05**	**0.04**	**0.035**	**0.05**	**0.05**	**0.04**
CV (%)		**4.78**	**4.78**	**4.48**	**4.57**	**4.36**	**4.59**	**2.88**	**3.27**	**3.18**

Table 41: Chlorophyll 'b' content (mg/g fresh weight) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	0.10	0.12	0.11	0.19	0.12	0.16	0.46	0.32	0.39
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	0.11	0.13	0.12	0.19	0.12	0.16	0.50	0.33	0.41
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	0.12	0.13	0.12	0.19	0.13	0.16	0.42	0.33	0.37
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.12	0.14	0.13	0.20	0.14	0.17	0.46	0.40	0.43
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.13	0.14	0.14	0.31	0.15	0.23	0.57	0.45	0.51
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	0.12	0.14	0.13	0.20	0.14	0.17	0.42	0.34	0.38
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	0.11	0.13	0.12	0.18	0.13	0.16	0.40	0.33	0.37
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	0.11	0.14	0.13	0.18	0.14	0.16	0.40	0.34	0.37
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.14	0.15	0.14	0.31	0.15	0.23	0.57	0.45	0.51
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.14	0.15	0.14	0.31	0.15	0.23	0.59	0.44	0.52
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	0.10	0.14	0.12	0.21	0.14	0.18	0.27	0.24	0.26
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	0.11	0.12	0.12	0.17	0.13	0.15	0.38	0.21	0.30
S.Em ±		**0.003**	**0.004**	**0.002**	**0.01**	**0.003**	**0.0035**	**0.01**	**0.005**	**0.006**
LSD (p=0.05)		**0.01**	**0.01**	**0.006**	**0.02**	**0.01**	**0.01**	**0.03**	**0.01**	**0.018**
CV (%)		**3.72**	**4.70**	**3.99**	**4.49**	**4.37**	**4.76**	**4.42**	**2.25**	**3.78**

At 120 DAS, total chlorophyll content (1.77) increased significantly with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% over other treatments. The total chlorophyll content (0.86) reduced significantly with polyethylene mulching treatment (T_{11}).

4.3.2.5 Anthocyanin content (mg/g fresh weight)

Pooled and yearwise data on anthocyanin content at 60, 90 and 120 DAS is presented in Table 43. At 60 DAS, no significant differences were observed among different treatments.

At 90 DAS, anthocyanin content (0.038) was significantly reduced incase of treatment T_{10} i.e., the soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% and was on par with T_9 and T_5 *viz.,* soil application of $MgSO_4$@ 25 kg/ha (0.039) and foliar application of KNO_3 @ 2% (0.042). Significantly highest anthocyanin content (0.39) at 120 DAS was recorded with polyethylene mulching (T_{11}) compared to rest of the treatments. At 120 DAS, the anthocyanin content was increased compared to 60 and 90 DAS and all the treatments followed the similar trend as observed at 90 DAS with respect to anthocyanin content.

4.3.3 Nutrient content in leaf of Bt cotton (cv. NCS-145)

4.3.3.1 Nitrogen content (%) in leaf

The pooled and yearwise data on nitrogen content (%) in leaf of Bt cotton at 60, 90 and 120 DAS is presented in Table 44. The nitrogen content (%) differed significantly among the treatments.

At 60 DAS, the N content (2.23%) in leaf was significantly increased with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) and it was on par with soil application of $MgSO_4$ @ 25 kg/ha (2.19%) (T_9). The lowest nitrogen content (1.44) in leaf was noticed with recommended package of practices (T_{12}).

At 90 DAS, the leaf nitrogen content (2.65%) was significantly higher with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) and it was on par with T_9 and T_5 *viz.,* soil application of $MgSO_4$ @ 25 kg/ha (2.54) and foliar application of KNO_3 @ 2% (2.56), respectively. The lowest leaf nitrogen content (1.81%) was recorded with polyethylene mulching (T_{11}).

At 120 DAS, soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) significantly increased the leaf nitrogen content (1.99%) compared to other treatments. The lowest leaf nitrogen content (1.22 %) was recorded with polyethylene mulching (T_{11}).

4.3.3.2 Phosphorus P content (%) in leaf

Pooled and yearwise data pertaining to phosphorus content (%) in leaf at 60, 90 and 120 DAS is presented in Table 45.

At 60 DAS, non-significant differences were observed among the treatments with respect to P content in leaf.

At 90 DAS, foliar application of DAP @ 2% (T_3) recorded significantly higher P content (1.07%) compared to other treatments. The lowest P content (0.78%) noticed with foliar application of calcium nitrate @ 1% (T_6) at 90 DAS. At 120 DAS, the P content (0.71%) observed with T_3 i.e., foliar application of DAP @ 2% and the lowest was with T_{12} i.e., recommended package of practice (0.41%).

4.3.3.3 Potassium content (%) in leaf

The pooled and yearwise data pertaining to K content (%) in leaf at 60, 90 and 120 DAS is presented in Table 46.

At 60 DAS, there was no significant difference with respect to K content in leaf among the treatments.

Table 42: Total chlorophyll content (mg/g fresh weight) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	0.28	0.32	0.30	0.88	0.98	0.93	1.47	1.46	1.46
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	0.31	0.34	0.33	0.88	1.07	0.98	1.43	1.61	1.52
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	0.29	0.35	0.32	0.88	1.10	0.99	1.44	1.53	1.49
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.32	0.35	0.33	0.98	1.13	1.05	1.53	1.65	1.60
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.31	0.36	0.34	1.07	1.25	1.16	1.67	1.72	1.70
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	0.30	0.35	0.32	0.90	1.08	0.99	1.44	1.54	1.49
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	0.30	0.34	0.32	0.91	0.98	0.94	1.40	1.52	1.46
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	0.30	0.35	0.32	0.84	1.02	0.93	1.33	1.57	1.45
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.31	0.37	0.34	1.15	1.22	1.19	1.65	1.75	1.70
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.33	0.36	0.35	1.18	1.26	1.22	1.72	1.81	1.77
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	0.22	0.33	0.28	0.69	0.77	0.73	0.82	0.91	0.86
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	0.28	0.35	0.31	0.71	0.86	0.79	1.45	1.42	1.44
S.Em ±		**0.005**	**0.01**	**0.0038**	**0.01**	**0.02**	**0.011**	**0.02**	**0.02**	**0.014**
LSD (p=0.05)		**0.01**	**0.02**	**0.011**	**0.02**	**0.05**	**0.032**	**0.05**	**0.05**	**0.038**
CV (%)		**2.71**	**3.10**	**2.93**	**1.47**	**3.03**	**2.76**	**2.04**	**1.84**	**2.21**

Table 43: Anthocyanin content (mg/g fresh weight) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	0.021	0.022	0.021	0.075	0.095	0.085	0.236	0.223	0.23
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	0.020	0.021	0.020	0.072	0.081	0.077	0.219	0.222	0.22
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	0.022	0.020	0.020	0.072	0.076	0.074	0.225	0.233	0.23
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.021	0.021	0.021	0.073	0.073	0.073	0.220	0.244	0.23
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.021	0.020	0.020	0.046	0.038	0.042	0.115	0.083	0.10
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	0.021	0.020	0.021	0.075	0.080	0.077	0.340	0.356	0.35
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	0.021	0.020	0.021	0.077	0.093	0.085	0.329	0.329	0.33
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	0.021	0.021	0.021	0.075	0.085	0.080	0.179	0.241	0.21
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.021	0.019	0.020	0.044	0.034	0.039	0.120	0.102	0.11
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.020	0.019	0.019	0.043	0.032	0.038	0.091	0.078	0.08
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	0.020	0.020	0.020	0.085	0.103	0.094	0.384	0.401	0.39
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	0.020	0.021	0.020	0.086	0.087	0.087	0.317	0.381	0.35
	S.Em ±	**0.001**	**0.0005**	**0.0003**	**0.002**	**0.002**	**0.0013**	**0.005**	**0.006**	**0.0036**
	LSD (p=0.05)	**NS**	**NS**	**NS**	**0.006**	**0.005**	**0.004**	**0.014**	**0.017**	**0.010**
	CV (%)	**4.54**	**2.60**	**4.19**	**4.82**	**4.07**	**4.53**	**3.59**	**4.26**	**3.75**

Table 44: Nitrogen content (%) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	1.43	2.27	1.85	1.56	2.45	2.01	1.56	1.46	1.49
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	1.45	2.26	1.86	1.60	2.71	2.16	1.60	1.61	1.61
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	1.44	2.28	1.86	1.72	2.77	2.24	1.72	1.71	1.67
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	1.46	2.24	1.85	1.92	2.72	2.32	1.92	1.68	1.63
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	1.46	2.20	1.83	2.21	2.92	2.56	2.42	1.82	1.84
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	1.47	2.29	1.88	1.66	2.69	2.18	1.66	1.46	1.51
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	1.47	2.27	1.87	1.61	2.68	2.15	1.61	1.46	1.49
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	1.49	2.28	1.89	1.77	2.68	2.23	1.77	1.56	1.58
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	1.64	2.81	2.23	2.22	2.86	2.54	2.22	1.77	1.81
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	1.66	2.72	2.19	2.42	2.87	2.65	2.21	1.87	1.99
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	1.45	2.29	1.87	1.61	2.02	1.81	1.79	1.23	1.22
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	1.31	1.56	1.44	1.79	2.47	2.13	1.61	1.36	1.37
S.Em ±		**0.02**	**0.06**	**0.03**	**0.04**	**0.05**	**0.03**	**0.04**	**0.05**	**0.03**
LSD (p=0.05)		**0.06**	**0.17**	**0.09**	**0.13**	**0.13**	**0.09**	**0.13**	**0.13**	**0.08**
CV (%)		**2.57**	**4.30**	**3.90**	**4.03**	**3.01**	**3.60**	**4.03**	**5.01**	**4.10**

Table 45: Phosphorus content (%) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	0.41	0.42	0.41	0.75	0.97	0.86	0.41	0.56	0.48
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	0.44	0.43	0.44	0.71	0.98	0.85	0.42	0.56	0.49
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	0.42	0.42	0.43	1.01	1.13	1.07	0.51	0.91	0.71
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.43	0.43	0.43	0.75	0.93	0.84	0.44	0.70	0.57
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.43	0.42	0.42	0.73	0.97	0.85	0.54	0.75	0.64
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	0.43	0.43	0.43	0.70	0.86	0.78	0.54	0.67	0.61
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	0.41	0.41	0.41	0.74	0.96	0.85	0.40	0.77	0.59
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	0.41	0.40	0.41	0.70	0.93	0.82	0.45	0.66	0.56
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.43	0.43	0.43	0.70	0.93	0.82	0.49	0.68	0.59
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.44	0.44	0.44	0.77	0.90	0.83	0.49	0.65	0.57
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	0.43	0.43	0.42	0.70	0.96	0.83	0.47	0.63	0.55
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	0.45	0.44	0.43	0.72	0.95	0.83	0.34	0.48	0.41
S.Em ±		**0.01**	**0.01**	**0.007**	**0.02**	**0.02**	**0.02**	**0.01**	**0.02**	**0.011**
LSD (p=0.05)		**NS**	**NS**	**NS**	**0.06**	**0.07**	**0.05**	**0.04**	**0.05**	**0.03**
CV (%)		**4.59**	**4.44**	**4.24**	**4.97**	**4.39**	**4.56**	**4.59**	**4.58**	**4.62**

At 90 DAS, foliar application of KNO_3 @ 2% (T_5) recorded significantly higher potassium content in leaf (2.43%) than other treatments. The lowest potassium content in leaf (1.53%) was recorded with treatment T_1.

At 120 DAS, significantly higher K content (1.02%) was recorded with foliar application of KNO_3 @ 2% (T_5). The lowest potassium content (0.61%) was recorded with treatment T_1.

4.3.3.4 Calcium content (%) in leaf

The pooled and yearwise data pertaining to calcium content (%) in leaf at 60, 90 and 120 DAS is presented in Table 47. The calcium content in leaf differed significantly among the treatments.

At 60 DAS, there was no significant effect observed with different treatments on calcium content in leaf in Bt cotton.

At 90 DAS, the calcium content (5.59%) in leaf was significantly increased due to foliar application of calcium nitrate @ 1% (T_6) than other treatments. The calcium content (4.13%) significantly reduced with polyethylene mulching (T_{11}).

At 120 DAS, the calcium content in leaf followed the similar trend as observed at 90 DAS.

4.3.3.5 Magnesium content (%) in leaf

Pooled and yearwise data pertaining to magnesium content in leaf at 60, 90 and 120 DAS is presented in Table 48. The results indicated significant difference among the treatments with respect to magnesium content in leaf.

At 60 DAS, the magnesium content (1.59%) significantly increased with soil application of $MgSO_4$ @ 25 kg/ha (T_9) and it was on par with T_{10} i.e., soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (1.56%). The lowest magnesium content (1.42%) leaf was observed with polyethylene mulching (T_{11}) and with the recommended package of practices (T_{12}).

At 90 and 120 DAS, the magnesium content in leaf followed the similar trend as observed at 60 DAS.

4.3.3.6 Zinc content (ppm) in leaf

Pooled and yearwise data on Zn content in leaf at 60, 90 and 120 DAS is presented in Table 49. The zinc content in leaf differed significantly among the treatments.

At 60 DAS, zinc content in leaf was not significantly differed among the treatments. At 90 DAS, there was significant increase in Zn content (62.70 ppm) in leaf with the foliar application of multimicronutrient @ 1% (T_7) than others. The lowest Zn content (27.10 ppm) was observed with foliar application of Urea @ 2%, DAP @ 2% (T_3) and polyethylene mulching (T_1).

At 120 DAS also Zn content (56.60 ppm) significantly increased with application of multimicronutrient @ 1% (T_7) than others. The lowest Zn content (25.80 ppm) was noticed with foliar application of Urea @ 2% (T_2).

4.3.3.7 Iron content (ppm) in leaf

The pooled and yearwise data on iron content (ppm) in leaf at 60, 90 and 120 DAS is presented in Table 50. Iron content in leaf differed significantly at all the growth stages among the treatments.

At 60 DAS, there was no significant difference observed with respect to iron content in leaf among the treatments. At 90 DAS, significantly higher iron content (855.8 ppm) was recorded with foliar application of multimicronutrient @ 1% (T_7) than other treatments. The lowest iron content (212.8 ppm) was observed with foliar application of cytokinin @ 20 ppm (T_8).

Table 46: Potassium content (%) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	0.44	0.98	0.71	1.67	1.38	1.53	0.51	0.71	0.61
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	0.43	1.01	0.72	1.68	1.42	1.55	0.56	0.73	0.64
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	0.45	1.01	0.73	1.69	1.48	1.58	0.57	0.73	0.65
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.43	0.99	0.71	1.64	1.51	1.58	0.61	0.72	0.67
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.45	1.09	0.73	2.64	2.21	2.43	0.89	1.16	1.02
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	0.45	0.94	0.70	1.79	1.51	1.65	0.65	0.71	0.68
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	0.47	1.01	0.74	1.79	1.61	1.70	0.69	0.69	0.69
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	0.46	1.00	0.73	1.68	1.57	1.63	0.59	0.68	0.64
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.47	1.01	0.74	1.76	1.65	1.70	0.68	0.69	0.68
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.44	1.01	0.72	1.65	1.63	1.64	0.67	0.68	0.67
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	0.47	0.98	0.72	1.68	1.50	1.59	0.68	0.70	0.69
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	0.46	0.97	0.72	1.68	1.43	1.56	0.51	0.72	0.62
S.Em ±		**0.01**	**0.03**	**0.02**	**0.04**	**0.03**	**0.02**	**0.02**	**0.02**	**0.014**
LSD (p=0.05)		**NS**	**0.08**	**NS**	**0.11**	**0.08**	**0.07**	**0.05**	**0.06**	**0.04**
CV (%)		**4.96**	**4.60**	**4.97**	**3.53**	**2.98**	**3.35**	**4.78**	**4.82**	**4.81**

Table 47: Calcium content (%) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	5.44	7.09	6.27	4.56	4.10	4.33	4.89	7.51	6.20
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	5.49	7.18	6.33	4.83	4.49	4.66	4.87	7.90	6.39
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	5.35	6.97	6.16	4.82	4.24	4.53	4.88	8.86	6.87
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	5.50	7.07	6.29	4.85	4.51	4.68	4.87	7.88	6.38
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	5.41	6.98	6.20	4.94	4.11	4.53	4.83	7.51	6.17
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	5.59	7.06	6.33	5.63	5.54	5.59	5.92	9.35	7.64
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	5.43	7.14	6.29	5.04	4.35	4.69	5.10	7.44	6.27
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	5.29	7.08	6.18	4.79	4.87	4.83	5.08	7.29	6.18
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	5.50	7.19	6.35	4.90	4.60	4.75	4.97	7.59	6.28
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	5.39	7.03	6.21	4.54	4.59	4.57	4.79	7.48	6.13
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	5.38	7.07	6.22	4.05	4.22	4.13	4.91	7.36	6.14
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	5.49	7.02	6.26	4.92	4.21	4.56	4.97	6.82	5.89
S.Em ±		**0.12**	**0.07**	**0.07**	**0.09**	**0.07**	**0.06**	**0.06**	**0.08**	**0.056**
LSD (p=0.05)		**NS**	**NS**	**NS**	**0.25**	**0.22**	**0.16**	**0.18**	**0.24**	**0.16**
CV (%)		**3.95**	**1.80**	**2.90**	**3.09**	**2.84**	**2.92**	**2.10**	**1.86**	**2.13**

Table 48: Magnesium content (%) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	1.41	1.46	1.43	0.63	0.70	0.66	1.40	1.32	1.36
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	1.41	1.46	1.44	0.66	0.80	0.73	1.31	1.31	1.31
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	1.37	1.39	1.38	0.69	0.69	0.69	1.49	1.42	1.45
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	1.34	1.39	1.37	0.76	1.11	0.94	1.71	1.73	1.72
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	1.41	1.47	1.44	0.94	0.71	0.82	0.96	1.31	1.13
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	1.34	1.53	1.44	0.66	0.70	0.68	1.08	1.38	1.23
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	1.40	1.48	1.44	0.60	0.74	0.67	0.93	1.31	1.12
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	1.46	1.48	1.47	0.50	0.72	0.61	1.34	1.36	1.35
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	1.52	1.67	1.59	1.23	1.21	1.22	1.96	1.68	1.82
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	1.50	1.63	1.56	1.33	1.28	1.31	2.01	1.70	1.86
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	1.38	1.46	1.42	0.70	0.73	0.72	1.25	1.37	1.31
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	1.42	1.42	1.42	0.73	0.71	0.72	1.13	1.51	1.32
S.Em ±		**0.04**	**0.04**	**0.03**	**0.02**	**0.02**	**0.01**	**0.04**	**0.03**	**0.024**
LSD (p=0.05)		**0.11**	**0.11**	**0.08**	**0.05**	**0.06**	**0.04**	**0.11**	**0.10**	**0.122**
CV (%)		**4.46**	**4.55**	**4.64**	**4.04**	**4.09**	**4.32**	**4.51**	**4.07**	**4.21**

Table 49: Zinc content (ppm) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	27.20	30.80	29.00	24.22	24.20	24.20	21.20	31.80	26.50
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	27.30	30.10	28.70	25.80	28.40	27.10	21.10	30.50	25.80
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	26.60	30.60	28.60	24.60	29.50	27.10	21.80	29.93	25.90
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	27.00	29.90	28.45	25.83	28.50	27.20	23.30	31.60	27.50
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	27.40	29.80	28.60	27.98	31.20	29.60	24.20	32.20	28.20
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	27.20	29.60	28.40	25.80	31.30	28.60	25.90	32.00	29.00
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	26.80	30.20	28.50	47.80	77.50	62.70	34.30	78.80	56.60
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	27.20	30.10	28.65	26.80	33.40	30.10	23.60	34.40	29.00
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	26.90	29.30	28.10	26.60	33.10	29.90	26.00	35.30	30.70
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	26.70	29.00	27.85	24.80	30.30	27.60	26.10	36.20	31.20
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	26.90	29.90	28.40	24.10	30.00	27.10	25.20	32.90	29.10
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	27.70	29.70	28.70	26.93	35.30	31.10	24.90	37.60	31.30
S.Em ±		**0.75**	**0.81**	**0.55**	**0.46**	**0.33**	**0.28**	**0.32**	**0.28**	**0.22**
LSD (p=0.05)		**NS**	**NS**	**NS**	**1.36**	**0.98**	**0.80**	**0.94**	**0.82**	**0.61**
CV (%)		**4.79**	**4.71**	**4.72**	**2.91**	**1.67**	**2.22**	**2.23**	**1.31**	**1.71**

Table 50: Iron content (ppm) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	757.5	763.8	760.7	262.0	208.0	235.0	857.5	771.8	814.7
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	756.5	767.5	762.0	250.5	206.2	228.3	876.2	775.5	825.9
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	757.5	760.7	759.0	264.0	208.2	239.1	834.5	758.0	796.3
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	752.0	754.3	753.1	256.5	210.8	233.7	851.7	772.0	811.8
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	751.0	760.1	755.5	231.5	205.7	218.6	872.8	775.3	824.1
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	753.0	756.8	755.0	251.0	206.5	228.8	874.7	781.8	828.3
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	754.5	760.2	757.3	676.5	1035.0	855.8	1250.5	930.2	1090.3
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	755.0	758.0	756.5	215.5	210.2	212.8	878.3	771.7	825.0
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	756.0	753.2	754.6	248.5	203.8	226.2	890.0	757.3	823.7
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	751.0	766.9	754.0	248.0	204.2	226.1	881.2	778.3	829.8
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	754.0	763.6	758.8	270.5	204.8	237.7	883.2	777.7	830.0
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	757.0	756.5	756.8	231.5	200.2	215.8	851.8	774.3	813.1
S.Em ±		**11.99**	**7.17**	**7.74**	**6.45**	**7.56**	**4.87**	**12.32**	**16.57**	**10.2**
LSD (p=0.05)		**NS**	**NS**	**NS**	**18.91**	**22.17**	**13.9**	**36.12**	**48.59**	**29.0**
CV (%)		**2.75**	**1.63**	**2.51**	**3.94**	**4.76**	**4.27**	**2.37**	**3.65**	**2.97**

At 120 DAS also iron content (1090.3 ppm) was significantly increased with foliar application of multimicronutrient @ 1% (T_7) than others. Foliar application of DAP @ 2% (T_3) reduced the iron content (796.3 ppm) in leaf.

4.3.3.8 Manganese content (ppm) in leaf

The pooled and yearwise data pertaining to manganese (ppm) content in leaf at 60, 90 and 120 DAS is presented in Table 51. Manganese content in leaf differed significantly among the treatments.

At 60 DAS, there was no significant effect on manganese content in leaf among treatments.

At 90 DAS, the manganese content (161.6 ppm) significantly increased with foliar application of multimicronutrient @ 1% (T_7) over other treatments. The lowest manganese content (82.8 ppm) in leaf was observed with foliar application of KNO_3 @ 2% (T_5).

At 120 DAS also manganese content (214.7 ppm) in leaf significantly increased with foliar application of multimicronutrient @ 1% (T_7) over others. The lowest manganese content (90.8 ppm) was observed with T_1 (120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha 10% N, full P_2O_5 and K_2O as basal and 90% N in equal 6 splits), foliar application of cytokinin @ 20 ppm (T_8) and soil application of $MgSO_4$ @ 25 kg/ha (T_9).

4.3.3.9 Copper (Cu) content (ppm) in leaf

The pooled and yearwise data pertaining to copper content (ppm) in leaf is presented in Table 52. Copper content (ppm) in leaf differed significantly among the treatments.

At 60 DAS, there were no significant differences observed among the treatments with respect to Cu content in leaf.

At 90 DAS, foliar application of multimicronutrient @ 1% (T_7) increased the copper content (22.0 ppm) in leaf than other treatments. The lowest copper content (7.40 ppm) in leaf was observed with foliar application of Urea @ 2% (T_2).

At 120 DAS also foliar application of multimicronutrient @ 1% (T_7) increased the copper content (28.78 ppm) in leaf over other treatments. The lowest Cu content (13.48 ppm) was observed with the recommended package of practices (T_{12}).

4.3.4 Soil nutrient content at harvest

4.3.4.1 Soil nitrogen content (kg/ha)

Pooled and yearwise data on soil nitrogen content (kg/ha) at harvest is presented in Table 53. Soil nitrogen content differed significantly among the treatments.

Pooled data (mean of T_1 to T_{11}) indicated that the soil nitrogen (187.08 kg/ha) found significantly increased with top dressing of 90 per cent recommended nitrogen (10% basal) into equal six splits over the recommended package of practices (184.60 kg/ha) i.e., 50 per cent N as basal and remaining 50 per cent nitrogen application into equal three splits (T_{12}). Significantly higher available soil N was observed with T_{11} mulching of inter rows space of 80 cm with polyethylene mulching (192.60 kg/ha) compared to other treatments (183.40 kg/ha). Lower available soil N observed with T_9 i.e., soil application of $MgSO_4$ @ 25 kg/ha (182.30 kg/ha) and T_{10}: soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (183.2 kg/ha).

4.3.4.2 Soil phosphorus content (kg/ha)

Pooled and yearwise data pertaining to soil phosphorus content (kg/ha) at harvest is presented in Table 53. The phosphorus content (kg/ha) at harvest differed significantly among the treatments.

Pooled data (mean of T_1 to T_{11}) indicated that the phosphorus content (14.28 kg/ha) decreased in comparison with recommended package of practices (22.65 kg/ha).

Table 51: Manganese content (ppm) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	80.8	109.0	94.9	82.2	84.5	83.3	76.2	105.3	90.8
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	81.5	111.5	96.5	80.0	88.0	84.0	76.3	106.5	91.4
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	87.0	110.5	98.8	85.5	85.5	85.5	76.0	106.8	91.4
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	84.5	105.5	95.0	82.8	87.0	84.9	76.0	107.7	91.8
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	84.5	109.5	97.0	83.5	82.0	82.8	77.3	116.0	96.7
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	84.0	107.5	95.8	82.5	86.5	84.5	78.8	104.0	91.4
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	88.0	111.0	99.5	106.5	216.7	161.6	214.5	214.8	214.7
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	85.5	110.0	97.8	84.0	86.5	85.3	75.5	106.0	90.8
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	86.0	108.0	97.0	84.6	88.5	86.5	76.7	105.0	90.8
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	83.0	107.5	95.3	85.0	84.0	84.5	76.7	106.2	91.4
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	87.5	103.0	95.3	84.5	89.0	86.8	77.2	110.2	93.7
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	87.0	106.5	96.8	85.3	88.0	86.7	76.5	106.0	92.3
S.Em ±		**2.09**	**2.24**	**1.52**	**1.91**	**2.13**	**1.47**	**1.39**	**3.29**	**1.85**
LSD (p=0.05)		**NS**	**NS**	**NS**	**5.61**	**6.25**	**4.20**	**4.07**	**9.65**	**5.26**
CV (%)		**4.26**	**3.57**	**3.86**	**3.87**	**3.80**	**3.85**	**2.73**	**4.91**	**4.42**

Table 52: Copper content (ppm) in leaf as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	11.13	13.83	12.48	7.07	8.17	7.62	8.93	18.90	13.92
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	11.10	13.47	12.28	7.20	7.60	7.40	9.60	18.10	13.85
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	10.80	13.57	12.18	7.90	7.73	7.82	9.50	18.23	13.87
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	11.10	13.85	12.47	7.10	8.40	7.75	9.60	18.93	14.27
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	11.00	13.77	12.38	7.60	7.90	7.75	9.07	18.70	13.88
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	11.10	13.80	12.45	7.80	8.07	7.93	9.03	19.10	14.07
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	10.90	14.17	12.53	16.30	27.60	22.0	15.13	42.43	28.78
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	10.93	14.50	12.72	7.20	8.40	7.80	9.54	18.90	14.22
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	11.13	14.43	12.78	7.33	8.13	7.73	9.10	19.13	14.12
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	11.07	14.20	12.63	7.50	7.83	7.67	9.80	18.40	14.10
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	11.00	14.10	12.55	7.80	8.03	7.92	9.60	18.47	14.03
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	10.53	13.80	12.17	7.20	8.10	7.65	9.90	17.07	13.48
S.Em ±		**0.30**	**0.38**	**0.24**	**0.22**	**0.28**	**0.186**	**0.20**	**0.53**	**0.28**
LSD (p=0.05)		**NS**	**NS**	**NS**	**0.65**	**0.81**	**0.53**	**0.59**	**1.57**	**0.81**
CV (%)		**4.74**	**4.77**	**4.77**	**4.67**	**4.94**	**5.11**	**3.53**	**4.51**	**4.56**

Table 53: Available nitrogen, phosphorus and potassium (kg/ha) in soil as influenced by different treatments in Bt cotton (Cv. NCS-145) at harvest

Sl. No.	Treatments	Available nitrogen (kg/ha)			Available phosphorous (kg P_2O_5/ha)			Available potassium (kg K_2O/ha)		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	182.36	192.97	187.70	14.30	13.80	14.05	475.20	481.23	484.90
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	181.56	196.20	188.90	13.00	13.98	13.49	482.00	489.70	485.90
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	182.07	195.83	188.90	14.93	14.63	14.78	478.20	484.50	483.00
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	182.97	191.90	187.40	13.90	13.97	13.93	468.50	479.50	482.30
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	181.50	193.30	187.40	14.23	14.47	14.35	491.50	488.50	485.00
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	185.40	188.30	186.80	13.37	15.80	14.58	481.00	488.60	484.80
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	182.03	190.67	186.40	13.87	14.37	14.12	466.00	480.33	481.50
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	182.80	189.70	186.30	14.22	15.13	14.68	451.50	484.17	484.00
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	184.50	180.54	182.30	14.43	14.53	14.48	487.50	484.50	482.70
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	186.20	180.20	183.20	13.97	13.87	13.92	491.50	492.50	492.00
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	196.20	188.90	192.60	15.23	14.27	14.75	357.40	480.90	485.80
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	186.56	181.76	184.60	22.92	22.38	22.65	412.70	477.80	481.90
	Initial nutrient status	**206.64**	**214.80**	**210.72**	**15.4**	**18.9**	**17.15**	**462.70**	**417.70**	**440.20**
	Sem +	**2.50**	**2.50**	**1.87**	**0.42**	**0.41**	**0.26**	**5.59**	**5.46**	**3.83**
	LSD (p=0.05)	**7.34**	**7.32**	**5.34**	**1.23**	**1.20**	**0.76**	**NS**	**NS**	**NS**
	CV (%)	**2.39**	**2.26**	**2.47**	**4.91**	**4.71**	**3.01**	**2.00**	**1.95**	**1.94**

4.3.4.3 Soil K content (kg/ha)

Pooled and yearwise data on soil K content (kg/ha) at harvest is presented in Table 53. The results indicated that soil K content at harvest was did not differ significantly among the treatments.

4.3.4.4 Soil calcium (Ca) content (meq/100 g)

Pooled and yearwise data on soil Ca content at harvest is presented in Table 54. The results indicated that soil Ca content at harvest was not significantly differed among the treatments.

4.3.4.5 Soil magnesium (Mg) content (meq/100 g)

The pooled and yearwise data pertaining to soil Mg content at harvest is presented in Table 54. The soil Mg content at harvest was differed significantly among the treatments.

Pooled data indicated that the soil Mg content (28.85 meq/100 g) was found significantly higher with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) over other treatments and it was on par with soil application of $MgSO_4$ @ 25 kg/ha (28.30 meq/100 g) (T_9). The lowest soil magnesium content (13.30 meq/100 g) was observed with foliar application of KNO_3 @ 2% (T_5).

4.3.4.6 Soil zinc content (ppm)

The pooled and yearwise data on soil zinc content (ppm) at harvest is presented in Table 55. Non-significant differences were observed among the treatments with respect to soil zinc content.

4.3.4.7 Soil iron content (ppm)

The pooled and yearwise data on soil iron content (ppm) at harvest is presented in Table 55. There was no significant effect of different treatments on soil iron content at harvest.

4.3.4.8 Soil manganese content (ppm)

Pooled and yearwise data on soil manganese content (ppm) at harvest is presented in Table 56. The soil manganese content (ppm) at harvest was differed significantly among the treatments.

4.3.4.8 Soil copper content (ppm)

The pooled and yearwise data pertaining to soil copper content (ppm) at harvest is presented in Table 56. The results indicated that the soil copper content (ppm) was not differed significantly among the treatments.

4.3.5 Canopy temperature at 60, 90 and 120 DAS

4.3.5.1 Canopy temperature at 60 DAS

The pooled and yearwise data pertaining to canopy temperature at 60 DAS recorded at 9 am, 1 pm and 5 pm is presented in Table 57.

At 9 am, there was no significant difference among the treatments with respect to canopy temperature. At 1 pm the canopy temperature (37.85^{0}C) significantly increased with polyethylene mulching (T_{11}) than others. The lowest canopy temperature (32.65^{0}C) was recorded with foliar application of $MgSO_4$ @ 1% (T_4).

At 5 am, significantly higher canopy temperature (32.68^{0}C) was recorded with polyethylene mulching (T_{11}) than other treatments. The lowest canopy temperature (26.95^{0}C) was recorded with recommended package of practices (T_{12}).

4.3.5.2 Canopy temperature at 90 DAS

Pooled and yearwise data on canopy temperature at 90 DAS, recorded at 9 am, 1 pm and 5 pm is presented in Table 58. Canopy temperature differed significantly among the treatments. At 9 am, the canopy temperature did not differ significantly among the treatments.

Table 54: Available calcium and magnesium (me/100 g) in soil as influenced by different treatments in Bt cotton (Cv. NCS-145) at harvest

Tr. No.	Treatments	Ca			Mg		
		2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	34.00	34.93	34.47	12.80	15.60	14.20
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	34.40	34.27	34.33	12.20	14.60	13.40
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	33.50	35.50	34.50	13.00	14.50	13.75
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	33.50	35.30	34.40	15.50	16.60	16.05
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	34.60	35.60	35.10	12.80	13.80	13.30
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	33.53	34.30	33.92	13.70	14.90	14.30
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	35.50	34.17	34.83	14.50	15.10	14.80
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	34.40	33.80	34.10	13.50	13.60	13.55
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	33.70	34.80	34.25	26.40	30.20	28.30
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	35.60	35.50	35.55	28.80	28.90	28.85
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	33.33	36.17	34.75	13.00	15.50	14.25
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	33.00	34.20	33.60	13.40	14.80	14.10
Initial nutrient status		30.80	**34.10**	32.49	18.10	**16.80**	17.45
S.Em ±		**0.94**	**0.92**	**0.65**	**0.29**	**0.48**	**0.28**
LSD (p=0.05)		**NS**	**NS**	**NS**	**0.85**	**1.41**	**0.79**
CV (%)		**4.78**	**4.53**	**4.60**	**3.18**	**4.80**	**4.11**

Table 55: Available zinc and iron (ppm) in soil as influenced by different treatments in Bt cotton (Cv. NCS-145) at harvest

Tr. No.	Treatments	Zn			Fe		
		2007	**2008**	**Pooled**	**2007**	**2008**	**Pooled**
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	27.35	28.23	27.78	1.72	1.96	1.84
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	28.22	27.80	28.01	1.66	1.85	1.76
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	27.89	28.39	28.14	1.76	1.95	1.86
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	27.73	28.10	27.92	1.75	1.94	1.85
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	28.60	29.07	28.83	1.67	1.95	1.81
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	28.70	27.73	28.26	1.74	1.90	1.82
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	27.13	28.22	27.68	1.70	1.85	1.78
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	27.93	28.90	28.41	1.84	1.92	1.88
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	28.80	28.87	28.83	1.85	1.86	1.86
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	27.50	29.96	28.73	1.85	1.85	1.85
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	27.07	28.88	27.98	1.84	1.90	1.87
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	28.66	29.30	28.98	1.85	1.87	1.86
Initial nutrient status		28.26	32.40	30.33	2.00	2.23	2.12
S.Em ±		**0.78**	**0.78**	**0.54**	**0.05**	**0.03**	**0.03**
LSD (p=0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)		**4.86**	**4.73**	**4.77**	**4.86**	**3.18**	**4.02**

At 1 pm, the canopy temperature (37.23 ^{0}C) significantly increased with polyethylene mulching (T_{11}) over other treatments. The lowest canopy temperature (32.57^{0}C) was recorded with foliar application of $MgSO_4$ @ 1% (T_4).

At 5 pm, also significantly increased canopy temperature (30.53^{0}C) was recorded with polyethylene mulching (T_{11}) than others. The lowest canopy temperature (26.67^{0}C) was recorded with foliar application of $MgSO_4$ @ 1% (T_4).

4.3.5.3 Canopy temperature at 120 DAS

The pooled and yearwise data pertaining to canopy temperature at 120 DAS, recorded at 9 am, 1 pm and 5 pm is presented in Table 59. Significant differences were observed among the treatments with respect to canopy temperature.

At 9 am, the canopy temperature was not significantly influenced by different treatments.

At 1 pm, the canopy temperature (38.77^{0}C) was significantly increased with polyethylene mulching (T_{11}) than others. The lowest canopy temperature (34.43^{0}C) was recorded with soil application of $MgSO_4$ @ 25 kg/ha (T_9).

At 5 pm, polyethylene mulching (T_{11}) significantly increased the canopy temperature (30.37^{0}C) compared to other treatments. The lowest canopy temperature (26.67^{0}C) was observed with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}).

4.3.5.4 NDVI values as influenced by different treatments in Bunny Bt (Cv. NCS-145)

The pooled and yearwise data pertaining to NDVI values as influenced by different treatments in Bunny Bt (Cv. NCS-145) at various growth stages presented in Table 60.

NDVI values were not significantly differed among the treatments at 60 and 90 DAS. At 120 DAS, significantly higher NDVI value (0.41) was recorded with soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (T_{10}) and it was on par with soil application of $MgSO_4$ @ 25 kg/ha alone (0.39) (T_9) and foliar application of KNO_3 @ 2% (0.39). The lowest NDVI value (0.19) was recorded with polyethylene mulching (T_{11}).

4.3.5.6 Red leaf index (RLI)

Pooled and yearwise data pertaining to red leaf index (RLI) scored at 90 and 120 DAS is presented in Table 61 and Plate 9, 10 11 12 13 and 14 The red leaf index was not scored at 60 DAS as there were no visual symptoms of reddening. The red leaf index differed significantly at 90 and 120 DAS among the treatments.

At 90 DAS, significantly reduced red leaf index (0.80) was noticed with soil application of $MgSO_4$ @ 25 kg/ha along with foliar application of $MgSO_4$ @ 1% (T_{10}) than others and it was on par with soil application of $MgSO_4$ @ 25 kg/ha (0.88) (T_9) and foliar application of KNO_3 @ 2% (0.88) (T_5). The highest red leaf index (1.57) was scored with polyethylene mulching (T_{11}) and recommended package of practices (T_{12}).

At 120 DAS, significantly reduced red leaf index (1.05) was recorded with the treatments; foliar application of KNO_3 @ 2% (T_5), soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (T_{10}) and soil application of $MgSO_4$ @ 25 kg/ha alone (T_9) than other treatments. The highest red leaf index (2.08) was scored with polyethylene mulching (T_{11}).

4.3.5.7 Correlation coefficient (r)

Correlation coefficient (r) was worked out between seed cotton yield and NDVI, total chlorophyll content, red leaf index and anthocyanin content as influenced by different treatments.

The data on correlation coefficient (r) analyzed between seed cotton yield and NDVI, total chlorophyll content, anthocyanin content and red leaf index is presented in Tables 62a and 62b.

Table 56: Available manganese and copper (ppm) in soil as influenced by different treatments in Bt cotton (Cv. NCS-145) at harvest

Tr. No.	Treatments	Mn			Cu		
		2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	27.35	28.23	27.78	1.72	1.96	1.84
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	28.22	27.80	28.01	1.66	1.85	1.76
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	27.89	28.39	28.14	1.76	1.95	1.86
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	27.73	28.10	27.92	1.75	1.94	1.85
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	28.60	29.07	28.83	1.67	1.95	1.81
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	28.70	27.73	28.26	1.74	1.90	1.82
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	27.13	28.22	27.68	1.70	1.85	1.78
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	27.93	28.90	28.41	1.84	1.92	1.88
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	28.80	28.87	28.83	1.85	1.86	1.86
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	27.50	29.96	28.73	1.85	1.85	1.85
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	27.07	28.88	27.98	1.84	1.90	1.87
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	28.66	29.30	28.98	1.85	1.87	1.86
Initial nutrient status		28.26	32.40	30.33	2.00	2.23	2.12
S.Em ±		**0.78**	**0.78**	**0.54**	**0.05**	**0.03**	**0.03**
LSD (p=0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)		**4.86**	**4.73**	**4.77**	**4.86**	**3.18**	**4.02**

Table 57: Canopy temperature (^{0}C) as influenced by different treatments in Bt cotton (Cv. NCS-145) at 60 DAS

Tr. No.	Treatments	At 9 am			At 1 pm			At 5 pm		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	31.03	31.13	31.08	32.37	33.27	32.82	28.07	26.27	27.17
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	31.33	31.07	31.20	32.90	33.80	33.35	28.57	27.67	28.12
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	31.13	31.53	31.33	33.37	34.13	33.75	29.67	27.00	28.33
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	30.40	31.20	30.80	31.07	34.23	32.65	28.63	27.27	27.95
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	30.77	29.80	30.28	33.00	33.13	33.07	28.30	27.87	28.08
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	31.20	31.07	31.13	33.80	33.73	33.77	28.03	27.80	27.92
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	30.77	29.63	30.20	33.53	34.73	34.13	28.10	27.33	27.72
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	31.87	30.93	31.40	33.23	34.00	33.62	29.07	27.27	28.17
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	30.47	31.53	31.00	33.07	33.63	33.35	28.50	26.23	27.37
T_{10}	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	31.07	30.67	30.87	33.90	33.33	33.62	27.40	27.33	27.37
T_{11}	T_9+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	30.07	31.60	30.83	38.20	37.50	37.85	31.77	33.60	32.68
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	31.47	29.07	30.27	34.87	34.00	34.43	27.37	26.53	26.95
S.Em ±		**0.65**	**0.59**	**0.45**	**0.52**	**0.62**	**0.40**	**0.36**	**0.70**	**0.39**
LSD (p=0.05)		**NS**	**NS**	**NS**	**1.52**	**1.81**	**1.13**	**1.07**	**2.04**	**1.10**
CV (%)		**3.62**	**3.32**	**3.54**	**2.68**	**3.14**	**2.88**	**2.20**	**4.36**	**3.37**

Table 58: Canopy temperature (^{0}C) as influenced by different treatments in Bt cotton (Cv. NCS-145) at 90 DAS

Tr. No.	Treatments	At 9 am			At 1 pm			At 5 pm		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	29.83	31.80	30.82	32.37	33.60	32.98	28.97	26.53	27.75
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	30.83	31.40	31.12	32.90	33.73	33.32	27.60	26.40	27.00
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	31.90	32.00	31.95	33.70	34.80	34.25	28.43	26.93	27.68
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	32.53	32.07	32.30	31.07	34.07	32.57	26.87	26.47	26.67
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	30.67	32.60	31.63	33.00	34.03	33.52	27.57	26.17	26.87
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	29.73	32.53	31.13	33.80	34.00	33.90	28.17	26.20	27.18
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	29.27	32.53	30.90	33.53	34.00	33.77	27.70	26.50	27.10
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	30.80	32.50	31.65	33.23	34.20	33.72	27.77	26.33	27.05
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	30.73	32.73	31.73	33.07	34.90	33.98	27.30	26.17	26.73
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	32.20	33.40	32.80	33.90	34.00	33.95	28.13	26.40	27.27
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	31.47	32.13	31.80	38.20	36.27	37.23	31.20	29.87	30.53
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	30.80	32.40	31.60	34.87	34.47	34.67	28.40	26.87	27.63
S.Em ±		**0.98**	**0.62**	**0.64**	**0.53**	**0.43**	**0.39**	**0.43**	**0.66**	**0.39**
LSD (p=0.05)		**NS**	**NS**	**NS**	**1.57**	**1.27**	**1.10**	**1.26**	**1.94**	**1.11**
CV (%)		**5.47**	**3.30**	**4.94**	**2.75**	**2.19**	**2.78**	**2.65**	**4.29**	**3.47**

Table 59: Canopy temperature (^0C) as influenced by different treatments in Bt cotton (Cv. NCS-145) at 120 DAS

Tr. No.	Treatments	At 9 am			At 1 pm			At 5 pm		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	31.13	32.67	31.90	35.17	34.87	35.02	26.60	28.00	27.30
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	31.07	32.43	31.75	35.70	33.60	34.65	28.10	28.77	28.43
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	31.53	33.17	32.35	35.60	34.60	35.10	27.97	28.47	28.22
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	31.20	32.27	31.73	35.13	34.73	34.93	27.87	28.33	28.10
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	29.80	32.67	31.23	34.27	34.23	34.25	27.73	28.33	28.03
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	31.07	32.73	31.90	35.33	34.80	35.07	27.80	28.33	28.07
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	29.63	31.83	30.73	34.47	35.27	34.87	28.00	27.93	27.97
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	30.93	32.40	31.67	35.53	33.47	34.50	27.67	28.00	27.83
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	31.53	32.73	32.13	33.73	35.13	34.43	27.07	27.97	27.52
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	30.67	32.90	31.78	35.00	35.13	35.07	26.07	27.27	26.67
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	31.60	32.93	32.27	37.87	39.67	38.77	30.60	30.13	30.37
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	29.07	30.67	29.87	34.40	34.73	34.57	26.87	27.93	27.40
S.Em ±		**0.59**	**0.67**	**0.44**	**0.65**	**0.62**	**0.45**	**0.57**	**0.38**	**0.34**
LSD (p=0.05)		**NS**	**NS**	**NS**	**1.91**	**1.81**	**1.29**	**1.66**	**1.12**	**0.96**
CV (%)		**3.32**	**3.55**	**3.40**	**3.21**	**3.05**	**3.17**	**3.54**	**2.33**	**2.96**

Table 60: NDVI value as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 60 DAS			At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	0.48	0.48	0.48	0.53	0.52	0.53	0.34	0.35	0.35
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	0.48	0.49	0.48	0.53	0.51	0.52	0.36	0.34	0.35
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	0.48	0.48	0.48	0.54	0.53	0.54	0.34	0.35	0.34
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.49	0.48	0.48	0.53	0.55	0.54	0.37	0.37	0.37
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.48	0.49	0.49	0.56	0.55	0.55	0.39	0.40	0.39
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	0.48	0.49	0.48	0.53	0.50	0.52	0.36	0.37	0.36
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	0.48	0.48	0.48	0.54	0.50	0.52	0.35	0.37	0.36
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	0.49	0.49	0.49	0.54	0.53	0.54	0.36	0.36	0.36
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.48	0.49	0.48	0.57	0.56	0.57	0.39	0.39	0.39
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.48	0.49	0.49	0.57	0.56	0.57	0.41	0.41	0.41
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	0.49	0.48	0.49	0.56	0.52	0.54	0.16	0.21	0.19
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	0.48	0.49	0.48	0.54	0.50	0.52	0.31	0.30	0.31
S.Em ±		**0.01**	**0.03**	**0.02**	**0.02**	**0.06**	**0.03**	**0.04**	**0.03**	**0.02**
LSD (p=0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.12**	**0.08**	**0.07**
CV (%)		**8.73**	**11.84**	**6.52**	**7.59**	**12.21**	**11.88**	**19.75**	**13.68**	**11.16**

Table 61: Red leaf index as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	At 90 DAS			At 120 DAS		
		2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	1.44 (1.95)	1.34 (1.66)	1.39 (1.80)	1.68 (2.65)	1.58 (2.00)	1.63 (2.31)
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	1.34 (1.66)	1.22 (1.00)	1.28 (1.51)	1.56 (2.28)	1.46 (2.00)	1.51 (2.14)
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	1.34 (1.66)	1.22 (1.00)	1.28 (1.51)	1.56 (2.28)	1.46 (2.00)	1.51 (2.14)
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	1.34 (1.66)	1.22 (1.00)	1.28 (1.51)	1.56 (2.28)	1.46 (2.00)	1.51 (2.14)
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	0.88 (0.69)	0.88 (0.69)	0.88 (0.69)	1.05 (1.00)	1.05 (1.00)	1.05 (1.00)
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	1.34 (1.66)	1.22 (1.00)	1.28 (1.51)	1.56 (2.28)	1.46 (2.00)	1.51 (2.14)
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	1.46 (2.00)	1.22 (1.00)	1.34 (1.66)	1.56 (2.28)	1.56 (2.28)	1.56 (2.24)
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	1.56 (2.28)	1.34 (1.66)	1.45 (1.95)	1.58 (2.00)	1.58 (2.00)	1.58 (2.12)
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	0.88 (0.69)	0.88 (0.69)	0.88 (0.69)	1.05 (1.00)	1.05(1.00)	1.05 (1.10)
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	0.88 (0.69)	0.71 (0.00)	0.80 (0.50)	1.05 (1.00)	1.05 (1.00)	1.05 (2.00)
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	1.68 (2.66)	1.46 (2.00)	1.57 (2.39)	2.08 (4.12)	2.08 (4.12)	2.08 (4.12)
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	1.58 (2.00)	1.56 (2.28)	1.57 (2.29)	1.77 (2.98)	1.87 (3.31))	1.82 (3.13)
S.Em ±		**0.14**	**0.09**	**0.082**	**0.17**	**0.13**	**0.11**
LSD (p=0.05)		**0.41**	**0.27**	**0.234**	**0.50**	**0.39**	**0.31**
CV (%)		**18.32**	**13.46**	**16.1**	**19.55**	**15.71**	**17.7**

* Figures in the paranthesis indicate the original values and analysed data are Öx + 0.5 transformed values

Table 62a: Correlation coefficient (r) between seed cotton yield and NDVI, total chlorophyll content, anthocyanin content and Red leaf index (RLI) at different growth stages (mean of 2007-08 and 2008-09)

Variable	Growth stage	Correlation coefficient (r)
NDVI	60 DAS	0.32
	90 DAS	0.72**
	120 DAS	0.62**
Total chlorophyll content	60 DAS	0.68*
	90 DAS	0.94**
	120 DAS	0.95**
SPAD reading	90 DAS	0.93**
	120 DAS	0.91**
Anthocyanin content	60 DAS	-0.25
	90 DAS	-0.87**
	120 DAS	-0.86**
Red leaf index	90 DAS	-0.89**
	120 DAS	-0.97**
Canopy temperature (^{o} C)	90 DAS recorded at 9 AM	0.22
	90 DAS recorded at 1 PM	-0.66
	90 DAS recorded at 5 PM	-0.81
	120 DAS recorded at 9 AM	-0.01
	120 DAS recorded at 1 PM	-0.78
	120 DAS recorded at 5 PM	-0.75

** - Significant at 1%   * - Significant at 5%

Table 62b: Correlation coefficient (r) between Red leaf index (RLI) and chlorophyll content in leaf (SPAD readings), total chlorophyll content, anthocyanin content and canopy temperature as influenced by different treatments in Bunny Bt (Cv.NCS-145)

Variable	Growth stage	Correlation coefficient (r)
SPAD reading	90 DAS	-0.95
	120 DAS	-0.92
Total chlorophyll content	90 DAS	-0.70
	120 DAS	-0.95
Anthocyanin content	90 DAS	0.86**
	120 DAS	0.92**
NDVI	90 DAS	-0.66
	120 DAS	-0.87
Canopy temperature (^{o} C)	90 DAS recorded at 9 AM	-0.32
	90 DAS recorded at 1 PM	0.54
	90 DAS recorded at 5 PM	0.70*
	120 DAS recorded at 9 AM	-0.13
	120 DAS recorded at 1 PM	0.63*
	120 DAS recorded at 5 PM	0.62*

** - Significant at 1%　　　　* - Significant at 5%

T_1-120 kg N, 60 kg P_2O_5 and 60 kg K_2 O/ha
(10%N, full P and K as basal and 90% N in equal 6 spilts

At 120 DAS

At harvest

T_2-T_1 + Foliar application of Urea @ 2% three
Times at an interval of 15 days from October II FN

At 120 DAS

At harvest

Plate 9: Photograph showing the treatment difference between T_1 and T_2 in Bunny Bt (Cv. NCS-145)

T_3-T_1 + Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN

At 120 DAS

At harvest

T_4-T_1 + Foliar application of MgSO4 @ 1% three times at an interval of 15 days from October II FN

At 120 DAS

At harvest

Plate 10: Photograph showing the treatment difference between T_3 and T_4 in Bunny Bt (Cv. NCS-145)

T_5-T_1 + Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN

At 120 DAS

At harvest

T_6-T_1 + Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN

At 120 DAS

At harvest

Plate 11: Photograph showing the treatment difference between T_5 and T_6 in Bunny Bt (Cv. NCS-145)

T_7-T_1 + Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN

At 120 DAS

At harvest

T_8-T_1+Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN

At 120 DAS

At harvest

Plate 12 : Photograph showing the treatment difference between T_7 and T_8 in Bunny Bt (Cv. NCS-145)

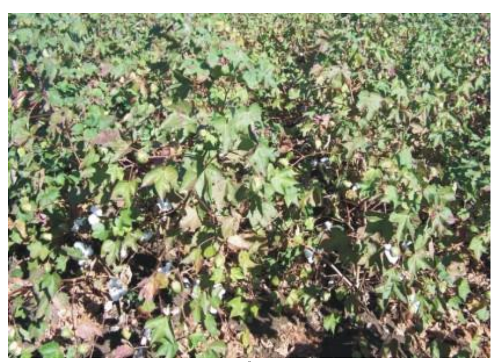
T_9-T_1+ Soil application of $MgSO_4$ @ 25 kg/ha

At 120 DAS

At harvest

T_{10}-T_9+Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN

At 120 DAS



At harvest

Plate 13: Photograph showing the treatment difference between T_9 and T_{10} in Bunny Bt (Cv. NCS-145)

T_{11}-T_1 + Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest

At 120 DAS

At harvest

T_{12}-120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50%N, full P and K as basal and top dressing of 50% N in equal 3 splits

At 120 DAS

At harvest

Plate 14: Photograph showing the treatment difference between T_{11} and T_{12} in Bunny Bt (Cv. NCS-145)

Significant positive correlation existed between seed cotton yield and NDVI values (r = 0.72 at 90 DAS, r = 0.62 at 120 DAS), total chlorophyll content (r = 0.68 at 60 DAS, r = 0.94 at 90 DAS and r = 0.95 at 120 DAS) and SPAD reading (r = 0.93 at 90 DAS and r = 0.91 at 120 DAS). However, significant negative correlation existed between seed cotton yield and anthocyanin content (r = -0.87 at 90 DAS, r = -0.86 at 120 DAS) red leaf index (r = -0.89 at 90 DAS and r= -0.97 at 120 DAS). Negative correlation was existed between seed cotton yield and canopy temperature recorded at 120 DAS (r = -0.01 recorded at 9 am, r = -0.78 recorded at 1 pm and r = -0.75 recorded at 5 pm). Significant and positive correlation existed between RLI and anthocyanin content recorded at 90 DAS (r = 0.86) and 120 DAS (r = 0.92). Negative correlation existed between RLI and chlorophyll content (SPAD readings), NDVI values and total chlorophyll content recorded at 120 DAS (Table 62b).

4.3.5.8 Fibre quality parameters

The pooled and yearwise data pertaining to fibre quality parameters is presented in Table 63.

2.5% span length (mm)

Significant differences were observed among the treatments with respect to 2.5% span length (mm). Foliar application of KNO_3 @ 2% (T_5) significantly increased the 2.5% span length (33.07 mm) than other treatments and it was on par with foliar application of cytokinin @ 20 ppm (32.57 mm) (T_8), foliar application of calcium nitrate @ 1% (32.28 mm) (T_6) and RDF (32.25 mm) (T_{12}). The lowest 2.5% span length (31.53 mm) was recorded with foliar application of DAP @ 2% (T_3).

Fibre fineness

Pooled and yearwise data indicated that there was no significant difference observed among the treatments with respect to fibre fineness.

Bundle strength (mm)

Foliar application of KNO_3 @ 2% (T_5) significantly increased the bundle strength (24.80 g/tex) than other treatments and it was on par with soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (24.23 g/tex) (T_{10}), foliar application of Urea @ 2% (24.13 g/tex). The lower bundle strength (23.45 g/tex) was observed with polyethylene mulching (T_{11}).

4.3.6 Economic analysis

The pooled and yearwise data on economic analysis of different treatments is presented in Table 64.

4.3.6.1 Cost of cultivation (Rs./ha)

The total cost of cultivation was higher for polyethylene mulching (Rs. 176561/ha) which includes major cost of polyethylene sheet (Rs. 150000/ha). Rest treatments cost includes additional split application of nitrogen and superimposed nutrients cost and application cost.

4.3.6.2 Gross return (Rs./ha)

Pooled data and yearwise data indicated that gross return differed significantly among the treatments. Foliar application of KNO_3 @ 2% (T_5) recorded significantly higher gross return (Rs. 56249/ha) and was on par with soil application of $MgSO_4$ @ 25 kg/ha (Rs. 55688/ha) (T_9) and soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (Rs. 55812/ha) (T_{10}). The lowest gross return (Rs. 30576/ha) obtained with polyethylene mulching (T_{11}).

4.3.6.3 Net return (Rs./ha)

Treatments differed significantly with respect to net return. Foliar application of KNO_3 @ 2% (T_5) recorded significantly higher net return (Rs. 27807/ha) (T_9) and was on par with soil application of $MgSO_4$ @ 25 kg/ha (Rs. 27722/ha) and soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (Rs. 26857/ha) (T_{10}). Negative net return (Rs. -145985/ha) was recorded with polyethylene mulching (T_{11}).

Table 63: Fibre quality parameters as influenced by different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatments	2.5% span length (mm)			Fibre fineness (micronair value)			Bundle strength (g/tex)		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	31.57	31.53	31.55	4.37	4.27	4.32	23.23	24.43	23.83
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	31.87	31.97	31.92	4.17	4.20	4.18	24.17	24.10	24.13
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	31.23	31.83	31.53	4.20	4.13	4.16	24.13	22.83	23.48
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	31.90	31.67	31.78	4.20	4.30	4.25	24.00	23.07	23.53
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	32.33	33.80	33.07	4.20	4.37	4.28	24.07	24.70	24.80
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	32.43	32.13	32.28	4.30	4.17	4.23	24.20	23.63	23.92
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	32.07	31.17	31.62	4.17	4.07	4.18	24.00	23.73	23.87
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	32.77	32.37	32.57	4.03	4.40	4.13	24.33	23.13	23.73
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	32.07	31.73	31.90	4.20	4.67	4.27	24.17	23.37	23.77
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	31.57	31.57	31.57	4.17	4.27	4.05	24.27	24.20	24.23
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	31.30	32.33	31.82	4.23	4.27	4.25	23.77	23.13	23.45
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	32.20	32.30	32.25	4.10	4.33	4.22	24.13	23.47	23.80
S.Em ±		**0.47**	**0.47**	**0.38**	**0.12**	**0.10**	**0.10**	**0.32**	**0.44**	**0.29**
LSD (p=0.05)		**NS**	**NS**	**1.08**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.82**
CV (%)		**2.57**	**2.52**	**2.90**	**4.89**	**4.17**	**5.84**	**2.31**	**3.22**	**2.96**

Table 64: Economic analysis of different treatments in Bt cotton (Cv. NCS-145)

Tr. No.	Treatment details	Cost of Cultivation (Rs./ha)			Gross return (Rs./ha)			Net return (Rs./ha)			BC ratio		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	26220	28306	27263	45349	46824	46087	19129	18518	18823	1.73	1.65	1.69
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	26896	29032	27964	45525	47326	46425	18629	18294	18461	1.69	1.63	1.66
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	27173	29253	28213	46053	47269	46661	18880	18016	18448	1.69	1.62	1.66
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	27862	30022	28942	45579	47541	46560	17717	17519	17618	1.64	1.58	1.61
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	28333	28550	28442	54939	57559	56249	26606	29009	27807	1.94	2.02	1.98
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	28522	30748	29635	44942	47598	46270	16420	16850	16635	1.58	1.55	1.56
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	30562	32638	31600	46216	47369	46792	15654	14731	15192	1.51	1.45	1.48
T_8	T_1+ Foliar application of cytokinin @ 2ppm three times at an interval of 15 days from October II FN	27540	29727	28634	45118	47441	46279	17578	17714	17646	1.64	1.60	1.62
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	26853	29079	27966	53760	57617	55688	26907	28538	27722	2.00	1.98	1.99
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	27212	30699	28956	53936	57688	55812	26724	26989	26857	1.98	1.88	1.93
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	177002	176119	176561	30910	30242	30576	-146092	-145877	-145985	0.17	0.17	0.17
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	24372	26188	25280	41935	42367	42151	14563	14179	14371	1.53	1.50	1.52
S.Em ±		**-**	**-**	**-**	**2737**	**3194**	**2123**	**2737**	**3194**	**2123**	**0.10**	**0.10**	**0.07**
LSD (p=0.05)		**-**	**-**	**-**	**8027**	**9367**	**6044**	**8027**	**9367**	**6044**	**0.28**	**0.30**	**0.20**
CV (%)		**-**	**-**	**-**	**10.26**	**11.51**	**11.04**	**78.23**	**89.12**	**84.4**	**10.42**	**11.23**	**10.94**

4.3.6.4 Benefit cost ratio

Benefit cost ratio differed significantly among treatments. Soil application of $MgSO_4$ @ 25 kg/ha (T_9) recorded significantly higher BC ratio (1.99) and was on par with foliar application of KNO_3 @ 2% (1.98) (T_5) and soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (1.93) (T_{10}). The lowest benefit cost ratio (0.17) was recorded with polyethylene mulching (T_{11}).

5. DISCUSSION

An area 9.4 m ha in India consisted entirely of Bt cotton contributing around 30 per cent of the gross domestic product of Indian agriculture (Anon., 2011a). Most of the cotton in India is grown under rainfed conditions and about 35 per cent is grown under irrigation (Anon., 2006). The area under Bt cotton in India is increasing every year since its release by GEAC in 2002. However, yields of cotton in India are low with an average lint yield of 494 kg /ha compared to world average of 725 kg/ha. As with many cotton growing areas of the world a major limiting factor is damage due to insect pests, specially the bollworm complex. In this regard transgenic Bt cotton has been commercialized in order to protect the losses of fruiting bodies by the entomological constraints. As expected Bt cotton had better retention of early formed squares and bolls due to better insect control. Synchronized boll development in Bt plants altered the source-sink relationship due to rapid translocation of saccharides and nutrients from leaves to the developing bolls. This has lead to the physiological disorders such as leaf reddening or premature senescence, square and boll shedding, parawilt or sudden wilt, bad opening of bolls etc., leading to early crop maturity (Hebbar and Mayee, 2011; Hebbar *et al.,* 2007b; Wright, 1999). However, the growth, temporal variation in fruit load and the associated physiological processes of Bt cotton hybrids especially with their non-Bt counterparts are not well known.

In the recent past leaf reddening is a major problem in Bt cotton growing areas of northern Karnataka. To quantify this problem a survey was undertaken to a sample of 100 farmers regarding the constrains of Bt cotton faced by them during May 2007. According to survey report (from Bt cotton growers in Belgaum and Haveri districts of Karnataka) more than 93 per cent farmers had faced the problem of leaf reddening irrespective of Bt hybrids used from different sources (Table 3b). Only 6-7 per cent farmers had adopted the recommendation of control measures with 2 per cent DAP or 1 per cent urea or 1 per cent $MgSO_4$ spray. However, the control was not to the satisfactory level. As per farmers feed back it was felt that a need based research needs has to be designed and undertaken to overcome the problem of leaf reddening malady. In the light of survey report and review of literature, two experiments were planned and executed on the Agronomy Post Graduate Block of Main Campus, UAS, Dharwad during *kharif* seasons of 2007 and 2008 and the results obtained during the course of investigation are discussed in the present chapter.

5.1 Weather and crop growth

5.1.1 Weather condition during experimental years

During the year 2007-08, a total of 1081.10 mm was received in 85 rainy days (Table 1a and Fig.1a). This was about 42 per cent excess over the normal rainfall of 759.5 mm. During the cropping period between June 2007 and March 2008, 865.2 mm rainfall was received in 75 rainy days. The monthwise distribution of rainfall during crop growth period, during the year 2007-08 was 220.1 mm, 211.2 mm, 176.0 mm, 18.1 mm, 74.8 mm, 54.0 mm, 0.0 mm, 0.0 mm, 0.0 mm and 111.0 mm in the month of June, July, August, September, October, November, December, January, February and March, respectively. The data indicates that during grand growth period of the cotton in the present study rainfall was evenly distributed except in the month of September (18.1 mm) during which time moisture stress was observed during this crop growing period.

There was not much deviation in monthly mean maximum as well as minimum temperature. The average maximum temperature for crop growth period was 29.77^0C when compared to the last 56 years (30.17^0C). Average minimum temperature during crop growth period was 19.58^0C while the average was 18.01^0C for the last 56 years. The temperature is known to have its profound effect on crop starting from germination to boll bursting and harvesting. However, the lower temperature prevailed during 2007-08 in the month of October (19.4^0C), November (15.1^0C), December (14.6^0C) and January (19.8^0C) coincided with leaf reddening in Bt cotton. Similar trend was also observed during 2006-07.

Average relative humidity (RH) was observed in July (85%) followed by August (85%). The average of 56 years indicated a mean RH of 71.3 per cent for the corresponding months during the cropping season. Thus a five per cent deviation in RH prevailed during the cropping season, compared to the average for 56 years. The RH is known to affect the crop growth through pest and disease incidence.

During the year 2008-09, total rainfall received was 928.9 mm in 75 rainy days. This was about 18 per cent excess over the normal rainfall of 759.5 cm. During the cropping period between June 2008 and March 2009, 760.60 mm rainfall was received in 65 rainy days. The monthwise distribution of rainfall during crop growth period of the year of 2008-09 was 101.6 mm, 121.0 mm, 213.2 mm, 162.4 mm, 60.4 mm, 72.2 mm, 0.8 mm, 0.4 mm, 0.0 mm and 29.8 mm, in the month of June, July, August, September, October, November, December, January, February and March, respectively. The data indicates that during grand growth period of the cotton in the present study the rainfall was evenly distributed and there was no prolonged moisture stress during the crop growing period, which helped the crop to express its full potential.

There was not much deviation in monthly mean maximum as well as minimum temperature. The average maximum temperature for crop growth period was 29.87^{0}C when compared to the last 56 years (30.17^{0}C). Average minimum temperature during crop growth period was 18.06^{0}C while the average was 18.01^{0}C for the last 56 years.

Average relative humidity (RH) for the cropping period i.e., June to March was 80.15 per cent. The highest RH was observed in June (91.8%) followed by August (91.50%). The average of 56 years indicates a mean RH of 71.3 per cent for the corresponding months during the cropping season. Thus, a 22 per cent deviation in RH prevailed during the cropping season compared to the average for 56 years. In all meteorological parameters indicated favorable condition for crop growth without any physiological or biological stresses which ultimately helped to realize better harvests.

5.1.2 Weather condition during cropping period

In the first season (2007-08), the total rainfall received during the cropping period (1st June to last week of January) was 922 mm in 51 rainy days (Table 1b and Fig.1b). The crop experienced well distributed rainfall during its grand growth period i.e., 188.8 mm at 31- 60 DAS in 9 rainy days, 104.8 mm at 61-90 DAS in 6 rainy days, 53.70 mm at 91-120 DAS in 2 rainy days. The average RH was 83.4 per cent during the cropping period. The maximum RH was provided at 31-60 DAS (92.2%) and decreased steadily at 61-90 DAS (79.2%) and at 91-120 DAS (79.2%) and at 91-120 DAS (71.4^{0}C).

The average mean maximum temperature prevailed during the cropping period was 28.5^{0}C. The mean maximum temperature 27.0^{0}C was prevailed at 0-30 DAS and it remained almost in the same range, 27.4^{0}C at 31-90 DAS, 29.4^{0}C at 91-120 DAS and 29.3^{0}C at 121 DAS-harvest. However, in comparison with mean maximum temperature, fluctuation in mean minimum temperature was prevailed. The average mean minimum temperature was $19.^{0}$C. The mean minimum temperature prevailed during 1st June to sowing ($21.^{0}$C), 31-60 DAS (20.7^{0}C) and at 61-90 DAS (20.8^{0}C) remained almost same. There was sudden drop in mean minimum temperature to 16.4^{0}C at 91-120 DAS and $14.^{0}$C at 121 DAS to harvest.

In the second season (2008-09) the total rainfall received during the cropping period (1st June to last week of January) was 730.8 mm in 46 rainy days. The crop experienced well distributed rainfall during its grand growth period i.e., 168.0 mm at 61 to 90 DAS in 13 rainy days, 60.4 mm at 91-120 DAS in 3 rainy days, 24.6 mm at 91-120 DAS in 2 rainy days and 47.6 mm at 120 DAS to lowest in 2 rainy days. The average RH was 85.3 per cent during the cropping period. The maximum RH was prevailed at 0 to 30 DAS (92.4%) and decreased steadily to 90 per cent at 31 to 60 DAS, 77.8 per cent at 91-120 DAS and 75.3 per cent at 121 DAS - harvest. The average mean maximum temperature 28.5^{0}C was prevailed at 1st June to sowing and it remained almost in the same range 26.2^{0}C at 0 to 30 DAS, 27.5^{0}C, at 31-60 DAS, 30.0 ^{0}C at 61 to 90 DAS and 91 to 120 DAS, 25.5^{0}C at 121 DAS to harvest. In 2008 also, there was sudden drop in mean minimum temperature 15.3^{0}C at 91-120 DAS and 13.8^{0}C at 121 DAS to harvest.

In both the season the mean minimum temperature dropped suddenly 91 to 120 DAS and 121 DAS to harvest. The RH also followed the similar trend.

5.2 Assessing leaf reddening malady in Bt cotton genotypes

Genotypes play an important role in determining yield of crops compared with environment in the expression of genetic potentiality. Genotypes differ in their yield potential depending on many factors and yield is the result of a complex process occurring in various parts of plant involved in many morphological changes controlled by both the genetic makeup and the environment. The crop experienced well distributed rainfall during the cropping period (June-March) in *kharif* seasons of 2007 and 2008. Hence, there was no moisture stress during grand growth period which helped the crop to express its full potential.

In the present investigation, among the different genotypes studied, Neeraja (BG II) Bt produced significantly higher yield (2483 kg/ha) compared to other genotypes. During the cropping period the crop experienced well distributed rainfall (922 mm in 51 rainy days in 2007, 730.8 mm in 46 rainy days in 2008). The yield of tested cotton genotypes was in the range 1131 kg/ha to of 2483 kg/ha. The lowest yield was observed in RCH-368 non-Bt (1131 kg/ha) (Table 4). The results suggest that all the Bt hybrids (BG I and BG II) were superior with respect to yield (1978 kg/ha) compared to their non Bt counterparts (1258 kg/ha). The Bt hybrids (BG I and BG II) produced 36 per cent higher yield compared to their non-Bt counter parts. Among the tested genotypes (4 Bt and 4 non-Bt genotypes), Neeraja (BG II) Bt recoded 36 and 43 per cent higher yield over check DCH-32 non-Bt hybrid and check Sahana non-Bt variety, respectively. Higher yield per ha is supported by seed cotton yield per plant which ranged between 142.95 g (Neeraja (BG II) Bt) to 57.73 g (JK-Durga non-Bt). Neeraja (BG II) Bt produced 48 and 52 per cent higher boll weight per plant than DCH-32 non-Bt hybrid and Sahana non-Bt variety, respectively. Among Bt genotypes Neeraja (BG II) Bt produced 32 per cent higher seed cotton yield and also 35 per cent higher seed cotton yield per plant when compared to other Bt genotypes, RCH-368 Bt (1679 kg/ha) and JK-Durga Bt (1679 kg/ha). Boll weight (g/boll) also followed the similar trend of seed cotton yield per plant (Table 5 and 6 and Fig.4).

DCH-32 non-Bt hybrid and Sahana non-Bt variety were ruling genotypes in northern transitional tract of Dharwad. The yield advantage of Bt genotypes; Neeraja (BG II) Bt to the extent of 36 per cent over DCH-32 non-Bt hybrid and 43 per cent over Sahana non-Bt variety noticed in the present investigation explicitly supports the superiority of Bt cotton cultivation over non-Bt ruling hybrids and varieties. The results obtained are similar to the findings of Joshi (2007), who indicated 56 per cent yield advantage of Bt genotypes over DCH-32. Halemani *et al.* (2004) indicated 36-80 per cent yield advantage of Bt genotypes over DCH-32 and DCH-11. Hallikeri *et al.* (2004) also reported 88-112 per cent yield advantage of Bt genotypes over non-Bt DHH-11 and NHH-44 genotypes. The study conducted in USA by Carlson *et al.* (1998) indicated 11.4 per cent yield advantage due to Bt genotypes over the conventional cotton genotypes.

Comparison within Bt genotypes in the present study has shown variations in (1-35%) yield advantage among different tested Bt genotypes which is higher than 14 per cent (Hallikeri *et al.,* 2004) and 2-10 per cent (Halemani *et al.,* 2004) yield advantage among the tested genotypes. However, Joshi (2007) reported greater variations in (1-53%) yield advantage among different tested Bt genotypes in comparison to the present findings. The results of the present study indicated that Bollgard II Bt is a high yielder comparison to single gene Bt genotype. However, Joshi (2007) reported that Bollgard II Bt genotypes were lower yielders in comparison to single gene Bt genotypes. The main yield contributing factor in the cotton is number of good opened bolls per plant which were found significantly higher in Neeraja (BG II) Bt (51.53) and it was on par with Bunny (BG I) Bt (49.76). Neeraja (BG II) Bt produced 19.6 and 40.40 per cent higher number of good opened bolls, respectively compared to DCH-32 non-Bt hybrid and Sahana non-Bt variety (Table 7, 8 and 9). Higher number of good opened bolls in these Bt genotypes also reflected their performance in lower bad opened bolls per plant (1.68 in Neeraja (BG II) Bt and 2.16 in Bunny (BG I) Bt) compared to DCH-32 non-Bt hybrid (12.80) and Sahana non-Bt variety (6.24). Similarly Hosmath *et al.* (2004) and Yenagi (2006) observed higher number of good opened bolls in Bt cotton genotypes in comparison with non-Bt cotton genotypes. Khadi *et al.* (2002) and Bhosale *et al.* (2004b) reported yield advantages of Bt version hybrids over non-Bt.

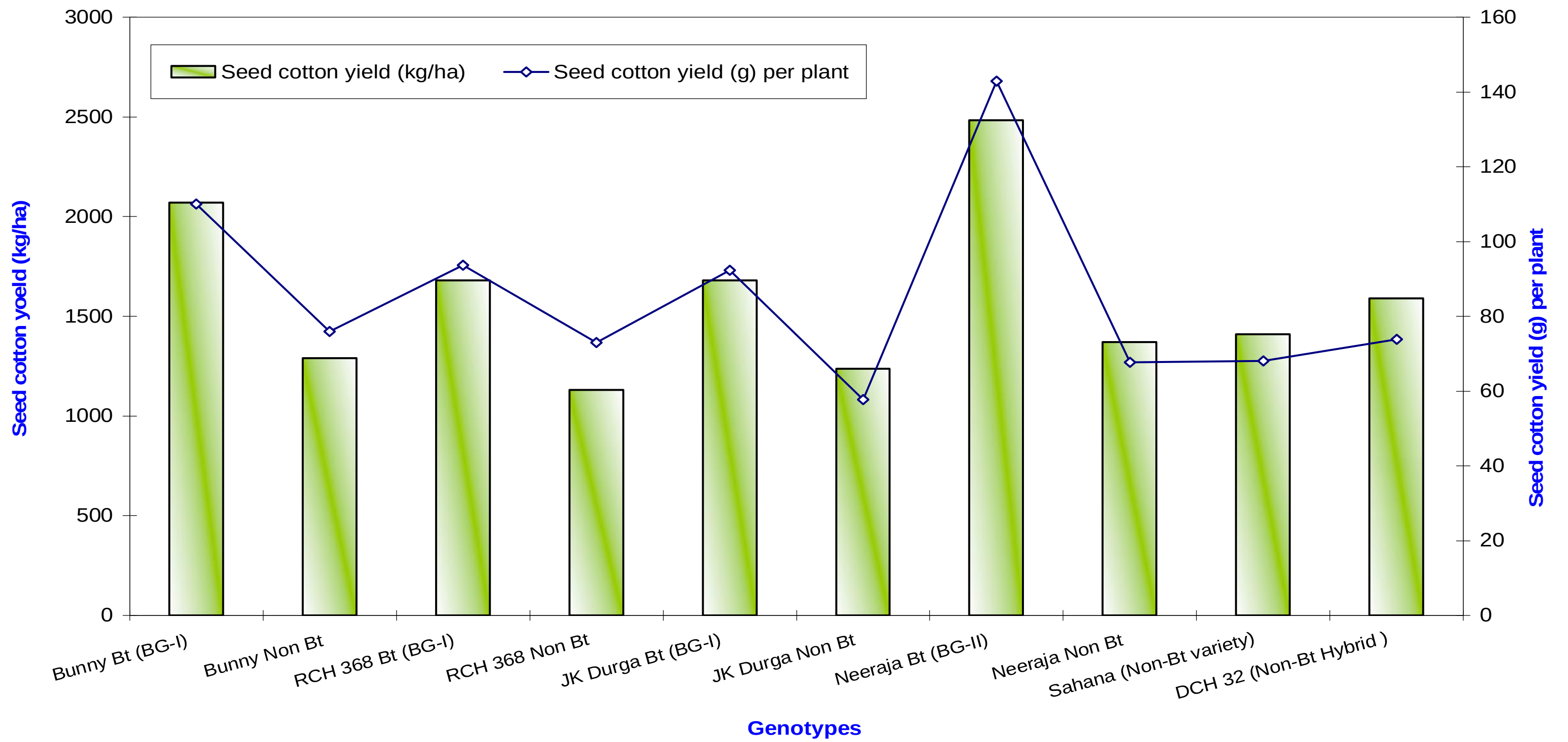


Fig. 4: Seed cotton yield (kg/ha) and seed cotton yield (g) per plant in different cotton genotypes

Fig. 4: Seed cotton yield (kg/ha) and seed cotton yield (g) per plant in different cotton genotypes

The main yield contributing factor in the cotton is sympodial branches which were found significantly higher in DCH-32 non-Bt hybrid (19.38) and it was on par with Neeraja (BG II) Bt (18.60) and Bunny (BG I) Bt (18.23) (Table 10). Though DCH-32 non-Bt hybrid produced more number of sympodial branches (19.38) but produced more number of bad opened bolls (12.80) whereas Neeraja (BG II) Bt and Bunny (BG I) Bt produced less number of sympodial branches (18.60 and 18.23, respectively) in comparison with DCH-32 non-Bt hybrid but produced less number of bad opened bolls (1.68 and 2.16, respectively). In Bt cotton, in addition to the number of sympodial branches, production of less number of bad opened bolls (on account of better boll worm control) contributes positively towards the seed cotton yield.

5.2.2 Biochemical characters

The total chlorophyll content determines the photosynthetic capacity of the genotypes and influences the rate of photosynthesis, dry matter production and the yield (Krasichkova *et al.,* 1989). In the present study, the total chlorophyll content increased among the genotypes progressively from 60 DAS (0.35 mg/g fresh weight) to 90 DAS (1.14 mg/g fresh weight) and 120 DAS (1.45 mg/g fresh weight). At 120 DAS, among the cotton genotypes, Neeraja non-Bt recorded significantly higher total chlorophyll content (1.66 mg/g fresh weight) compared to other genotypes (Table 21, 22, 23 and Fig.5). The lowest total chlorophyll content (1.04 mg/g fresh weight) was recorded with Sahana non-Bt variety. Between Bt and non-Bt genotypes, significantly higher total chlorophyll content (1.47 mg/g fresh weight) was observed with non-Bt compared to Bt (1.42 mg/g fresh weight). The total chlorophyll content was increased by 3.4 per cent in Bt cotton genotypes over non-Bt cotton genotypes. Pagare and Durge (2011) reported chlorophyll content reduced in Bt genotypes in comparison with non-Bt genotypes. Among Bt cotton genotypes, significantly higher total chlorophyll content was observed with Neeraja (BG II) Bt (1.61 mg/g fresh weight) it was on par with Bunny (BG I) Bt (1.60 mg/g fresh weight).

Among the chlorophyll fractions, both chlorophyll ‘a’ and ‘b’ contents were higher in the genotypes at 60, 90 and 120 DAS having higher seed cotton yield. Since, chlorophyll ‘a’ content is essential for the conversion of radiant energy into chemical energy (carbohydrates) and consists a major portion of both the pigment system I and pigment system II, the increase of chlorophyll ‘a’ content could be advantageous for efficient exploitation of the available radiant energy relatively higher level of chlorophyll ‘b’ content is an indicative of higher PS-II activity. This trait is desirable under arid tropical environment (Bharadwaj and Singh, 1988).

The chlorophyll content in leaf (SPAD readings) indicated (Table 12, 13, 14 and Fig. 5), the similar trend was observed with chlorophyll ‘a’ content, chlorophyll ‘b’ content and total chlorophyll content at 60, 90 and 120 DAS.

Wells (2001) in the field study examined in cotton the changes in leaf chlorophyll and anthocyanin contents and their relationship to canopy photosynthetic patterns in response to removal of flowers for the 2 weeks of flowering. It was observed that chlorophyll concentrations were higher in leaves from the flower removal treatments after 100 days after planting. Anthocyanin levels were higher in controls during the same period indicating significant negative relationship between anthocyanin levels and either chl a/b ratio or total chlorophyll concentrations. Pigment differences late in development were associated with delayed senescence of plants from the removal treatment. Similar findings also reported by Bhatt (1978). In the present study the similar trend was observed as reported by Wells (2001). The total chlorophyll content was found higher (1.47 mg/g fresh weight at 120 DAS) in non-Bt genotypes with less number of total bolls (35.18/plant) in comparison with less chlorophyll content (1.42 mg/g fresh weight) with more number of total bolls (48.95/plant) in Bt genotypes. This indicates that the reproductive parts demand more photosynthates for its development which is more retained in Bt genotypes because of better control of boll worm and reduced boll drop as compared to non-Bt genotypes.

The anthocyanin content in the present investigation increased from 90 DAS (0.100 mg/g fresh weight) and progressed at 120 DAS (0.204 mg/g fresh weight) among genotypes (Table 25, 26, 27 and Fig. 6). Similar finding was observed by Wells (2001).

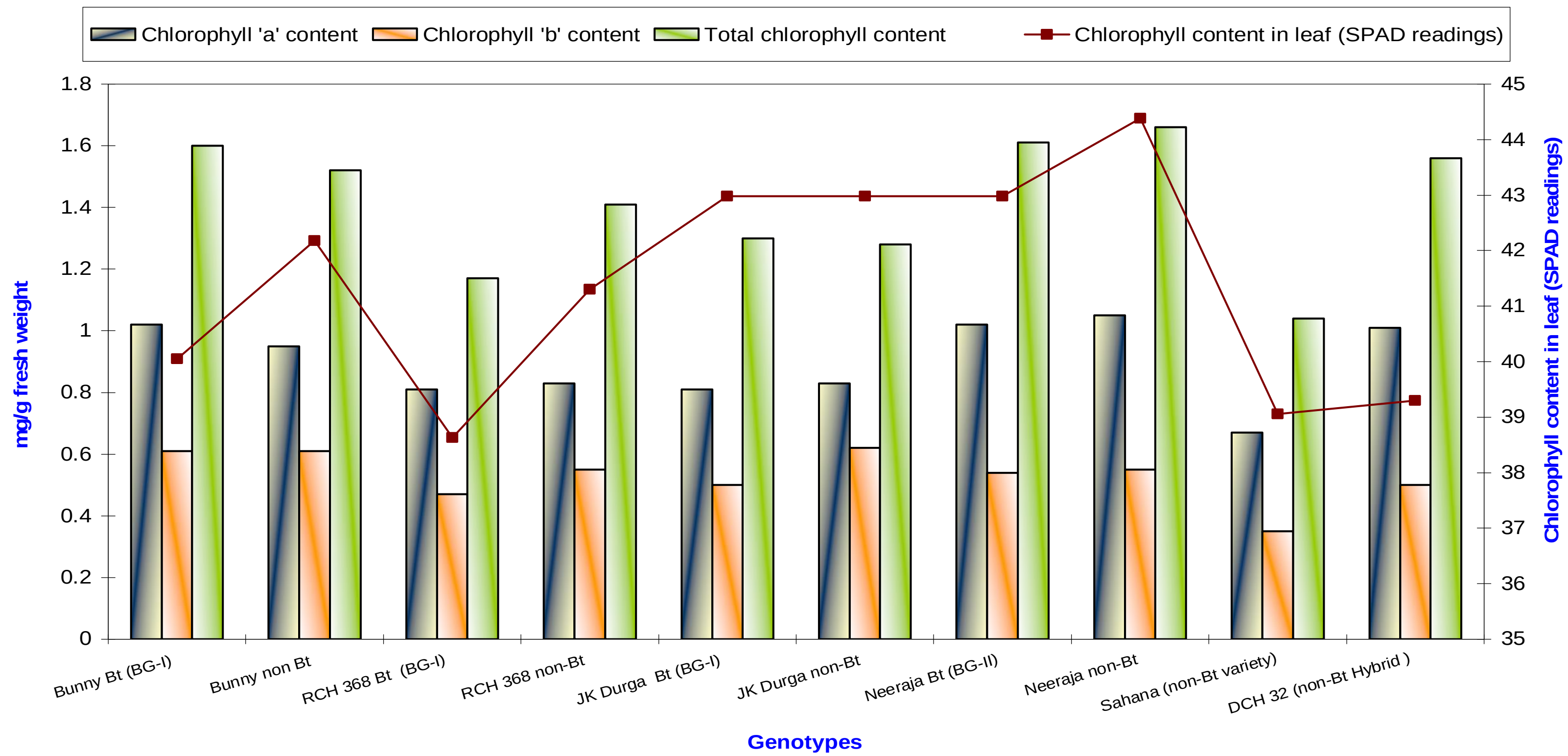


Fig. 5: Cholorophyll 'a' content, Cholorophyll 'b' content ,Total Cholorophyll content and Chlorophyll content in leaf (SPAD readings) at 120 DAS in different cotton genotypes

Fig. 5: Cholorophyll 'a' content, Cholorophyll 'b' content ,Total Cholorophyll content and Chlorophyll content in leaf (SPAD readings) at 120 DAS in different cotton genotypes

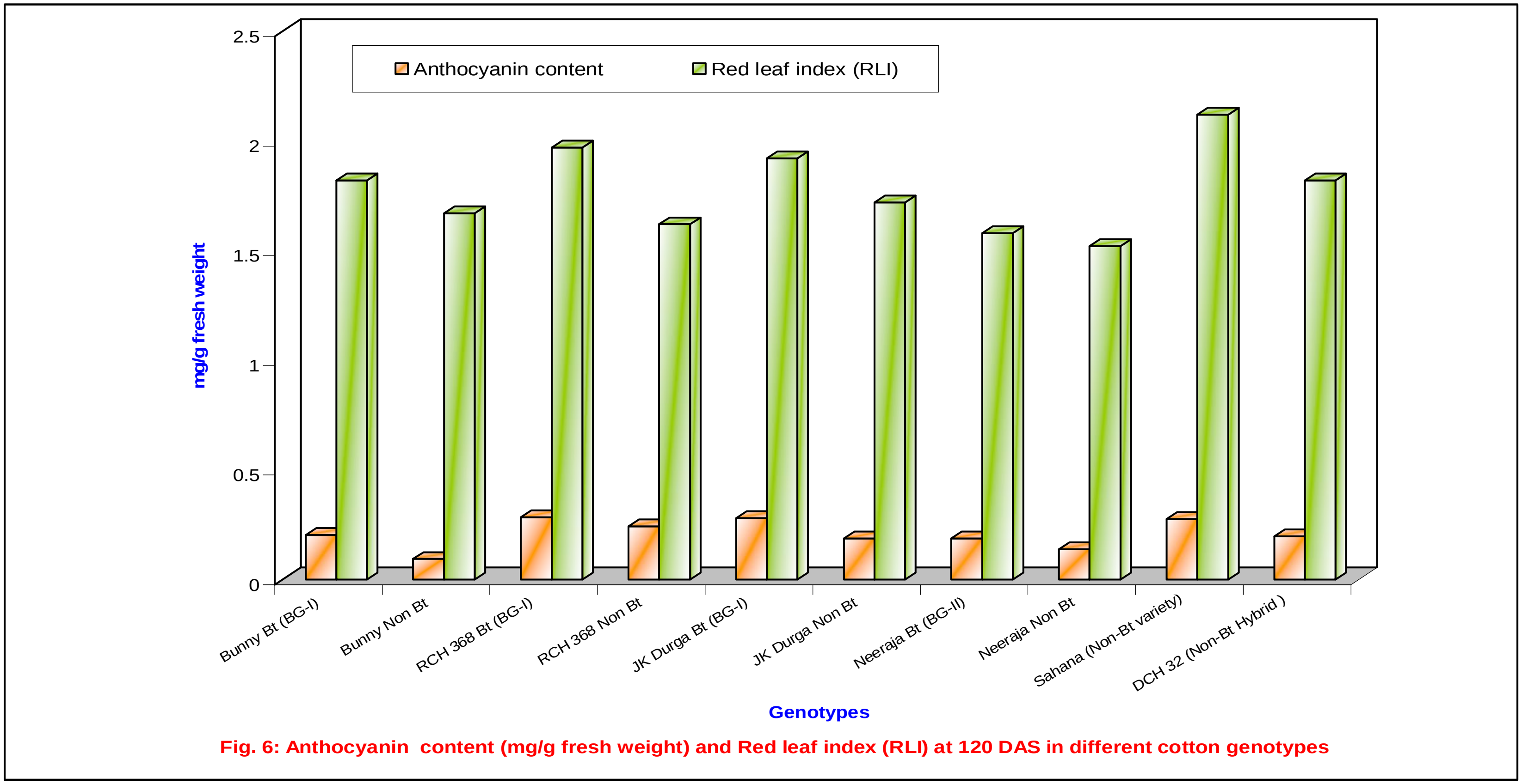


Fig. 6: Anthocyanin content (mg/g fresh weight) and Red leaf index (RLI) at 120 DAS in different cotton genotypes

At 120 DAS, RCH-368 (BG I) Bt recorded significantly higher anthocyanin content (0.284 mg/g fresh weight) followed by JK Durga (BG I) Bt (0.280 mg/g fresh weight) (Table 26). Between Bt and non-Bt genotypes, significantly higher anthocyanin content (0.237 mg/g fresh weight) was observed with Bt in comparison with non-Bt genotypes (0.156 mg/g fresh weight). The anthocyanin content increased by 34.2 per cent in Bt cotton genotypes compared to non-Bt cotton genotypes. Pagare and Durge (2011) reported that anthocyanin content in reddening affected leaves was maximum in MRC-6301 Bt cotton variety.

5.2.3 Red leaf index (RLI)

Red leaf index (RLI) is the manifestation of all the factors responsible for reddening of leaves in cotton. RLI indicates the degree of leaf reddening quantitatively (Dastur *et al.,* 1952). In the present investigation, there were no visual symptoms of leaf reddening at 60 DAS; from 90 DAS onwards the crop exhibited reddened leaves (Table 27). RLI at 90 DAS was 1.32 and increased to 1.77 at 120 DAS among the genotypes (Table 27,28 and Fig 6). At 120 DAS, check Sahana non-Bt variety recorded significantly higher RLI (2.12) and it was on par with RCH 368 (BG I) Bt (1.97) and JK Durga (BG I) Bt (1.92) (Table 28). Between Bt and non-Bt genotypes, Bt genotypes recorded significantly higher RLI (1.82) compared to non-Bt genotypes (1.63). Among Bt genotypes, Neeraja (BG II) Bt recorded significantly lower RLI (1.58) than others. Chimmad (1989) observed higher RLI with interspecific hybrids than the varieties. However, in the present investigation Sahana non-Bt variety recorded higher RLI (2.12).

In the present investigation the results obtained in biochemical observations (chlorophyll ‘a’ content, chlorophyll ‘b’ content, total chlorophyll content and anthocyanin content) are in line with the RLI results. Hence, the intensity of leaf reddening was observed more with Sahana non-Bt variety followed by RCH-368 (BG I) Bt and JK Durga (BG I) Bt. The leaf reddening was observed more with Bt genotypes than non-Bt genotypes. A positive and significant correlation observed between red leaf index and anthocyanin content (r = 0.69 at 90 DAS and r = 0.68 at 120 DAS) (Table 28a). Among Bt genotypes less leaf reddening incidence observed with Neeraja (BG II) Bt (1.58). Pagare and Durge (2011) reported that anthocyanin content in reddening affected leaves was maximum in Bt cotton genotypes.

In the present investigation at 91-120 DAS in both the seasons there was sudden drop in mean minimum temperature from 20.8^{0}C (61-90 DAS) to 16.4^{0}C in 2007 and from 19.5^{0}C (61-90 DAS) to 15.3^{0}C in 2008 (Table 1b). Again the mean minimum temperature dropped from 16.4^{0}C to 14.0^{0}C at 121 DAS to harvest in 2007 and from 15.3 ^{0}C to 13.8 ^{0}C at 121 DAS to harvest in 2008. It clearly indicates in both seasons the crop was subjected to low temperature conditions between 90 DAS and at harvest and higher RLI values were also recorded. This implies that the lower temperature favours the synthesis of anthocyanin content (Table 24, 25 and 26) and so also at this period (120 DAS) Sahana non-Bt variety recorded higher RLI value (2.12) compared to Bt version hybrids (1.82). Similarly, Shanmugham (1992) reported that drop in day temperature below 21^{0}C and sudden fall in night temperature below 15^{0}C stimulate the formation of anthocyanin pigment. Chimmad (1989) also observed higher RLI values with the onset of winter in interspecific cotton hybrid.

5.2.4 Quality parameters

The data on quality parameters revealed that the differences among the cotton genotypes were significant (Tables 30 and 31). DCH-32 non-Bt hybrid recorded significantly higher 2.5% span length (33.82 mm) compared to other cotton genotypes under test. Neeraja (BG II) Bt recorded significantly higher fibre fineness (4.56 micronaire value) whereas Neeraja non Bt recoded higher bundle strength (25.60 g/tex) compared to other cotton genotypes under investigation. No significant differences were observed between Bt and non Bt genotypes with respect to 2.5% span length, fibre fineness and bundle strength. It has been reported that in general all the Bt cotton genotypes were superior with respect to fibre qualities in comparison with non-Bt cotton genotypes (Hallikeri *et al.,* 2004; Halemani *et al.,* 2004; Yenagi, 2006; Khadi *et al.,* 2008).

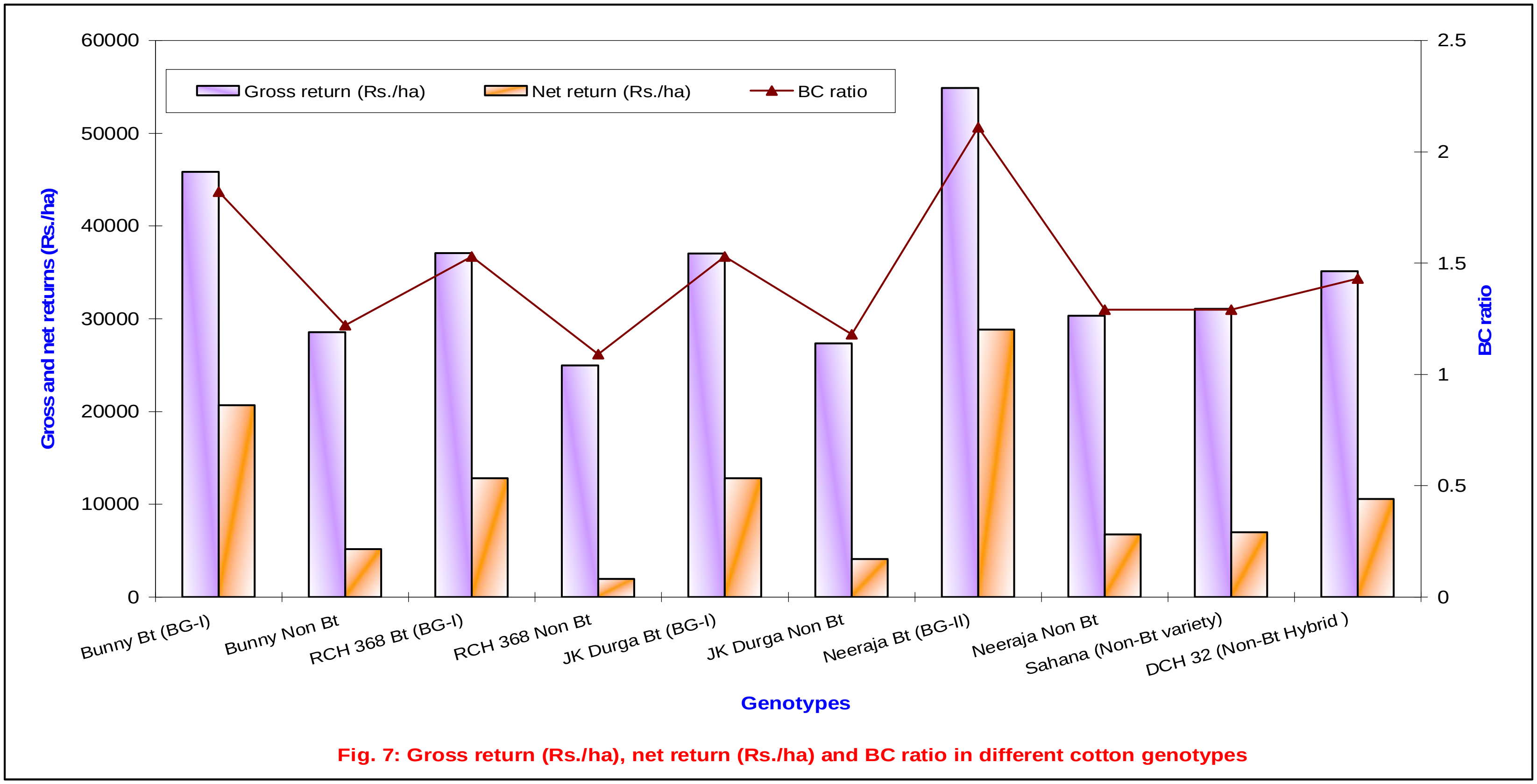


Fig. 7: Gross return (Rs./ha), net return (Rs./ha) and BC ratio in different cotton genotypes

5.2.5 Economics

Economics is the ultimate criteria for acceptance and wider adoption of any technology and Bt technology is also no exception. In all the treatments same cultural practices and plant protection measures were applied to both Bt and non-Bt cotton hybrids. The total cost of cultivation was maximum for Bollgard II Bt (Neeraja) (Rs. 26063/ha) and Bolgard I Bt (Bunny) (Rs. 25157/ha) compared to DCH-32 non-Bt hybrid (Rs. 24513/ha) and Sahana non-Bt variety (Rs. 24082/ha) (Table 32).

The gross return in the study were in the range of Rs. 24968/ha to Rs.54895/ha. Neeraja (BG II) Bt recorded significantly higher gross return (Rs. 54895/ha), net return (Rs. 28832/ha) and benefit cost ratio (2.11) compared to other genotypes under investigation. In comparison with checks, Neeraja (BG II) Bt produced 36 and 43 per cent higher gross return over DCH-32 non-Bt hybrid and Sahana non-Bt variety, respectively (Table 33 and Fig.7). Similar trend was followed in net return where Neeraja (BG II) Bt produced 63 and 75 per cent higher net return over DCH-32 non-Bt hybrid and Sahana non-Bt variety (Table 34 and Fig.7). BC ratio was in the range of 1.09 to 2.11 rupee per rupee invested. Similar trend was reported by Joshi (2007) and Patil *et al.* (2004).

Between Bt and non-Bt genotypes, significantly higher gross return (Rs. 43698/ha), net return (Rs. 18780/ha) and BC ratio (1.75) were obtained in comparison with non-Bt genotypes (gross return Rs. 27804/ha, net return Rs. 4491/ha and BC ratio 1.19). Among Bt genotypes, Neeraja (BG II) Bt produced 16, 32 and 33 per cent higher gross return over Bunny (BG I) Bt, RCH-368 (BG I) Bt and JK Durga (BG I) Bt. Net return and BC ratio also followed the similar trend.

5.3 Studies on nutrient management to overcome leaf reddening in Bt cotton

It is well known from numerous nutrient studies that yield of a crop strongly depends on the supply of mineral nutrients, such as N, which has been used in crop cultivation to exploit the full genetic potential of the plant (Khan, 1996). Mineral nutrient supply on a number of sink organs has got a positive effect. So also with the increase in the photosynthate supply to the sink sites or hormonal effect (Borowski, 2001). In Bt cotton, synchronized boll development altered the source-sink relationship due to rapid translocation of saccharides and nutrients from leaves to the developing bolls (Wright, 1999; Hebbar *et al.,* 2007a). By balancing the source-sink relationship, occurrence of physiological disorders like leaf reddening, square and boll dropping, bad boll opening, premature senescence could be prevented. Another important factor in Bt cotton cultivation is sustained cry protein synthesis wherein nitrogen is very much involved (Bruns and Abel, 2003; Kranthi *et al.*, 2005). In order to balance the source-sink relationship by way of sustained photosynthetic efficiency and cry protein synthesis at grand growth period of Bt cotton, the leaf nitrogen content (3.5-4.5%) has to be maintained (Brar *et al.,* 2008; Rajendran *et al.,* 2010). In this regard, an attempt was made in the present study with respect to split application of recommended dose of nitrogen (10% basal, remaining 90% into equal six splits) into total seven N splits in comparison with the recommended 4 splits of N application (50% as basal remaining 50% in equal three splits).

In addition to this, foliar nutrition (with urea 2%, DAP 2%, $MgSO_4$ 1%, KNO_3 2%), growth hormone (Cytokinin) application and polyethylene mulching were tried from October II fortnight (coinciding cotton growth stage with onset of low temperature) onwards in order to ensure adequate nutrient supply to keep the pace of source-sink relationship and cry protein synthesis. The results of the investigation made on nutrient management in Bunny Bt (Cv. NCS-145) are discussed here as under.

Regarding the rainfall pattern, the crop experienced evenly distributed rainfall from June to March in *kharif* 2007 and 2008 seasons. Hence, there was no moisture stress occurred during the grand growth period also. The crop exhibited its full potentiality towards yield. The increase or decrease in yield was again influenced by different treatments under investigation on Bunny Bt (Cv. NCS-145).

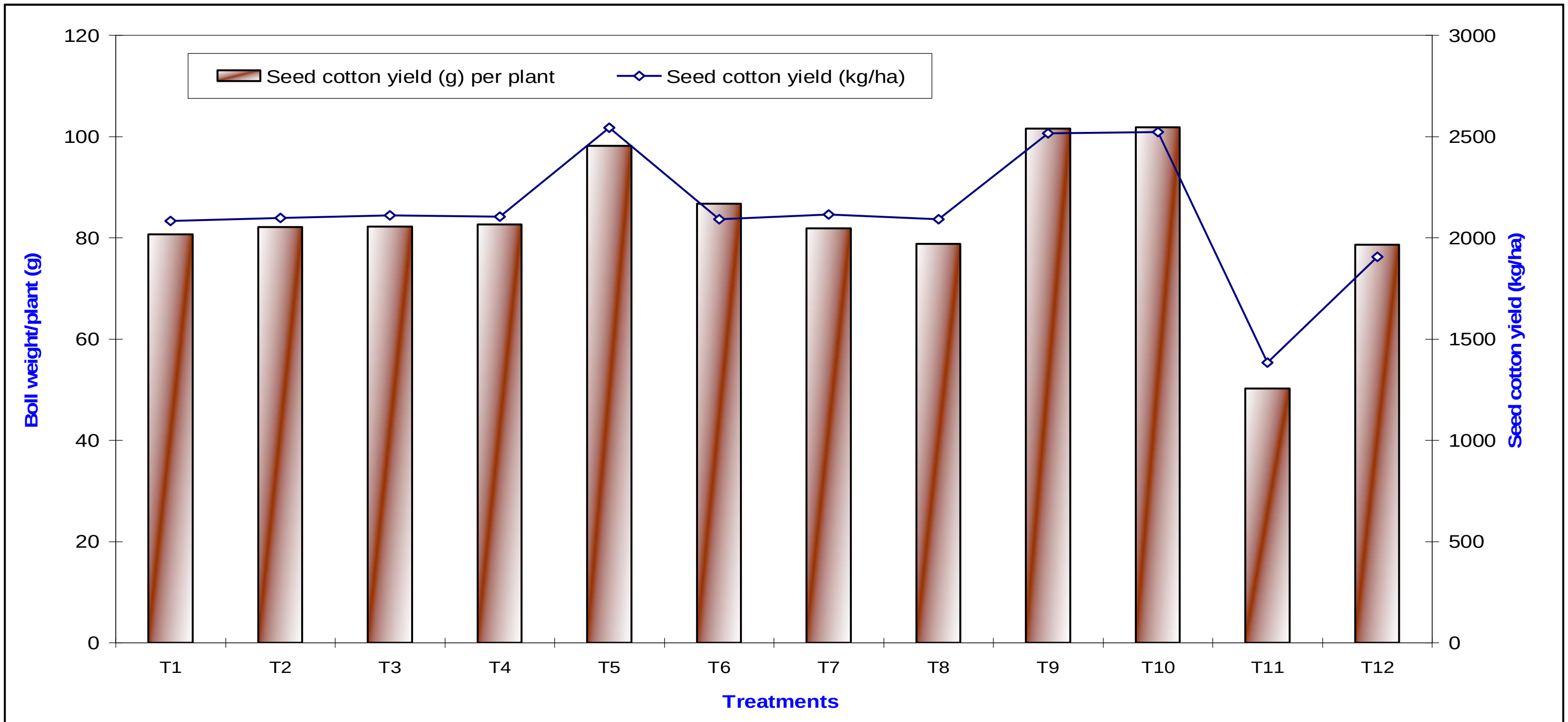


Fig. 8: Seed cotton yield (kg/ha) and seed cotton yield (g) per plant as influenced by different treatments in Bt cotton (Cv. NCS-145)

Fig. 8: Seed cotton yield (kg/ha) and seed cotton yield (g) per plant as influenced by different treatments in Bt cotton (Cv. NCS-145)

5.3.1 Yield and yield attributes

Foliar application of KNO_3 @ 2% (T_5) produced significantly higher seed cotton yield (2543 kg/ha) over others and was on par with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (2522 kg/ha) and soil application of $MgSO_4$ @ 25 kg/ha alone (2517 kg/ha) (Table 36 and Fig.8). The lowest seed cotton yield (1383 kg/ha) was recorded with the polyethylene mulching treatment (T_{11}). Foliar application of KNO_3 @ 2%, soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively and soil application of $MgSO_4$ @ 25 kg/ha alone increased the seed cotton yield by 25.01, 24.43 and 24.27 per cent, respectively over the recommended package. Foliar application of KNO_3 which is a source of both K and N, is highly beneficial in increasing the seed cotton yield (Brar *et al.,* 2008). Soil and foliar application of $MgSO_4$ also increased the seed cotton yield because of magnesium which is an integral part of chlorophyll. Mg helps in increased photosynthesis and thereby increase seed cotton yield. The results obtained are in conformity with the findings of Brar *et al.* (2008), Rajendran *et al.* (2010), Sharma and Singh (2007) and Kaur *et al.* (2007) who also reported the increased seed cotton yield with KNO_3@ 2% foliar application. Brar *et al.* (2008) reported that foliar application of KNO_3 @ 2% gave additional yield of 300 kg/ha in potash deficient soils than soil application of 60 kg K_2O/ha. Rajendran *et al.* (2010) observed foliar application of 2% KNO_3 at 25 days after planting gave 31, 29 and 49 per cent than application of K_2SO_4. Sharma and Singh (2007) found that 2% KNO_3 at initial and peak boll formation increased the seed cotton yield (8.2%), number of opened bolls per plant (34.15%), boll weight (50%) compared to soil application of N, P and K. The increased seed cotton yield with the soil application of $MgSO_4$ @ 25 kg/ha also reported (Ikisan, 2004 and Anon., 2008).

In cotton, yield is directly related to boll number, boll weight and seed cotton yield per plant. The higher seed cotton yield with the foliar application of KNO_3 @ 2% is supported by significantly increased boll weight (4.85 g/boll) and seed cotton yield per plant (98.19 g) (Table 36 and Fig.8). Foliar application of 2% KNO_3 (T_5) increased 18% boll weight (g/boll) and 19% seed cotton yield (g/plant) than the recommended package (T_{12}). Similar trend was observed with the soil application of 25 kg $MgSO_4$/ha and also with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1% foliar application, respectively. Studies of Sharma and Singh (2007), Blaise *et al.* (2009), Rajendran *et al.* (2010), Oosterhuis (1993) and Oosterhuis *et al.* (1990) also indicated that foliar application of 2% KNO_3 resulted in increased boll weight. Blaise *et al.* (2009) reported increased boll weight due to foliar application of KCl.

Total number of bolls is the result component of number of good opened bolls and number of bad opened bolls per plant. Significantly higher number of good opened bolls per plant (49.27), lower number of bad opened bolls per plant (2.67) and increased total number of bolls per plant (51.93) were noticed with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively and it was on par with the foliar application of KNO_3 @ 2% (T_5) and soil application of $MgSO_4$ @ 25 kg/ha (T_9) (Table 37). Sympodial branches per plant also followed the similar trend whereas the numbers of monopodial branches were not significantly differed among the treatments (Table 38). It has been reported that foliar application of KNO_3 @ 2% increased the number of good opened bolls, boll weight (Kaur *et al.*, 2007; Sharma and Singh, 2007) and the number of sympodial branches per plant (Brar *et al.,* 2008).

5.3.2 Leaf nutrient content/concentration

All the physiological growth stages in cotton are equally important and are independent in nutritional requirements (Oosterhuis, 1990). Nitrogen is a vital plant nutrient which is most frequently deficient among of all the nutrients observed in the early and mid season, reduces plant height, shortens branches and increases boll shedding (Hodges, 1975). In the Bt cotton scenario, recent reports indicated that synchronized boll development resulted in imbalance in source-sink relationship and led to the physiological disorders like leaf reddening, square and boll shedding (Hebbar *et al.,* 2007a; Wright, 1999). To support the development of retained bolls and for cry protein synthesis, nitrogen is essential. Positive correlation has been established between nitrogen and cry protein synthesis (Bruns and Abel, 2003, Pettigrew and Adamczyk, 2006; Hallikeri, 2008). Hence, in Bt cotton balancing the source-sink relationship, to support cry protein synthesis for imparting season long protection against boll worms and to avoid further occurring of physiological disorders like leaf reddening, square and boll shedding proper nutrition is need of the hour.

Leaf nitrogen content is an important indicator for diagnosing plant nitrogen status (Gerik *et al.,* 1994; Bell *et al.,* 2003). In cotton, the critical nitrogen requirement of leaf is 2.0-2.6 per cent, if it falls below this range, reddening of leaf begins (Shanmugham, 1992). For harnessing the fullest production potentiality of any cotton genotypes, the sufficiency range for leaf nitrogen content 3.5-4.5 per cent has to be maintained (Anon., 2009).

In the present investigation, the leaf nitrogen content among the treatments at various growth stages varied (1.88% at 60 DAS, 2.24% at 90 DAS and 1.60% at 120 DAS). At 90 DAS, higher leaf nitrogen content (2.29%) was recorded in the treatments T_1-T_{11} (nitrogen was applied into seven splits) whereas reduced leaf nitrogen content (1.81%) was observed with the recommended package (nitrogen was applied into three splits) (Table 44). Advantages of nitrogen application into seven splits observed with increased level of cry protein synthesis (Hallikeri *et al.,* 2004, Pettigrew and Adamczyk, 2006). In the present study foliar application of KNO_3 @ 2% significantly increased the leaf nitrogen content (2.56% at 90 DAS and 1.84% at 120 DAS) over other treatments. These findings are in conformity with the findings of Shanmugham (1992) wherein the critical level of leaf nitrogen was maintained for prevention of occurrence of leaf reddening. Brar *et al.* (2008) too reported increased in N content of cotton leaves with foliar application of potassium nitrate.

The lowest leaf nitrogen content (1.22%) was recorded with polyethylene mulching at 120 DAS. The decreased leaf N content was associated with increased canopy temperature (38.77^{0}C) recorded at 1 pm and 30.37^{0}C recorded at 5 pm at 120 DAS (Table 57, 58 and 59). The soil temperature in polyethylene mulched treatment found increased by 1.0-1.5^{0}C at 2 pm and 5 pm from October 15th to December 31st during 2007 and 2008 (Appendix IV). The decreased leaf nitrogen content was associated with increased canopy temperature. At higher temperature, transgenic potato`s photosynthetic rate was reduced due to oxidative mechanism of chlorophyll (Tang *et al.,* 2006). Similarly, in the present investigation also at 120 DAS reduced leaf nitrogen content was recorded due to reduced total chlorophyll content (0.86 mg/g fresh weight) (Table 42) and increased anthocyanin content (0.39 g/fresh weight) (Table 43) resulted in reduced photosynthetic ability of the crop under polyethylene mulched treatment.

The leaf phosphorus content varied among the treatments (0.41-0.44% at 60 DAS, 0.78-1.07% at 90 DAS and 0.48-0.71% at 120 DAS) and found above the sufficiency range (0.20-0.65%). Significantly higher leaf phosphorus content was recorded with the foliar application of DAP @ 2% at 90 DAS (1.07%) and at 120 DAS (0.71%). The leaf phosphorus content (0.48 – 0.71%) found increased with the treatments T_1-T_{11} compared to RDF (T_{12}) (0.41%). Application of nitrogen into 7 splits in the treatments T_1-T_{11} resulted in better uptake of phosphorus from the soil due to synergistic effect (Table 53). Wherein, reduced available phosphorus content in soil was observed in T_1-T_{11} (13.49 – 14.78 kg P_2O_5/ha) compared to RDF (T_{12}) (22.65%) (Table 53). Newman *et al.* (2009) reported that nitrogen application enhanced uptake and consequently reduced P transport to deep (> 13 cm) soil depths in grasses. The lowest leaf phosphorus content was recorded with T_6 at 90 DAS (0.78%) and 120 DAS (0.61%) (Table 45).

Potassium deserves special attention as a plant nutrient in cotton production because of its high uptake rate, the relative inefficiency of potash uptake mechanism compared to many other crops (Kerby and Adamas, 1985). Signs of emerging K deficiencies in cotton have become more common in recent years, partially in modern high yielding cotton varieties such as Bt transgenic cotton (Tian *et al.,* 1999 ; Phipps *et al.,* 2003). The sensitivity of high yielding cotton to K limitations has led to much research on K nutrition and fertilization with the focus on the yield and yield components throughout the world (Howard and Gwathmey, 1998; Mullins *et al.,* 1999; Howard *et al.,* 2000; Gormus and Yucel, 2002; Roslem *et al.,* 2003).

The traditional K deficiency which was first described in 1960's was a yellowish white mottling of the older foliage that changes the leaf colour to light yellowish-green. As the whole leaf breakdown progresses, the whole leaf becomes reddish-brown, dries and finally become rust coloured and brittle.

Another type of K-deficiency usually occurs in young leaves of top canopy and spread from the top to the bottom during flowering and boll development (Maples *et al.,* 1988), differing occurring mostly in late season and spreading from the bottom to the top. Potassium related premature senescence recently described in Australia (Wright, 1999), USA (Oosterhuis, 2001) and China (Zheng and Dai, 2000) may be a typical K deficiency occurred in top canopy. Reddy *et al.* (2000) indicated that leaf growth was the most sensitive physiological process to K deficient conditions. Leaf growth rate were 14 per cent lower in plants that had only 1.9 per cent K in the leaves compared to fully fertilized plants with 3 per cent K in the leaves.

Zhao *et al.* (2001) reported that the poor chloroplast ultrastructure including starch granule accumulation low chlorophyll content, fewer grana, disorientation of grana and thylakoids that occurred as they were pushed towards the periphery of the chloroplast be one of the causes of low photosynthetic rate in K deficient cotton.

Adoption of modern cotton varieties is another important factor for K deficiency, since sensitivity of cotton to potassium varies with genotypes. Many reports have indicated that modern cotton varieties with fast fruiting, high yielding or heavy boll load and early maturity, seem to be more susceptible to K limitation than traditional varieties (Oostrerhuis, 1990 ; Tupper *et al.,* 1996 ; Wright, 1999). Transgenic cotton varieties with Bt gene seem to be more susceptible than the conventional varieties because of their higher retention of early fruit (Wright, 1999).

Cotton requires potash 150 kg/ha almost equal to nitrogen 156 kg/ha to give a yield of 2500 kg/ha of ginned cotton (Silvertooth, 2007). Hence, an adequate potash supply is crucial during entire cotton growth and development (Makhadum *et al.,* 2007) mainly due to its vital role in biomass production (Zhao *et al.,* 2001) leaf area expansion, CO_2 assimilation (Reddy *et al.,* 2004), photosynthesis, leaf pressure potential, transpiration and water use efficiency (Pervez *et al.,* 2004), boll weight and size, lint yield (Akhtar *et al.,* 2003) and fibre quality (Pettigrew *et al*., 1996). Hence, potash nutrition of cotton appeared to be very indispensable.

In the present study at 90 DAS, the leaf potash content (2.43%) was significantly increased with foliar application of KNO_3 @ 2% compared to other treatments (Table 46). Similar trend was observed at 120 DAS also wherein the leaf potash content (1.02%) decreased from 90 DAS on account of translocation towards fruiting bodies. Wright (1999) and Brar *et al.* (2008) also reported increased potash content in leaf with the foliar application of potassium nitrate. It can be inferred from the results obtained at 90 DAS that the increased leaf nitrogen (2.56%) (Table 44) and potash (2.43%) (Table 46) content with the application of KNO_3 @ 2% is a good source of nitrogen and potash nutrition for maintaining the threshold level for Bt cotton growth and development.

In cotton, among the secondary nutrients magnesium plays an important role than calcium. Calcium is required in cotton for translocation of carbohydrates and it serves to increase the salt tolerance capacity. The productivity of any crop depends on the processes of photosynthesis which intern depends on the chlorophyll content of leaves in plants and the magnesium is an important constituent of chlorophyll and is indispensable in the relation of photosynthesis and also an activator of many enzymes involved in photosynthesis and also help in uptake and translocation of sugars in the plant (Shaha and Dasgupta, 1974). Similarly, nitrate reductase enzyme is known to be involved in assimilation of nitrogen (Kiran Bhagat, 2003). Fontes *et al.* (2008) reported that the nitrate reductase activity was highly correlated with the photochemical efficiency of the PS II in the papaya cultivars (Cv. Tainung and Sunine solo) suggesting that there is a correlation between chlorophyll of fluorescence and nitrate reductase activity in these plants. In the present investigation the results indicated that magnesium application as ($MgSO_4$ @ 25 kg/ha) in soil increased the leaf nitrogen content in cotton leaves compared to no magnesium application. Karibasappa *et al.* (2007) reported that the application of RDF + $MgSO_4$ (50 kg/ha) in Arka Anamika was found to be more effective in enhancing chlorophyll content, nitrate reductase activity and seed quality attributes in okra. In the present study, no significant effect observed at 60 DAS, whereas at 90 and 120 DAS the leaf calcium content varied (4.13-5.59% at 90 DAS and 5.89-7.64% at 120 DAS, respectively) and found well above the sufficiency range (1.25-3.0%). However, significantly higher leaf calcium content was recorded with the foliar application of calcium nitrate @ 1% (5.59% at 90 DAS and 7.64% at 120 DAS) than other treatments (Table 47).

In contrast to Ca, Mg is very mobile in phloem and can be translocated from older leaves to younger leaves or to apex. Earlier reports indicated that leaf reddening occurs due to magnesium deficiency and could be corrected by foliar application of $MgSO_4$ @ 1% (Prabhakar, 1981; Chimmad, 1989; Ikisan, 2004; Anon., 2008). In the present investigation, the leaf magnesium content increased significantly with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (1.31% at 90 DAS and 1.86% at 120 DAS) and with the soil application of $MgSO_4$ @ 25 kg/ha alone (1.22% at 90 DAS and 1.82% at 120 DAS) compared to other treatments including the recommended practice T_{12} (0.72% at 90 DAS and 1.32% at 120 DAS) (Table 48). In the present investigation, despite the leaf magnesium content (1.37% - 1.59% at 60 DAS, 0.61% - 1.31% at 90 DAS and 1.12% -1.86% at 120 DAS) observed well above the sufficiency range (0.25-0.50%), the leaf reddening was noticed in all the treatments except with the treatments of foliar application of KNO_3 @ 2%, soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively and soil application of $MgSO_4$ @ 25 kg/ha alone.

Reduced red leaf index (RLI) values were observed with soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (0.80 at 90 DAS and 1.05 at 120 DAS) followed by foliar application of KNO_3 @ 2% (0.88 at 90 DAS and 1.05 at 120 DAS) and soil application of $MgSO_4$ @ 25 kg/ha (0.88 at 90 DAS and 1.05 at 120 DAS).

Micronutrients are essential that are required in smaller quantities for normal plant nutrition. At 60 DAS, there was no significant difference observed among the treatments with respect to leaf micronutrient content (Zn, Fe, Mn and Cu). At 90 and 120 DAS, the leaf micronutrient contents (Zn, Fe, Mn and Cu) significantly increased with the foliar application of multimicronutrient @ 1%. At 90 DAS, the leaf micronutrients content (Zn, Fe, Mn and Cu) decreased compared to 60 DAS and again increased at 120 DAS, on account of translocation towards fruiting bodies (Table 49, 50, 51 and 52). In all the treatments and at all the growth stages leaf micronutrient content; Zn (27.85-29.0 ppm at 60 DAS, 27.10-31.10 ppm at 90 DAS and 25.80-56.60 ppm at 120 DAS), Fe (753.1-762.0 ppm at 60 DAS, 212.8-855.8 ppm at 90 DAS and 796.3-1090.3 ppm at 120 DAS), Mn (94.9-99.5 ppm at 60 DAS, 82.8–161.6 ppm at 90 DAS and 90.8-214.7 ppm at 120 DAS) and Cu (12.17-12.78 ppm at 60 DAS, 7.40-22.0 ppm at 90 DAS and 13.48-28.78 ppm at 120 DAS) found well above the sufficiency range Zn (20-40 ppm), Fe (50-250 ppm), Mn (20-350 ppm) and Cu (5-25 ppm). Hence, in the present investigation no micronutrient deficiency observed among the treatments. Similarly, Knowles *et al.* (1999) observed no significant effect of micronutrients on cotton lint yield.

5.3.3 Biochemical characters

5.3.3.1 Chlorophyll ‘a’content, Chlorophyll ‘b’content and Total chlorophyll content

The total chlorophyll content determines the photosynthetic capacity of the genotypes and induces the rate of photosynthesis, dry matter production and the yield (Krasichkova *et al.,* 1989). The variation in chlorophyll content due to different treatments may be attributed to decreased chlorophyll degradation and increased chlorophyll synthesis. In the present investigation, the total chlorophyll content significantly increased with increasing trend from 60 DAS to 90 and 120 DAS with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively compared to other treatments and it was on par with the soil application of $MgSO_4$ @ 25 kg/ha alone also and with foliar application of KNO_3 @ 2% (Table 42 Fig.9). Chlorophyll content in leaf (SPAD readings) also indicated the similar trend (Table 43 and Fig.9). It is well documented that red purple coloured leaves of cotton are caused by lower content of magnesium in leaf (Chakravarty, 1980; Prabhakar, 1981; Bhatt *et al.,* 1982; Chimmad, 1989, Ikisan, 2004; Anon., 2002).

However, in the present investigation, foliar application of $MgSO_4$ did not influence the leaf magnesium content and thereby total chlorophyll content in Bunny Bt (Cv. NCS-145). It clearly indicates that soil application of $MgSO_4$ @ 25 kg/ha was superior to foliar application of $MgSO_4$ @ 1%. Among the chlorophyll fractions, both chlorophyll ‘a’ content and chlorophyll ‘b’ content were higher with the treatments, of soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively followed by soil application of $MgSO_4$ @ 25 kg/ha alone and foliar application of KNO_3 @ 2%. Since, chlorophyll is essential for the conversion of radiant energy into chemical energy (carbohydrates) and consists a major portion of both the pigment system-I and pigment system-II, the increase of chlorophyll ‘a’ content would be advantages on for efficient exploitation of the available radiant energy.

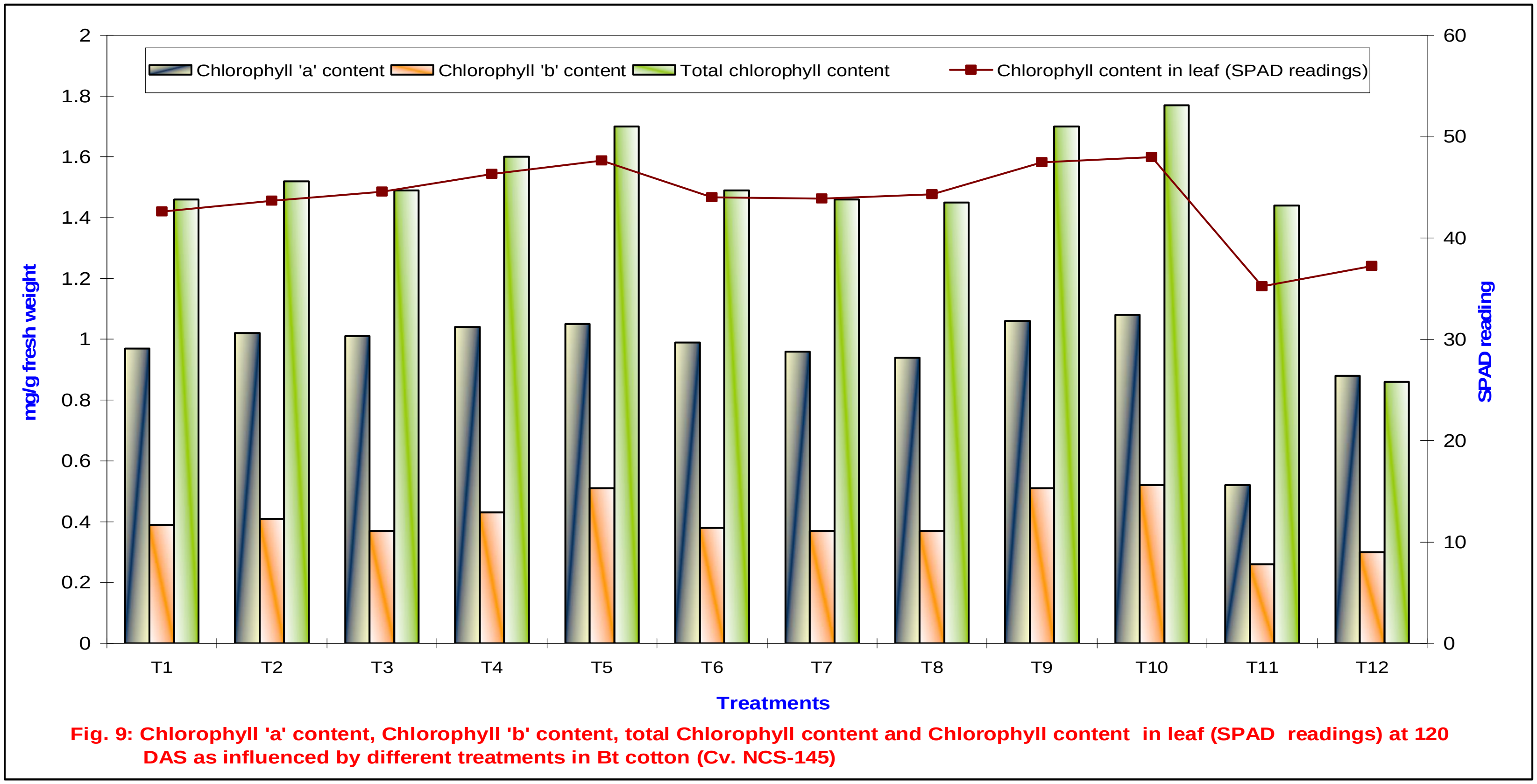


Fig. 9: Chlorophyll 'a' content, Chlorophyll 'b' content, total Chlorophyll content and Chlorophyll content in leaf (SPAD readings) at 120 DAS as influenced by different treatments in Bt cotton (Cv. NCS-145)

Relatively higher level of chlorophyll ‘b’ content is indicative of higher PS-II activity. This trait is desirable under arid tropical environment (Bharadwaj and Singh, 1988). It is an indication that the final product i.e., cotton yield would be greatly influenced by the chlorophyll contents of cotton genotypes. Correlation study revealed that seed cotton yield was positively correlated (r = 0.95) with total chlorophyll content at 120 DAS (Table 62a).

As the chlorophyll pigments decreased, the accumulation of anthocyanin content increased. The red colour became apparent when the green chlorophyll content decomposes with the approach of winter and the intense light and low temperature favour the anthocyanin pigments (Anon., 2007). At Dharwad, Prabhakar (1981) and Chimmad (1989) reported occurrence of reddening in cotton with the onset of winter (in October, November and December months). Shanmugham (1992) reported that drop in day temperature below 21^0C and sudden fall in night temperature below 15^0C stimulate the formation of anthocyanin pigment. In the present investigation also there was no significant difference observed with respect to anthocyanin pigment synthesis among the treatments at 60 DAS (the crop stage was in the September month). The anthocyanin pigment was synthesized and differed significantly among the treatments at 90 DAS (the crop stage was in the October month) and progressed steadily at 120 DAS (the crop stage was in the November month). Significantly lower anthocyanin content was recorded with soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (0.038 mg/g fresh weight at 90 DAS and 0.080 mg/g fresh weight at 120 DAS) than others and it was on par with soil application of $MgSO_4$ @ 25 kg/ha (0.039 mg/g fresh weight at 90 DAS and 0.110 mg/g fresh weight at 120 DAS) and foliar application of KNO_3 @ 2% (0.042 mg/g fresh weight at 90 DAS and 0.100 mg/g fresh weight at 120 DAS) (Table 43).

It has been documented (Rajegowda *et al.,* 1988) that during November to February, the reception of solar radiation is highest at Dharwad when compared to other months. Prabhakar (1981) observed increased anthocyanin content (67.17%) and decreased leaf nitrogen content by 41 per cent. Chimmad (1989) also observed that anthocyanin accumulation was significantly and negatively correlated with N, P, K, Ca and Mg contents in leaf. Reports indicated that the low temperature with the onset of winter is also one of causes for leaf reddening in cotton (Prabhakar, 1981; Chimmad, 1989; Shanmugham, 1992 and Anon., 2007). On the basis of such reports, polyethylene mulching was tried in the present study with the hypothesis to increase the soil temperature which may reduce the reddening. On the contrary the results revealed that the highest anthocyanin pigment (0.390 mg/g fresh weight) with polyethylene mulching than other treatments. The soil temperature recorded in the afternoon at 2 pm in polyethylene mulching (23-27^0C) was higher than the non polyethylene mulching (21-25^0C) (Appendix IV). Increased temperature is found to degrade the chloroplast in transgenic potato (Tang *et al.,* 2006). Increased canopy temperature in polyethylene mulching resulted on account of heating up of the canopy microclimate due to back radiation from the surface of the polyethylene sheets. Similarly, the research conducted in both Arizona and Mississippi indicate that reproductive performance of upland cotton declines once mean crop temperatures exceed approximately 28-30^0C (Hodges *et al.,* 1993; Brown and Zeiher, 1998 ; Brown and Paul, 2001). In the present investigation in polyethylene mulched treatment total chlorophyll content (0.86 mg/g fresh weigh) decreased at 120 DAS and anthocyanin content (0.39 mg/g fresh weight) increased at 120 DAS) (Table 43) on account of higher canopy temperature prevailed at 1 pm (38.77^0C) and 5 pm (30.37^0C) at 120 DAS (Table 59) in comparison with other treatments. In the present investigation, in polyethylene mulched treatment, on account of higher soil temperature (Appendix IV) restricted the oxygen at the root region and higher canopy temperature (Tables 57,58 and 59 and Fig.10) might have led to the accumulation of anthocyanin pigment. Correlation studies (Tables 62a and 62b) indicated that the seed cotton yield of Bunny Bt (Cv. NCS-145) was significantly and negatively correlated with anthocyanin content (r = -0.87 at 90 DAS and r = -0.86 at 120 DAS) and red leaf index (r = -0.89 at 90 DAS and r = -0.97 at 120 DAS)

Regarding anthocyanin pigmentation the precise biochemical mechanism from leucoanthocyanidin (colourless pigment) to anthocyanidin (red coloured pigment) has not been clarified to date (Nakajima *et al.,* 2007).

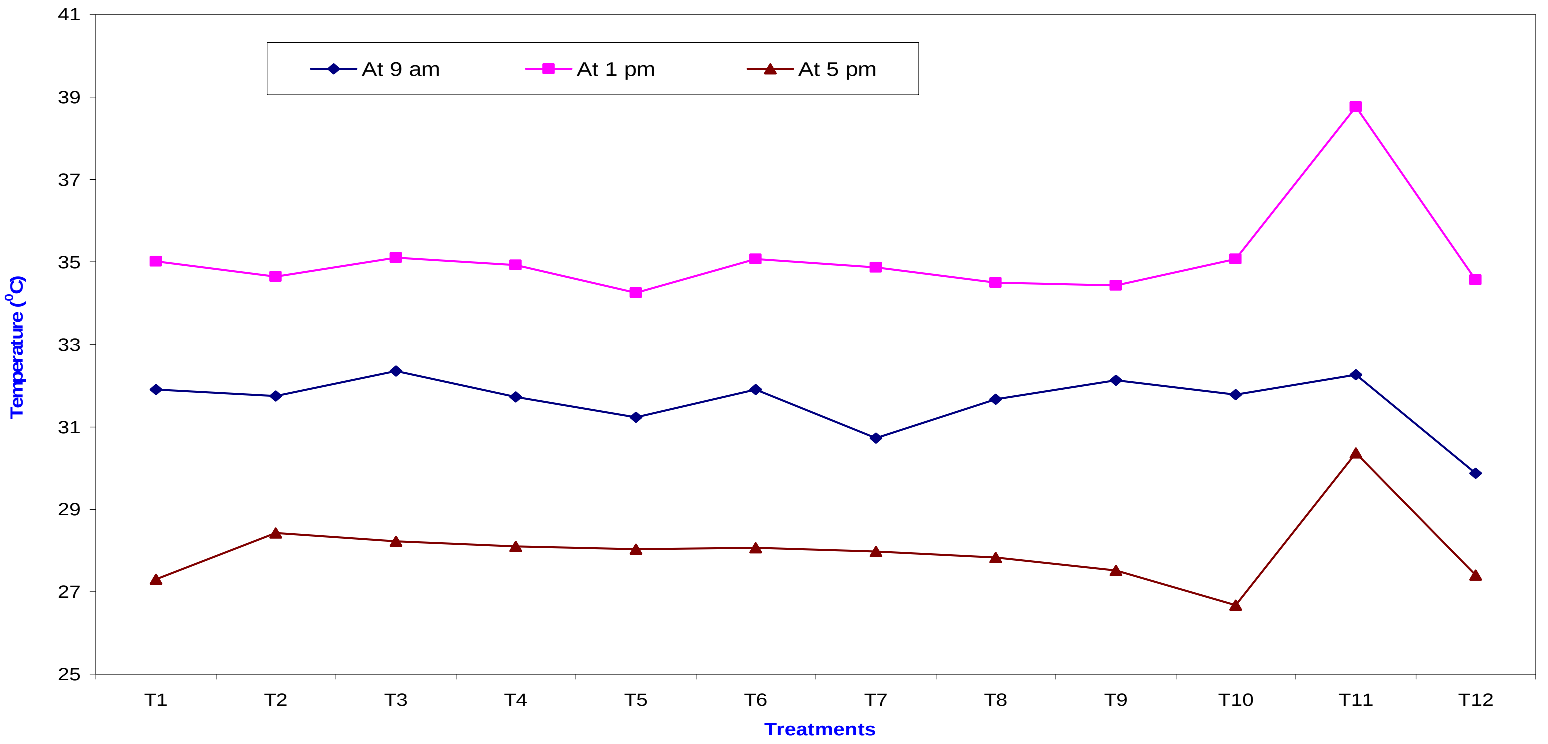


Fig. 10 : Canopy temperature (^{0}C) as influenced by different treatments in Bt cotton (Cv. NCS-145) at 120 DAS

Fig. 10 : Canopy temperature (0C) as influenced by different treatments in Bt cotton (Cv. NCS-145) at 120 DAS

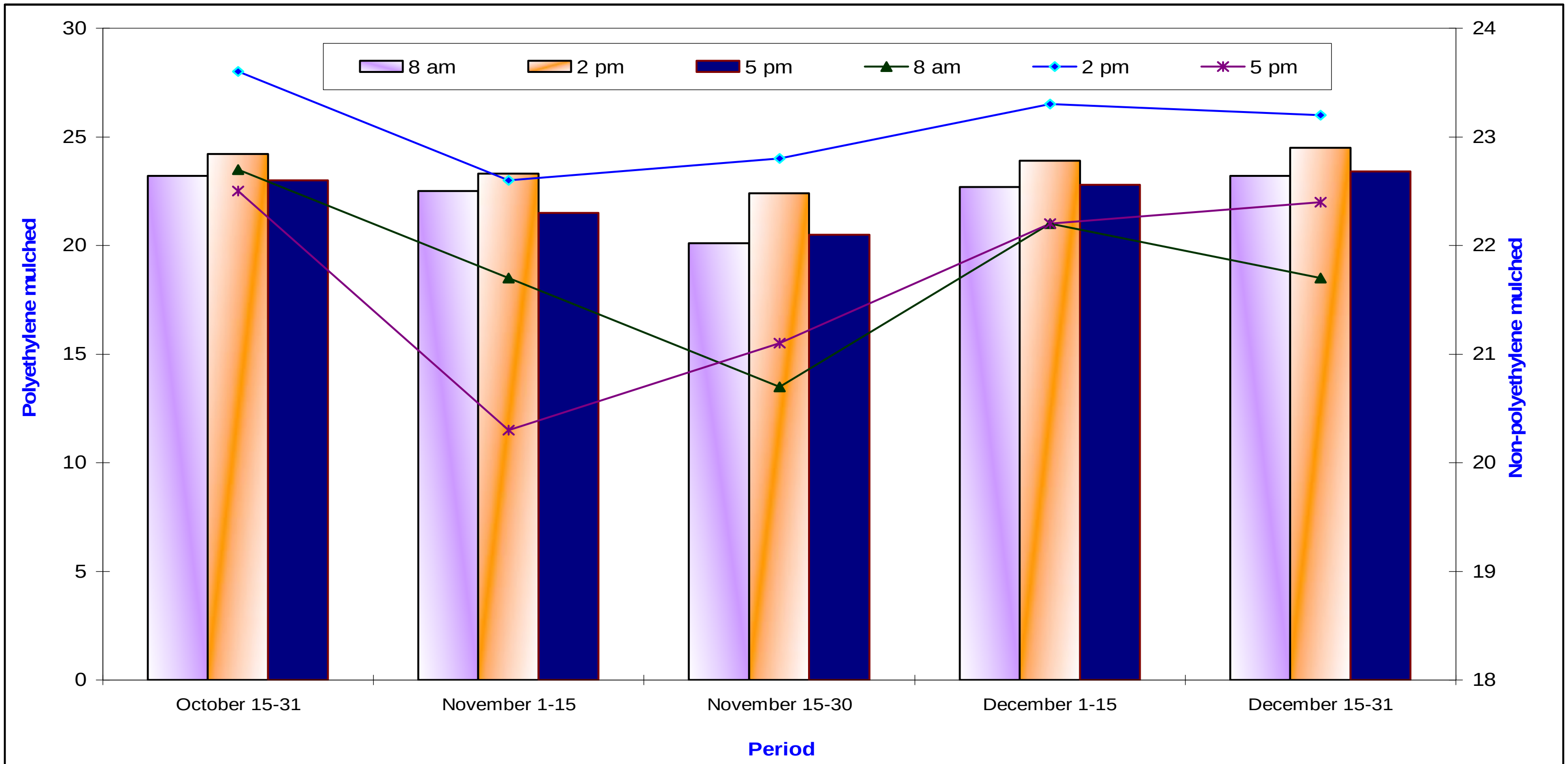


Fig. 11: Soil temperature recorded in polyethylene mulched and non-polyethylene mulched treatments

Fig. 11: Soil temperature recorded in polyethylene mulched and non-polyethylene mulched treatments

The conversion from colourless leucoanthocyanidin to coloured anthocyanidin 3-glucoside at least two enzymes, anthocyanidin synthase (ANS) and UDP-glucose, flavonoid 3-O-glucosyltransferase (3-GT) are postulated to be involved. The research efforts to arrest the activity of these enzymes may help to reduce the reddening problem to a greater extent.

5.3.4 Canopy temperature

Canopy temperature is an indicator of crop water stress. In the present investigation canopy temperature effect was studied in relation to leaf reddening in Bunny Bt (Cv. NCS-145). At 60, 90 and 120 DAS, the canopy temperature recorded at 9 am did not differ significantly among the treatments whereas, it differed significantly in respect of temperature recorded at 1 pm and 5 pm at 60, 90 and 120 DAS (Table 57, 58 and 59). The canopy temperature significantly increased with polyethylene mulching recorded at 1 pm (37.85^{0}C at 60 DAS, 37.23^{0}C at 90 DAS and 38.77^{0}C at 120 DAS) and at 5 pm (32.68^{0}C at 60 DAS, 30.53^{0}C at 90 DAS and 30.37^{0}C at 120 DAS) in comparison with other treatments. Increased canopy temperature in polyethylene mulching resulted on account of heating up of the canopy microclimate due to back radiation from the surface of the polyethylene sheets. Similarly, the research conducted in both Arizona and Mississippi indicated that reproductive performance of upland cotton declines once mean crop temperature exceed approximately 28-30^{0}C (Wanjura *et al.,* 1984; Hodges *et al.,* 1993; Brown and Zeiher, 1998 and Brown and Paul, 2001). Recent studies showed that temperature affects the growth dependencies of rubisco kinetics and activation state in photosynthetic acclimation (Yamori *et al.,* 2006; Hikosaka *et al.,* 2006; Weston *et al.,* 2007). In the present investigation in polyethylene mulched treatment total chlorophyll content (0.86 mg/g fresh weight) decreased at 120 DAS and anthocyanin content (0.39 mg/g fresh weight increased at 120 DAS) on account of higher canopy temperature prevailed at 1 pm (38.77^{0}C at 120 DAS) and 5 pm (30.37^{0}C at 120 DAS) in comparison with other treatments. Hence, the photosynthetic capacity of the leaf reduced thus affecting the growth and yield attributes which were lower in the present study (Table 59). The study clearly indicates that optimum canopy temperature of 30-31^{0}C (Table 57, 58 and 59) is ideal for Bt cotton growth under Dharwad conditions.

5.3.5 NDVI values

Rouse *et al.,* (1974) proposed a vegetation index depending on the differences in the reflectance in near infrared and red regions, which was called Normalized Difference Vegetation Index (NDVI). This index is sensitive to the presence of green vegetation and permits the prediction of agricultural crops and precipitation in semi-arid areas. The success of NDVI as descriptor of vegetation variation in spite of atmospheric influences and radiometric degradation in red and near infrared bands resides in the normalization it permits (Holben *et al.,* 1990). Normalized value reduces the effect of sensor calibration, degradation by approximately 6 per cent of overall index value. Pearson and Miller (1972) also proved that combination of red and near infrared spectral domains permits to differentiate vegetation from soils and to determine photosynthetically active biomass through vegetation over density. These linear combinations satisfy quite specific applications in remote sensing the crop yield, vegetation management etc.

In the present study, also the NDVI proposed by Rouse *et al.* (1974) was used considering its various advantages as suggested by many scientists. At 60 and 90 DAS, there was no significant difference observed among the treatments with respect to NDVI value however, it differed significantly at 120 DAS (Table 60 and Fig.12). At 120 DAS significantly higher NDVI (0.41) value was recorded with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively and it was on par with the soil application of $MgSO_4$ @ 25 kg/ha (0.39) and foliar application of KNO_3 @ 2% (0.39). The lowest NDVI (0.19) at 120 DAS was recorded with polyethylene mulching. Correlation studies indicated that the seed cotton yield of Bunny Bt (Cv. NCS-145) was significantly and positively correlated with NDVI values at 90 DAS (r = 0.72) and at 120 DAS (r = 0.62) (Table 62a). Similarly, Li *et al.* (2001) and Zhao *et al.* (2007) found a close correlation between cotton yield and NDVI measurements with regard to nitrogen management.

5.3.6 Red leaf index

For quantitative estimation of degree of leaf reddening, observations were recorded as outlined by Dastur *et al.* (1952). The intensity of leaf red colour can be visualized with the help of red leaf index (RLI). RLI indicates the manifestation of all the factors responsible for leaf reddening. In the present study, at 60 DAS there was no significant difference observed among the treatments with respect to RLI and differed significantly at 90 and 120 DAS (Table 61 and Fig.12). Significantly reduced RLI was observed with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (0.80 at 90 DAS and 1.05 at 120 DAS) and it was on par with the foliar application of KNO_3 @ 2% (0.88 at 90 DAS and 1.05 at 120 DAS) and the soil application of $MgSO_4$ @ 25 kg/ha alone (0.88 at 90 DAS and 1.05 at 120 DAS). Prabhakar (1981) and Chimmad (1989) reported reduced RLI with $MgSO_4$ @ 1% foliar application. However, in the present study 1% $MgSO_4$ foliar application was ineffective in Bt cotton. In the present investigation, the leaf nutrient content (particularly N, K and Mg), total chlorophyll content, anthocyanin content, NDVI values followed the similar trend of RLI at 90 and 120 DAS. RLI clearly indicates the intensity of leaf reddening in the promising treatments undertaken. The highest RLI (1.57 at 90 DAS and 2.08 at 120 DAS) was observed with polyethylene mulching and proved beyond doubt that it is ineffective measure against leaf reddening in Bt cotton. The soil (Appendix IV) and canopy (57, 58 and 59) temperatures were higher at 1 and 5 PM but the crop suffered due to aeration at root region and the higher temperature affected the photosynthetic rate (reduced chlorophyll, a, b and total chlorophyll contents) observed in the present investigation.

The reduced chlorophyll content, under lower temperature conditions during 90 and 120 DAS period (16.4^{0}C at 90-120 DAS and 14.0^{0}C at 121 DAS - harvest in 2007). Similarly, 15.3^{0}C at 90-120 DAS and 13.8^{0}C at 121 DAS – harvest in 2008, favours the leaf reddening. In the present investigation sudden drop in temperature led to the development of leaf reddening. Shanmugham (1992) reported that drop in day temperature below 21 ^{0}C and sudden drop in night temperature below 15 ^{0}C stimulated the formation of anthocyanin content.

5.3.7 Correlation coefficient

Significant positive correlation existed (Tables 62a and 62b) between seed cotton yield and NDVI values (r = 0.72 at 90 DAS, r = 0.62 at 120 DAS) and total chlorophyll content (r = 0.68 at 60 DAS, r = 0.94 at 90 DAS and r = 0.95 at 120 DAS). However, significant negative correlation existed between seed cotton yield and anthocyanin content (r = -0.87 at 90 DAS, r = -0.86 at 120 DAS) red leaf index (r = -0.89 at 90 DAS and r = -0.97 at 120 DAS).

5.3.8 Fibre quality

The data on quality parameters revealed that differences among the treatments were significant. Foliar application of KNO_3 @ 2% significantly increased the 2.5% span length (33.07 mm) and bundle strength (24.80 g/tex) over other treatments (Table 63). The fibre fineness did not differ significantly among the treatments. Venugopalan *et al.* (2004) reported that the soil application of potash 30 kg/ha along with foliar spray of potash @ 15 kg/ha significantly increased the 2.5 per cent span length (37.4 mm) over soil application of 45 kg/ha (34.0 mm).

5.3.9 Economics

Economics is the ultimate criteria for acceptance and wider adoption of any technology. In all the treatments same cultural practices and plant protection measures were applied except the cost of the technology about which the investigation was intended to carry out. The economic analysis of different treatments in the study indicated that the total cost of cultivation was maximum for the treatment comprising polyethylene mulching (Rs. 1765561/ha) when compared to other treatments. The treatment (T_5) consisting foliar application of KNO_3 @ 2% recorded significantly higher gross return (Rs. 56249/ha) and it was on par with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (Rs.55812) and soil application of $MgSO_4$ @ 25 kg/ha (Rs. 55688/ha) (Table 64 and Fig.13). In comparison with the existing package, foliar application of KNO_3 @ 2% produced 25.3 per cent higher gross return followed by soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (24.8%) and soil application of $MgSO_4$ @ 25 kg/ha alone (24.6%).

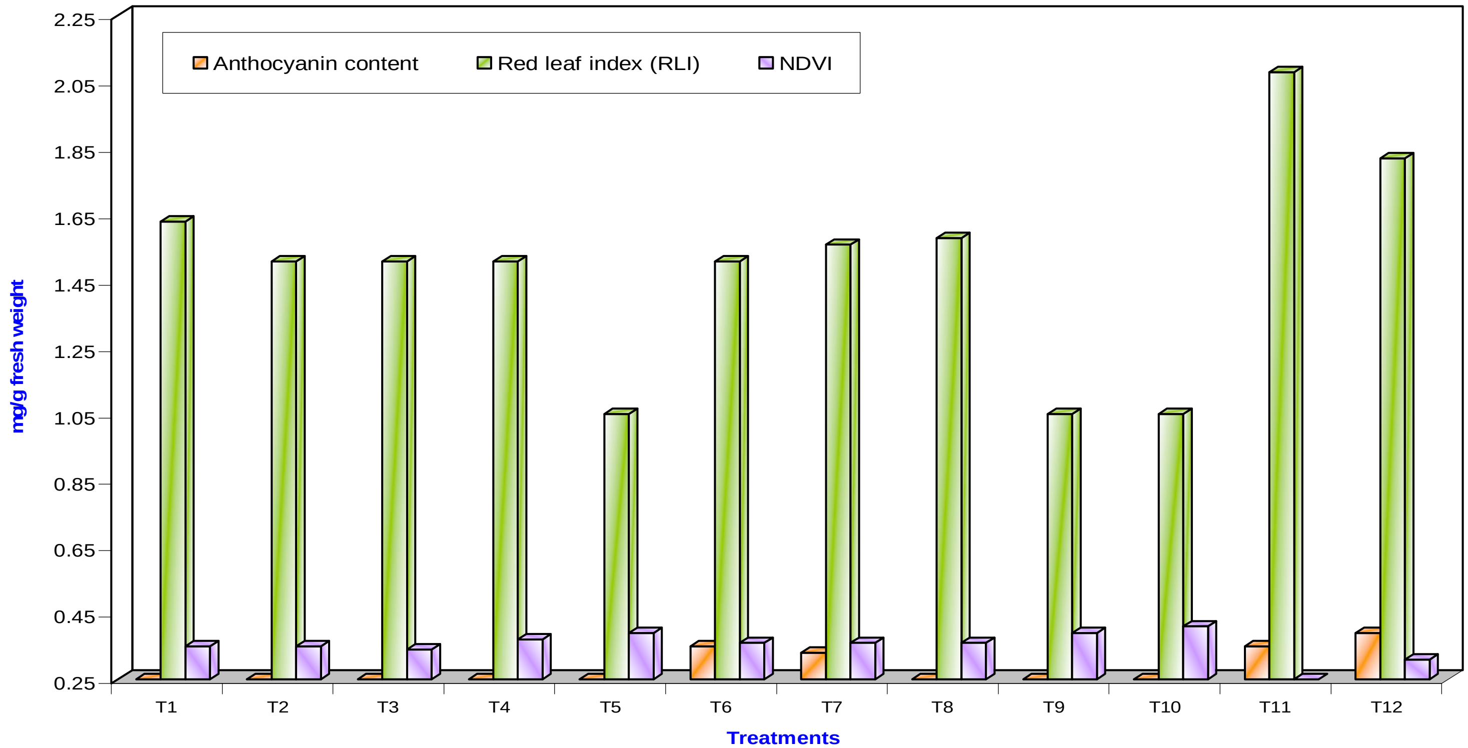


Fig. 12: Anthocyanin content, Red leaf index (RLI) and NDVI value as influenced by different treatments in Bt cotton (Cv. NCS-145)

Fig. 12: Anthocyanin content, Red leaf index (RLI) and NDVI value as influenced by different treatments in Bt cotton (Cv. NCS-145)

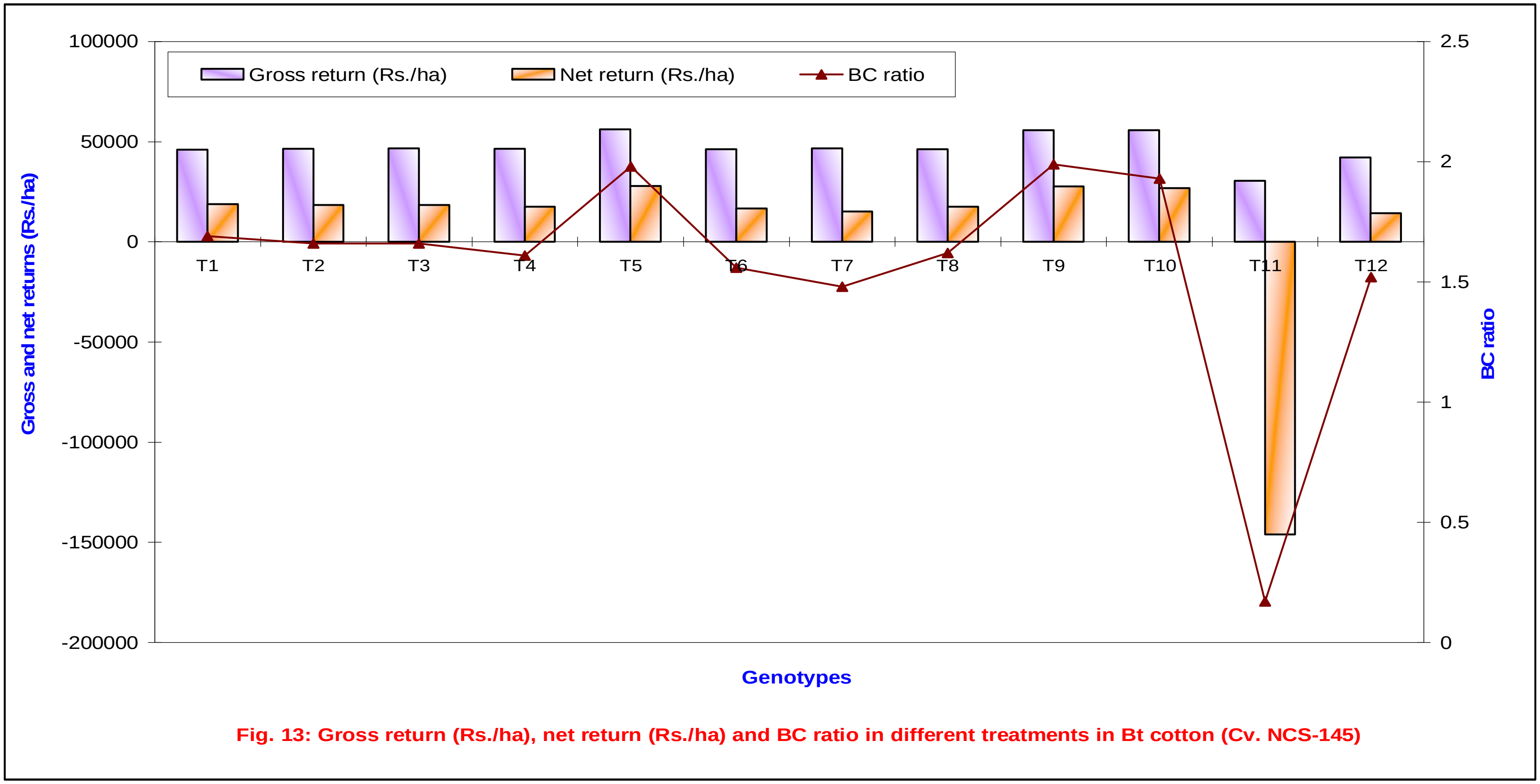


Fig. 13: Gross return (Rs./ha), net return (Rs./ha) and BC ratio in different treatments in Bt cotton (Cv. NCS-145)

Significantly higher net return (Rs. 27807/ha) was realized with the foliar application of KNO_3 @ 2% and it was on par with the soil application of $MgSO_4$ @ 25 kg/ha alone (Rs. 27722/ha) and soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (Rs. 26857/ha). However, negative net return (Rs. -145985/ha) was obtained with polyethylene mulching which indicates economically non-viable production technology which involved major polyethylene sheet cost (Rs. 1,50,000/ha). The benefit cost ratio also followed the similar trend of net return. Brar *et al.* (2008) reported that foliar application of KNO_3 @ 2% yielded higher gross return, net return and BC ratio in cotton than soil application of potassic fertilizers. Benefit cost ratio differed significantly among treatments. Soil application of $MgSO_4$ @ 25 kg/ha (T_9) recorded significantly higher BC ratio (1.99) and was on par with foliar application of KNO_3 @ 2% (1.98) (T_5) and soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (1.93) (T_{10}). The lowest benefit cost ratio (0.17) was recorded with polyethylene mulching (T_{11}).

Results of practical utility

- Bollgard-II (Neeraja Bt) recorded significantly higher seed cotton yield (2483 kg/ha) gross return (Rs. 54895/ha), net return (Rs.28,832/ha) and BC ratio (2.11).
- The next genotype in order was Bunny Bt (Cv.NCS-145) recorded seed cotton yield (2071 kg/ha), gross return (Rs. 45826/ha), net return (Rs. 20669/ha) and BC ratio (1.82) with reduced leaf reddening.
- Foliar application of KNO_3 @ 2% (three sprays on 15th October, 1st November and 31st November) significantly increased seed cotton yield (2543 kg/ha), gross return (Rs. 56,249/ha), net return (Rs. 27,807/ha) and BC ratio (1.98).
- The next treatment in the order was soil application of $MgSO_4$ @ 25 kg/ha alone recorded seed cotton yield (2517 kg/ha), gross return (Rs. 55688), net return (Rs. 27722/ha), and BC ratio (1.99).

Future line of work

- Soil application of $MgSO_4$ at different levels with foliar application of KNO_3 at different concentrations may be attempted for standardization of nutrient management strategy for leaf reddening management in Bt cotton.
- The nutrition may be tried by maintaining the different nutrient threshold levels with reference to the sufficiency range in leaf during boll development and boll bursting period in order to overcome leaf reddening.
- Different liquid fertilizers need to be evaluated for effective nutrient management through foliar application.
- Need to identify the enzyme responsible for anthocyanin pigmentation and agronomic means to arrest its activity during onset of winter.

6. SUMMARY AND CONCLUSIONS

The constraints of Bt cotton cultivation were documented in major cotton growing districts (Haveri and Belgaum) of northern Karnataka by a short survey during May 2007. The survey report revealed that more than 93 per cent farmers had faced the problem of leaf reddening irrespective of Bt hybrids used from different sources.

To address the leaf reddening malady in Bt cotton cultivation, two field experiments were planned and executed in 'E' block, plot No. 131 at the Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, during *kharif* 2007 and 2008. The experiments 1 and 2 were laid out in randomized complete block design (RCB) with three replications in 8.1 x 9.6 m plot size with spacing of 90 x 60 cm.

Experiment 1 was on "Assessing leaf reddening malady in Bt cotton genotypes" comprised (4 Bt and 4 non-Bt cotton genotypes) and two check cotton genotypes *viz.,* Bunny (BG I) Bt, Bunny non-Bt, RCH-368 (BG I) Bt, RCH 368 non-Bt, JK Durga (BG I) Bt, JK Durga non-Bt, Neeraja (BG II) Bt, Neeraja non-Bt, checks; Sahana non-Bt variety and DCH-32 non-Bt hybrid. The results obtained pertaining to experiment 1 during the investigation (2007 and 2008) are summarized (only pooled data given) here under.

Among the tested genotypes, Neeraja (BG II) Bt recorded significantly higher seed cotton yield (2483 kg/ha), the next best Bt genotype was Bunny (BG I) Bt (2071 kg/ha). Neeraja (BG II) Bt recorded 36 and 43 per cent higher yield over non-Bt hybrid check DCH-32 and check non-Bt variety Sahana, respectively. The lowest seed cotton yield was recorded with RCH-368 non-Bt (1131 kg/ha). Between Bt and non-Bt cotton genotypes, Bt cotton genotypes recorded significantly higher seed cotton yield (1978 kg/ha) compared to their corresponding non-Bt genotypes (1258 kg/ha).

Neeraja (BG II) Bt produced significantly higher number of good opened bolls per plant (51.53) and it was on par with Bunny (BG I) Bt (49.76). Neeraja (BG II) Bt produced 19.6 and 40.40 per cent higher number of good opened bolls, respectively compared to DCH-32 non-Bt hybrid and Sahana non-Bt variety. Higher number of good opened bolls in these Bt genotypes reflected their performance in lower bad opened bolls per plant (1.68 in Neeraja (BG II) Bt and 2.16 in Bunny (BG I) Bt) compared to DCH-32 non-Bt hybrid (12.80) and Sahana non-Bt variety (6.24).

DCH-32 non-Bt hybrid recorded significantly higher number of sympodial branches (19.38) followed by Neeraja (BG II) Bt (18.60) and Bunny (BG I) Bt (18.23). Significantly higher number of monopodial branches was noticed with Sahana non-Bt variety (3.85) compared to others.

The total chlorophyll content increased among the genotypes from 60 DAS (0.35 mg/g fresh weight) to 90 DAS (1.14 mg/g fresh weight) and 120 DAS (1.45 mg/g fresh weight). At 120 DAS, among the cotton genotypes, Neeraja non-Bt recorded significantly higher total chlorophyll content (1.66 mg/g fresh weight) compared to other genotypes. Between Bt and non-Bt genotypes, significantly higher total chlorophyll content was recorded with non-Bt genotypes (1.47 mg/g fresh weight) compared to Bt (1.42 mg/g fresh weight). The lowest total chlorophyll content (1.04 mg/g fresh weight) was observed with Sahana non-Bt variety. Similar trend was observed with chlorophyll 'a' content and chlorophyll 'b' content.

At 90 DAS, Sahana non-Bt variety recorded significantly higher anthocyanin content (0.210 mg/g fresh weight) than others whereas at 120 DAS, RCH-368 (BG I) Bt recorded significantly higher anthocyanin content (0.284 mg/g fresh weight). The lowest anthocyanin content was recorded with Neeraja non-Bt (0.076 mg/g fresh weight at 90 DAS and 0.137 mg/g fresh weight at 120 DAS). Between Bt and non-Bt genotypes, the anthocyanin content was significantly higher in Bt genotypes (0.104 mg/g fresh weight at 90 DAS and 0.237 mg/g fresh weight at 120 DAS) compared to non-Bt genotypes (0.065 mg/g fresh weight at 90 DAS and 0.156 mg/g fresh weight).

The red leaf index was significantly higher with Sahana non-Bt variety (1.88 at 90 DAS and 2.12 at 120 DAS) compared to red leaf index recorded with Neeraja non-Bt (0.96 at 90 DAS and 1.52 at 120 DAS).

DCH-32 non-Bt hybrid recorded significantly higher 2.5% span length (33.82 mm) compared to other cotton genotypes. Neeraja (BG II) Bt recorded significantly higher fiber fineness (4.56 micronair value) whereas Neeraja non Bt recorded higher bundle strength (25.60 g/tex) compared to other genotypes. No significant differences were observed between Bt and non-Bt genotypes with respect to 2.5% span length, fibre fineness and bundle strength.

Neeraja (BG II) Bt resulted in the highest of gross return (Rs. 54895/ha), followed by Bunny (BG I) Bt (Rs. 45826/ha). The highest net return was observed with Neeraja (BG II) Bt (Rs. 28832/ha) followed by Bunny (BG I) Bt (Rs. 20669). Highest profit in terms of BC ratio was found with Neeraja (BG II) Bt (2.11) followed by Bunny (BG I) Bt (1.82). Bt cotton cultivation yielded higher gross return (Rs. 43698/ha), net return (Rs. 18780/ha) and BC ratio (1.75) over non-Bt cotton; gross return (Rs. 27804/ha), net return (Rs. 4491/ha) and BC ratio (1.19).

Experiment 2 was focused on “Studies on nutrient management to overcome leaf reddening in Bt cotton” which comprised treatments on soil and foliar application of nutrients, growth hormone (Cytokinin) and polyethylene mulching practice. The results of the experiment 2 conducted during 2007, 2008 and pooled is summarized here under.

Foliar application of KNO_3 @ 2% (T_5) produced significantly higher seed cotton yield (2543 kg/ha) and was on par with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1% (T_{10}), respectively (2522 kg/ha) and with the treatment T_9 i.e., soil application of $MgSO_4$ @ 25 kg/ha alone (2517 kg/ha). The lowest seed cotton yield (1383 kg/ha) was recorded with the polyethylene mulching treatment. The yield levels in $T_{5,}$ T_{10} and T_9 were higher by 25.01, 24.43 and 24.47 per cent, respectively compared to yields (1906 kg/ha) under the recommended package.

Significantly increased boll weight (4.85 g/boll) and seed cotton yield per plant (98.19 g) were recorded with the foliar application of KNO_3 @ 2% compared to other treatments. Total number of bolls is the result component of number of good opened bolls and number of bad opened bolls per plant. Significantly higher number of good opened bolls per plant (49.27) lower number of bad opened bolls per plant (2.67) were noticed with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively and it was on par with foliar application of KNO_3 @ 2% (43.73 good opened bolls and 2.73 bad opened bolls) and soil application of $MgSO_4$ @ 25 kg/ha (47.78 good opened bolls and 2.55 bad opened bolls). Sympodial branches per plant also followed the similar trend whereas the number of monopodial branches was not significantly differed among the treatments.

Nitrogen content at various growth stages varied among the treatments (1.89% at 60 DAS, 2.25% at 90 DAS and 1.60% at 120 DAS). At 90 DAS, higher leaf nitrogen content (2.29%) was recorded in the treatments T_1-T_{11} (nitrogen was applied into seven splits) whereas reduced leaf nitrogen content (1.44%) was observed with the recommended package (nitrogen was applied into three splits). Foliar application of KNO_3 @ 2% significantly increased the leaf nitrogen content (2.56% at 90 DAS and 1.84% at 120 DAS) over other treatments. The lowest leaf nitrogen content (1.22%) was associated with polyethylene mulching (T_{11}).

The leaf phosphorous content varied among the treatments (0.41-0.44% at 60 DAS, 0.78-1.07% at 90 DAS and 0.48-0.71% at 120 DAS) and found above the sufficiency range (0.2-0.65%). Significantly higher leaf phosphorus content was recorded with the foliar application of DAP @ 2% at 90 DAS (1.07%) and 120 DAS (0.71%). At 120 DAS, highest leaf phosphorous content (0.71%) was recorded with T_3 i.e., foliar application of DAP @ 2% and the lowest was recorded with T_{12} i.e., recommended package of practice (0.41%).

At 90 DAS, the leaf potash content (2.43%) was significantly increased with the foliar application of KNO_3 @ 2% compared to other treatments. Similar trend was observed at 120 DAS also wherein the leaf potash content (1.02%) decreased from 90 DAS.

The leaf calcium content did not differ significantly at 60 DAS. Foliar application of calcium nitrate 1% significantly increased the leaf calcium content (5.59% at 90 DAS and 7.64% at 120 DAS) than other treatments.

The leaf magnesium content increased significantly with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (1.31% at 90 DAS and 1.86% at 120 DAS) and with the soil application of $MgSO_4$ @ 25 kg/ha (1.22% at 90 DAS and 1.82% at 120 DAS) compared to other treatments including the recommended practice (0.72% at 90 DAS and 1.32% at 120 DAS).

The leaf micronutrient contents (Zn, Fe, Mn and Cu) did not differ significantly at 60, 90 and 120 DAS. The leaf micronutrient contents (Zn, Fe, Mn and Cu) significantly increased with the foliar application of multimicronutrient @ 1%, at 90 DAS compared to 60 DAS and again increased at 120 DAS. In all the treatments and at all the growth stages leaf micronutrient content; Zn (27.85-29.0 ppm at 60 DAS, 27.10-31.10 ppm at 90 DAS and 25.80-56.60 ppm at 120 DAS), Fe (753.1-762.0 ppm at 60 DAS, 212.8-855.8 ppm at 90 DAS and 796.3-1090.3 ppm at 120 DAS), Mn (94.9-99.5 ppm at 60 DAS, 82.8–161.6 ppm at 90 DAS and 90.8-214.7 ppm at 120 DAS) and Cu (12.17-12.78 ppm at 60 DAS, 7.40-22.0 ppm at 90 DAS and 13.48-28.78 ppm at 120 DAS) found well above the sufficiency range Zn (20-40 ppm), Fe (50-250 ppm), Mn (20-350 ppm) and Cu (5-25 ppm).

The total chlorophyll content significantly increased with increasing trend from 60 DAS to 90 and 120 DAS with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (1.22 mg/g fresh weight) at 90 DAS and 1.77 mg/g fresh weight at 120 DAS compared to other treatments. The lowest total chlorophyll content (0.73 mg/g fresh weight at 90 DAS and 0.86 mg/g fresh weight at 120 DAS) was recorded with polyethylene mulching practice. Chlorophyll 'a' content and Chlorophyll 'b' content were also followed the similar trend of total chlorophyll content.

Anthocyanin content was not significantly differed at 60 DAS. At 90 DAS, significantly lower anthocyanin content was recorded with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (0.038 mg/g fresh weight at 90 DAS and 0.080 mg/g fresh weight at 120 DAS) than others and it was on par with the soil application of $MgSO_4$ @ 25 kg/ha (0.039 mg/g fresh weight at 90 DAS and 0.110 mg/g fresh weight at 120 DAS) and foliar application of KNO_3 @ 2% (0.042 mg/g fresh weight at 90 DAS and 0.100 mg/g fresh weight at 120 DAS).

At 60 and 90 DAS, there was no significant difference observed among the treatments with respect to NDVI values. However, it differed significantly at 120 DAS. At 120 DAS, significantly higher NDVI (0.41) value was recorded with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively and it was on par with the soil application of $MgSO_4$ @ 25 kg/ha (0.39) and foliar application of KNO_3 @ 2% (0.39). The lowest NDVI (0.19) at 120 DAS was recorded with the polyethylene mulching. Correlation studies indicated that the seed cotton yield of Bunny Bt (Cv. NCS-145) was significantly and positively correlated with NDVI values at 90 DAS ($r = 0.72$) and 120 DAS ($r = 0.62$).

At 60 DAS there was no significant difference observed among the treatments with respect to red leaf index (RLI) but differed significantly at 90 and 120 DAS. Significantly reduced RLI was observed with the soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (0.80 at 90 DAS and 1.05 at 120 DAS) and it was on par with the foliar application of KNO_3 @ 2% (0.88 at 90 DAS and 1.05 at 120 DAS) and with the soil application of $MgSO_4$ @ 25 kg/ha alone (0.88 at 90 DAS and 1.05 at 120 DAS).

Foliar application of KNO_3 @ 2% significantly increased the 2.5% span length (33.07 mm) and bundle strength (24.80 g/tex) over other treatments. The fibre fineness was not affected by different treatments.

The total cost of cultivation was maximum for the treatment comprising polyethylene mulching (Rs. 176561/ha) compared to other treatments. The treatment comprising foliar application of KNO_3 @ 2% recorded significantly higher gross return (Rs. 56249/ha) and it was on par with soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (Rs. 55812/ha) and soil application of MgSO4 @ 25 kg/ha (Rs. 55688/ha). In comparison with the existing package, foliar application of KNO_3 @ 2% produced 25.3 per cent higher gross return followed by soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (24.8%) and soil application of $MgSO_4$ @ 25 kg/ha alone (24.6%).

Significantly higher net return (Rs. 27807/ha) was realized with the foliar application of KNO_3 @ 2% and it was on par with soil application of $MgSO_4$ @ 25 kg/ha alone (Rs. 27722/ha) and soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (Rs. 26857/ha). However, negative net return (Rs. -145985/ha) was obtained with polyethylene mulching.

Benefit cost ratio differed significantly among treatments. Soil application of $MgSO_4$ @ 25 kg/ha recorded significantly higher BC ratio (1.99) and was on par with foliar application of KNO_3 @ 2% (1.98) and soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (1.93). The lowest benefit cost ratio (0.17) was recorded with polyethylene mulching.

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Appendix I: Survey questionnaire for collecting the information on existing Bt cotton cultivation practices in Belgaum and Haveri districts during May 2007

Name of the farmers and address :

Age :

Village / Taluk / District :

Educational status :

Land holding :

Land holding	Area (acres)
Dryland	
Irrigated land	
Garden land	
Total	

Family size : Male Female

Family income (Rs.) :

Area of cotton cultivation :

Irrigated / Rainfed :

Source of irrigation : Well / Canal / Others

Cotton cultivation details

a. Variety cultivated
b. Source of seed material for sowing Certified seed
c. Seed material used Quantity / Acre
d. Seed treatment Yes / No
e. If Yes Chemical / Other treatment
f. Rate of seed / Plant geometry
g. Sowing time
h. Method of sowing
i. Gap filling
j. Refuge
k. Regulation of monopodial / sympodial branches
l. Nipping

Nutrition

a. Organic manures FYM / Compost used

Own source / borrowed :

Rate (if purchased) :

Quantity :

Time of application :

b. Green manuring : Yes / No
If Yes, what species :
Quantity :

c. Poultry manure used : Yes / No
If Yes, what quantity :

d. Biofertilizers : Yes / No
If Yes, what biofertilizer used :
Quantity :

e. Fertilizers used
Nitrogen :
Phosphorus :
Potash :
Micronutrients :

Irrigation

Interval of irrigation :
Method employed :
Source of irrigation :

Intercultivation and weeding

Intercultivation :
Weeding : Manual / Chemical

Intercropping **: Yes / No**

If Yes, what crop? Row proportion

Pest management

Pests

a. Sucking pests (jassids/thrips/whiteflies)
Pest load
Management measures

b. Bollworms | Stage of infestation | Management
Helicoverpa
Spotted bollworm
Pink bollworm
Number of sprays
IPM : Followed / Not
Disease management :
Physiological disorder :
Disease plant protection chemical used

Yield kg/ha)

	First	Second	Third	Total
Picking				

Leaf reddening management :

Flower dropping management :

Bad opening of bolls :

Yield (kg/ha)

Appendix II: Plant protection interventions made in different treatments in Experiment 1

Interventions	Treatments																			
	2007-08										2008-09									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Seed treatment with imidacloprid 70 WS	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Sucking pests management by foliar insecticide spray with imidacloprid 200 SL (0.25 ml/l) at 30 and 100 DAS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2 acetamiprid 20 SP 0.2 g/l at 50 DAS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Myrid bug management acephate 75 SP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bollworm management with Cypermethrin 10EC (0.5 ml/lit) at 90 DAS	-	1	-	1	-	1	-	1	1	1	-	1	-	1	-	1	-	1	1	1
Chlorpyriphos 20 EC (2.5 ml/lit) at 105 DAS	-	1	-	1	-	1	-	1	1	1	-	1	-	1	-	1	-	1	1	1
Profenophos 50 EC (2.5 ml/lit) at 120 DAS	-	1	-	1	-	1	-	1	1	1	-	1	-	1	-	1	-	1	1	1
Bacterial blight management with Blitox @ 1 kg/ha at 100 DAS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wilt management with carbandizim @ 2 g/lit at 120 DAS	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1

Appendix III: Plant protection interventions made in different treatments in Experiment 2

Interventions	Treatments																							
	2007-08												2008-09											
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
Seed treatment with imidacloprid 70 WS	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Sucking pests management by foliar insecticide spray with imidacloprid 200 SL (0.25 ml/l) at 30 and 100 DAS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2 acetamiprid 20 SP 0.2 g/l at 50 DAS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Myrid bug management acephate 75 SP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bacterial blight management with Blitox @ 1 kg/ha at 100 DAS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wilt management with carbandizim @ 2 g/lit at 120 DAS	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1

Appendix IV: Soil temperature recorded in polyethylene mulched and non-polyethylene mulched treatments

Dates	Polythene mulched									Non-polythene mulched								
	8 AM			2 PM			5 PM			8 AM			2 PM			5 PM		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
October 15	23.0	20.0	**21.5**	25.0	21.0	**23.0**	23.0	20.0	**21.5**	24.0	20.0	**22.0**	25.0	21.0	**23.0**	22.0	20.0	**21.0**
October 16	23.0	23.0	**23.0**	25.0	24.0	**24.5**	24.0	22.5	**23.3**	24.0	23.0	**23.5**	24.0	24.0	**24.0**	23.5	23.5	**23.5**
October 17	23.5	23.0	**23.3**	25.0	24.0	**24.5**	23.0	23.0	**23.0**	23.0	24.0	**23.5**	24.0	25.0	**24.5**	21.0	23.0	**22.0**
October 18	23.0	23.0	**23.0**	25.0	24.0	**24.5**	23.0	23.5	**23.3**	22.0	22.5	**22.3**	23.0	23.0	**23.0**	21.0	23.0	**22.0**
October 19	24.5	23.0	**23.8**	25.0	23.5	**24.3**	23.0	23.0	**23.0**	22.0	22.0	**22.0**	24.0	23.5	**23.8**	23.0	22.0	**22.5**
October 20	24.0	23.0	**23.5**	25.0	23.5	**24.3**	25.0	23.0	**24.0**	25.0	23.0	**24.0**	25.5	23.5	**24.5**	25.5	23.0	**24.3**
October 21	24.0	23.0	**23.5**	25.0	23.5	**24.3**	23.0	23.0	**23.0**	24.0	23.0	**23.5**	24.0	22.5	**23.3**	21.0	22.5	**21.8**
October 22	23.0	23.0	**23.0**	24.0	23.5	**23.8**	23.0	23.0	**23.0**	22.0	22.0	**22.0**	23.0	22.5	**22.8**	23.0	22.0	**22.5**
October 23	24.0	23.0	**23.5**	25.0	23.5	**24.3**	24.0	23.0	**23.5**	24.0	22.0	**23.0**	25.0	23.5	**24.3**	24.0	23.0	**23.5**
October 24	24.0	23.0	**23.5**	26.0	23.5	**24.8**	24.0	23.0	**23.5**	23.0	22.0	**22.5**	24.0	22.5	**23.3**	24.0	22.0	**23.0**
October 25	24.0	23.0	**23.5**	25.0	23.5	**24.3**	24.0	23.0	**23.5**	24.5	22.5	**23.5**	25.0	22.0	**23.5**	24.0	22.0	**23.0**
October 26	23.0	23.0	**23.0**	24.0	24.0	**24.0**	23.0	23.0	**23.0**	23.0	22.0	**22.5**	24.0	22.5	**23.3**	22.0	22.0	**22.0**
October 27	23.0	23.0	**23.0**	24.0	24.0	**24.0**	23.0	23.0	**23.0**	22.0	22.5	**22.3**	23.0	24.0	**23.5**	22.0	24.0	**23.0**
October 28	24.0	23.0	**23.5**	25.0	24.0	**24.5**	24.0	23.0	**23.5**	22.0	23.0	**22.5**	24.0	24.0	**24.0**	23.0	23.0	**23.0**
October 29	24.5	23.0	**23.8**	25.0	24.0	**24.5**	23.0	23.0	**23.0**	24.0	22.0	**23.0**	25.5	22.5	**24.0**	22.0	22.0	**22.0**
October 30	24.0	23.0	**23.5**	25.0	24.0	**24.5**	24.0	23.0	**23.5**	24.0	22.0	**23.0**	25.0	22.5	**23.8**	21.0	22.0	**21.5**
October 31	23.0	23.0	**23.0**	23.5	24.0	**23.8**	22.0	20.0	**21.0**	20.0	22.5	**21.3**	23.0	23.0	**23.0**	21.0	22.0	**21.5**

Dates	Polythene mulched									Non-polythene mulched								
	8 AM			2 PM			5 PM			8 AM			2 PM			5 PM		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
Oct 15-Oct 31	**23.6**	**22.8**	**23.2**	**24.8**	**23.6**	**24.2**	**23.4**	**22.6**	**23.0**	**23.1**	**22.4**	**22.7**	**24.2**	**23.0**	**23.6**	**22.5**	**22.4**	**22.5**
November 1	23.0	22.0	**22.5**	24.0	23.0	**23.5**	21.0	23.0	**22.0**	22.0	22.0	**22.0**	23.0	22.50	**22.8**	19.0	22.0	**20.5**
November 2	23.0	22.0	**22.5**	23.5	25.0	**24.3**	22.0	22.0	**22.0**	21.0	22.5	**21.8**	22.0	23.5	**22.8**	21.0	22.5	**21.8**
November 3	23.0	23.0	**23.0**	24.0	24.0	**24.0**	21.5	23.0	**22.3**	22.0	22.0	**22.0**	23.0	22.5	**22.8**	19.0	22.0	**20.5**
November 4	24.0	23.0	**23.5**	25.0	23.5	**24.3**	22.0	23.0	**22.5**	24.0	22.0	**23.0**	24.5	22.50	**23.5**	20.0	22.50	**21.3**
November 5	24.0	22.0	**23.0**	25.5	22.5	**24.0**	21.0	22.0	**21.5**	23.0	22.5	**22.8**	24.0	24.0	**24.0**	19.0	22.50	**20.8**
November 6	23.0	22.0	**22.5**	23.5	22.5	**23.0**	21.0	22.0	**21.5**	22.0	22.5	**22.3**	22.5	23.0	**22.8**	20.0	22.50	**21.3**
November 7	22.0	23.0	**22.5**	22.5	23.5	**23.0**	19.0	22.5	**20.8**	22.0	21.0	**21.5**	23.0	22.5	**22.8**	18.0	22.0	**20.0**
November 8	22.0	22.5	**22.3**	22.5	23.5	**23.0**	21.0	23.0	**22.0**	22.0	22.0	**22.0**	22.5	22.5	**22.5**	19.0	22.0	**20.5**
November 9	22.0	22.0	**22.0**	23.0	22.5	**22.8**	21.0	22.0	**21.5**	20.0	22.0	**21.0**	23.0	23.0	**23.0**	18.0	22.50	**20.3**
November 10	22.0	23.0	**22.5**	24.0	24.0	**24.0**	21.0	23.0	**22.0**	21.0	22.50	**21.8**	24.0	23.0	**23.5**	19.0	22.50	**20.8**
November 11	21.0	23.0	**22.0**	22.5	23.5	**23.0**	20.0	23.0	**21.5**	20.0	22.0	**21.0**	21.0	23.0	**22.0**	19.0	22.50	**20.8**
November 12	22.0	23.0	**22.5**	22.5	23.5	**23.0**	19.0	23.0	**21.0**	22.0	22.50	**22.3**	22.5	23.0	**22.8**	18.0	22.50	**20.3**
November 13	21.0	23.0	**22.0**	21.5	23.0	**22.3**	19.0	22.5	**20.8**	20.0	22.0	**21.0**	21.0	22.5	**21.8**	17.0	22.0	**19.5**
November 14	21.0	23.0	**22.0**	22.0	23.5	**22.8**	19.5	23.0	**21.3**	19.0	20.0	**19.5**	20.0	21.0	**20.5**	17.0	20.0	**18.5**
November 15	22.0	23.0	**22.5**	22.5	23.5	**23.0**	19.0	21.5	**20.3**	20.0	22.0	**21.0**	20.5	22.5	**21.5**	17.0	19.0	**18.0**
Nov 1-Nov 15	**22.3**	**22.6**	**22.5**	**23.2**	**23.4**	**23.3**	**20.5**	**22.6**	**21.5**	**21.3**	**22.0**	**21.7**	**22.4**	**22.7**	**22.6**	**18.7**	**21.9**	**20.3**
November 16	20.5	23.0	**21.8**	22.0	23.5	**22.8**	21.0	23.0	**22.0**	10.3	20.0	**15.2**	20.5	23.0	**21.8**	19.0	21.0	**20.0**
November 17	22.0	23.0	**22.5**	21.0	23.5	**22.3**	21.0	23.0	**22.0**	11.0	22.50	**16.8**	29.0	23.0	**26.0**	18.0	22.50	**20.3**
November 18	16.0	22.0	**19.0**	24.0	23.0	**23.5**	25.0	22.0	**23.5**	20.0	22.50	**21.3**	22.0	23.0	**22.5**	21.0	22.0	**21.5**

Dates	Polythene mulched									Non-polythene mulched								
	8 AM			2 PM			5 PM			8 AM			2 PM			5 PM		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
November 19	17.0	20.0	**18.5**	21.0	21.0	**21.0**	16.0	19.0	**17.5**	22.0	22.0	**22.0**	23.0	22.5	**22.8**	20.0	22.0	**21.0**
November 20	18.0	20.0	**19.0**	23.0	23.0	**23.0**	21.0	23.0	**22.0**	20.0	22.0	**21.0**	22.0	22.5	**22.3**	22.0	22.0	**22.0**
November 21	15.0	20.0	**17.5**	19.0	23.0	**21.0**	18.0	22.5	**20.3**	18.0	22.0	**20.0**	22.0	22.5	**22.3**	21.0	22.0	**21.5**
November 22	13.0	20.0	**16.5**	21.0	21.0	**21.0**	15.0	20.0	**17.5**	21.0	19.0	**20.0**	24.0	20.0	**22.0**	22.0	20.0	**21.0**
November 23	17.0	22.0	**19.5**	21.0	22.5	**21.8**	16.0	22.5	**19.3**	22.0	22.0	**22.0**	23.0	22.5	**22.8**	20.0	22.5	**21.3**
November 24	20.0	22.5	**21.3**	21.0	23.0	**22.0**	15.0	22.5	**18.8**	22.0	22.0	**22.0**	24.0	22.5	**23.3**	21.0	22.0	**21.5**
November 25	20.0	22.5	**21.3**	24.0	23.0	**23.5**	18.0	21.0	**19.5**	21.0	22.5	**21.8**	22.0	23.0	**22.5**	21.0	20.5	**20.8**
November 26	18.0	22.5	**20.3**	25.0	23.5	**24.3**	18.0	23.0	**20.5**	20.0	22.0	**21.0**	22.0	22.5	**22.3**	21.0	22.0	**21.5**
November 27	19.0	23.0	**21.0**	22.0	23.5	**22.8**	22.0	23.0	**22.5**	20.0	22.5	**21.3**	23.0	23.0	**23.0**	20.0	22.5	**21.3**
November 28	25.0	23.0	**24.0**	27.0	23.5	**25.3**	21.0	23.5	**22.3**	23.0	22.0	**22.5**	25.0	22.5	**23.8**	19.0	22.0	**20.5**
November 29	16.0	23.0	**19.5**	17.0	23.5	**20.3**	16.0	22.5	**19.3**	22.0	22.0	**22.0**	22.0	22.5	**22.3**	21.0	22.0	**21.5**
November 30	18.0	23.0	**20.5**	19.0	24.0	**21.5**	17.0	23.0	**20.0**	21.0	22.0	**21.5**	21.0	23.0	**22.0**	20.0	22.5	**21.3**
Nov15-Nov30	**18.3**	**22.0**	**20.1**	**21.8**	**23.0**	**22.4**	**18.7**	**22.2**	**20.5**	**19.6**	**21.8**	**20.7**	**23.0**	**22.5**	**22.8**	**20.4**	**21.8**	**21.1**
December 1	23.0	23.0	**23.0**	27.0	24.0	**25.5**	23.0	23.0	**23.0**	18.0	22.5	**20.3**	23.0	22.0	**22.5**	22.0	22.0	**22.0**
December 2	19.5	23.0	**21.3**	21.5	24.0	**22.8**	19.0	23.0	**21.0**	23.0	22.5	**22.8**	25.0	23.0	**24.0**	20.0	22.5	**21.3**
December 3	18.0	22.0	**20.0**	19.0	23.0	**21.0**	20.0	22.5	**21.3**	22.0	22.5	**22.3**	23.0	23.0	**23.0**	22.0	22.0	**22.0**
December 4	18.0	23.0	**20.5**	18.0	23.5	**20.8**	16.0	23.5	**19.8**	23.0	22.5	**22.8**	24.0	23.0	**23.5**	22.0	22.5	**22.3**
December 5	22.0	23.0	**22.5**	25.0	24.0	**24.5**	23.0	23.0	**23.0**	21.0	22.5	**21.8**	22.0	23.0	**22.5**	21.0	22.5	**21.8**
December 6	24.5	23.0	**23.8**	26.5	23.0	**24.8**	23.0	23.5	**23.3**	23.0	22.0	**22.5**	28.0	22.0	**25.0**	21.0	22.5	**21.8**
December 7	24.0	23.0	**23.5**	25.0	24.0	**24.5**	24.0	23.0	**23.5**	22.0	22.0	**22.0**	23.5	22.5	**23.0**	22.0	22.5	**22.3**

Dates	Polythene mulched									Non-polythene mulched								
	8 AM			2 PM			5 PM			8 AM			2 PM			5 PM		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
December 8	23.0	23.0	**23.0**	24.0	23.5	**23.8**	25.0	23.5	**24.3**	21.0	22.0	**21.5**	22.5	23.0	**22.8**	23.0	22.5	**22.8**
December 9	23.0	22.0	**22.5**	25.0	23.0	**24.0**	24.0	23.0	**23.5**	21.0	22.0	**21.5**	23.0	22.5	**22.8**	22.0	22.5	**22.3**
December 10	24.0	23.0	**23.5**	26.0	24.0	**25.0**	24.0	23.5	**23.8**	23.0	22.0	**22.5**	24.0	23.0	**23.5**	23.0	22.0	**22.5**
December 11	24.5	22.0	**23.3**	26.0	23.0	**24.5**	24.0	23.0	**23.5**	22.0	22.0	**22.0**	24.0	22.0	**23.0**	23.0	22.5	**22.8**
December 12	23.0	23.0	**23.0**	25.0	23.0	**24.0**	23.0	22.0	**22.5**	25.0	22.5	**23.8**	23.5	22.0	**22.8**	22.0	22.0	**22.0**
December 13	24.5	23.0	**23.8**	26.0	23.0	**24.5**	24.0	22.0	**23.0**	22.0	21.5	**21.8**	24.0	22.50	**23.3**	23.0	22.5	**22.8**
December 14	25.0	23.0	**24.0**	26.5	24.0	**25.3**	24.0	22.0	**23.0**	23.5	22.0	**22.8**	25.0	23.0	**24.0**	23.0	22.0	**22.5**
December 15	23.0	22.0	**22.5**	25.0	23.0	**24.0**	24.5	23.0	**23.8**	22.0	22.0	**22.0**	24.0	22.5	**23.3**	22.0	22.5	**22.3**
Dec1-Dec 15	**22.6**	**22.7**	**22.7**	**24.4**	**23.5**	**23.9**	**22.7**	**22.9**	**22.8**	**22.1**	**22.2**	**22.2**	**23.9**	**22.6**	**23.3**	**22.1**	**22.3**	**22.2**
December 16	24.0	22.0	**23.0**	26.0	23.0	**24.5**	25.0	23.0	**24.0**	23.0	22.0	**22.5**	24.0	22.5	**23.3**	23.0	22.5	**22.8**
December 17	24.5	22.0	**23.3**	25.0	23.0	**24.0**	24.0	22.0	**23.0**	23.0	22.5	**22.8**	24.0	23.0	**23.5**	22.5	22.0	**22.3**
December 18	24.0	22.0	**23.0**	25.0	23.0	**24.0**	24.0	21.0	**22.5**	23.0	22.5	**22.8**	24.0	23.0	**23.5**	23.0	22.5	**22.8**
December 19	23.5	23.0	**23.3**	25.0	23.5	**24.3**	25.0	23.0	**24.0**	22.0	22.0	**22.0**	23.0	22.5	**22.8**	23.0	22.5	**22.8**
December 20	24.0	23.0	**23.5**	25.0	23.5	**24.3**	25.0	23.0	**24.0**	18.0	22.0	**20.0**	21.0	22.5	**21.8**	23.0	22.0	**22.5**
December 21	24.5	23.0	**23.8**	25.0	23.5	**24.3**	25.0	23.0	**24.0**	19.0	22.0	**20.5**	21.0	22.5	**21.8**	23.0	22.0	**22.5**
December 22	25.0	23.0	**24.0**	26.0	24.0	**25.0**	25.0	22.5	**23.8**	18.0	22.0	**20.0**	21.0	23.5	**22.3**	22.5	22.5	**22.5**
December 23	24.0	22.0	**23.0**	26.0	23.5	**24.8**	24.0	23.0	**23.5**	19.0	22.0	**20.5**	23.0	22.5	**22.8**	23.0	22.5	**22.8**
December 24	25.0	22.0	**23.5**	26.0	23.5	**24.8**	24.0	23.0	**23.5**	20.5	22.0	**21.3**	23.0	22.5	**22.8**	23.0	22.5	**22.8**
December 25	24.0	21.0	**22.5**	26.0	22.0	**24.0**	25.0	22.0	**23.5**	21.0	20.0	**20.5**	24.0	21.0	**22.5**	24.0	21.0	**22.5**
December 26	25.0	23.0	**24.0**	27.0	25.0	**26.0**	26.0	24.0	**25.0**	21.0	21.0	**21.0**	26.0	22.0	**24.0**	25.0	22.0	**23.5**

Dates	Polythene mulched									Non-polythene mulched								
	8 AM			2 PM			5 PM			8 AM			2 PM			5 PM		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
December 27	25.0	23.0	**24.0**	26.0	24.0	**25.0**	24.0	23.0	**23.5**	21.5	21.0	**21.3**	25.5	24.0	**24.8**	23.0	22.0	**22.5**
December 28	25.0	25.0	**25.0**	27.0	26.5	**26.8**	24.0	25.5	**24.8**	19.0	21.0	**20.0**	26.0	23.0	**24.5**	23.0	22.5	**22.8**
December 29	25.0	25.0	**25.0**	27.0	26.0	**26.5**	23.0	24.5	**23.8**	21.0	22.0	**21.5**	25.0	23.0	**24.0**	21.0	22.5	**21.8**
December 30	26.0	25.0	**25.5**	27.0	27.0	**27.0**	24.0	25.5	**24.8**	22.0	22.5	**22.3**	24.0	23.0	**23.5**	23.0	23.0	**23.0**
December 31	25.0	24.0	**24.5**	26.0	26.5	**26.3**	24.0	26.0	**25.0**	21.0	22.0	**21.5**	24.0	23.5	**23.8**	22.0	23.0	**22.5**
Dec15-Dec 31	**23.6**	**22.9**	**23.2**	**25.2**	**23.8**	**24.5**	**23.6**	**23.1**	**23.4**	**21.4**	**22.0**	**21.7**	**23.8**	**22.7**	**23.2**	**22.5**	**22.3**	**22.4**

Appendix V: Dates of seed cotton picking

a) Experiment I

Picking	2007-08	2008-09
1st picking	12-11-2007	18-11-2008
2nd picking	15-12-2007	21-12-2008
3rd picking	29-12-2007	31-12-2008
*4th picking	20-01-2008	23-01-2009
Note: * Neeraja (BG II) Bt, Neeraja non-Bt and DCH-32 were harvested upto 4th picking, rest genotypes were harvested upto 3rd picking		

b) Experiment II

Picking	2007-08	2008-09
1st picking	10-11-2007	15-11-2008
2nd picking	12-12-2007	18-12-2008
3rd picking	28-12-2007	27-12-2008
Note: Bunny (BG I) Bt (Cv.NCS-145) genotype was used		

Appendix VI: Prices of inputs and outputs used in cost of cultivation and returns

Items		Units	Prices (Rs.)		
			2007-08	2008-09	20010-11
	A. Inputs				
Seeds	Bunny Bt	Pkt 450 g	750.00	750.00	750.00
	RCH-368 Bt	450 g	750.00	750.00	750.00
	JK Durga Bt	450 g	750.00	750.00	750.00
	Bollgard III Bt	450 g	1500.00	1500.00	1500.00
	Sahana	Kg	50.00	50.00	50.00
	DCH-32	Kg	360.00	360.00	400.00
Fertilizers	DAP	Qtl.	972.00	972.00	985.00
	Urea	Qtl.	500.00	500.00	516.00
	MOP	Qtl.	462.00	462.00	472.00
	KNO_3	1 kg	100.00	100.00	100.00
	$MgSO_4$	1 kg	50.00	50.00	50.00
	Calcium nitrate	1 kg	80.00	80.00	80.00
	Micnelf (multi micronutrient)	1 kg	160.00	170.00	170.00
Manure	FYM	Tonne	500.00	500.00	800.00
Growth hormone	Cytokinin (Kinetin)	1 gm	575.00	575.00	575.00
Polythene sheet	Polythene sheet (100 micron)	1 m	15.00	15.00	19.00
Pesticides	Acetamiprid 20 SP	20 g	100.00	70.00	119.00
	Imidacloprid 200SL	100 ml	220.00	230.00	625.00
	Cypermethrin 20EC	Lit	200.00	200.00	220.00
	Chlorpyriphos 20EC	1 Lit	190.00	190.00	190.00
	Profenophos 50EC	250 ml	151.00	151.00	160.00
	Blitox	1 kg	390.00	410.00	410.00
	Carbandizim 50EC	500 gm	220.00	230.00	240.00
Labour	Men	Day	60.00	60.00	70.00
	Women	Day	50.00	60.00	60.00
	Bullock pair	1	200.00	250.00	250.00
Others	Baradon	Each	75.00	75.00	75.00
	Tractor (Transport)	Day	800.00	800.00	800.00
Output	**Seed cotton cost (Rs)**	Qtl.	2150.00	2275.00	40000.00

Appendix VII: Economic analysis of Experiment-1 on "Assessing leaf reddening malady in Bt cotton genotypes" during 2010-11

Tr. No.	Treatment details	Cost of cultivation (Rs./ha)			Gross return (Rs./ha)			Net return (Rs./ha)			BC ratio		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	Bunny Bt (BG-I)	30401	30562	30482	81747	47713	64730	51346	83891	67618	2.69	2.74	2.72
T_2	Bunny Non Bt	28153	28133	28143	51773	29296	40534	23620	51509	37565	1.84	1.83	1.83
T_3	RCH 368 Bt (BG-I)	29770	28846	29308	73333	34699	54016	43563	61009	52286	2.46	2.12	2.29
T_4	RCH 368 Non Bt	29929	28683	29306	48133	24064	36099	18204	42311	30258	1.61	1.48	1.54
T_5	JK Durga Bt (BG-I)	28133	27836	27985	75453	33466	54460	47320	58842	53081	2.68	2.11	2.40
T_6	JK Durga Non Bt	28133	27836	27985	51507	27045	39276	23374	47552	35463	1.83	1.71	1.77
T_7	Neeraja Bt (BG-II)	31904	31533	31719	101787	55080	78433	69883	96844	83363	3.19	3.07	3.13
T_8	Neeraja Non Bt	28448	28318	28383	55707	30700	43203	27259	53978	40619	1.96	1.91	1.93
T_9	Sahana (Non-Bt variety)	29284	27723	28504	66853	26185	46519	37569	46040	41805	2.28	1.66	1.97
T_{10}	DCH 32 (Non-Bt Hybrid)	29514	28574	29044	69920	32635	51278	40406	57380	48893	2.37	2.01	2.19
S.Em ±		**-**	**-**	**-**	**3444**	**3428**	**2315**	**3444**	**6028**	**3331**	**0.12**	**0.21**	**0.12**
LSD (p=0.05)		**-**	**-**	**-**	**10232**	**10186**	**6878**	**10232**	**17909**	**9895**	**0.35**	**0.63**	**0.35**
CV (%)		**-**	**-**	**-**	**8.82**	**17.42**	**7.88**	**15.49**	**17.42**	**11.75**	**8.93**	**17.88**	**9.27**

Appendix VIII: Economic analysis of Experiment-2 on "Studies on nutrient management to overcome leaf reddening in Bt cotton" during 2010-11

Tr. No.	Treatment details	Cost of cultivation (Rs./ha)			Gross returns (Rs./ha)			Net returns (Rs./ha)			BC ratio		
		2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled	2007	2008	Pooled
T_1	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (10% N, full P and K as basal and 90% N in equal to 6 splits)	38499	44367	41433	84370	82328	83349	45871	37961	41916	2.19	1.86	2.02
T_2	T_1+ Foliar application of Urea @ 2% three times at an interval of 15 days from October II FN	32867	32756	32812	84697	83210	83954	51830	50455	51142	2.58	2.54	2.56
T_3	T_1+ Foliar application of DAP @ 2% three times at an interval of 15 days from October II FN	33158	32965	33062	85680	83110	84395	52522	50144	51333	2.58	2.52	2.55
T_4	T_1+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	35731	35955	35843	84798	83588	84193	49067	47633	48350	2.37	2.32	2.35
T_5	T_1+ Foliar application of KNO_3 @ 2% three times at an interval of 15 days from October II FN	34936	34942	34939	102211	101203	101707	67275	66262	66768	2.93	2.90	2.91
T_6	T_1+ Foliar application of calcium nitrate @ 1% three times at an interval of 15 days from October II FN	34634	34431	34533	83614	83689	83651	48980	49258	49119	2.41	2.43	2.42
T_7	T_1+ Foliar application of multimicronutrient @ 1% three times at an interval of 15 days from October II FN	36671	36631	36651	85982	83286	84634	49312	46655	47983	2.34	2.27	2.31
T_8	T_1+ Foliar application of cytokinin @ 2ppm three timesat an interval of 15 days from October II FN	35856	36153	36005	83941	83412	83677	48085	47259	47672	2.34	2.31	2.32
T_9	T_1+ Soil application of $MgSO_4$ @ 25 kg/ha	35661	35742	35702	100019	101304	100661	64358	65562	64960	2.80	2.83	2.82
T_{10}	T_9+ Foliar application of $MgSO_4$ @ 1% three times at an interval of 15 days from October II FN	36201	36282	36242	100346	101430	100888	64145	65148	64647	2.77	2.80	2.78
T_{11}	T_1+ Mulching of inter row space of 80 cm with polyethylene (100 micron) during the period of October II FN to harvest	220428	220103	220265	57506	53172	55339	-162922	-166931	-164926	0.26	0.24	0.25
T_{12}	120 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha (50% N, full P and K as basal and 50% N in equal 3 splits)	30436	30172	30304	78019	74491	76255	47583	44319	45951	2.56	2.47	2.52
S.Em ±		**-**	**-**	**-**	**5271**	**5615**	**3193**	**5092**	**5615**	**3193**	**0.14**	**0.15**	**0.08**
LSD (p=0.05)		**-**	**-**	**-**	**15460**	**16469**	**9364**	**14934**	**16469**	**9364**	**0.40**	**0.40**	**0.25**
CV (%)		**-**	**-**	**-**	**10.63**	**11.51**	**6.49**	**24.84**	**28.91**	**15.99**	**10.16**	**11.45**	**6.30**

EVALUATION OF BT COTTON GENOTYPES AND NUTRIENT MANAGEMENT TO CONTROL LEAF REDDENING

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ABSTRACT

Two field experiments on "Assessing leaf reddening malady in Bt cotton genotypes" and "Studies on nutrient management to overcome leaf reddening in Bt cotton" were conducted on vertisols at MARS, University of Agricultural Sciences, Dharwad during *kharif* 2007 and 2008. Mean of two years data from the first experiment indicated that cv. Neeraja-BG-II-Bt recorded significantly higher seed cotton yield (2483 kg/ha) and net monetary return (Rs. 28,832/ha) compared to other cultivars (1131 to 2071 kg/ha and Rs. 1950 to 20,669, respectively). At 120 DAS, cv. Neeraja-Non-Bt recorded significantly higher total chlorophyll (1.66 mg/g fresh weight) and lower anthocyanin (0.137 mg/g fresh weight) while cv. Sahana-Non-Bt recorded significantly higher red leaf index (2.12). Seed cotton yield was positively correlated with total chlorophyll (r=0.34) while negative correlation with anthocyanin (r=-0.09) and red leaf index (r=-0.03) was observed among the genotypes studied at 120 DAS. Results from the second experiment revealed that foliar application of KNO_3 @ 2% produced significantly higher seed cotton yield (2543 kg/ha) and net monetary return (Rs. 27807/ha) compared to other treatments (1383 to 2522 kg/ha and Rs. -145985 to 27722, respectively). At 120 DAS, significantly increased total chlorophyll, decreased anthocyanin and lower red leaf index were recorded with soil and foliar application of $MgSO_4$ @ 25 kg/ha and 1%, respectively (1.77, 0.08 mg/g fresh weight and 1.05, respectively) which were on par with treatments of KNO_3 @ 2% foliar application (1.70,0.10 mg/g fresh weight and 1.05, respectively) and soil application of $MgSO_4$ @ 25 kg/ha (1.70, 0.11 mg/g fresh weight and .05, respectively). Significant positive correlation between seed cotton yield and total chlorophyll (r=0.95) was observed while negative correlation with anthocyanin (r=-0.86) and red leaf index (r=-0.97) was noted at 120 DAS. Polyethylene mulching in between two Bt cotton rows did not influence significantly in overcoming leaf reddening.