SOIL AND FOLIAR NUTRIENT MANAGEMENT IN Bt AND NON-Bt COTTON GENOTYPES UNDER PROTECTIVE IRRIGATION

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CERTIFICATE

This is to certify that the thesis entitled "SOIL AND FOLIAR NUTRIENT MANAGEMENT IN Bt AND NON-Bt COTTON GENOTYPES UNDER PROTECTIVE IRRIGATION" submitted by Mr. SANTHOSHA K. R., for the degree of MASTER OF SCIENCE (AGRICULTURE) in AGRONOMY, to the University of Agricultural Sciences, Dharwad is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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1. INTRODUCTION

Cotton plays a pivotal role in Indian's agrarian and industrial economy and also provides a livelihood to more than 60 million peoples by way of support in agriculture, processing and use of cotton in textiles. However, during the last decade, existing cotton cultivars turn down in seed cotton yields. Hence, the farmers have chosen alternate crops, *i.e.* Bt cotton (*Gossypium hirsutum* L.) Owing to fast growth and better performance of Bt cotton hybrids in terms of high seed cotton yield, it became popular among cotton growing farmers. Apart from improvement in yield, Bt cotton hybrids have also lowered the pest incidence (specially cotton bollworm) and reduced environmental pollution by limited use of insecticides. Other special features of Bt cotton are shorter crop duration, compact crop canopy, synchronized boll bursting, capable of accommodating a higher plant population per unit area and to withstand high fertility conditions (Venugopal, 2004). With the introduction of Bt cotton hybrids, there has been a significant change in the cotton cultivation scenario of India. Now, around 70 per cent area under cotton is occupied by Bt cotton hybrids.

Based on the conclusive evidences from the field trials and demonstrations in India, the Genetic Engineering Approval Committee (GEAC) under the Government of India has approved commercial cultivation of three Bt-cotton hybrids MECH-184 Bt, MECH-162 Bt and MECH-12 Bt developed by M/S. Mahyco-Monsanto Ltd., Jalna, Mumbai and Maharashtra on March 26, 2002. Recently, it has also approved commercial cultivation of RCH-2 Bt, RCH-20 Bt and RCH-144 Bt hybrids developed by M/s. Rasi Seeds Co. Ltd., Coimbatore, Tamil Nadu during April, 2004. The GEAC approved by commercial cultivation of six more genetically modified (GM) Bt-cotton hybrids developed for the northern region by Maharashtra Hybrid Seeds Company Ltd. (MAHYCO) (MRC-6301 and MRC-6304), Rasi Seeds Private Ltd., (RCH-134 and RCh-138) and Ankur Seeds Ltd., (Ankur-651 and Ankur-254) (Anonymous, 2005). With this, a total of 12 Bt-cotton hybrids have been approved for commercial cultivation in the country.

The deployment of Bt cotton over the last years has resulted in India becoming the number one exporter of cotton globally as well as the second largest cotton producer in the world. Socio-economic surveys confirm that Bt cotton continues to deliver significant and multiple agronomic, economic, environmental and welfare benefits to farmers and society of the 8.4 million hectares of hybrid Bt cotton grown in India in 2009, 35 per cent was under irrigation and 65 per cent rainfed. A total of 522 Bt cotton hybrids (including a Bt cotton variety) were approved for planting in 2009 compared with 274 Bt cotton hybrids in 2008, 137 in 2007, 62 in 2006, 20 in 2005 only 4 Bt cotton hybrids in 2004. Over the last eight years, India has greatly diversified deployment of Bt genes and genotypes, which are well adopted to the different agro-ecological zones to ensure equitable distribution to small and resource poor cotton growers. It is estimated that Bt cotton would cover an area of 15.0 million ha by 2015 (Anon., 2011). The major states growing Bt cotton are Maharashtra (38.72 lakh hectares), Gujarat (26.91 lakh hectares), Andhra Pradesh (21.42 lakh hectares) and Karnataka (5.78 lakh hectares) (Anon., 2014).

In recent years, there has been an increasing trend to adopt multiple gene (mostly two genes) Bt cotton hybrids by cotton farmers in India. The area under single gene Bt cotton hybrids increased to 5.74 million hectares in 2007 and then registered a decline to 5.56 million hectares in 2008 and 3.58 million hectares in 2009. During the same time, multiple gene Bt cotton area grew rapidly to 0.46 million hectares in 2007 to 2.04 million hectares in 2008. In 2009, the multiple gene Bt cotton hybrids were planted for the first time on a large area (57 %) occupying 4.82 million hectares as compared to 3.58 million (4.3 %) occupied by single Bt gene hybrids. The multiple gene Bt cotton hybrids occupied approximately 90 per cent of total Bt cotton area in 2010. In 2009, a total of six events were approved for incorporation in a total of 522 hybrids. There has been a substantial increase in the area and number of hybrids with two genes (BT II event) in 2009. The use of BG II cotton hybrids were more than doubled to 248 in 2009 from 94 in 2008 and only 21 hybrids in 2007. This trend is due to the multiple benefits offered by double genes in terms of more effective control of American bollworm, pink bollworm and spotted bollworm and additional protection to *Spodoptera*. It is reported that multiple gene Bt cotton farmers earn higher profit through cost savings associated with fewer sprays of *Spodoptera* control as well as increasing yields by 8-10 per cent over single gene Bt cotton hybrids (Clive, 2009).

Cry protein synthesis in the plant though was a core genetic trait, but it was known to change its levels with fertility supply pattern (Arnold and Craig, 2005). Possible alteration of *Cry* protein levels with manipulation of management practices could be a sound practice to increase production, so also helps for further extension of *Cry* protein levels at later stages of crop cycle when, the natural levels in the plant will decline (Adamczyk *et al.*, 2001; Holt, 1998; Fitt, 1998; Sachs *et al.*, 1998 and Greenplate John, 1999).

Studies made worldwide on transgenic crops as reported by Arnold and Craig (2003) in maize and by Rochester (2006) in cotton indicated that nitrogen enhances the *Cry* protein concentration in the plant. This gives more and more protection to the crop from pest incidence. Nitrogen management in Bt-cotton is a better challenge to boost production and protecting the crop from bollworm incidence. Nitrogen supplement pattern by split application becomes important as it is supplied ideally in a time when crop critically requires. Bt-cotton may differ in its requirement either by total or part of it in the different stages of crop. Thus, nitrogen use efficiency can be increased and better used to attain the objective of higher production. Cotton is long duration crop with an indeterminate growth habit. The N supplementation period can be increased with number of splits, which provides long time from square formation to boll development. Hence, nitrogen requirement during critical stages can be better met with split application pattern.

However, to meet the requirement of 2020 AD (*i.e.* 320 lakh bales), the current production has to be increased by nearly 50 per cent. This increase has to come from increased productivity (Anon., 1998). The higher yield in future would have to be harvested from vertical rather than horizontal expansion of net cropped area. Not doubt, high analysis chemical fertilizers increased the productivity but due to high fertilizer cost, the profit margin was low. Soil fertility is the primary limiting factor which influences production under intensive crop cultivation.

After introduction of exhaustive high yielding varieties and hybrids in many crops including cotton, increased use of high analysis chemical fertilizers devoid of micronutrients and inadequate application of organic manures due to scarcity resulted in wide spread micronutrient deficiency and nutrient imbalance which adversely affected yield of cotton and many others crops. Therefore, it is essential to supply macro and micro nutrients in a balanced ratio in required quantity for obtaining higher cotton kapas yield.

Foliar feeding with plant nutrients gives quick benefits and economizes nutrient element as compared to soil application (Verma, 1973). Foliar feeding is often effective when roots are unable to absorb sufficient nutrients from the soil due to high degree of fixation, losses from leaching, low soil temperature and lack of soil moisture (Sing *et al*., 1970).

Transgenic cotton varieties modified to express the *Cry1Ac* insecticidal toxin (Bt cotton) that is toxic to some insect pests is now grown worldwide. Through the products of introduced genes, modified rhizosphere chemistry or altered crop residue quality, genetically modified plants have the potential to significantly change microbial dynamics, soil biodiversity and essential ecosystem functions, such as nutrient mineralization, disease incidence, carbon turnover and plant growth. *Cry*1Ab protein from biomass of Bt rice degraded faster in alkaline soil (half- life 11.5 d) than in acidic soil (half-life 34.3 d). However, there are few experimental data available, especially quantitative data, on the environmental consequences of sustained expression and or presence of Bt toxin in various parts of Bt cotton plants.

Although there are diverse benefits of Bt cotton, public concern also exist because both in vitro and in vivo studies on Bt cotton showed that Bt toxin produced in leaves, stems and roots of Bt cotton plants is introduced in to the soil through two pathways, *i.e*., biomass incorporation and root exudates (Saxena and Stotzky, 2001; Usha *et al*., 2008). Bt toxin released in soil get adsorbed or bound on clay particles, humic components or organic mineral complexes and then be protected against degradation by soil microorganisms. Although Bt toxin also found naturally in many soils, but continuous growing of Bt crops on same location enhance its existing levels to a certain concentration that might affect the composition and activity of soil microbial communities and the soil biochemical properties (Sarkar *et al*., 2009). Some studies indicated that Bt cotton has no negative effects on soil flora and fauna and may even have beneficial effects (Saxena and Stotzky, 2001) while some have reported adverse effects. However, similar experimental studies on risk assessment of Bt cotton with respect to soil ecosystem in India.

Keeping in view of all these points, the present investigation was undertaken with the following objectives;

1. To assess the interactive effect of Bt and non-Bt cotton genotypes on *Cry* protein content in plant,
2. To assess the effect Bt and non-Bt cotton genotypes and nutrient levels on *Cry* protein expression.
3. To assess the interactive effect of Bt and non-Bt cotton genotypes on soil enzymes and AM fungal root colonisation.

2. REVIEW OF LITERATURE

In the present investigation efforts were made to evaluate soil and foliar nutrient management in Bt and non-Bt cotton genotypes under protective irrigation. Nitrogen fertilization pattern, N application pattern, and foliar application requirement and to study the effects of these factors on growth, yield, fibre quality and *Cry* protein concentration at various growth stages. The literature pertaining to these aspects are reviewed and presented in this chapter.

2.1 Performance of Bt cotton hybrids

The development of Bt cotton represents a significant technological landmark in the global cotton research. India adopted this technology during 2002. Commercial of Bt cotton in India began during 2002-03 with three hybrids *viz.,* MECH-12 Bt, MECH-162 Bt and MECH-184 Bt (Anon., 2006) and during 2008 there were 274 hybrids officially approved by the Genetic Engineered Approval Committee (GEAC). The national cotton productivity increased by over 85 per cent in the last five years from 302 kg ha^{-1} during 2002-03 to 532 kg lint ha^{-1} during 2013-14 (Anon., 2014).

2.1.1 Growth, yield and yield components

Several studies have been made on the field performance of Bt hybrids. Initial multilocation trials conducted under the aegis of Indian Council of Agricultural Research on three hybrids (MECH-12, MECH-162 and MECH-184) indicated yield increases over the local popular non-Bt cotton and among the Bt cotton hybrids, MECH-162 recorded significantly higher seed cotton yield (Anon., 2014).

Field experiments conducted on seven farmers fields under different agro-ecological situations of Marathwada region of Maharashtra state revealed that the genotypes of *Gossypium arboreum viz.,* J. Tapti and NA-398 were found to be the best performers in four agro-ecological situations *viz.,* deep soil + medium high – high rainfall, deep soil + medium rainfall, medium soil + medium - medium high rainfall and shallow soil + low-medium rainfall. Both *Gossypium arboreum* and *hirsutum* hybrids/varieties (NHH-44/NH-545) gave on par yield under shallow and medium soil with medium to high rainfall situations (Bhatade *et al*., 2008).

Yield potential of approved Bt cotton hybrids under rainfed condition was assessed at cotton research station, Nanded in medium black soil. The study revealed that Bt cotton hybrids *viz.,* MRC-7301 BG-II (2,095 kg ha^{-1}) and Ajeet-II BG-II (1,928 kg ha^{-1}) recorded the highest seed cotton yield with significant superiority over checks. Ankur-651 BG-I and NHH-44 (non-Bt). MRC-7301 BG-II depicted superior staple length of 29.4 mm and Ajeet-II BG-II exhibited higher ginning percentage (37.00 %) over other check, RCH-2 BG-I (36.66 %) (Phad *et al*., 2010).

Ramamurthy and Venugopalan (2009) study focused on the on-farm participatory evaluation of Bt cotton MECH-84 against the locally popular hybrids NHH-44 for its potentiality, quality and economics on three soil types, Typic Haplustepts, Vertic Haplustepts and Typic Haplusterts. Growing of cotton on Typic Haplusterts was found significant than Vertic Haplusterpts and Typic Haplustepts. Higher number of bolls (32.00 $plant^{-1}$), boll weight (4.7 g $boll^{-1}$) and total dry matter production (502 g $plant^{-1}$) were recorded in MECH-184 grown on Typic Haplusterts.

Performance of Bt hybrids was carried on clayey soil under rainfed conditions at Parbhani (Maharashtra) by Giri *et al.* (2008). The results indicated that Bt hybrid NCS-145 recorded significantly higher number of sympodia per plant (20.63) and seed cotton yield per plant (166 g $plant^{-1}$) as against Bt hybrid RCH-2 with lower sympodial per plant (16.7) and seed cotton yield per plant (127.17 g $plant^{-1}$).

Brahma Bt recorded higher yield of 2950 kg per ha with the application of 150 kg N, 60 kg P_2O_5 and 60 kg K_2O per ha in Alfisols (Reddy and Kumar, 2010).

Sunitha *et al.* (2010) conducted field experiment in clayey soil under rainfed condition with Bt hybrids and non-Bt hybrids. More number of bolls, higher mean boll weight was noticed in Bt hybrids over its non-Bt hybrids. Both the Bt hybrids Bunny Bt and Mallika Bt showed higher yield parameters and seed cotton yield over that of non-Bt hybrids.

An experiment was conducted to assess the performance of Bt cotton hybrids with their non-Bt hybrids in clay loam soil at Coimbatore (Sankaranarayan *et al.*, 2004). The results indicated that Bt cotton hybrid (MECH-162) recorded higher seed cotton yield, number of sympodia and number of bolls over non-Bt hybrids.

The evaluation of Bt cotton hybrids for seed cotton yield and fibre quality traits under rainfed condition was done by Sarang *et al.* (2010). The study revealed that Bt cotton hybrids depicted wide range for seed cotton yield (855-2,397 kg ha^{-1}), ginning outturn of *intra-hirsutum* hybrids ranged from 28.17 to 39.22 per cent and 2.5 per cent span length ranged from medium (23.59 mm) to long (34.72 mm), micronnaire value between fine (2.9) to medium (4.78).

Seed cotton yield was significantly higher in MECH-162 Bt (1,172.39 kg ha^{-1}) than DHH-11 (875.96 kg ha^{-1}) and non-Bt MECH-162 (719.31 kg ha^{-1}) in medium black soil. Similar trend was observed in respect of cotton yield per plant (g), boll weight per plant (g), leaf area index and number of monopodial and sympodial branches per plant (Hosmath *et al.*, 2004).

Performance of Bt cotton hybrids was exceedingly superior and produced 69 to 93 and 71 to 95 per cent more yield than DHH-11 and NHH-44 in medium deep black soil. MECH-184 was the highest yielder (2,183 kg ha^{-1}) and recorded 1,468 and 1,053 kg per ha more yield than MECH-184 non-Bt (715 kg ha^{-1}) and DHH-11 (1,130 kg ha^{-1}). Higher yields of Bt hybrids were due to more number of bolls and yield per plant as compared to their non-Bt hybrids (Hallikeri *et al.,* 2004).

RCH-2 Bt recorded 2,857 kg per ha of seed cotton yield followed by RCH-144 Bt (2,794 kg ha^{-1}) and were superior to RCH-20 Bt hybrid (2,585 kg ha^{-1}) as well as MECH-184 Bt hybrid (2,575 kg ha^{-1}) in medium deep black soil. The RCH-2 Bt cotton hybrid recorded higher 2.5 per cent staple length, micronnaire value, maturity percentage and tenacity (Halemani *et al.*, 2004a).

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 in clay soil at MARS, UAS, Dharwad.

2.1.2 Effect of genotypes on *Cry* protein expression

Jiang *et al.* (2004) observed in the experiment to know the effect of NaCl salinity on growth and *Bt* protein content in two *Bt* cotton genotypes 99B and GK 9708-41. They reported that seedling growth of both cultivars was significantly inhibited by NaCl treatments. The *Bt* protein concentration of seedling roots was not affected by NaCl treatments. However, 200 mM NaCl treatment increased the stem *Bt* protein up to 3.45 µg g^{-1} of fresh weight in 99B and 2.33 µg g^{-1} of fresh weight in SGK 9708-41 cultivars at 200 mM NaCl concentration. Leaf protein concentration decreased to 0.74 µg g^{-1} of fresh weight in 99B cultivar whereas it was at par with 0, 50, and 100 mM NaCl concentration treatment for *Bt* protein concentration for both stem and leaves of two cultivars.

Wan *et al.* (2005) studied insecticidal protein levels of specific tissue type in *Bt* cotton plants. It was found that there was no significant difference between the *Cry1Ac* protein contents in various tissues of two *Bt* cotton lines in 2001 and 2002. Usually the toxin content in leaf, square, petal and stamens were much higher than ovule and boll. In 2001, *Cry1Ac* levels in top leaves of GK19 decreased to 62.42 ng g^{-1} at around 120 DAS from 529.45 ng g^{-1} at around 90 DAS and then again increased to 509.45 ng g^{-1} at around 135 DAS. Similar trend was observed for another genotype BC1560 also during the year 2002.

Olsen *et al.* (2005) studied changes in efficacy of *Cry1Ac* induced by two environmental factors, temperature, and insect damage. The results obtained revealed that temperature is not affecting the efficacy but the damage caused by insects specially chewing insects found to increase proportion of *Bt* toxin in total protein estimate of plant samples analyzed using ELISA-kit.

Kranthi *et al*. (2005a) reported that *Cry1Ac* expression varies among different plant parts. Leaves of *Bt* cotton had the highest level followed by squares, bolls and flowers. The toxin expression in boll rind, square bud and ovary of flower was clearly inadequate to confer full protection to the fruiting bodies.

Kranthi *et al.* (2005b) reported that the *Cry1Ac* expression was found to be variable among hybrids and also in different parts. Leaves have the highest of *Cry1Ac* expression wherein in upper canopy leaves, *Cry1Ac* expression was high at 4.42-6.61 µg g^{-1} of fresh weight in early season at 30 DAS with a gradual decline over time. Among mid canopy leaves *Cry1Ac* levels were in the range of 2.32-4.26 µg g^{-1} of fresh weight during 58-85 DAS and in lower canopy leaves expression varied between 2.22 and 6.49 µg g^{-1} of fresh weight during 58 - 95 DAS and the declining trend of *Cry1Ac* was in both mid and lower canopy leaves followed upper canopy leaves. Further, Leaves of Bt cotton had highest level followed by squares, bolls and flowers. The toxin expression in boll rind, square bud and ovary of flower was clearly inadequate to confer full protection to the fruiting bodies. Increasing levels of insect survival was noticed when the toxin levels decreased below 1.8 g g^{-1} in the plants parts. *Cry1Ac* expression decreased consistently as the plant aged. The choice of parental background appeared to be crucial for sustainable expression of the *Cry1Ac* transgene.

Leaf *Cry1Ac* protein expression significantly increased with increasing N fertilizer application in cotton. As the season progressed, symptoms of N deficiency (shorter and light green plants) and excess (dark green vegetative plants) were observed in the deficient and excessive N rate treatments, respectively.

Cry1Ac protein expression was significantly higher in the older leaves (nodes) than the younger leaves (node 18). The N deficient plants had 2 to 3 fewer nodes than those in the over fertilized N treatment, which may have influenced the relative differences between the N treatments. In another trial conducted with N applications significantly increased leaf *Cry1Ac* protein expression was observed in both low and high N systems to cotton crop (Rochester, 2006).

Joshi (2007) observed that JK- Durga *Bt* recorded significantly higher delta endotoxin at all stages compared to other genotypes. Further, it was in the range 0.013-1.57 mg/g fw at 60 DAS and increased substantially at 75 DAS (0.725-4.02 mg g^{-1} fw) and delta endotoxin found to decline steadily at 105 (0.405-1.266 mg g^{-1} fw) and 120 DAS (0.121-0.689 mg g^{-1} fw).

At Stoneville, MS, USA, Pettigrew and Adamczyk (2006) observed that plants that received the highest nitrogen application (168 kg N ha^{-1}) exhibited 14% greater leaf *Cry1Ac* concentration and a three per cent greater leaf chlorophyll concentration than plants which only received 112 kg N ha^{-1}. Further, they observed that early planted *Bt* cotton had 5 per cent greater leaf chlorophyll concentration but 12 per cent lower leaf delta endotoxin concentration.

Increase in fertilizer level increased the delta endotoxin concentration. Significantly higher delta-endotoxin concentration was recorded with 217:59:148 NPK kg ha^{-1} (2.04 mg g^{-1} fw) at 75 DAS followed 181:49:124 and 145:39:99 NPK kg ha-1 (Police Patil, 2007).

Manjunatha *et al*. (2009) reported that the expression of *Cry1Ac* was declined over season independent of the genotype, among the hybrids the expression level was different. The *Cry1Ac* content was high *i.e*., 5.51-7.85, 3.88-5.97 and 2.97-6.34 µg g^{-1} dry weight in leaves, squares and bolls, respectively at 80 DAS. Later on the *Cry1Ac* content expression was declined throughout the season in squares and bolls of all the hybrids. MRC-7201 hybrid expressed the highest concentration of 7.85, 5.97 and 5.84 µg g^{-1} in leaves, squares and bolls respectively at 80 DAS and similar trend was followed during subsequent periods of crop growth. Lowest concentration was noticed in SP-911 hybrid.

Cry1Ac content in squares and boll rind marginally increased with increase in fertilizer levels from 50 to 150 per cent RDF and it declined with the advancement of the crop growth (Ghongane *et al*., 2009).

Cry protein levels were high in leaves followed by squares and boll rind at early stages of crop growth (100 DAS) which progressively declined and reached minimum at 160 DAS. The second generation *Bt* cotton genotypes recorded higher content of *Cry* protein in all plant parts as compared to corresponding first generation *Bt* cotton genotypes both in inter specific and intra specific *Bt* genotypes (Sagar *et al.,* 2011)

Hallikeri *et al*. (2011) indicated that N fertilization significantly affected the *Cry* protein concentration in leaf at various growth stages. At 60 days after sowing (DAS) increased level of nitrogen from 120 and 160 kg N increased *Cry* protein by 9.3 and 14.8 per cent over 80 kg ha^{-1} . Similar trend was observed at 90, 120 and 150 DAS.

Ranjithkumar *et al*. (2011) observed higher *Cry* protein levels in squares and boll rind in the early stages (90 DAS) of crop growth which declined progressively and reached to a negligible amount at 165 DAS. Application of 150 per cent RDF recorded significantly higher *Cry* protein in all the growth stages compared to lower levels.

Application of 200:100:100 kg NPK ha^{-1} recorded significantly higher endotoxin content (2.24, 2.10, 2.02 and 1.50 mg/g of leaf) at 45, 75, 105 and 135 DAS, respectively (Basavaneppa, 2012).

Amandeep *et al*. (2013) conducted a field experiment at research farm of Cotton Section, Ludhiana during *kharif* 2011 to work out the fertilizers level for *hirsutum* cotton. They have reported that application of 100 % RDF (2,220 kg ha^{-1}) was statistically at par with 125 % RDF (2,189.6 kg ha^{-1}) and both these treatments registered significantly higher seed cotton yield than 75 % RDF (1,976.3 kg ha^{-1}).

Barathi *et al*. (2013) conducted an experiment to evaluate *Cry1Ac*, *Cry 2Ab* expression in cotton hybrids as influenced by nutrient management. The highest kapas yield (2127 kg ha^{-1}) was recorded at 150-75-75 NPK kg ha^{-1} and there is no significant difference in *Cry1Ac*, *Cry 2Ab* expression under different nutrient levels.

The laboratory experiments studied the *Cry*stalline protein (*Cry* toxins) levels in four *Bt* cotton hybrids (RCH 2 *Bt*, RCH 2 BG II, JK Durga *Bt*, and Nath baba *Bt*) and indicated *Cry* protein content in different plant parts was in the order of leaves > squares > bolls > flowers. The *Cry* protein content in all the plant parts decreased by 90 days after sowing as compared to 60 DAS and it further decreased at 120 DAS and reached to negligible levels by 150 DAS. The expression of the protein content was significantly high in leaves from upper canopy and it decreased with advancement of crop age advanced (Chinnu Babu *et al*., 2013).

Application of nutrients for the target yield of 4.0 t ha^{-1} (195:100:200 NPK kg ha^{-1}) recorded significantly higher *Cry1Ac* (3.69, 2.31 and 1.82 mg g^{-1} fresh weight at 60, 90, 120 DAS and at harvest, respectively) and *Cry2Ab* protein at all the growth stages (61.7, 44.3 and 32.8 mg g^{-1} fresh weight at 60, 90, 120 DAS and at harvest, respectively) as compared to other nutrient levels applied based on target yield (Manjunath, 2014).

2.2 Effect of application of nutrients on growth and yield of *Bt* cotton

Bastia (2000) reported that number of bolls per plant showed highest number (48.1) for 140-70-70 kg NPK per ha. The boll weight and seed cotton yield per plant were maximum (3.9 g and 141 g) in 120-60-60 kg NPK per ha. Benefit: cost ratio (₹ 2.61) was realized from the fertilizer dost of 120-60-60 kg NPK per ha.

Sasthri *et al*. (2001) reported that the seed cotton yield of both variety and hybrid were higher with fertilizer dose of 200-150-100 kg per ha and recorded 48 and 41 per cent higher seed cotton yield than the recommended level, respectively. The higher doses of NPK increased 41, 64, 35 per cent more seed cotton yield in variety and 42, 45, 40 and 32 per cent higher yield in hybrid, respectively.

Hosmath *et al*. (2004) studied effect of organic amendments on performance of *Bt* and non-Bt cotton. Study revealed that among different sources of nutrients significantly higher cotton yield was obtained in RDF + FYM (1169 kg ha^{-1}) compared to RDF (938 kg ha^{-1}), Vermicompost (854 kg ha^{-1}), Vermicompost + RDF (829 kg ha^{-1}), RDF + Green manure (785 kg ha^{-1}) and green manure (713 kg ha^{-1}).

Krishnegowda (2004) reported that medium black soil cotton hybrid RCH-2 *Bt* recorded significantly higher seed cotton yield with increase in the levels of fertilizer from 100 to 150 per cent RDF. Total dry matter production and uptake of nutrients increased with increase in the levels of fertilizers.

On the contrary, field trials at Dharwad in Karnataka did not indicate any significant yield increase by applying nutrients beyond RDF on Vertic Ustropepts of Coimbatore. (Hallikeri *et al.,* 2004).

Significant differences were not observed in seed cotton yield in the first picking but, in the second picking, 125 per cent RDF resulted in significantly higher yield when compared with RDF (Singh *et al*., 2003). Application of 150 per cent of the RDF *i.e*., 135-29.5-56.0 kg NPK ha^{-1} was on par with 125 per cent RDF (Sankaranarayanan *et al*., 2004).

Nitrogen nutrition has the potential to affect protein synthesis and *Cry1Ac* protein levels in *Bt*-cotton. Applying N fertilizer at rates beyond that required to optimize lint yield did not afford greater expression of *Cry1Ac* protein. *Cry1Ac* expression tended to be lower with low N fertilizer inputs and low N fertility sites. The high fertility sites required about 50 kg N per ha, while the lower fertility sites required 100 to 150 kg N per ha (Rochester ian, 2006). Field experiment studies of maize crop indicted that concentration of *Bt Cry* protein in both the husk and ear leaf sheath tissue of the MoN-810 *Bt* hybrid improved with increasing levels of N fertility. The linear relationships between N fertility rates and *Bt*-endotoxin were significant and positive (Arnold and Craig, 2005).

N fertilizer application can promote the expression of insecticidal protein in leaves of *Bt* cotton and the content of *Bt*-protein was more with high N (375 kg ha^{-1}) as compared to medium N (225 kg ha^{-1}) and check (0 kg ha^{-1}). At full boll formation stage, reduction of insecticidal protein content for the medium N treatments was less than check N treatment and the reduction of insecticidal protein content for the high N treatment was the smallest among three treatments. Further studies indicated that the content of *Bt*-protein was closely and positively correlated with the physiological activities of N metabolism (Chang *et al*., 2005).

Increasing levels of available N are known to increase protein levels in most plant species, especially in vegetative cells (Tisdale and Nelson, 1975). Much of this increase is in the form of enzymes used in further growth and development. Because of the increased availability of N to the plant, as N fertility levels are increased, greater quantities of the *Bt*-endotoxin synthesizing enzymes and or M-RNA are likely to produce, thus greater quantities of the *Bt*-endotoxin protein will be synthesized as a result (Arnold and Craig, 2006).

Pettigrew and Adamczyk (2006) studied the effect of N fertilizer on lint yield and *Cry1Ac* endotoxin production. They concluded that plant receiving the 112 kg N/ha (split application) treatment exhibited 14% greater leaf *Cry1Ac* concentrations and a 3 % greater leaf chlorophyll concentration than the other N treatments.

Sawan *et al.* (2006) reported significant increase in seed cotton yield per plant as well as seed cotton and lint yield ha^{-1} with increase in the N rate from 95 to 143 kg ha^{-1}. Similarly, Tuteja *et al.* (2008) reported increase in nitrogen levels increased the seed cotton yield and application of 175 kg N ha^{-1} recorded significantly highest seed cotton yield (2,506 kg ha^{-1}) compared to lower levels of nitrogen.

Srinivasan (2006) also reported that yield, net monetary return and benefit: cost ratio increased with increasing nitrogen level in cotton. Application of 125 per cent recommended dose of fertilizers per hectare was at par with recommended dose of fertilizer (RDF) *i.e.,* 50-25-25 kg NPK ha^{-1}.

Venugopalan and Blaise (2007) reported that cotton on shallow soil gave 61 per cent more yield, 49.7 per cent more dry matter and absorbed 45.7 per cent more N than in deep soil. Soil $\times$ N interaction was significant, the yield and boll number increased significantly up to 80 kg N per ha on shallow but only up to 40 kg N per ha on deep soil.

In North China, the transgenic cultivars were more sensitive to K deficiency than the conventional cultivars. Foliar application of 2 % KNO_3 during boll development phase increased the seed cotton yield irrespective to the soil K status and K fertilizer applied (Brar *et al.*, 2008).

Application of highest level of NPK, 100-50-50 kg NPK per ha, respectively proved beneficial than lower levels (80-40-40 and 60-30-30 NPK kg ha^{-1}) (Giri *et al.*, 2008).

A field experiment conducted at Dharwad, significantly increase in the seed cotton yield per hectare was observed when N application was increased from 80 kg (2,034 kg ha^{-1}) to 120 kg (2,279 kg ha^{-1}) per ha and Further, upto 160 kg ha^{-1} (2,412 kg ha^{-1}). Number of bolls per plant and seed cotton yield per plant was increased with increase nitrogen levels (Hallikeri, 2008).

Improved growth attributes and yield of *Bt* cotton were observed by Narayana *et al.* (2008) at Guntur with higher fertilizer levels over two years of investigation. Application of 180:140:140 kg NPK ha^{-1} recorded significantly higher bolls plant^{-1} (49.5), boll weight (5.26) and kapas yield (3,921 kg ha^{-1}) over 120:60:60 and 150:100:100 kg NPK ha^{-1}.

Aruna and Reddy (2009) conducted a field experiment at Nandyal on vertisols to evaluate the effect of varied fertilizer levels on performance of *Bt* cotton. The results revealed that 150-75-75 kg NPK ha^{-1} gave higher kapas yield (1,942 kg ha^{-1}) in *Bt* cotton.

Bandopadhyay *et al*. (2009) observed 60 kg N ha^{-1} as optimum dose for high yield and N use efficiency in RCH-2 *Bt*. For *Bt* cotton on sandy loam soils of north zones, recommended dose of N-150, P-22, K-25 + Zn 3 kg ha^{-1} and substitution of 25 per cent of the above recommended dose of N through FYM was found significantly superior to RDN alone for *Bt* cotton in this zone.

Doli *et al*. (2009) observed at Parabani that application of 120:60:60 kg NPK ha^{-1} and 100:50:50 NPK ha^{-1} resulted in comparable higher seed cotton yield (2,631 and 2,583 kg ha^{-1}) over application of 80:40:40 kg NPK ha^{-1} (2,187 kg ha^{-1}).

Gadhiya *et al.* (2009) reported fertilizing *Bt* cotton crop with 240 kg N ha^{-1} significantly increased yield attributes *viz.,* plant height, sympodial branches per plant, number of bolls per plant, number of seeds per boll and boll weight and seed cotton yield per ha. Whereas, application of 80 kg K_2O ha^{-1} resulted in increased yield attributes *viz.,* plant height, sympodial branches per plant, number of bolls per plant, boll weight and seed cotton and stalk yield.

Ghongane *et al.* (2009) at Raichur revealed that yield components like good opened bolls, boll weight and seed cotton yield increased with increased fertilizer levels. Application of 150 per cent RDF (150:75:75 NPK kg ha^{-1}) recorded significantly higher seed cotton yield (2,953 kg ha^{-1}), boll weight (4.38 g) and good opened bolls (39.90) over 50 and 100 per cent RDF.

Nehra and Godara (2009) evaluated the effect of the fertilizer on *Bt* cotton for two year and reported application of 125 % RDF recorded significantly higher seed cotton yield (3,067 kg ha^{-1}) but was at par with 100 per cent RDF (150:40:20 NPK kg ha^{-1}) as compared to 75 % RDF (2,477 kg ha^{-1}).

SreeRekha *et al.* (2009) reported that application of Nitrogen at 180 kg ha^{-1} recorded significantly higher seed cotton yield (3,939 kg ha^{-1}) over 120 kg N ha^{-1} (3,595 kg ha^{-1}) but was on par with 150 kg N ha^{-1} (3,774 kg ha^{-1}).

Experiment conducted at Junagad significantly with higher seed cotton (2,345 kg ha^{-1}) and stalk (3,679 kg ha^{-1}) yield of cotton were recorded with K120 and K180 treatments, respectively. The plant height (138.1 cm), boll weight (20.4 g) and oil content (18.52 %) were significantly higher with the application of potassium @ 120, 150 and 180 kg ha^{-1}, respectively (Sakarvadia *et al.,* 2009).

Dong *et al.* (2010) observed that application of 240:150 kg NK ha^{-1} with plant density of 7.5 plants m^{-2} recorded significantly higher seed cotton yield (1,545 and 2,158 kg ha^{-1}) in low and high fertility fields, respectively.

Reddy and Kumar (2010) reported that Brahma *Bt* recorded higher yield of 2950 kg ha^{-1} with the application of 150 kg N, 60 kg P_2O_5 and 60 kg K_2O ha^{-1} in Alfisols (sandy loam). And same author reported at Warangal in Bt cotton hybrid Brahma responded positive with higher level of 250 kg N ha^{-1} and recorded significantly higher seed cotton yield (3628 kg ha^{-1}) as compared to lower levels of Nitrogen 150 and 200 kg ha^{-1}, whereas application of 60 kg P_2O_5 and K_2O ha^{-1} recorded significantly higher seed cotton yield over 30 kg ha^{-1}.

Sarang *et al.* (2010) revealed that *Bt* cotton hybrids depicted wide range for seed cotton yield (855-2,397 kg ha^{-1}), ginning out turn of intra-hirsutum hybrids ranged from 28.17 to 39.22 per cent and 2.5 per cent span length ranged from medium (23.59 mm) to long (34.72 mm), micronnaire value between fine (2.9) to medium (4.78).

Saleem *et al.* (2010) observed that highest seed cotton yield per hectare (3,002 kg ha^{-1}) with application of nitrogen at the rate of 180 kg ha^{-1} which differed significantly from all other levels (0, 60 and 120 kg ha^{-1}), while minimum yield was recorded in control (2,716.0 kg ha^{-1}).

Singh *et al.* (2010) at Pali-Marvar revealed that progressive increase in the nitrogen levels up to 200 kg ha^{-1} increased the seed cotton yield. Application of 200 kg N ha^{-1} recorded significantly higher bolls per plant (73.0), boll weight (3.24) and seed cotton yield (3,080 kg ha^{-1}) and it was on par with 160 kg N ha^{-1}.

Application of 90 kg P ha^{-1} recorded significantly higher No. of bolls per plant (21.5), boll weight (2.9 g), seed cotton yield per plant (63.9 g) and seed cotton yield (1,787 kg ha^{-1}) and it was on par with 60 kg P ha^{-1} (Saleem *et al.,* 2010).

Nalayani *et al.* (2010) reported that significant response of Bt cotton to the graded levels of N and P. Application of 100 per cent RDNP recorded significantly higher plant height (85.4 cm), dry matter $plant^{-1}$ (111.3 g), bolls per plant (25.2), boll weight (4.04 g) and seed cotton yield (2450 kg ha^{-1}) than 75 and 50 per cent RDNP.

Pawar *et al.* (2010) reported that RCH-2 Bt hybrid with application higher fertilizer dose of 100:50:50 NPK kg ha^{-1} recorded significantly higher seed cotton yield (2,183 kg ha^{-1}) as compared to 80:40:40 kg NPK ha^{-1} (1942 kg ha^{-1}) under rainfed condition.

Kaur *et al.* (2010) revealed that Bt cotton hybrid RCH-134 Bt with 125 per cent (187.5:37.5:37.5 NPK kg ha^{-1}) produced significantly higher seed cotton yield (3,145 kg ha^{-1}), number of bolls per plant, mean boll weight and yield per plant as to application of 100 per cent RDF (150:30:30 kg NPK ha^{-1}).

Sunitha *et al.* (2010) reported that significantly recorded maximum plant height and dry matter accumulation, seed cotton yield per ha with application of 240 kg N ha^{-1}.

Buttar *et al.* (2010) observed that significantly higher seed cotton yield with nitrogen level of 200 kg ha^{-1} (2908 kg ha^{-1}) which was at par with 175 kg N (2,865 kg ha^{-1}) and significantly lower seed cotton yield was recorded in 150 kg N ha^{-1} (2,653 kg ha^{-1}).

Field experiments were conducted by Bhalerao and Gaikwad (2010) for 3 years at Akola and recorded significantly higher seed cotton yield (910 kg ha^{-1}), bolls per plant (22.1) and stalk yield (1,650 kg ha^{-1}) application of 125 % RDF (62.5:31.5:31.5 kg NPK ha^{-1}) than 75 % RDF but it was at par with RDF.

Majid and Mohammad (2011) reported that cotton yield significantly increased with increased of N application. The highest seed cotton yield (4,363 kg ha^{-1}) was recorded in case of 200 kg ha^{-1} N treatment and there was no significant difference between 200 and 300 kg ha^{-1} N treatments.

Nehra and Yadav (2011) conducted fertilizer experiment on *Bt* cotton Singanganagar on loamy soil and observed that significantly higher number of bolls per at plant (129), boll weight (4.41 g) and seed cotton yield (3,213 kg ha^{-1}) with application of 125 per cent RDF (182.5:50 kg NP ha^{-1}) over 75 and 100 per cent RDF.

Rajendran *et al.* (2011) observed that higher nutrient levels (150:80:80 NPK kg ha^{-1}) induced significantly higher dry matter production (4,624 kg ha^{-1}), number of bolls per plant (34.06), boll weight (5.41 g) and seed cotton yield (2,411 kg ha^{-1}) compared to 120:60:60 kg NPK ha^{-1} (2,164 kg ha^{-1}).

Singh *et al.* (2011) reported that increased fertilizer levels imparted increased growth and yield of *Bt* cotton. Growth parameters like plant height (129.4 cm), leaf area index (5.16), monopodia (2.81), sympodia (26.4), bolls per plant (55.0) and lint yield (887.2 kg ha^{-1}) significantly higher in application of 150 per cent RDNP over 100 per cent RDNP (121.3, 4.42, 2.51, 22.3, 49.2 and 660.7, respectively). Application of 150 per cent RDNP (225:45 kg ha^{-1}) recorded higher seed cotton yield (2,591 kg ha^{-1}) than 100 per cent RDNP.

Devraj *et al.* (2011) reported that highest seed cotton yield (3,061 kg ha^{-1} and 3902 kg ha^{-1} at Hissar and Sirsa, respectively) with a fertilizer dose of 125 per cent RDF (187.5:75:75 NPK ha^{-1}) as compared to 75 and 100 per cent RDF at both the locations.

Amboti and Thakare (2012) at Nagur, Madhya Pradesh reported that application of 150 per cent RDF imparted significantly higher seed cotton yield (1.9 t ha^{-1} and biomass yield 2.46 t ha^{-1}) compared to lower levels of fertilizers.

Bhalerao *et al.* (2012) at Akola, indicated that maximum cotton yield plant^{-1}, number of bolls plant^{-1} were found with application of 150 per cent and was at par with 125 per cent RDF over three year. Application of 150 per cent RDF recorded significantly higher seed cotton yield than 100 per cent RDF but it was at par with 125 per cent RDF.

Basavaneppa (2012) at Siruguppa observed that application of 200:100:100 kg NPK ha^{-1}recorded maximum plant height, monopodia, and sympodia per plant and it was at par with 160:80:80 kg NPK ha^{-1}. Corresponding higher seed cotton yield (2,515 kg ha^{-1}), yield per plant (135.8 g) and boll weight (5.09 g) were recorded in application of 180:90:90 kg NPK ha^{1}.

Gawade and Bhalerao (2012) noticed that highest seed cotton yield (6.86 q ha^{-1}) was recorded with the application of nitrogen in six splits (25 per cent Basal remaining in five splits + 15, 30, 45, 60, 75 DAS). Significantly lowest seed cotton yield (5.29 q ha^{-1}) was recorded with the application of nitrogen in two splits (Basal + 30 DAS (50 + 50 %) and Maximum stalk yield (18.35 q ha^{-1}) was recorded with three split application, However, split application of nitrogen at later stage was useful.

SreeRekha and Pradeep (2012) at Adilabad revealed that nitrogen levels of 120 to 180 kg ha^{-1} did not influenced the seed cotton yield, number of monopodia and sympodia plant^{-1}. However, the highest seed cotton yield (3,614 kg ha^{-1}) was noticed in 180 kg ha^{-1}.

Modhvadia *et al.* (2012) observed that seed cotton yield of *Bt* cotton increased with application of 240:50:120 kg NPK ha^{-1} to the tune of 20.51, 6.90 and 13.27 per cent as compared to 120:50:120; 180:50:120 kg NPK ha^{-1} and control, respectively.

Asewar *et al.* (2013) at Parabani under vertisol, reported the highest seed cotton was recorded with fertility level of 200:100:100 kg NPK ha^{-1} (2,864 kg ha^{-1}) over three years of experimentation and was at par with the fertility level of 175:87.5:87.5 kg NPK ha^{-1} (2,754 kg ha^{-1})

Hosamani *et al.* (2013) at Raichur reported that application of 125 per cent RDF produced significantly higher seed cotton yield (19.25 q ha^{-1}), seed cotton yield per plant (106.92 g), mean boll weight (4.13 g), total number of bolls per plant (26.19), number of good opened bolls (22.15) and lowest bad opened bolls per plant (4.02) over 100 per cent RDF (17.04 q ha^{-1}, 94.86 g plant^{-1}, 3.89, 24.42, 20.14 and 4.31, respectively).

A study conducted at Dharwad by Gundlur *et al.* (2013) revealed that growth and yield parameters were significantly increased by nutrient levels. Application of 175 per cent RDF significantly increased the seed cotton yield (2,303 kg ha^{-1}) compared to 100 per cent RDF (1,986 kg ha^{-1}).

Ashaq *et al*. (2014) conducted field experiment on nutrient omission plot technique (NOPT) on *Bt* cotton-wheat cropping system was conducted at research farm, New Delhi during rainy season of 2010 and 2011. Results showed that there was a reduction in the seed cotton yield to the tune of 28, 6.5 and 14.5 per cent due to N, P and K 50 per cent omission of during the year 2010. The corresponding figures for the year 2011 were 26.5, 15.5 and 12.4 per cent, respectively. N continued to be the most limiting nutrient followed by P and K during the year 2011. P omission led to the higher yield reduction during the second year of experimentation which proves that P supplies fast depleted in the cotton-wheat cropping than the K supply. Lint yield followed similar trends.

Gangaiah and Ahlawat (2014) at New Delhi reported that application of 180 kg N ha^{-1} recorded significantly higher plant height (127 cm), LAI (3.87), number of bolls per plant (54.0) and seed cotton yield (2,980 kg ha^{-1}) over other nitrogen levels.

Giri *et al*. (2014) observed that application of N in 6 splits as 20 per cent at sowing and remaining 5 in equal splits at 30, 45, 60, 75 and 90 DAS recorded significantly higher seed cotton (30,14.99 kg ha^{-1}) and stalk yield (10,590.49 kg ha^{-1}), gross (₹ 1,27,402) and net returns (₹ 56,303 ha^{-1}) from Bt cotton overall other treatments. The lowest seed cotton (1,071.21 kg ha^{-1}), and stalk (5,846.28 kg ha^{-1}), yield gross (₹ 44,302) and net (₹ 2,359 ha^{-1}) were recorded with no fertilizer nitrogen application.

Jikun *et al*. (2014) observed that the expression of *Bt* toxin in agricultural production is significantly affected by farm management practices. In contrast to nitrogen fertilizer has a positive impact on the expression of *Bt* toxin (Yang *et al*. 2005), results shows that nitrogen fertilizer application has no significant impact on the expression of Bt toxin in farmer's fields. On the other hand, the expression of *Bt* toxin has a positive relationship with phosphate fertilizer, potash fertilizer and manure application.

Bhati *et al*. (2015) revealed that split application of N and NK did not have any significant effect on seed cotton yield, yield per plant, bolls/plant, boll weight, seed index, lint yield and Ginning Percentage, similar findings by Solaiappan and Sheriff (1994) and Hallikeri *et al*. (2010).

Oil content was significantly higher in NK split application (22.76 %) as compared to N split application. Timing of fertilizer application did not show any significant effect on oil content but higher (22.77 %) amount was noted when the fertilizer was applied in three splits (50-50-25) at sowing, 30 and 60 DAS, Timing of fertilizer application at different stages of crop growth did not show any significant effect on any of these parameters but interaction between the fertilizer and timing of application Split application of both N and K at basal and 45 DAS and basal, 45 and 75 DAS (50-25-25) gave higher bolls per plant than other combinations. split application of N at basal, 30 and 60 DAS (50-25-25) gave higher bolls per plant as compared to NK split application at same timings. Supplementation of N at these stages may be ideal to meet the requirement even for Bt- cotton (Srinivasan, 2003). At any other timing, split application of N and NK both exhibit non-significant differences.

Hosmath *et al*. (2015) observed increase of total number of bolls per plant were noticed with the soil application of $MgSO_4$ (25 kg ha^{-1}) and foliar application of $MgSO_4$ (1 %) and it was at par with the foliar application of KNO_3 (2 %) and soil application of $MgSO_4$ (25 kg ha^{-1}) and sympodial branches/plant also followed the similar trend whereas the number of monopodial branches were not influenced by the treatments. Earlier reports indicated 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 sympodial branches/plant (Brar *et al*., 2008). The higher seed-cotton yield with the foliar application of KNO_3 (2 %) is supported by significantly increased boll weight and seed cotton (25.4 t/ha) yield/plant foliar application of KNO_3 (2 %) increased 18 per cent boll weight (g $boll^{-1}$) and 19 per cent seed cotton yield (g $plant^{-1}$) than the recommended package. Similar trend was observed with the soil application of $MgSO_4$ (25 kg ha^{-1}) and also with the soil application of $MgSO_4$ (25 kg ha^{-1}) and foliar application of $MgSO_4$ (1 %).

2.2.1 Nutrient uptake studies in *Bt* cotton

Nalayani *et al.* (2010) reported that the plot which received 100 per cent RDNP recorded significantly higher nitrogen uptake (98.4 kg ha^{-1}) and phosphorus (18.4 kg ha^{-1}) and was on par with application of 75 per cent RDNP (92.6 and 17.2 kg ha^{-1}, respectively). Significantly lower uptake was recorded in 50 per cent RDNP and absolute control.

Police Patil (2007) at Dharwad reported that, MRC-6322 recorded significantly increased the nitrogen uptake (141.1 kg ha^{-1}), phosphorus uptake (20.18 kg ha^{-1}) and potassium uptake (174.3 kg ha^{-1}) as compared to other *Bt* cotton hybrids. The MRC-6322 recorded significantly low in available nitrogen, phosphorus and potassium (203.5, 42.0 and 320.5 kg ha^{-1}) as compared to other *Bt* cotton hybrids. Nutrient uptake was differed significantly due to application of different nutrient levels based on target yield. Application of nutrients for the target yield of 3.0 t ha^{-1} (217:59:148 NPK kg ha^{-1}) recorded significantly higher nitrogen, phosphorus and potassium uptake (142 kg ha^{-1}, 19.25 kg ha^{-1},166 kg ha^{-1} respectively) as compared to other nutrient levels applied based on target yield.

Manjunatha *et al.* (2010) at Raichur, observed that, Bunny *Bt* BG-II recorded significantly higher nitrogen uptake (105.5 kg ha^{-1}), phosphorus uptake (22.08 kg ha^{-1}) and potassium uptake (114.25 kg h^{-1} a) as compared to Bunny *Bt* BG-I, non-Bt hybrids (NCS 145) and cotton variety (RAS 299-1) while lowest nitrogen uptake (87.17 kg ha^{-1}), phosphorus uptake (15.67 kg ha^{-1}) and potassium uptake (99.2 kg ha^{-1}) was observed in RAS 299-1.

Application of 125 per cent RDF showed maximum uptake of N being at par with RDF. P uptake was statistically equal at 125 and 100 per cent RDF and similar type of trend was observed in K uptake (Bhalerao *et al*. 2010).

The NPK uptake by cotton at harvest increased significantly with the application of 100-50-50 and 80-40-40 kg NPK per ha as compared to application of FYM 10 t per ha (Tayade and Dhoble, 2010).

Sudha (2011) at Dharwad, reported that, MRC-6918 *Bt* recorded significantly higher leaf nitrogen content (2.45 %, 2.52 % and 2.0 %), phosphorus content (0.47 %, 0.48 % and 0.49 %), potassium content (2.39 %, 2.44 % and 2.47 %), magnesium content (0.31 %, 0.33 % and 0.35 %) at 60, 90 and 120 DAS, respectively as compared to nutrient content of other *Bt* cotton hybrids in both black and red soil of farmers fields of Dharwad district.

Venugopalan *et al.* (2012) reported that, RCH 2*Bt* recorded significantly higher nutrient uptake (69.3 kg ha^{-1}), nutrient use efficiency (12.56 %) and nutrient uptake efficiency (0.77 %) as compared to other *Bt* cotton hybrids at Nagpur. The significantly lowest nutrient uptake (64.4 kg ha^{-1}) observed in MECH-184*Bt*, nutrient use efficiency (10.12 %) in NSC 145 *Bt* and nutrient uptake efficiency (0.71 %) in MECH-184*Bt*.

Hosamani *et al.* (2013) at Raichur reported that application of 125 per cent RDF produced significantly higher uptake of nitrogen (107.81 kg ha^{-1}), phosphorus (30.08 kg ha^{-1}) and potassium (109.25 kg ha^{-1}) over 100 per cent RDF (98.38 kg ha^{-1}, 23.39 kg ha^{-1},100.67 q ha^{-1}).

Thimmareddy *et al*. (2013) at Raichur observed that application of 150 per cent RDF (225:105.5:105.5 kg NPK ha^{-1}) found significantly higher uptake and availability of N (132.4 and 212.48 kg ha^{-1}), P (32.44 and 39.21 kg ha^{-1}) and K (147.2 and 353.4 kg ha^{-1}, respectively) over 100 per cent RDF.

Gundlur *et al.* (2013) at Dharwad indicated that nitrogen, phosphorus and potassium uptake by *Bt* cotton significantly increased with increase in nutrients levels from 100 per cent to 175 per cent RDF. The uptake of Nitrogen (93.18 kg ha^{-1}), phosphorus (14.02 kg ha^{-1}) and potassium (82.66 kg ha^{-1}) were higher with the application of 175 per cent RDF.

Nutrients uptake at harvest differed significantly due to application of different levels of nutrients based on target yield. The pooled data of two years indicated that application of nutrients for the target yield of 4.0 t ha^{-1} (195:100:200 NPK kg ha^{-1}) recorded significantly higher NPK uptake (162.8 kg ha^{-1}, 52.6 kg ha^{-1}, 174.9 kg ha^{-1} respectively) as compared to other nutrients applied based on target yield. Significantly, lower NPK (109.1 kg ha^{-1}, 32.9 kg ha^{-1}, 120.9 kg ha^{-1} respectively) uptake was observed with application of RDF (120:60:60 NPK kg ha^{-1}) (Manjunath, 2014).

2.2.2 Effect of major nutrients on quality of *Bt* cotton

The quality fibre quality parameters like fibre strength, fineness, and uniformity percentage and maturity ratio did not differ significantly with increase in nitrogen levels from 80 to 120 kg ha^{-1} (Hallikeri, 2008).

Narayana *et al.* (2008) at Guntur, reported that application of 180:140:140 kg NPK ha^{-1} to soil registered significantly higher ginning percentage (33.2 %), fibre length (30.28) and lower micronnaire (4.32) compared to lower levels of fertilizers. However, lint index and fibre elongation recorded non-significant difference to fertilizer levels.

Tuteja *et al.* (2008) reported insignificant effect of nitrogen levels on fibre length and uniformity ratio, but application of 175 kg ha^{-1} recorded significantly lower micronaire value (4.1) over 75 and 125 kg N ha^{-1}.

Ghongane *et al.* (2009b) at Raichur revealed that application 150 per cent RDF recorded significantly highest fibre length (33.7 mm) followed by 100 and 50 per cent RDF (32.6 and 30.4 mm, respectively).

Amboti and Thakare (2012) observed ginning per centage, 2.5% span length, uniformity ratio and bundle strength did not differ significantly to fertilizer levels. Whereas, application of 150 per cent RDF recorded significantly lower micro naire (3.07) compared to 125 and 100 per cent RDF (3.19 and 3.21, respectively).

Hosamani *et al.* (2013a) at Raichur reported that application of 125 per cent RDF produced significantly higher ginning percentage (36.17) over 100 per cent RDF (35.62)

Thimmareddy *et al.* (2013) reported that application of 150 per cent RDF imparted significantly higher ginning percentage (35.2 %), lint index (5.6) and fibre length (32.82 mm) over 100 per cent RDF (32.77 %, 4.05, 31.68 mm, respectively). However, which was at par with 125 per cent RDF.

Manjunath (2014) reported that application of nutrients for the target yield of 4.0 t ha^{-1} (195:100:200 NPK kg ha^{-1}) recorded significantly lower micronnaire value (3.54 µg $inch^{-1}$) and higher fibre strength (22.76 g tex^{-1}), fibre length (32.16 mm), uniformity ratio (56.31 %), fibre elongation (9.31), fibre maturity (0.79 %) and ginning out turn (38.13 %) as compared to other nutrient levels applied based on target yield. However, it was on par with nutrient applied based on target yield of 3.5 t ha^{-1}.

Giri *et al*. (2014) recorded the higher value of ginning per cent (35.47 %) was recorded with application of N in 6 splits, higher value 2.5 pre cent, staple length (32.60 mm), was recorded with application of N in 3 splits + foliar application of 2 % Urea at 60, 75 and 90 DAS and uniformity ratio was higher with the treatment of application N at 4 splits however at par with application N at 3 splits + foliar application 2 % KNO_3 and N application in 20, 40, 40 % splits + foliar application 2 % Urea. And lowest micronnaire (4.02) value was recorded with application of N in 3 splits + foliar application 2 per cent Urea, higher value tenacity (22.75 g tax^{-1}) were recorded N application in 20, 40, 40 per cent splits + foliar application 2 per cent KNO_3.

2.2.3 Effect of foliar application on growth and yield components

Chitdeshwari *et al*. (1997) revealed that foliar application of 1.0 per cent magnesium sulphate increased the seed cotton yield with reduced the leaf reddening.

Hanumantha (1999) at Dharwad observed that foliar application of 1.0 per cent $MgSO_4$ in combination with 10 ppm NAA at 75, 95 and 115 DAS increased the number of monopodial and sympodial branches, number of good bolls per plant, average boll weight, seed weight per plant, number of seed per boll. The highest kapas yield was recorded with spraying of $MgSO_4$ (1 %) in combination with 10 ppm NAA as compared to control.

Brar and Brar (2001) observed that foliar application of 2.0 per cent urea or KNO_3 at flower initiation and a week later increased the seed cotton yield by 25.3 and 33.1 per cent, respectively. Further, they opined that application of KNO_3 containing both potassium and nitrate, applied at critical growth period helped in the retention and development of the bolls on the plant which significantly contributed to increase of seed cotton yield.

Setty *et al*. (2002) noticed that significant improvement in growth parameters (dry matter production per plant, LAI *etc.*) and seed cotton yield with foliar spray of 1.0 per cent $MgSO_4$ (1,721 kg ha^{-1}), 1.0 per cent $MgSO_4$ + 1.0 per cent DAP (1,664 kg ha^{-1}) and 2.0 per cent DAP (1,630 kg ha^{-1}) at 75 and 105 DAS over water spray treatment (1,520 kg ha^{-1}).

Sing *et al*. (2004) noticed that highest yield was obtained with 2.0 per cent KNO_3, followed by 2.0 per cent urea. These two treatments were on par but resulted in significantly higher seed cotton yield as compared to 2.0 per cent DAP, 2.0 per cent SSP, 0.5 per cent $ZnSO_4$ and 1.0 per cent $MgSO_4$ treated plots and control. DAP (2.0 %) and $ZnSO_4$ (0.5 %) were found superior to 2.0 per cent SSP, 1.0 per cent $MgSO_4$ and control.

Katkar *et al*. (2005) observed that three sprays of $MgSO_4$ (1.0 %) + $ZnSO_4$ (0.5 %) at square, flowering and boll development stage gave higher seed cotton yield over control.

At Nanded, Maharashtra, it was found that foliar application of micronutrients with spraying of $MgSO_4$ (1.0 %) gave significantly higher number of bolls per plant and boll weight (Anon., 2009).

Amrutha *et al*. (2009) noticed that the foliar spray of TNAU formulation (Salicyclic acid, $MgSO_4$, KNO_3, Zn, B, urea and planofix) at flowering stage and boll formation stage proved to be best with respect of plant height (107.3 cm), number of sympodial branches (14.6 $plant^{-1}$), number of bolls $plant^{-1}$ (24.7), boll weight (3.7 g) and seed cotton yield (811.5 kg ha^{-1}). The increase in yield over control was 19.0 per cent. Further, it was noticed that foliar spray of DAP (1 %) and 19:19:19. (2 %) + multiK (2 %) also exhibited significant increase in all growth parameters and seed cotton yield.

Basavanneppa *et al*. (2009) reported that foliar application of 1.0 per cent $MgSO_4$ at flowering stage and boll development stage results in higher seed cotton yield (2,066 kg ha^{-1}) and yield per plant (139.60 g) closely followed by the foliar spray of 0.5 per cent $FeSO_4$+0.5 per cent $ZnSO_4$ (1,990 kg ha^{-1}) and both were significantly higher as compared to the yield obtained with soil application of RDF without foliar spray of $MgSO_4$ (1,627 kg ha^{-1}).

At Dharwad, while, studying effect of foliar application of nutrients on Bt cotton, it was observed that foliar application of $MgSO_4$ (1.0 %) at flowering stage and boll development stage + 2.0 per cent DAP at and boll development stage significantly increased the seed cotton yield (2,399 kg ha^{-1}) over control treatments (2,245 kg ha^{-1}) (Anon., 2010a). Similarly in another study at Dharwad.

It was found that combined foliar sprays of KNO_3 (2 %) at 80 and 100 DAS + $MgSO_4$ (1 %) at 80, 100 and 120 Das (3,371 kg ha^{-1}) registered higher yield and on par seed cotton yield with $MgSO_4$ (1 %) spray (3,235 kg ha^{-1}) at 90 and 110 DAS (Anon., 2010).

Patel *et al.* (2011) reported that application of RDF based on soil test valve along with one spray of each 1 per cent and 2 per cent urea and 1 per cent $MgSO_4$ during flowering to boll development stage significantly reduced the incidence of leaf reddening and increased the seed cotton yield.

Basavanneppa *et al.* (2011) at ARS, Siruguppa, reported that, two foliar application of 1 % $MgSO_4$ at flowering and to boll development stage was significantly higher seed cotton yield (2,031 kg ha^{-1}) over no spray (1,620 kg ha-^{1}) and rest of the nutrient sprays. It was on par with that of 0.5 % $FeSO_4$ + 0.5 % $ZnSO_4$ (1,930 kg ha^{-1}).

Shivamurthy *et al.* (2014) revealed that soil application of $MgSO_4$ (25 kg ha^{-1}) + 3 foliar sprays of 1 per cent $MgSO_4$ and 1 per cent 19:19:19 water soluble fertilizer at 70, 90 and 110 DAS along with RDF (100: 50: 50 kg NPK ha^{-1}) + FYM (10 t ha^{-1}) recorded significantly higher plant height, monopodia, sympodia, total dry matter production, number of bolls /plant and seed cotton yield (2,781 kg ha^{-1}) as compared to other nutritional treatments. It was on par with the soil application of $MgSO_4$ (25 kg ha^{-1}) + 3 foliar sprays of 1Per cent $MgSO_4$ and 2 per cent KNO_3 water soluble fertilizer at 70, 90 and 110 DAS along with RDF +FYM (T10), soil application of $MgSO_4$ (25 kg ha-^{1}) + 3 foliar sprays of 1 per cent $MgSO_4$ and 1 per cent 13:40:13 water soluble fertilizer at 70, 90 and 110 DAS along with RDF +FYM and soil application of $MgSO_4$ (25 kg ha^{-1}) + 3 foliar sprays of 1 per cent $MgSO_4$ and 1 per cent 16:08:24 water soluble fertilizer at 70, 90 and 110 DAS along with RDF +FYM Significantly lowest seed cotton yield (2,254 kg ha^{-1}) was recorded with the application of RDF + FYM + water spray (control). The yield levels in other treatments ranged from 18.1 to 23.3 per cent were higher when as compared to control. Similar trend was registered with respect to net returns obtained in different treatments. Further, highest net returns of ₹ 62,563 ha^{-1} was registered with soil application of $MgSO_4$ (25 kg ha^{-1}) + 3 foliar sprays of 1 per cent $MgSO_4$ and 1 per cent 19:19:19 water soluble fertilizer at 70, 90 and 110 DAS along with RDF + FYM.

Sawan (2014) found that application of P at 74 kg ha^{-1}, and foliar application of Zn and Ca at different concentrations (Ca concentration of 60 ppm) beneficially affected cottonseed yield, seed index, seed oil content, in addition with K at 47.4 kg ha^{-1}, spraying cotton plants with Zn twice (at 57.6 g ha^{-1}), and also with P twice (especially the P concentration of 1728 g ha^{-1}) along with the soil fertilization used P at sowing time have been proven beneficial to the quality and yield of cotton plants. These combinations appeared to be the most effective treatments In comparison with the ordinary cultural practices.

Hosmath *et al.* (2015) observed that significantly Increase total number of bolls/plant were noticed with the soil application of $MgSO_4$ (25 kg ha^{-1}) and foliar application of $MgSO_4$ (1 %) and it was a at par with the foliar application of KNO_3 (2 %) and soil application of $MgSO_4$ (25 kg ha^{-1}) and sympodial branches per plant also followed the similar trend whereas the number of monopodial branches were not influenced by the treatments.

Earlier reports indicated 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 sympodial branches per plant (Brar *et al*., 2008). The higher seed-cotton yield with the foliar application of KNO_3 (2 %) is supported by significantly increased boll weight and seed cotton (25.4 t ha^{-1}) yield per plant. Foliar application of KNO_3 (2 %) increased 18 per cent boll weight (g $boll^{-1}$) and 19 per cent seed cotton yield (g $plant^{-1}$) than the recommended package. Similar trend was observed with the soil application of $MgSO_4$ (25 kg ha^{-1}) and also with the soil application of $MgSO_4$ (25 kg ha^{-1}) and foliar application of $MgSO_4$ (1 %).

Santhosh *et al*. (2014) revealed that application of 150 per cent RDF and 125 per cent RDF significantly superior over the 100 per cent RDF. Among the nutrient management practices soil application of $MgSO_4$ + three foliar spray of $MgSO_4$ (1 %) + KNO_3 (2 %) recorded maximum seed cotton yield (3056 kg ha^{-1} as compared to control. However, the combination resulted in at par seed cotton yield with soil application of $MgSO_4$, with three soil application of $MgSO_4$ (1 %) + 19:19:19 (1 %) and soil application of $MgSO_4$ + three soil application of $MgSO_4$ treatments.

2.3 Effect of microbial load on *Cry* protein expression

Saxena and Stotzky (2001) reported that no signicant differences in the colony-forming units of culturable bacteria (including actinomycetes) and fungi and in the numbers of protozoa and nematodes between rhizosphere soil of *Bt* and non-*Bt* corn or between soil amended with biomass of *Bt* and non-*Bt* corn. The *Cry*1Ab protein in root exudates and biomass of *Bt* corn appears non toxic to earthworms, nematodes, protozoa, bacteria, and fungi.

Ren fang *et al*. (2006) reported that significant differences in enzyme activities between *Bt* and non-*Bt* cottons at any of the growth stages and after harvest; amendment with cotton biomass to soil enhanced soil enzyme activities, but there were no significant difference between *Bt* and non-*Bt* cotton; the richness of the microbial communities in rhizosphere soil did not differ between *Bt* and the non-*Bt* cotton, and close to that of control soil; the functional diversity of microbial communities were not different in rhizosphere soils between *Bt* and non-*Bt* cotton.

Isik icoz and Guenther (2007) they reported that plants produces the *Cry* proteins through all parts of the plant, they observed the few or no toxic effects of *Cry* proteins on woodlice, collembolans, mites earthworms, nematodes, protozoa, and the activity of various enzymes in soil have been reported. Although some effects, ranging from no effect to minor and significant effects of *Bt* plants on microbial communities in soil have been reported, using both culturing and molecular techniques.

Sarkar *et al*. (2008) reported that significant reduction in dehydrogenase activity (17 %) and soil respiration (3.5 %) in the rhizosphere of *Bt*-cotton over non-*Bt* isoline. Total mineral-N (NH4-N + NO_3 -N) in soil was reduced by 14 %, whereas Olsen-P was increased by 8 % because of *Bt*-cotton. Root biomass yields were not different ($P > 0.05$), but root volume was significantly higher in *Bt* than non-*Bt* isoline.

Jagadish *et al*. (2011) reported that significant decline in actinobacteria (17 %), bacterial (14 %) count as well as acid phosphatase (27 %), phytase (18 %), nitrogenase (23 %) and dehydrogenase (12 %) activities in *Bt* cotton compared with non-Bt cotton fields. Fungal and nitrifier counts, and esterase and alkaline phosphatase activities were not affected by the introduction of *Bt*-cotton in fields. However, significant decline between 8 and 9 % in MBC and MBN was noticed.

Usha Mina *et al*. (2008) reported that no significant difference in alkaline phosphatase, nitrate reductase and urease activity between *Bt* and non- *Bt* cotton rhizosphere during crop growth period. However, dehydrogenase activity was significantly high in the *Bt* cotton rhizosphere as compared to non-Bt cotton rhizosphere throughout the observation period. At most of the growth stages numbers of micro, meso and macro fauna were more in *Bt* cotton rhizosphere as compared to non-Bt cotton rhizosphere.

Biradar *et al*. (2012) conducted field experiments over three rainy seasons of 2005-06 to 2007-08 on a Vertisol at Dharwad, Karnataka. To study the effect of intercropping and plant protection schedules on productivity, soil microflora and enzyme activities in the rhizosphere of transgenic *Bt* cotton hybrid. They reported that population of total bacteria, fungi and actinomycetes were the highest in the treatment of *Bt* cotton + chilli + onion with zero protection but were on par with the treatment *Bt* cotton + chilli with zero protection at 135 days of crop growth. Dehydrogenase activity was found to be the highest in the treatment of *Bt* cotton + red gram with zero protection at 135 days of crop growth.

Raman *et al*. (2012) reported that significantly higher dehydrogenase enzyme activity and $KMnO_4$ N content of soil were observed in *Bt* cotton with cover crop of peanut over pure *Bt* cotton followed by pure peanut at all the crop growth stages. However, higher microbial population was maintained by pure peanut over intercropped *Bt* cotton, but these differences were related to the presence of high amount of $KMnO_4$-N content of soil. By growing cover crop of peanut between *Bt* cotton rows, bacteria, fungi, and actinomycetes population increased by 60, 14 and 10 per cent, respectively, over *Bt* cotton alone. *Bt* cotton fertilized by combined application of urea and farm yard manure (FYM) maintained higher dehydrogenase enzyme activity, $KMnO_4$-N content of soil and microbial population over urea alone.

Wude Yang *et al*. (2012) reported that the concentration of the *Bt* protein in the rhizosphere soil of *Bt*Xincai1 reached a peak at 56.14 ng g^{-1} during the flowering period. However, the *Bt* protein would not continuously accumulate in the soil. The rhizosphere soil of *Bt*Xincai1 was more suitable for the growth and proliferation of bacteria and fungi but it had no significant impact on the number of actinomycetes. *Bt*Xincai1 had some inhibitory effects on alkaline phosphatase activity in the rhizosphere soil, and it might promote dehydrogenase activity during the blooming period. However, it had no significant influence on protease, urease, or sucrose activities. Further, it had no significant impact on the contents of organic matter, total nitrogen, available nitrogen, or potassium in rhizosphere soil. It could significantly decrease the content of available phosphorus during the flowering period.

Kasturikasen and Amitava (2013) reported that soil under *Bt* cotton cultivar produced significantly higher amount of phosphatase activity than both non- *Bt* and no crop treatments at three growth stages, and the value decreased as the crop growth period advanced. The interaction effect between soil type and *Bt*-crop was found to be significant in different growth stages throughout the growing season. Results from the study revealed that a significant reduction (9.4 %) of the dehydrogenase activity and soil respiration (5 %) in the rhizosphere of *Bt* cotton over non-*Bt* isoline.

2.4 Economics of Bt cotton hybrids

Patil *et al*. (2004) reported that MECH-184 Bt recorded significantly higher profit of ₹ 41,332 ha^{-1} in research station and ₹ 40,090 in the farmers field as compared to other Bt (MECH-162) and non-Bt cotton hybrids (NHH-44) in both situation.

Yenagi *et al*. (2006) reported that, RCH-20 Bt recorded significantly higher gross return (₹ 52,225 ha^{-1}), net return (₹ 34,054 ha^{-1}) and B:C (2.87) than the other Bt cotton genotypes. It was at par with MECH-184 Bt.

Police Patil (2007) found that, MRC-6322 recorded significantly higher gross return (₹ 83,066 ha^{-1}), net return (₹ 65,620 ha^{-1}) and B:C ratio (3.76) as compared to other Bt cotton hybrids. The lowest grown return (₹ 57,357 ha^{-1}), net return (₹ 38,009 ha^{-1}) and B:C ratio (1.96) was obtained with MRC-7201.

Solunke *et al.* (2009) noticed that application of 150 per cent RDF (₹ 53,188 and 2.24) and 125 per cent RDF (₹ 50,541 and 2.21) recorded significantly maximum net return and B:C ratio over 100 per cent RDF (₹ 45,532 ha^{-1} and 2.15 respectively).

Manjunatha *et al*. (2010) reported that, Bunny Bt BG-II recorded significantly higher gross return (₹ 59,583 ha^{-1}), net return (₹ 39,152 ha^{-1}) and B: C ratio (2.91) as compared to that of Bunny Bt BG-I, non-Bt hybrids (NCS 145) and cotton variety (RAS-299-1) and it was followed by Bunny Bt BG-I (₹ 53,875 ha^{-1}, ₹ 32,392 ha^{-1} and 2.59 of gross, net return and B: C ratio, respectively) under Raichur conditions.

Hosmath *et al*. (2011) reported that, Neeraja (BG-II) Bt recorded significantly higher grow return (₹ 54,895 ha^{-1}), net return (₹ 28,832 ha^{-1}) and B:C ratio (2.11) as compared to other genotypes. Next best genotype is Bunny (BG-I) Bt, recorded ₹ 45,826 ha^{-1}, ₹ 20,669 ha^{-1} and 1.83 of gross, net return and B: C ratio, respectively. The lowest gross return (₹ 37,058 ha^{-1}), net return (₹ 12,826 ha^{-1}) and B:C ratio (1.53) was recorded with RCH-368 Bt cotton.

Biradar *et al*. (2011) revealed that nutrient application for a yield target of 3 t ha^{-1} resulted higher net return of INR ₹ 68,970 ha^{-1}, with a B: C of 3.5 when compared to either the fertilizer doses based on the general recommended dose or farmers practice.

Application of nutrients for the target yield of 4.0 t ha^{-1} (195:100:200 NPK kg ha^{-1}) recorded significantly higher gross return (₹ 1,77,305 ha^{-1}), net return (₹ 1,21,022 ha^{-1}) and B:C ratio (3.10) as compared to other nutrient levels applied based on target yield However, B:C ratio was on par with nutrient levels applied based on target yield of 3.5 t ha^{-1} (3.03) (Manjunatha *et al*., 2015).

3. MATERIAL AND METHODS

A field experiment on soil and foliar nutrient management in Bt and non-Bt cotton genotypes under protective irrigation was conducted during *kharif* 2014 at the Main Agricultural Research Station, Dharwad. The details of the materials used and the experimental techniques followed during the course of investigation are presented in this chapter.

3.1 Experimental site

The experiment was conducted at Main Agricultural Research Station (MARS) (Plot No. 75, C Block), College of Agriculture, Dharwad which is situated at 15°29' N latitude, 74°59' E longitudes and at an altitude of 689 m above mean sea level and it comes under Northern Transition Zone (Zone-8) of Karnataka.

3.2 Soil characteristics of the experimental site

The experiment was carried out on black clayey soil (Vertisols). Composite soil samples were collected from experimental site before sowing and were analysed for various physical and chemical characteristics. The data of soil analysis along with methods employed are furnished in Table 1. The soil pH was 7.40 and its nutrient status was medium in available nitrogen (252 kg ha^{-1}), phosphorous (32.20 kg ha^{-1}) and potassium (278 kg ha^{-1}).

3.3 Climatic condition

The MARS, College of Agriculture, Dharwad is located in Northern Transition Zone (Zone 8) of Karnataka state. This zone receives the rainfall both from South West and North East monsoons which is well distributed from June to November with lower co-efficient of variation. The monthly mean meteorological data of rainfall, temperature and relative humidity for the experimental year from January to December and the average of past 63 years rainfall and relative humidity are furnished in Table 2.

The average annual rainfall (past 63 years) was 711.44 mm which was fairly well distributed from April to November. The mean maximum temperature varied from 27.27° C (July) to 36.6° C (April) whereas, mean minimum temperature varied from 13.39° C (December) to 22.01° C (June). The mean monthly highest and the lowest relative humidity were 89.09 per cent (July) and 54 per cent (Feb), respectively.

During the experimental year (2014), rainfall of 962.20 mm was received which was 250.76 mm higher than the normal. The rainfall during cropping period (June-Oct) was 633.5 mm which was well distributed during crop growth period. The rainfall received in the month of July (242.20 mm) and August (158.40 mm) ensured the adequate stored moisture for growth of the crop. The rainfall received during September was 100.20 mm. During the crop growth period, the highest and the lowest maximum temperature recorded was 30.0 °C (October) and 27.0 °C (July and Aug.) respectively, while the highest and the lowest minimum temperature was 21.6 °C (June) and 19.0 °C (October) respectively. The mean relative humidity ranged from 42.0 per cent in March to 89.0 per cent during July.

Table 1. Physical and chemical properties of soil at the experimental field

Sl. No.	Particulars	Values	Method adopted
A.	Physical properties		
	Particle size analysis		
	a. Course sand (%)	7.14	International Pipette method (Piper, 1966)
	b. Fine sand (%)	12.64	
	c. Silt (%)	29.52	
	d. Clay (%)	50.70	
	e. Textural class	Clay	
	f. Bulk density (g cc^{-1})	1.32	
B.	Chemical properties		
	a. Organic carbon (%)	0.71	Walkey and Black wet oxidation method (Jackson, 1973)
	b. pH	7.4	Glass electrode pH meter (Piper, 1966)
	c. EC (dS m^{-1})	0.24	EC bridge (Jackson, 1973)
	d. Available N (kg ha^{-1})	252	Alkaline permanganate method (Subbiah and Asija, 1966)
	e. Available P_2O_5 (kg ha^{-1})	32.20	Olsen's method (Muhr *et al.,* 1965)
	f. Available K_2O (kg ha^{-1})	278	Flame photometer method (Muhr *et al.,* 1965).
	g. Exchangeable Mg (cmol(p+) kg^{-1})	19.50	Standard versenate method Block (1965).

Table 2: Monthly meteorological data during 2014-15 and the average of 64 years (1950-2013) at the Main Agriculture Research Station, University of Agricultural Sciences, Dharwad

Month	Rainfall (mm)		Rainy days (2014)	Mean Temperature (^{o}C)				Relative humidity (%)	
				Maximum		Minimum			
	2014	*1950-2013		2014	*1950-2013	2014	*1950-2013	2014	*1950-2013
January	0.00	0.79	-	29.5	28.74	14.7	14.10	53	64.00
February	0.00	11.16	-	31.0	31.61	16.1	16.5	45	54.35
March	11.40	2.13	1	34.3	34.90	18.6	19.59	42	63.65
April	44.90	48.10	3	36.3	36.60	21.0	20.10	49	77.28
May	197.40	21.33	7	37.8	35.20	21.1	21.34	61	75.17
June	29.30	104.93	4	29.9	30.16	21.6	22.01	89	86.03
July	242.20	153.48	17	27.0	27.27	21.0	20.89	84	89.09
August	158.40	100.74	19	27.0	27.29	20.4	20.09	84	88.44
September	100.20	107.61	8	28.0	27.90	20.2	20.31	81	86.41
October	103.40	124.52	7	30.0	29.49	19.0	18.61	71	79.15
November	48.80	31.63	2	29.0	28.90	15.5	15.89	59	73.25
December	26.20	5.02	1	27.8	27.81	14.5	13.39	64	68.65
Total	962.20	711.44	69	-	-	-	-	-	-

*Average of 64 years (1950-2013)

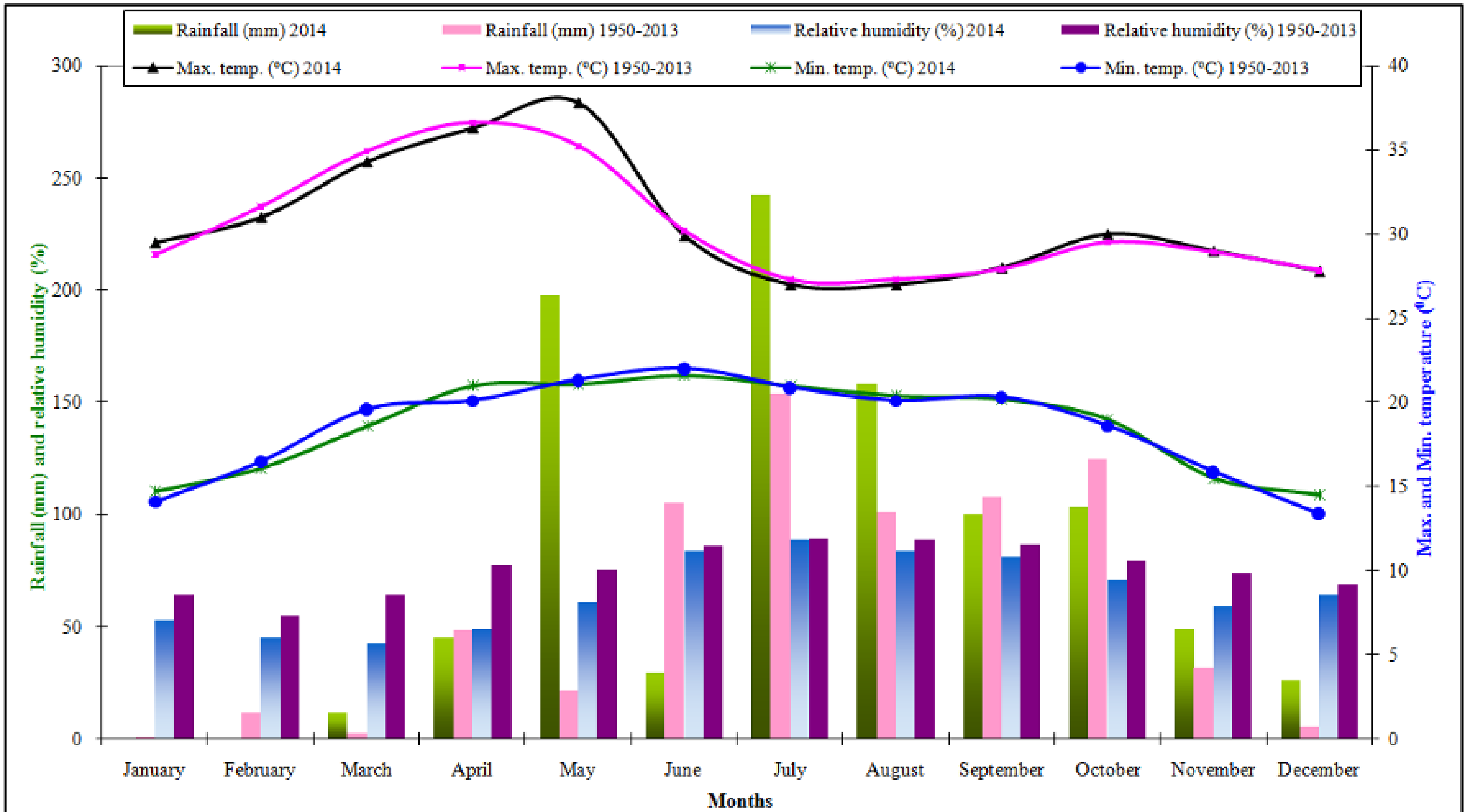


Fig. 1. Monthly meteorological data during crop growth period (2014) and the average of 63 years (1950-2013) at the Main Agricultural Research Station, Dharwad

Fig. 1. Monthly meteorological data during crop growth period (2014) and the average of 63 years (1950-2013) at the Main Agricultural Research Station, Dharwad

3.4 Previous cropping history

During *kharif* the land was used for general soybean production and during *rabi* chickpea was cultivated (2013-2014).

3.5 Experimental details

The details of experiment with regards to treatments, design adopted and plot sizes are given below

3.5.1 Treatment details

Main plots: (Hybrids)

1. BG-I Bt cotton : RCH-2
2. BG-II Bt cotton : Chiranjeevi
3. non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

1. RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)
2. RDF + Foliar application of KNO_3 2 per cent
3. RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application
4. Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS..

Seed source are indicated below

Chiranjeevi BG-II Bt	M/s. Sri Ram Bio Seed Co. Ltd., Hyderabad(Andhra Pradesh)
RCH-2 BG-I Bt	M/s. Rasi Seeds Co. Ltd., Attur, Coimbatore(Tamil Naidu)
NHH-44 non-Bt	CICR, Nagpur, Maharashtra

The BG-I term indicates first generation transgenic Bt cotton (BG-I) expressing *Cry1Ac* and BG-II term indicates second generation transgenic Bt cotton (BG-II) expressing *Cry1Ac*+*Cry2Ab* delta endotoxins.

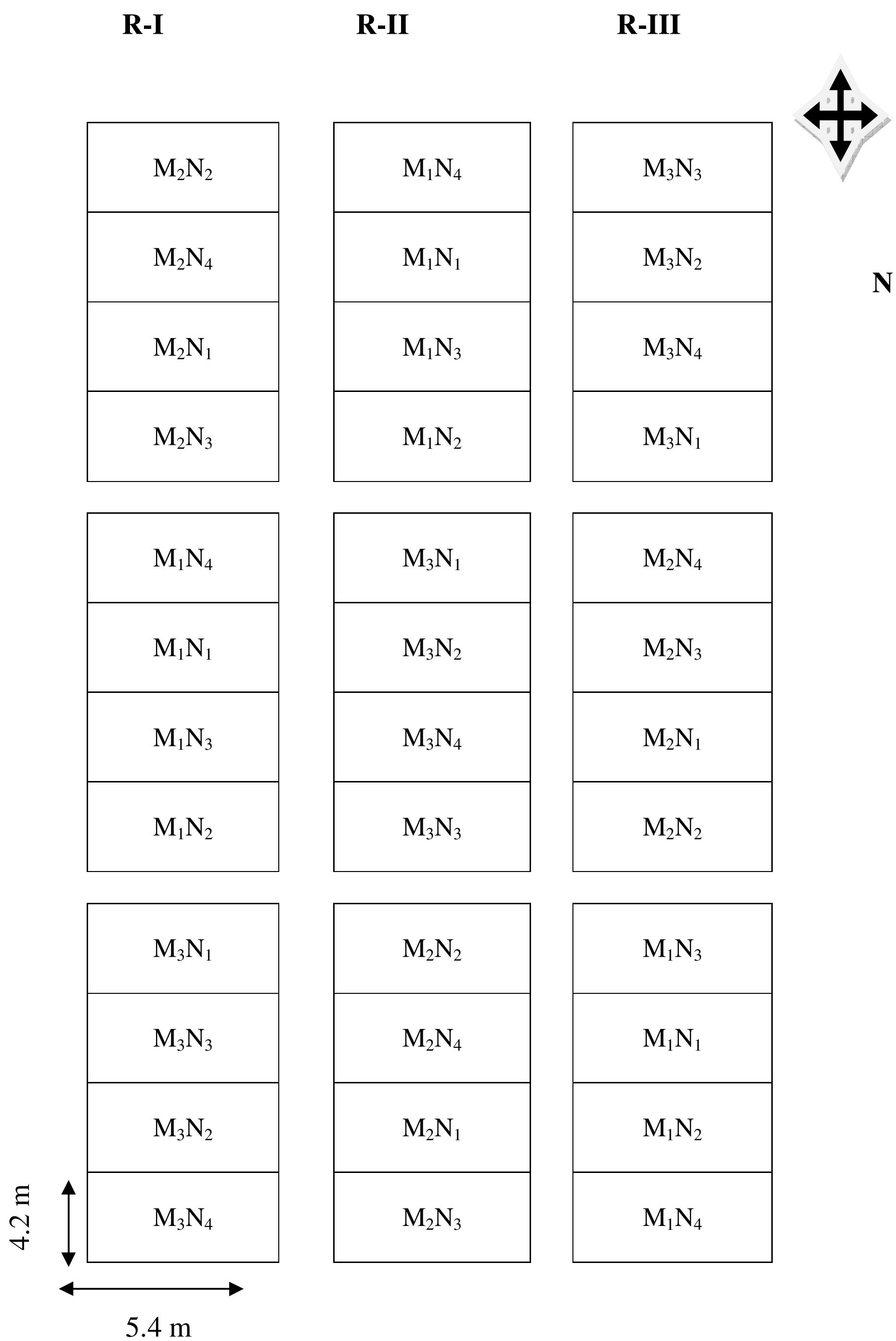


Fig. 2. Plan of layout

Plate1. General view at 25 DAS

3.5.2 Design and layout

The experiment was laid out in the split plot with three replications. Plan of layout of the experiment is presented in Fig 2.

Hybrids	: Chiranjeevi (BG-II), RCH-2 (BG-I) and NHH-44 non-Bt
Replication	: Three
Treatments	: Twelve
Spacing	: 90 cm x 60 cm
Gross plot size	: 5.4 m × 4.2 m
Net plot size	: 2.7 m × 2.4 m
Fertilizer	:100:50:50 N:P_2O_5:K_2O kg ha^{-1} and FYM @10 t ha^{-1}
Situation	: Rainfed
Season	: *Kharif* 2014

3.6 Cultural operation

3.6.1 Land preparation

The land was ploughed tractor by once after the harvest of previous crop followed by harrowed twice to get a fine tilth. Weeds were removed from the experimental area and smoothened with wooden plank to prepare fine seed bed. Later the plots were laid out as per the plan.

3.6.2 Seeds and sowing

The different cotton hybrids were dibbled at 90 cm apart with intra row spacing of 60 cm during *kharif* season on 18.07.2014. Two seeds per spot were dibbled to a depth of 4 cm on flat bed. Gap filling was done 10 days after sowing. Thinning was done 20 days after sowing (DAS) to retain one plant per spot.

3.6.3 Manure and fertilizer application

Well decomposed FYM @ 10 t ha^{-1} was incorporated into soil three weeks prior to sowing of the crop. The recommended dose fertilizer rainfed cotton is 100:50:50 kg N:P_2O_5:K_2O per hector. N, P_2O_5 and K_2O were applied in the form of Urea, Di-ammonium Phosphate and Muriate of Potash respectively. The fertilizer were applied as per recommendations is as follows

Treatments	Time	Schedule
N1	Basal	50 % N entire P_2O_5 and K_2O
	50 DAS	16.6 % N
	80 DAS	16.6 % N
	110 DAS	16.6 % N
N2	Basal	10 % N entire P_2O_5 and K_2O
	30 DAS	15 % N
	60 DAS	15 % N
	75 DAS	15 % N
	90 DAS	15 % N
	105 DAS	15 % N
	120 DAS	15 % N
N3	Basal	50 % N entire P_2O_5 and K_2O
	30 DAS	25 % N
	50 DAS	25 % N

Foliar supplies of nutrients were taken at different stages to control leaf reddening. The nutrient schedules for foliar sprays as follows.

	Time	Schedule
N1	50 DAS	1 % $MgSO_4$
	80 DAS	1 % $MgSO_4$
N2	October onwards at 15 days interval	2 % KNO_3
N3	70 DAS	0.5 % 19:19:19 and 1 % $MgSO_4$
	90 DAS	0.5 % 19:19:19 and 1 % $MgSO_4$
	110 DAS	0.5 % 19:19:19 and 1 % $MgSO_4$

3.6.4 Hand weeding and inter-cultivation

Two inter-cultivations were carried out at 40 DAS and 70 DAS and twice hand weeding at 30 and 60 DAS were carried out to keep the plots free from weeds and for better aeration during the crop period and also earthing up soil was done to prevent the lodging of plants.

3.6.5 Plant protection schedule

The plant protection measures for sucking pests (thrips, jassids, aphids, mired bugs, midges and white flies) and diseases were taken in all the treatments. Chemical protection was offered against bollworms for non-Bt hybrid offering complete protections against them. The plant protection measures were as per package of practices for Bt cotton for zone 8 (Anon., 2011). The detailed plant protection schedule undertaken during the investigation is given in Appendix.

3.6.6 Harvesting

Harvesting of seed cotton (Two pickings, first picking on 20/1/2015 to 21/1/2015 and second picking on 13/03/2015 to 16/03/2015) from the net plot area was taken up separately for computing yield per hectare.

3.7 Collection of experimental data

Five plants were randomly selected and tagged in each plot for biometric observations at 60, 90 and 120 DAS. Observations were recorded from the net plot where as destructive sampling was done within the net plot. Procedures and the units of the various biometric observations are presented below.

3.7.1 Growth components

3.7.1.1 Plant height

Plant height was measured at 60, 90 and 120 DAS from the base of the plant to tip of fully opened leaf on main shoot and expressed in centimetre (cm).

3.7.1.2 Leaf area per plant

Leaf area at 60, 90 and 120 DAS was measured by disc method by and was expressed in desimeter square per plant (dm^2 $plant^{-1}$) Fifty leaf discs of known size were taken through a cork bore from randomly selected leaves of two plants. Both discs and remaining leaf blades were oven dried at 65 ^{0}C and leaf area was calculated using formula as suggested by Vivekanandan *et al* (1972).

$$LA = Wa \times A/wd$$

Where,

LA is leaf area in dm^2

Wa is oven dry weight of all leaves in grams

wd is oven dry weight of 50 disc in grams

A is area of 50 discs in dm^2

3.7.1.3 Leaf area index

Leaf area index (LAI) was calculated as per the procedure given by Sestak *et al*. (1997) .

$$LAI = \frac{\text{Land area per plant } (dm^2)}{\text{Land area occupied by the plant } (dm^2)}$$

3.7.1.4 Leaf area duration

The leaf area duration (LAD) is the integral of LAI over the growth period and was worked out as per the formula given by Power *et al.* (1967).

$$LAD = \frac{Li + L\ (i+1)}{2} \times (t_2 - t_1)$$

Where,

LAD = Mean of leaf area duration (days)

Li = LAI at i^{th} stage

L (i+1) = LAI at I + 1^{st} stage

(t_2-t_1) = Time interval between i^{th} and $i+1^{st}$ stage.

3.7.1.5 Chlorophyll content

Leaf chlorophyll content was determined by light absorbance in the red and infrared light with a chlorophyll meter (SPAD-502, Minolta France SA, Currieres-Sur-Seine, France) Teng *et al*. (2004) was used to take the chlorophyll meter readings. Chlorophyll meter observations were expressed as SPAD readings. These observations were taken at 60, 90 and 120 days after sowing.

3.7.1.6 Number of monopodial branches per plant

The monopodial branches bearing at least one functional sympodial branch were counted separately in five tagged plants and recorded at 60, 90 and 120 DAS. The average value these five plants was expressed as number of monopodials per plant.

3.7.1.7 Number of sympodial branches per plant

The fruiting braches arising on the main stem were counted separately in the five tagged plants and the average value was recorded. at 60, 90 and 120 DAS. The average value these five plants was expressed as number of sympodial per plant.

3.7.1.8 Dry matter production and its distribution

The five randomly selected plants from destructive sampling area were used to record the dry matter production. These samples were oven dried at 65 ℃ to 70 ℃ to a constant weight. Dry weight was recorded separately at each stage for calculating total dry matter production which expressed in grams per plant (g $plant^{-1}$).

3.7.2. Yield and yield components

3.7.2.1 Number of bolls per plant

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

3.7.2.2 Mean boll weight

Seed cotton obtained from 10 randomly selected bolls from net plot covering top to bottom in each picking were weighed. The mean boll weight was worked and expressed in grams (g).

3.7.2.3 Seed cotton yield per plant

Seed cotton from the five tagged plants was picked separately at each picking. Seed cotton yield per plant was obtained by adding cotton yield of all pickings and was expressed in grams (g).

3.7.2.4 Seed cotton yield per hectare

The seed cotton from five tagged plants was picked separately at each picking and weighed. The sum of seed cotton picked at different pickings was averaged and presented as seed cotton yield per plant in kilogram (kg).

3.7.2.5 Harvest index

Harvest index was defined as the ratio of economic yield to biological yield and expressed in per cent. Harvest index was estimated as per the formula suggested by Donald (1962).

$$\text{HI (\%)} = \frac{\text{Economic yield (q ha}^{-1}\text{)}}{\text{Biological yield (q ha}^{-1}\text{)}} \times 100$$

3.8 Quality parameters

Important quality characteristics of fibre such as, span length, fibre fineness, bundle strength, fibre elongation and tenacity were assessed at Central Institute for Research on Cotton Technology (CIRCOT) regional centre, Dharwad by using a high volume instrument (HVI model statex Fibrotex).

3.8.1 Fibre length

2.5 per cent span length of samples were determined and expressed in millimetre mm (Sundaram, 1979).

3.8.2 Fibre uniformity ratio

The length to uniformity ratio was calculated by using following formula and expressed in percentage (%) (Sundaram, 1979).

$$\text{Fibre uniformity ratio (\%)} = \frac{\text{50 per cent span length}}{\text{2.5 per cent span length}} \times 100$$

3.8.3 Micronnaire value

The fibre fineness is the measure of fibre weight in microgram (µg) per unit length of fibre and was expressed in µg $inch^{-1}$ (Sundaram, 1979).

3.8.4 Fibre strength

Fibre strength is the ratio of breaking strength of a bundle of fibre to weight. The value is expressed as gram (g) g per tex (Sundaram, 1979).

3.8.5 Ginning out turn

Seed cotton obtained of all pickings from each treatment net plot was mixed thoroughly. A representative sample of 300 grams from each treatment net plot was taken for ginning. Ginning percentage was calculated by using the following formula.

$$\text{Ginning out turn} = \frac{\text{Weight of lint (g)}}{\text{Weight of seed cotton (g)}} \times 100$$

3.9 Quantitative estimation of *Cry1Ac* and *Cry2Ab* endotoxin

`Fully opened leaf samples from top portion of the plant were collected from each plot. Each sample was immediately transferred to ice box and brought to laboratory for further analysis as per the protocol provided with quantification kit (Quanta-T ELISA plate kit from Desi-Gen, Janla).

3.9.1 Endotoxin quantification protocol

Sample preparation

- 5 mg of lyophilized leaf tissue from each leaf sample was placed in 1.5 ml microfuge tube.
- 500 µl of ice-cold 1X sample extraction buffer was added (add 0.2 g powder A and 12 g powder B to 100 ml sample extraction buffer prepared freshly at the time of sample extraction).
- Tissue powder was macerated at 30 rpm using a motor driven pestle for 30 sec.
- The contents were chilled on ice for 10 min and again macerated for 30 sec.
- The contents were spinned at 8,000 rpm for 15 min and supernatant was pipetted out.
- Pipetted supernatant was diluted at 1:4 proportion using 1X diluent buffer (diluents buffer: Add 100 ml of 10X buffer A, dilute it to 1lit by deionized water added with 0.5% ovalbumin in 1X buffer).
- Trypsinization: 3.5 µl of 5 mg ml^{-1} Trypsin per 100 ml of extract was added.
- The contents were incubated at 37 °C for 30 min.

- After incubation the contents were added with 2.5 µl of 50 mM PMSF per 100 ml extract (8.7 mg Phenyl methane sulfonyl fluoride dissolved in 1 ml of isopropanol). Preparation of Positive and Negative QC seed extract
- Positive and negative seed samples crushed in 500 µl 1X Buffer A, spinned for 30 sec in micro centrifuge, and 100 µl of each supernatant was used per well.
- Standard curve generation: 20 ng m^{-l} working stock solution was prepared from 1 µl ml^{-1} *Cry1Ac* stock solution provided in 1X diluent buffer. Other quantification standards were prepared as under.
- Goat anti-*Cry1Ac* (Ab2) preparation: Goat anti-*Cry1Ac* 1:1000 diluted in 1X diluents buffer and added @ 150 µl to each well in the plate.
- Plate loading: Exactly 100 µl of buffer stock, standards: positive and negative controls, and diluted samples in 1X diluent buffer added in the wells as indicated follow:

	1	2	3	4	5	6	7	8	9	10	11	12
A	Blank	Std1	Std1	Std1	S4	S7	S10	S12	S15	S18	S20	S23
B	+Ve	Std2	Std2	Std2	S5	S7	S10	S13	S15	S18	S21	S23
C	-Ve	Std3	Std3	Std3	S5	S8	S10	S13	S16	S18	S21	S24
D	S1	Std4	Std4	Std4	S5	S8	S11	S13	S16	S19	S21	S24
E	S1	Std5	Std5	Std5	S6	S8	S11	S14	S16	S19	S22	S24
F	S1	Std6	Std6	Std6	S6	S9	S11	S14	S17	S19	S22	-Ve
G	S2	S2	S3	S4	S6	S9	S12	S14	S17	S20	S22	+Ve
H	S2	S3	S3	S4	S7	S9	S12	S15	S17	S20	S23	Blank

- The plate was incubated at 37 °C for 1.5 hr in humid environment.
- After incubation samples were discarded and the plate was washed with 1X wash buffer (wash buffer: 100 ml of 10X Buffer A diluted to 1lit. using deionized water).
- Plate was dried on paper towel.
- AP-conjugated Ab was diluted to 1:1000 in 1X diluent Buffer and added 250 µl per well.
- The contents in plate were mixed and incubated at 37 °C for 45 min. in humid environment.
- Again contents of the plate were discarded and the plate was washed twice using 1X wash buffer, allowing the plate to stand for 5 min. with wash buffer in the well between washes.
- Plate was dried on paper towel.
- Substrate preparation: 1 mg ml^{-1} pNPP solution was freshly prepared in 1X substrate buffer and added @ 250 µl per well.

- Plate was immediately transferred to dark place and incubated exactly for 30 min.
- Exactly after 30 min. of incubation absorbance of plate was read at 405 nm after setting one of the blank as blank using Microplate reader.
- Standard curve was plotted with standard protein concentration on X-axis and OD values on Y-axis.
- *Cry1Ac* concentration of each sample was determined by finding its OD value and the corresponding concentration level from graph.
- Dry weight expression level: Dry weight levels for leaf tissues were calculated as follows.

$$\text{Dry wt } (\mu g\ g^{-1}) = \frac{(\text{ng ml}^{-1}\text{ value from linear plot})\ (\text{Dilution factor})\ X\ (\text{T:B Ratio})}{100}$$

3.10 Soil enzyme activity

3.10.1 Dehydrogenase activity

The dehydrogenase activity (µg TPF g^{-1} soil day^{-1}) in the soil samples was determined by following the procedure as described by Casida *et al.* (1964). Ten gram of soil and 0.2 g $CaCO_3$ were thoroughly mixed and dispensed in the conical flasks. Each flask was added with 1.0 ml of 1.5 per cent, 2, 3, 5-triphenyl tetrazolium chloride (TTC), 1.0 ml of 1 % glucose solution and 8.0 ml of distilled water to leave a thin film of water above soil layer. The flasks were stoppered with rubber bunks and incubated at 30 °C for 24 hours. At the end of incubation, the contents of the flask were rinsed down into small beaker and slurry was made by adding 10 ml of methanol. The slurry was filtered through Whatman No. 42 filter paper. Repeated rinsing of soil with methanol was continued till the filtrate ran free of red colour. The filtrate was made up to 50 ml with methanol in volumetric flask. The intensity of red colour was measured at 485 nm against a methanol blank using spectrometer.

The standard curve preparation: Graded concentration of TTC (2, 3, 5-triphenyl tetrazolium chloride) (0.0 – 50.0 µg) were prepared in methanol. In each tube, 5 ml of phosphate buffer (7.4 pH) and adequate amount (150 mg) of fresh sodium dithionate ($Na_2S_2O_4.H_2O$) were added. When the reduction was complete pink colour intensity of graded concentration of triphenyl formazon (TPF) was red as before. The results were expressed as µg of TPF formed per g of soil per day.

3.10.2 Phosphatase activity

Phosphatase activity (µg pnp g^{-1} soil hr^{-1}) of soil samples was determined by following the procedure of Evazi and Tabatabai (1979). One gram of soil sample was placed in a 50 ml Erlenmeyer flask to which 0.2 ml toluene followed by 4 ml of modified universal buffer (pH 7.5) was added. One ml of P-nitrophenol phosphate solution made in modified universal buffer was added to the flasks and contents of the flasks were mixed by swirling for two minutes. The flasks were stoppered and incubated at 37 °C for one hour. After incubation, one ml of 0.5 M $CaCl_2$ and four ml of 0.5 M NaOH were added to the flask, swirled and filtered through Whatman No. 42 filter paper. The intensity of yellow colour developed was measured at 420 nm against the reagent blank using Graphicord.

Shimadzu UV-visible Spectrophotometer (Model UV-240). Controls were maintained for each soil sample and were analyzed by following the same procedure described above except that the paranitrophenol phosphate solution was added after the addition of 0.5 M $CaCl_2$ and 0.5 M NaOH and just before filtration. The phosphatase activity in the soil samples was expressed as µg paranitrophenol formed per gram soil per hour with reference to the standard curve prepared by using graded concentrations of P-nitrophenol phosphate.

3.10.3 Urease activity

The procedure adopted to determine the urease activity (µg NH_4-N g^{-1} soil day^{-1}) of soil was essentially the same as adopted by Pancholy and Rice (1973) except that the ammonia liberated due to hydrolysis used in the reaction mixture was determined by nesslerization as described by Jackson (1973).

Ten grams each of freshly collected soil samples were placed in 100 ml capacity Erlenmeyer flasks to which one ml toluene was added and allowed to stand for 15 minutes to permit complete penetration into soil. Each of these flasks were added with 10 ml of phosphate buffer (pH 6.7) and 10 ml of 10 per cent urea solution. For control flasks, urea solution was replaced by equal quantity of distilled water. The contents of the flasks were well shaken for five minutes and incubated at 30 °C for 24 hrs. After incubation, the contents of the flasks were filtered through Whatman No. 42 filter paper. The remaining soil in the flask was added with 15 ml of 1 N KCl solution shaken for five minutes and filtered. The volume of the total filtrate was made upto 100 ml in a volumetric flask using distilled water.

The amount of ammonia present in the filtrate was determined by nesslerization. 1 ml filtrate of each sample was transferred to a 20 ml volumetric flask to which 2 ml of 10 per cent sodium tartarte solution and 0.5 ml of Nessler's reagent were added. The volume was made up to 20 ml with distilled water. The yellow color developed after 30 minutes was measured at 410 nm using Graphicord Shimadzu UV-visible spectrophotometer (model UV 240) against the reagent blank.

3.10.4 Arbucular Mycorrhizal fungi (AM fungi) root colonization

Arbucular Mycorrhizal fungi (%) are one of the most important components of the soil biota in natural and agricultural systems. They are obligate symbionts currently placed within the Glomeromycota.AMF are particularly important in tropical and sub tropical regins, where the soils are usually of low fertility and mycorrhizae is thought to play a crucial role for the growth (soil microbiology manual).

Protocol: Trypan blue staining of roots for Arbucular Mycorrhizal colonization

- Collect the root samples and wash with water
- Cut the roots in to 1 cm pieces
- Clear the root samples in 10 % KOH at 121 °C for 10 minutes in an autoclave. The KOH solution clears the host cytoplasm and readily allows stain penetration

- Remove the KOH solution and rinse the roots with several changes of tap water to remove traces of KOH.
- Add 2 N HCL in the test tube, soak the roots pieces for 3-4 minutes and then pour off the solution.
- Stain the root segments in 0.1 % trypan blue and keep it overnight.
- Store the roots in lacto glycerol.
- Mount the root segments on a slide (10-20) with a drop of lacto glycerol. Place a cover slip over them and press gently.
- Observe for vesicles and arbuscles and calculate the percentage of infection.

$$\text{Percentage root colonization} = \frac{\text{No. colonized root bits} \times 100}{\text{Total No. of root bits examined}}$$

3.10.5 Methods of soil analysis

3.10.5.1 Soil reaction

Soil pH was determined in 1:2.5 soil: water suspension using pH meter with glass electrode (Jackson 1973).

3.10.5.2 Electrical conductivity

Electrical conductivity was determined in the supernatant solution 1:2.5 soil: water suspension using digital conductivity bridge (Jackson, 1973) expressed in desisimons per meter (dS m^{-1}).

3.10.6 Available nutrients

3.10.6.1 Nitrogen

Available nitrogen (N) of soil was determined by alkaline potassium permanganate distillation method as described by Subbiah and Asija (1956).

1.10.6.2 Phosphorus

Available phosphorus (P) content of the soil was determined by Olsen's method as outlined by Jackson (1973).

1.10.6.3 Potassium

Available potassium (K) content of the soil was determined flame photometrically after extracting the soil with neutral normal ammonium acetates as described by Jackson (1973).

1.10.6.4 Exchangeable magnesium

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

3.10.7 Collection and preparation of plant samples

Treatment wise plant samples were collected at harvest by uprooting the entire plant carefully. The plant samples were first dried and then rinsed with distilled water. The samples were dried in shade and then oven dried at 65 °C. 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 and magnesium content by following standard procedures (Table 3).

3.10.7.1 Nitrogen

Nitrogen was determined by Kjeldahl's 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).

3.10.7.2 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 perchloric acid (10:4:1). The clear digested material was used for analyzing P, K and Mg.

3.10.7.2.1 Phosphorus

The phosphorus in the plant sample was determined by Vanedomolybdate yellow colour method in nitric acid medium. The intensity of colour was read at 420 nm wave length using spectrophotometer (Jackson, 1973).

3.10.7.2.2 Potassium

Potassium in the plant sample was estimated by atomizing the diluted plant extract in the flame photometer as described by Jackson (1973).

3.10.7.4 Magnesium

Magnesium in plant sample was estimated by making use of chelating property of EDTA.

3.10.8. Economics

The cost of cultivation and gross returns per hectare for each treatment was computed based on the prices of inputs and outputs that were prevailing at the time of their use during the period of experimentation (2014-15). The net return per hectare was calculated by deducting the cost of cultivation from the total monetary value of the produce. Benefit: cost (B: C) ratio was calculated as follows.

$$\text{B:C ratio} = \frac{\text{Gross return (₹ /ha)}}{\text{Cost of cultivation return (₹ /ha)}}$$

3.10.9 Statistical analysis

The statistical analysis and interpretation of data was done using the Fischer's method of analysis of variance technique as described by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P = 0.05. Critical difference values were calculated wherever the 'F' test was significant.

Table 3. Methods of analysis of plant samples

Sl. No.	Particulars	Methods	References
1.	Total nitrogen	Micro kjeldahl method	Jackson (1973)
2.	Total phosphorus	Vanadomolybdate yellow colour method	Jackson (1973)
3.	Total potassium	Flame photometric method	Jackson (1973)
4	Magnesium	EDTA method	Tandon (1998)

4. EXPERIMENTAL RESULTS

A field experiment was conducted to evaluate soil and foliar nutrient management in Bt and non-Bt cotton genotypes under protective irrigation during *kharif* 2014 at the Main Agricultural Research Station, Dharwad. The results of the investigation are presented in this chapter, under the following sub headings:

4.1 Growth parameters

4.1.1 Plant height (cm)

Data pertaining to the effect of different hybrids, split and foliar application of nutrients on plant height are presented in Table 4 and Fig. 3.

Data indicated that significantly highest plant height was recorded with Chiranjeevi BG-II Bt hybrid at 60, 90 and 120 DAS (55.60, 77.69 and 104.16, respectively) as compared to other hybrids. However, next best treatment was NHH-44 non-Bt (50.07, 69.97 and 100.68, respectively) at 60, 90 and 120 DAS. The lowest plant height was registered with RCH-2 Bt BG-I (47.77, 67.56 and 100.34, respectively) at 60, 90 and 120 DAS.

Plant height of Bt cotton differed significantly due to nutrient application at all the growth stages. The data indicated that, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher plant height at 60, 90 and 120 DAS (54.62, 77.96 and 104.63, respectively) as compared to other nutrient levels. However, next treatment with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and RDF treatments on par (51.58, 75, 103.62, 50.53, 72.46 and 102.09, respectively) at 60, 90 and 120 DAS. However, significantly the lowest plant height (47.33, 61.68 and 96.20, respectively) was registered in absolute control treatment at 60, 90 and 120 DAS.

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher plant height at 60, 90 and 120 DAS as compared to other treatment combinations.

4.1.2 Number of monopodia per plant

Number of monopodia per plant of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application is presented in Table 4 and Fig. 4.

Data indicates that significantly higher monopodia per plant was recorded with Chiranjeevi BG-II Bt hybrid at 90 and 120 DAS (2.82 and 3.76, respectively) as compared to other hybrids, however it was on par with NHH-44 non-Bt (2.68 and 3.64 respectively) at 90 and 120 DAS.

Monopodia per plant of Bt cotton differed significantly due to nutrient application at all the growth stages. The data indicated that, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher monopodia per plant at 60, 90 and 120 DAS (2.60, 3.13 and 3.90, respectively) as compared to other nutrient levels.

Table 4: Plant height and number of monopodial branches of different Bt and non-Bt cotton hybrids at all growth stages

Treatment	Plant height (cm)			Monopodial branch per plant		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Hybrids (H)						
M_1-RCH-2 BG-I	47.77	67.56	100.34	2.18	2.60	3.43
M_2-Chiranjeevi BG-II	55.60	77.69	104.16	2.22	2.82	3.76
M_3- NHH-44 Non Bt	50.07	69.67	100.68	2.37	2.68	3.64
S.Em.±	1.06	1.46	0.64	0.05	0.04	0.04
C. D. (P=0.05)	4.15	1.12	2.50	NS	0.15	0.17
Nutrient levels (N)						
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + 1 % $MgSO_4$)	50.53	72.46	102.09	2.38	2.80	3.53
N_2-RDF+Foliar application with KNO_3	54.62	77.96	104.63	2.60	3.13	3.90
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	51.58	75.00	103.62	2.40	2.73	3.76
N_4-Absolute control	47.84	61.14	96.56	1.64	2.13	3.25
S.Em.±	0.87	1.11	0.35	0.05	0.03	0.06
C. D. (P=0.05)	2.60	3.29	1.04	0.13	0.08	0.17
Interaction (H×N)						
M_1N_1	46.20	67.13	101.03	2.20	2.67	3.42
M_1N_2	51.47	73.70	102.73	2.53	3.00	3.85
M_1N_3	48.80	70.02	102.47	2.33	2.87	3.60
M_1N_4	44.60	59.37	95.13	1.67	1.87	2.86
M_2N_1	53.73	81.38	103.58	2.33	2.93	3.72
M_2N_2	59.80	84.41	108.63	2.60	3.27	3.97
M_2N_3	57.27	82.60	106.08	2.33	2.73	3.85
M_2N_4	51.60	62.37	98.33	1.60	2.33	3.49
M_3N_1	51.67	68.85	101.66	2.60	2.80	3.46
M_3N_2	52.60	75.77	102.53	2.67	3.13	3.86
M_3N_3	48.67	72.37	102.32	2.53	2.60	3.83
M_3N_4	47.33	61.68	96.20	1.67	2.20	3.40
S.Em.±	1.52	1.92	0.60	0.08	0.05	0.10
C. D. (P=0.05)	NS	5.69	1.79	NS	0.14	0.30

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton	:	RCH-2
M_2 - BG-II Bt cotton	:	Chiranjeevi
M_3 - Non-Bt cotton	:	NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

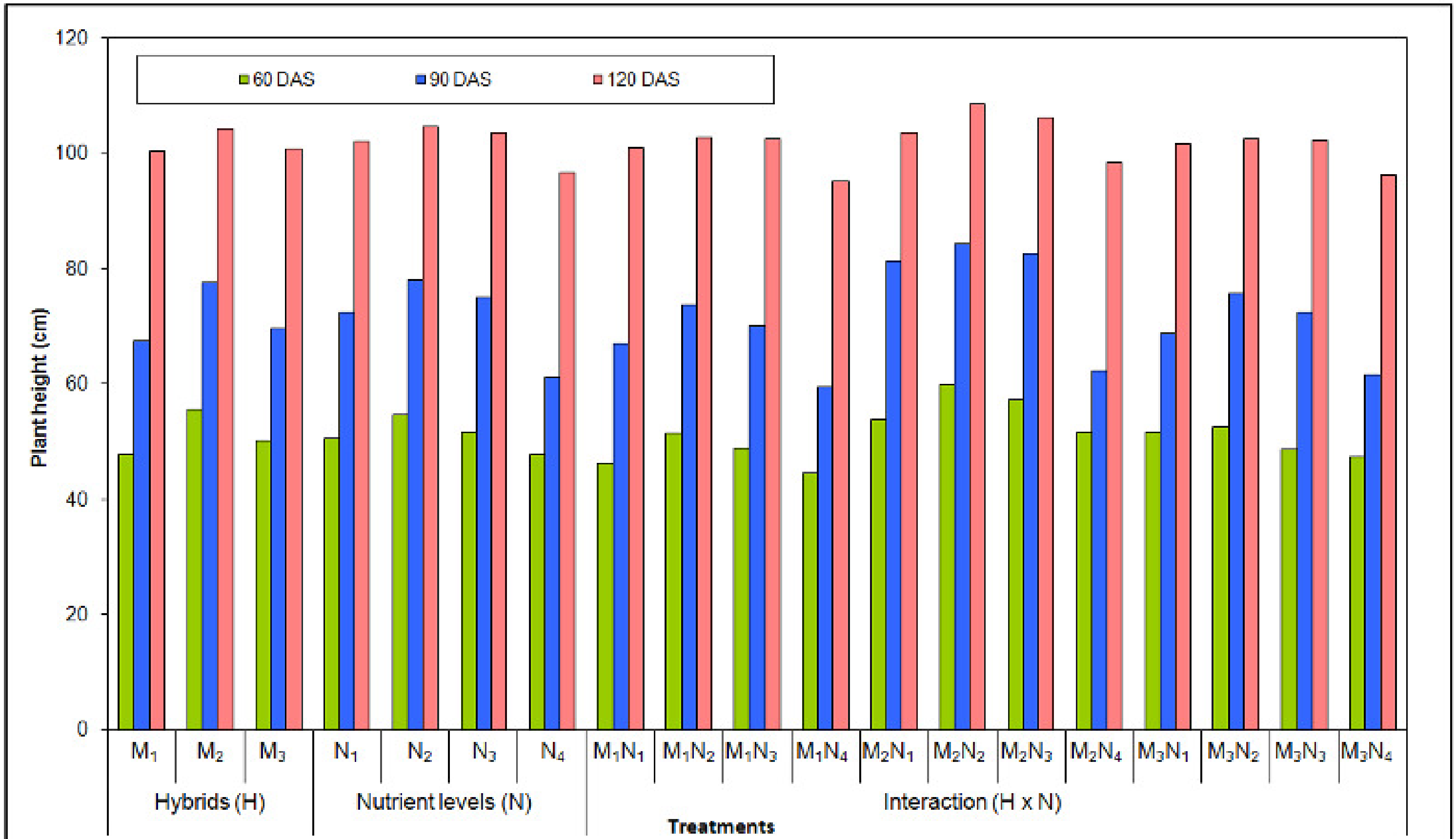


Fig. 3. Plant height of different Bt and non-Bt cotton hybrids at all growth stages

Fig. 3. Plant height of different Bt and non-Bt cotton hybrids at all growth stages

Table 5: Number of sympodia per plant and chlorophyll content of different Bt and non-Bt cotton hybrids at all growth stages

Treatment	Sympodial branch per plant			Chlorophyll content		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Hybrids (H)						
M_1-RCH-2 BG-I	6.88	9.27	14.81	32.01	37.28	41.10
M_2-Chiranjeevi BG-II	7.40	10.17	16.23	34.23	40.09	41.50
M_3- NHH-44 Non Bt	6.62	9.52	13.49	31.94	37.11	39.72
S.Em.±	0.20	0.21	0.14	0.33	0.24	0.17
C. D. (P=0.05)	NS	0.83	0.55	1.31	0.95	0.67
Nutrient levels (N)						
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + 1 % $MgSO_4$)	7.26	9.40	14.60	32.77	38.29	41.44
N_2-RDF+Foliar application with KNO_3	7.81	10.97	16.77	34.50	40.18	42.65
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil an foliar application	7.47	10.57	15.79	33.40	39.18	41.99
N_4-Absolute control	5.31	7.67	12.21	30.22	34.99	37.02
S.Em.±	0.15	0.22	0.36	0.33	0.41	0.33
C. D. (P=0.05)	0.45	0.64	1.06	0.98	1.21	0.99
Interaction (H×N)						
M_1N_1	7.07	8.67	14.54	32.35	36.80	41.31
M_1N_2	7.67	10.60	16.57	33.14	38.74	42.37
M_1N_3	7.47	10.20	15.65	32.82	37.83	41.89
M_1N_4	5.30	7.60	12.48	29.72	35.74	38.84
M_2N_1	7.65	10.07	15.75	34.27	40.22	42.34
M_2N_2	8.57	11.90	18.95	36.52	42.72	43.37
M_2N_3	8.00	10.91	17.52	34.92	40.33	42.55
M_2N_4	5.37	7.80	12.68	31.20	37.09	37.73
M_3N_1	7.07	9.47	13.50	31.69	37.85	40.66
M_3N_2	7.20	10.42	14.80	33.84	39.07	42.21
M_3N_3	6.93	10.60	14.20	32.46	39.39	41.52
M_3N_4	5.27	7.60	11.47	29.75	32.14	34.50
S.Em.±	0.26	0.38	0.62	0.57	0.71	0.58
C. D. (P=0.05)	NS	NS	NS	NS	2.10	1.71

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

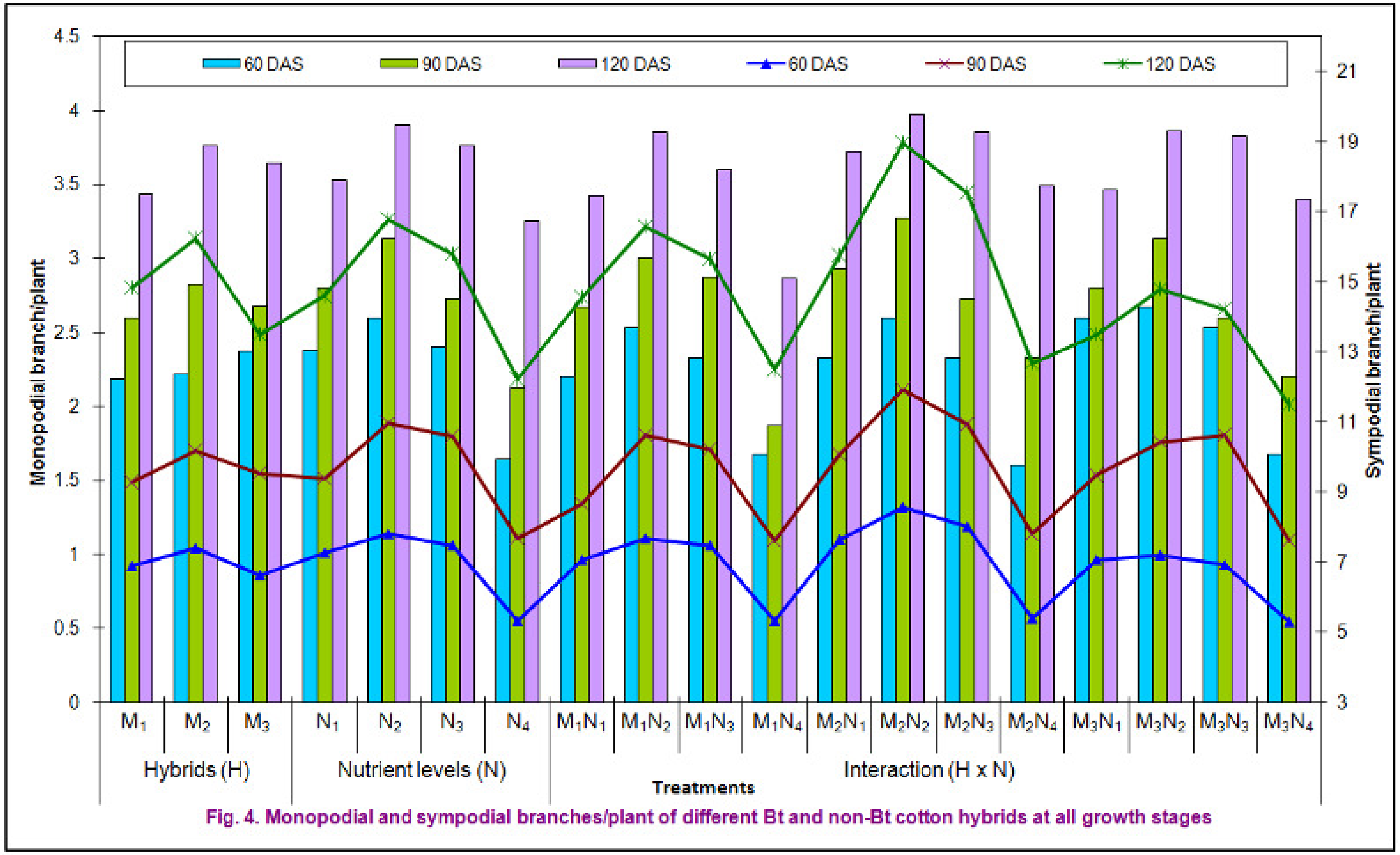


Fig. 4. Monopodial and sympodial branches/plant of different Bt and non-Bt cotton hybrids at all growth stages

However next treatment with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par (2.40, 2.73 and 3.76 respectively) at 60, 90 and 120 DAS. However, significantly the lowest monopodia per plant (1.64, 2.13 and 3.25, respectively) were registered in absolute control treatment at 60, 90 and 120 DAS.

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher monopodia per plant at 90 and 120 DAS as compared to other combinations.

4.1.3 Number of sympodia per plant

Number of sympodia per plant of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 5 and Fig. 4.

The data indicated that significantly higher sympodia per plant recorded in Chiranjeevi BG-II Bt hybrid at 90 and 120 DAS (10.17 and 16.23, respectively). The lowest sympodia per plant were recorded in NHH-44 non-Bt hybrid (9.52 and 13.49, respectively) at 90 and 120 DAS.

Among the different nutrient level treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher sympodia per plant at 60, 90 and 120 DAS (7.81, 10.97 and 16.77, respectively) as compared to other nutrient levels. However, next treatment with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par (7.47, 10.57 and 15.79, respectively) at 60, 90 and 120 DAS. However, significantly the lowest sympodia per plant (5.31, 7.67 and 12.21, respectively) were registered in absolute control treatment at 60, 90 and 120 DAS.

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher number sympodia per plant at 90 DAS as compared to other treatment combinations.

4.1.4 Chlorophyll content

Chlorophyll content value of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 5.

Chiranjeevi BG-II Bt hybrid had significantly higher chlorophyll content recorded at 60, 90 and 120 DAS (34.23, 40.09 and 41.50, respectively) followed by RCH-2 BG-I Bt hybrid was recorded at 60 and 90 DAS (32.01 and 37.28, respectively). But in 120 DAS, chlorophyll content of RCH-2 BG-1 Bt (41.10) at par with Chiranjeevi BG-II Bt hybrid (41.50). However, the lowest chlorophyll content were recorded in NHH-44 non-Bt hybrid (31.94, 37.11, and 39.72, respectively) at 60, 90 and 120 DAS.

Among the different nutrient level treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher chlorophyll content at 60, 90 and 120 DAS (34.50, 40.18 and 42.65, respectively) as compared to other nutrient levels. However, the next best treatment was with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded chlorophyll content 33.40 at, 60 DAS.

However, at 90 and 120 DAS chlorophyll content (39.18 and 41.99, respectively) were at par with the above treatment. However, significantly the lowest chlorophyll content (30.22, 34.99 and 37.02, respectively) were registered in absolute control treatment at 60, 90 and 120 DAS.

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher chlorophyll content at 90 and 120 DAS as compared to other combinations. The lowest chlorophyll content (32.14 and 34.50, respectively) recorded in NHH-44 non-Bt hybrid in absolute control at 90 and 120 DAS.

4.1.5 Leaf area (dm^2 $plant^{-1}$)

Leaf area per plant of Bt and non-Bt hybrids as influenced by split nitrogen and foliar application of nutrients are presented in Table 6 and Fig. 5.

Chiranjeevi BG-II Bt hybrid recorded significantly higher leaf area at 60, 90 and 120 DAS (30.77, 83.26 and 133.05, respectively), followed by RCH-2 BG-I Bt hybrid at 60, 90 and 120 DAS (23.99, 78.55 and 123.36. respectively). However, at 90 DAS leaf area (78.55) was at par with NHH-44 non-Bt hybrid (77.07). The lowest leaf area was recorded in NHH-44 non-Bt hybrid at 60 and 120 DAS (22.38 and 119.64, respectively).

Among the different nutrient level treatments, significantly higher leaf area was recorded with the application of nitrogen in seven splits with foliar application of KNO_3 at 60, 90 and 120 DAS (26.28, 81.91 and 126.28, respectively) as compared to other nutrient levels. However, application of nitrogen in three splits with foliar application of 19:19:19, $MgSO_4$ and application of recommended dose of fertilizer were on par to above treatments at 60, 90 and 120 DAS. The lowest leaf area was recorded in absolute control at 60, 90 and 120 DAS (25.14, 75.61 and 123.95, respectively).

Interaction due to genotypes and nutrient schedule effect was found non-significant on leaf area among the different treatment combinations.

4.1.6 Leaf area index (LAI)

LAI of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 6.

Higher LAI was registered in Chiranjeevi BG-II Bt hybrid at 60, 90 and 120 DAS (0.57, 1.54 and 2.46, respectively). However, the lowest LAI was recorded in NHH-44 non-Bt hybrid at 60 and 120 DAS (0.41, and 2.22, respectively). However, at 90 DAS, there was no significant difference observed between RCH-2 BG-I Bt (1.45) and NHH-44 non-Bt (1.43) with respect to LAI.

Among the different nutrient level treatments, significantly higher LAI was recorded in the application of nitrogen in seven splits with foliar application of KNO_3 at 60, 90 and 120 DAS (0.49, 1.52 and 2.34, respectively) as compared to other nutrient levels. However, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer were on par with above treatments at 60, 90 and 120 DAS (0.48, 1.50, 2.33, 0.48, 1.48 and 2.33, respectively). The lowest LAI was recorded in absolute control at 60, 90 and 120 DAS (0.47, 1.40 and 2.30, respectively).Interaction effect was found non-significant on LAI among the different treatment combinations.

Table 6: Leaf area and leaf area index of different Bt and non-Bt cotton hybrids at all growth stages as influenced by nutrient management practices

Treatment	Leaf area (dm^2 $plant^{-1}$)			Leaf area index (LAI)		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Hybrids (H)						
M_1-RCH-2 BG-I	23.99	78.55	123.36	0.44	1.45	2.28
M_2-Chiranjeevi BG-II	30.77	83.26	133.05	0.57	1.54	2.46
M_3- NHH-44 Non Bt	22.38	77.07	119.64	0.41	1.43	2.22
S.Em.±	0.24	0.71	0.37	0.00	0.01	0.01
C. D. (P=0.05)	0.94	2.81	1.44	0.02	0.05	0.03
Nutrient levels (N)						
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + 1% $MgSO_4$)	25.72	79.97	125.61	0.48	1.48	2.33
N_2-RDF+Foliar application with KNO_3	26.28	81.91	126.28	0.49	1.52	2.34
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	25.70	81.01	125.55	0.48	1.50	2.33
N_4-Absolute control	25.14	75.61	123.95	0.47	1.40	2.30
S.Em.±	0.29	1.03	0.37	0.01	0.02	0.01
C. D. (P=0.05)	0.85	3.07	1.11	0.02	0.06	0.02
Interaction (H×N)						
M_1N_1	23.69	78.64	124.16	0.44	1.46	2.30
M_1N_2	24.50	80.59	123.87	0.45	1.49	2.29
M_1N_3	24.13	79.80	123.82	0.45	1.48	2.29
M_1N_4	23.63	75.19	121.59	0.44	1.39	2.25
M_2N_1	30.89	83.37	133.34	0.57	1.54	2.47
M_2N_2	31.48	85.78	134.22	0.58	1.59	2.49
M_2N_3	30.59	85.32	132.85	0.57	1.58	2.46
M_2N_4	30.11	78.58	131.78	0.56	1.46	2.44
M_3N_1	22.57	77.89	119.35	0.42	1.44	2.21
M_3N_2	22.85	79.37	120.74	0.42	1.47	2.24
M_3N_3	22.39	77.92	119.99	0.41	1.44	2.22
M_3N_4	21.69	73.07	118.48	0.40	1.35	2.19
S.Em.±	0.49	1.79	0.65	0.01	0.03	0.01
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton	:	RCH-2
M_2 - BG-II Bt cotton	:	Chiranjeevi
M_3 - Non-Bt cotton	:	NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

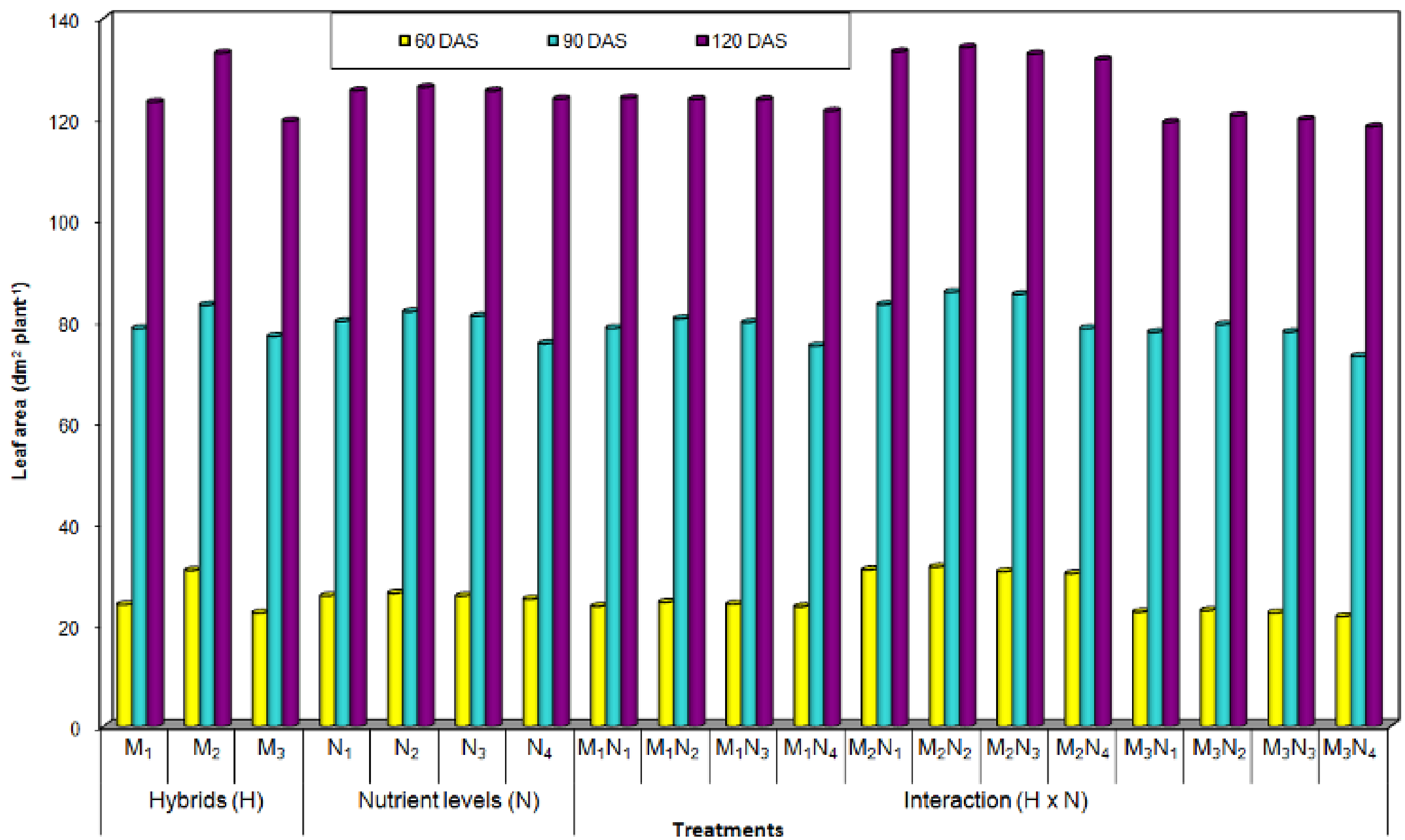


Fig. 5. Leaf area of different Bt and non-Bt cotton hybrids at all growth stages as influenced by nutrient management practices

Fig. 5. Leaf area of different Bt and non-Bt cotton hybrids at all growth stages as influenced by nutrient management practices

4.1.7 Leaf area duration (LAD)

The data on LAD of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 7.

The LAD increased from 60-90 DAS growth interval to 90-120 DAS growth interval. Genotypes differed significantly with respect to LAD at different growth intervals. Chiranjeevi BG-II Bt hybrid recorded higher LAD at 60-90 DAS growth interval to 90-120 DAS growth interval (31.68 and 60.09, respectively) followed by RCH-2 BG-I Bt hybrid at 60-90 DAS growth interval to 90-120 DAS growth interval (28.48 and 56.09, respectively). However, the lowest LAD was registered in NHH-44 non-Bt hybrid at 60-90 growth intervals to 90-120 DAS growth interval (27.62 and 54.64, respectively).

Among the different nutrient level treatments, significantly higher LAD was recorded in the application of nitrogen in seven splits with foliar application of KNO_3 at 60- 90 growth interval to 90-120 DAS (30.05 and 57.83, respectively) as compared to other nutrient levels. However, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer were at par to above treatments from 60-90 growth intervals to 90-120 DAS. The lowest LAD was recorded in absolute control from 60-90 growth intervals to 90-120 DAS (27.99 and 55.43, respectively).

Interaction effect was found non-significant on LAD among the treatment combinations.

4.2 Yield and yield components

4.2.1.1 Dry matter production in stem

Dry matter production in stem of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 8 and Fig. 6.

Higher Dry matter production in stem was registered significantly in Chiranjeevi BG-II Bt hybrid at 60, 90 and 120 DAS (49.88, 107.63 and 117.08 g plant^{-1}, respectively), followed by RCH-2 BG-I Bt hybrid at 60, 90 and 120 DAS (47.82, 102.35 and 112.22 g plant^{-1}, respectively). However, the lowest dry matter production in stem was recorded in NHH-44 non-Bt hybrid at 60, 90 and 120 DAS (44.99, 95.93 and 106.75 g plant^{-1}, respectively).

Among the different nutrient level treatments significantly higher dry matter production in stem was recorded in the application of nitrogen in seven splits with foliar application of KNO_3 at 60, 90 and 120 DAS (50.74, 109.36 and 116.33 g plant^{-1}, respectively) as compared to other nutrient levels. However, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer were at par to above treatments at 60 DAS (49.40 and 48.96 g plant^{-1}, respectively). But in 90 DAS the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par to above treatment (106.51). However, the lowest dry matter production in stem was recorded in absolute control at 60, 90 and 120 DAS (41.15, 88.38 and 103.84 g plant^{-1}, respectively).

Table 7: Leaf area duration (LAD) of different Bt cotton hybrids at all growth stages as influenced by nutrient management practices

Treatment	LAD	LAD
	60-90 DAS	90-120 DAS
Hybrids (H)		
M_1-RCH-2 BG-I	28.48	56.09
M_2-Chiranjeevi BG-II	31.68	60.09
M_3- NHH-44 Non Bt	27.62	54.64
S.Em.±	0.18	0.15
C. D. (P=0.05)	0.71	0.58
Nutrient levels (N)		
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + (1%) $MgSO_4$)	29.36	57.11
N_2-RDF+Foliar application with KNO_3	30.05	57.83
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	29.64	57.38
N_4-Absolute control	27.99	55.43
S.Em.±	0.28	0.31
C. D. (P=0.05)	0.82	0.93
Interaction (H×N)		
M_1N_1	28.43	56.33
M_1N_2	29.19	56.79
M_1N_3	28.87	56.56
M_1N_4	27.45	54.66
M_2N_1	31.74	60.20
M_2N_2	32.57	61.11
M_2N_3	32.20	60.60
M_2N_4	30.19	58.43
M_3N_1	27.91	54.79
M_3N_2	28.40	55.59
M_3N_3	27.86	54.97
M_3N_4	26.32	53.21
S.Em.±	0.48	0.54
C. D. (P=0.05)	NS	NS

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

Table 8. Dry matter production in stem and leaf of different Bt and non-Bt cotton hybrids at all growth stages as influenced by nutrient management practices

Treatment	Dry matter in stem (g plant^{-1})			Dry matter in leaf (g plant^{-1})		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Hybrids (H)						
M_1-RCH-2 BG-I	47.82	102.35	112.22	36.83	40.05	52.92
M_2-Chiranjeevi BG-II	49.88	107.63	117.08	37.34	42.80	56.60
M_3- NHH-44 Non Bt	44.99	95.93	106.75	32.80	38.89	50.78
S.Em.±	0.38	2.35	0.88	0.59	0.26	0.37
C. D. (P=0.05)	1.49	9.21	3.47	2.34	1.02	1.46
Nutrient levels (N)						
N_1-RDF (100:50:50 NPK kg ha^{1}+10t FYM + (1%) $MgSO_4$)	48.96	103.62	112.43	36.75	41.86	56.32
N_2-RDF+Foliar application with KNO_3	50.74	109.36	116.33	39.39	44.46	58.40
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	49.40	106.51	115.45	37.58	43.25	57.03
N_4-Absolute control	41.15	88.38	103.84	28.89	32.76	42.00
S.Em.±	0.75	1.59	0.85	0.36	0.52	0.71
C. D. (P=0.05)	2.22	4.73	2.53	1.07	1.55	2.11
Interaction (H×N)						
M_1N_1	49.19	104.95	113.24	37.90	41.52	55.30
M_1N_2	51.24	109.85	113.29	41.39	43.48	58.13
M_1N_3	49.45	106.88	112.71	38.40	42.57	56.53
M_1N_4	41.42	87.71	109.62	29.63	32.65	41.73
M_2N_1	51.67	109.34	118.58	39.15	44.93	60.03
M_2N_2	53.57	115.45	123.86	41.44	47.19	61.73
M_2N_3	53.05	112.85	122.45	40.15	45.63	60.75
M_2N_4	41.22	92.88	103.42	28.60	33.45	43.90
M_3N_1	46.02	96.58	105.45	33.20	39.13	53.62
M_3N_2	47.42	102.79	111.86	35.35	42.72	55.34
M_3N_3	45.69	99.81	111.19	34.20	41.53	53.81
M_3N_4	40.82	84.55	98.49	28.43	32.18	40.36
S.Em.±	1.29	2.76	1.48	0.62	0.90	1.23
C. D. (P=0.05)	NS	NS	4.39	1.86	NS	NS

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

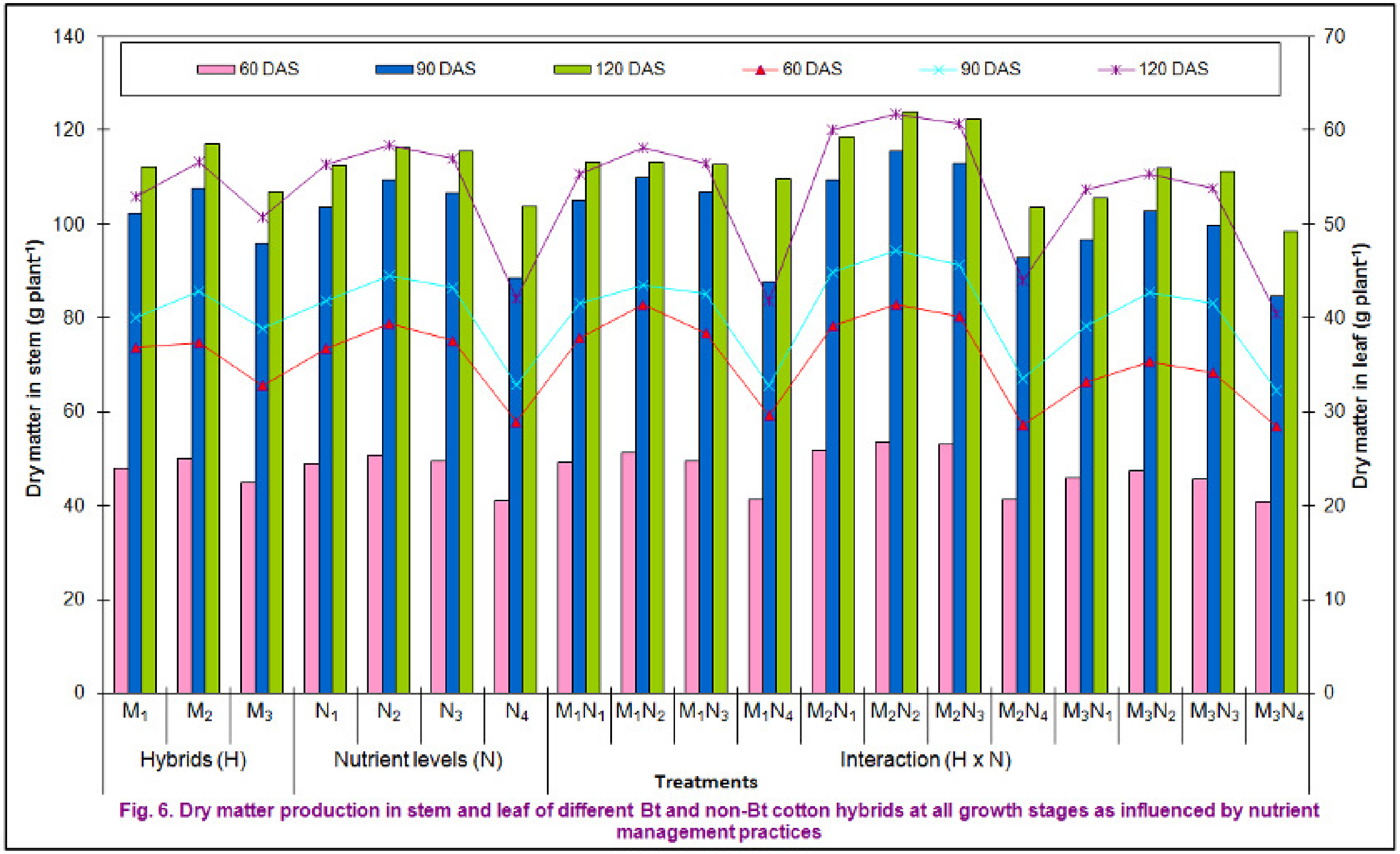


Fig. 6. Dry matter production in stem and leaf of different Bt and non-Bt cotton hybrids at all growth stages as influenced by nutrient management practices

In interaction there is no significant differences were observed between the treatment combinations at 60 and 90 DAS. However at 120 DAS higher dry matter production in stem was recorded in Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3.

4.2.1.2 Dry matter production in leaves

Dry matter production in leaves of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 8 and Fig. 6.

Higher Dry matter production in leaves was registered significantly in Chiranjeevi BG-II Bt hybrid at 60, 90 and 120 DAS (37.34, 42.80 and 56.60 g plant^{-1}, respectively) compared to other hybrids. However, RCH-2 BG-I Bt hybrid was on par with Chiranjeevi BG-II Bt hybrid at 60 DAS (36.83 g plant^{-1}). Lowest dry matter production in leaves was recorded significantly in NHH-44 non-Bt hybrid at 60, 90 and 120 DAS (32.80, 38.89 and 50.78 g plant^{-1}, respectively).

Application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher dry matter production in leaves at 60, 90 and 120 DAS (39.39, 44.46 and 58.40 g plant^{-1}, respectively) and the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par at 90 DAS and 120 DAS (43.25 and 57.03 g plant^{-1}, respectively) and application of recommended dose of fertilizer were at par with above treatment at 120 DAS (56.32 g plant^{-1}). The lowest dry matter production in leaves was recorded in absolute control at 60, 90 and 120 DAS (28.89, 32.76 and 42.00 g plant^{-1}, respectively).

In interaction no significant difference was observed between the treatment combinations at 90 and 120 DAS. However, in 60 DAS, higher dry matter production in leaves was recorded in Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3. However, RCH-2 BG-I Bt hybrid was on par to the same treatment. In Chiranjeevi BG-II Bt hybrid with the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par to above treatment at 60 DAS.

4.2.1.3 Dry matter production in reproductive parts

Dry matter production in reproductive parts of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 9 and Fig. 7.

Higher dry matter production in reproductive parts was recorded significantly in Chiranjeevi BG-II Bt hybrid at 90 and 120 DAS (56.17 and 74.55 g plant^{-1}, respectively) compared to other hybrids followed by RCH-2 BG-I Bt hybrid at 90 and 120 DAS (52.13 and 70.21 g plant^{-1}, respectively). The lowest dry matter production in reproductive parts was recorded in NHH-44 non-Bt hybrid at 90 and 120 DAS (50.1 and 65.59 g plant^{-1}, respectively).

Application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher dry matter production in reproductive parts at 90 and 120 DAS (57.86 and 74.33 g plant^{-1}, respectively) compared to other treatments. However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par to above treatment at 90 DAS and 120 DAS.

Table 9. Dry matter production in reproductive parts and total dry matter production of different Bt and non-Bt cotton hybrids at 60, 90 and 120 DAS as influenced by nutrient management practices

Treatment	Dry matter in reproductive parts (g plant^{-1})		Total dry matter production (g plant^{-1})		
	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Hybrids (H)					
M_1-RCH-2 BG-I	52.13	70.21	84.65	194.53	235.35
M_2-Chiranjeevi BG-II	56.17	74.55	87.22	206.60	248.23
M_3- NHH-44 Non Bt	50.01	65.59	77.78	184.83	223.12
S.Em.±	0.97	1.04	0.89	2.28	1.71
C. D. (P=0.05)	3.79	4.09	3.48	8.97	6.71
Nutrient levels (N)					
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM+ (1%) $MgSO_4$)	54.70	72.33	85.71	200.19	241.07
N_2-RDF+Foliar application with KNO_3	57.86	74.33	90.14	211.68	249.07
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	56.45	73.59	86.98	206.21	246.07
N_4-Absolute control	42.07	60.21	70.04	163.21	206.05
S.Em.±	0.82	0.92	0.87	2.22	1.45
C. D. (P=0.05)	2.44	2.75	2.57	6.58	4.29
Interaction (H×N)					
M_1N_1	52.42	72.93	87.09	198.88	241.47
M_1N_2	58.14	73.73	92.64	211.46	245.15
M_1N_3	56.10	73.06	87.85	205.56	242.30
M_1N_4	41.88	61.13	71.05	162.23	212.48
M_2N_1	59.29	76.69	90.82	213.56	255.30
M_2N_2	62.23	80.13	95.01	224.87	265.72
M_2N_3	60.33	78.57	93.20	218.81	261.77
M_2N_4	42.84	62.80	69.82	169.17	210.12
M_3N_1	52.40	67.37	79.22	188.12	226.45
M_3N_2	53.20	69.14	82.77	198.71	236.34
M_3N_3	52.92	69.14	79.89	194.25	234.14
M_3N_4	41.51	56.70	69.25	158.24	195.55
S.Em.±	1.42	1.60	1.50	3.84	2.50
C. D. (P=0.05)	NS	NS	4.46	NS	7.44

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

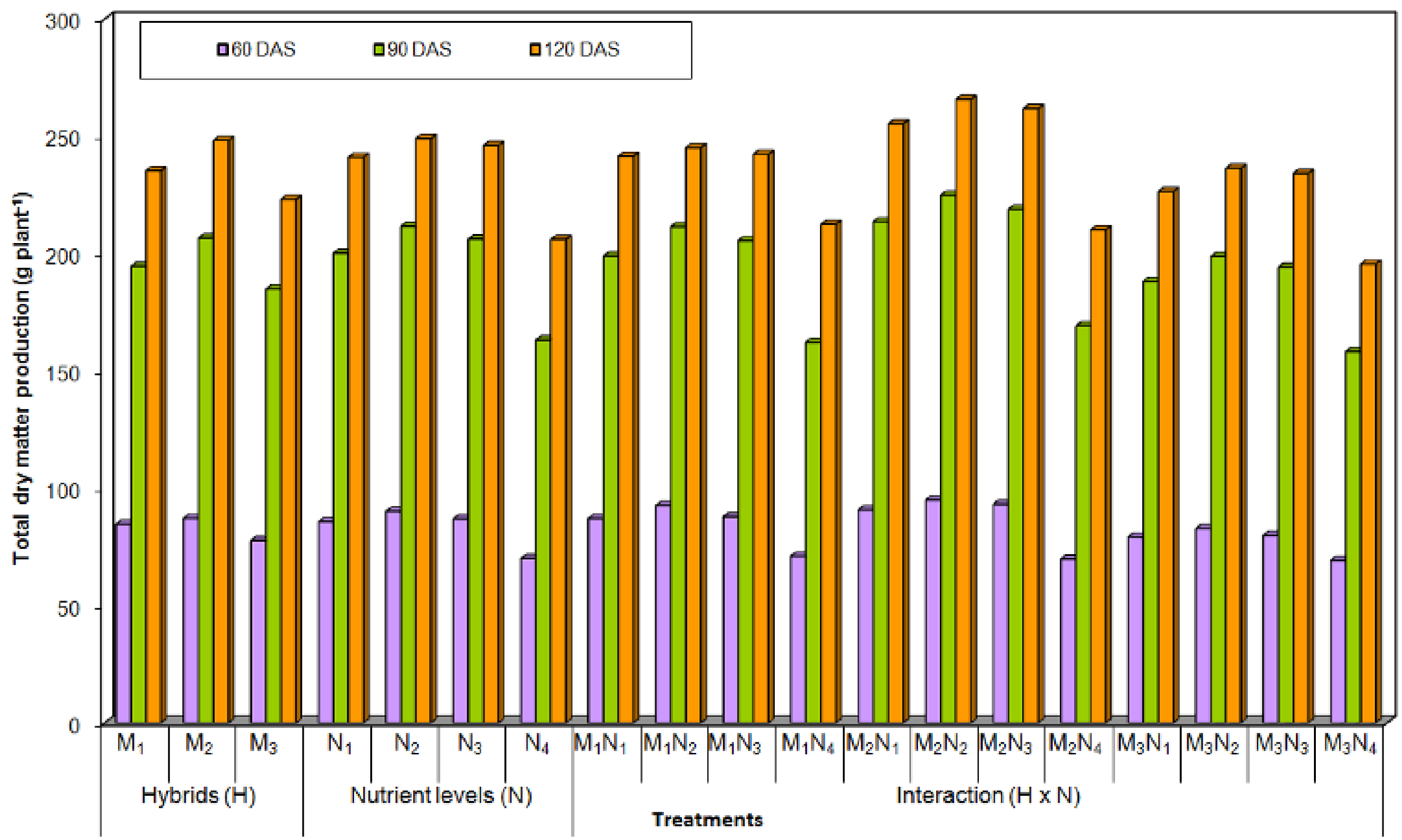


Fig. 7. Dry matter production in reproductive parts of different Bt and non-Bt cotton hybrids at 60, 90 and 120 DAS as influenced by nutrient management practices

Fig. 7. Dry matter production in reproductive parts of different Bt and non-Bt cotton hybrids at 60, 90 and 120 DAS as influenced by nutrient management practices

The application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer were on par to above treatment at 120 DAS (73.59 and 72.33 g plant^{-1}, respectively). The lowest dry matter production in reproductive parts was registered in absolute control at 90 and 120 DAS (42.07 and 60.21 g plant^{-1}, respectively).

Interaction was found non-significant on dry matter production in reproductive parts among the treatment combinations.

4.2.1.4 Total dry matter production

Total dry matter production of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients is presented in Table 9.

Significantly higher total dry matter production was registered in Chiranjeevi BG-II Bt hybrid at 60, 90 and 120 DAS (87.22, 206.60 and 248.23 g plant^{-1}, respectively). However, RCH-2 BG-I Bt hybrid was on par at 60 DAS (84.66 g plant^{-1}) with Chiranjeevi BG-II Bt hybrid (87.22 g plant^{-1}). The lowest total dry matter production was recorded in NHH-44 non-Bt hybrid at 60, 90 and 120 DAS (77.78, 184.83 and 223.12 g plant^{-1}, respectively).

Application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher total dry matter production at 60, 90 and 120 DAS (90.14, 211.68 and 249.07 g plant^{-1}, respectively) compared to other treatments. However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par to above treatment at 60, 90 and 120 DAS (86.98, 206.21 and 246.07 g plant^{-1}, respectively). The lowest total dry matter production was registered in absolute control at 60, 90 and 120 DAS (70.04, 163.21 and 206.05 g plant^{-1}, respectively).

In interaction significant difference was observed between the treatment combinations at 60 and 120 DAS. Total dry matter production was higher in Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3. The lowest total dry matter production was recorded in NHH-44 non-Bt hybrid in absolute control treatment.

4.2.1.5 Total number of bolls per plant

Total number of bolls per plant of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 10 and Fig. 8.

Among the different genotypes Chiranjeevi BG-II Bt was recorded significantly higher total number of bolls per plant (32.15) compared to other genotypes followed by RCH-2 BG-I Bt hybrid (30.96). The lowest total bolls per plant were recorded in NHH-44 non-Bt genotype (28.75).

The application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher total bolls per plant (32.23) compared to other nutrient levels, followed by the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was (31.58). However, the lowest bolls per plant were recorded in absolute control (28.23).

Table 10. Yield parameters of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Treatment	Total bolls per plant	Mean boll weight (g/boll)	Good opened bolls per plant	Bad opened bolls per plant
Hybrids (H)				
M_1-RCH-2 BG-I	33.96	4.27	28.86	2.10
M_2-Chiranjeevi BG-II	32.15	5.00	30.07	2.08
M_3- NHH-44 Non Bt	29.75	3.85	26.12	2.63
S.Em.±	0.20	0.01	0.15	0.07
C. D. (P=0.05)	0.78	0.04	0.57	0.27
Nutrient levels (N)				
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + (1%) $MgSO_4$)	30.98	4.69	28.71	2.27
N_2-RDF+Foliar application with KNO_3	32.23	5.11	29.85	2.38
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (%) soil and foliar application	30.58	4.71	28.90	2.29
N_4-Absolute control	28.23	2.98	25.94	2.15
S.Em.±	0.19	0.06	0.29	0.12
C. D. (P=0.05)	0.58	0.17	0.87	NS
Interaction (H×N)				
M_1N_1	29.10	4.40	28.65	0.37
M_1N_2	32.52	5.07	30.63	1.89
M_1N_3	31.87	4.73	29.68	2.19
M_1N_4	28.55	2.87	26.48	2.07
M_2N_1	31.88	5.53	29.54	2.27
M_2N_2	33.93	5.73	31.86	2.07
M_2N_3	33.12	5.40	31.02	2.10
M_2N_4	29.96	3.33	27.87	2.09
M_3N_1	29.99	4.13	27.93	2.06
M_3N_2	29.99	4.53	27.07	2.83
M_3N_3	28.83	4.00	26.00	2.83
M_3N_4	26.59	2.73	23.47	2.72
S.Em.±	0.34	0.10	0.51	2.13
C. D. (P=0.05)	1.00	0.30	1.51	NS

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton	:	RCH-2
M_2 - BG-II Bt cotton	:	Chiranjeevi
M_3 - Non-Bt cotton	:	NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

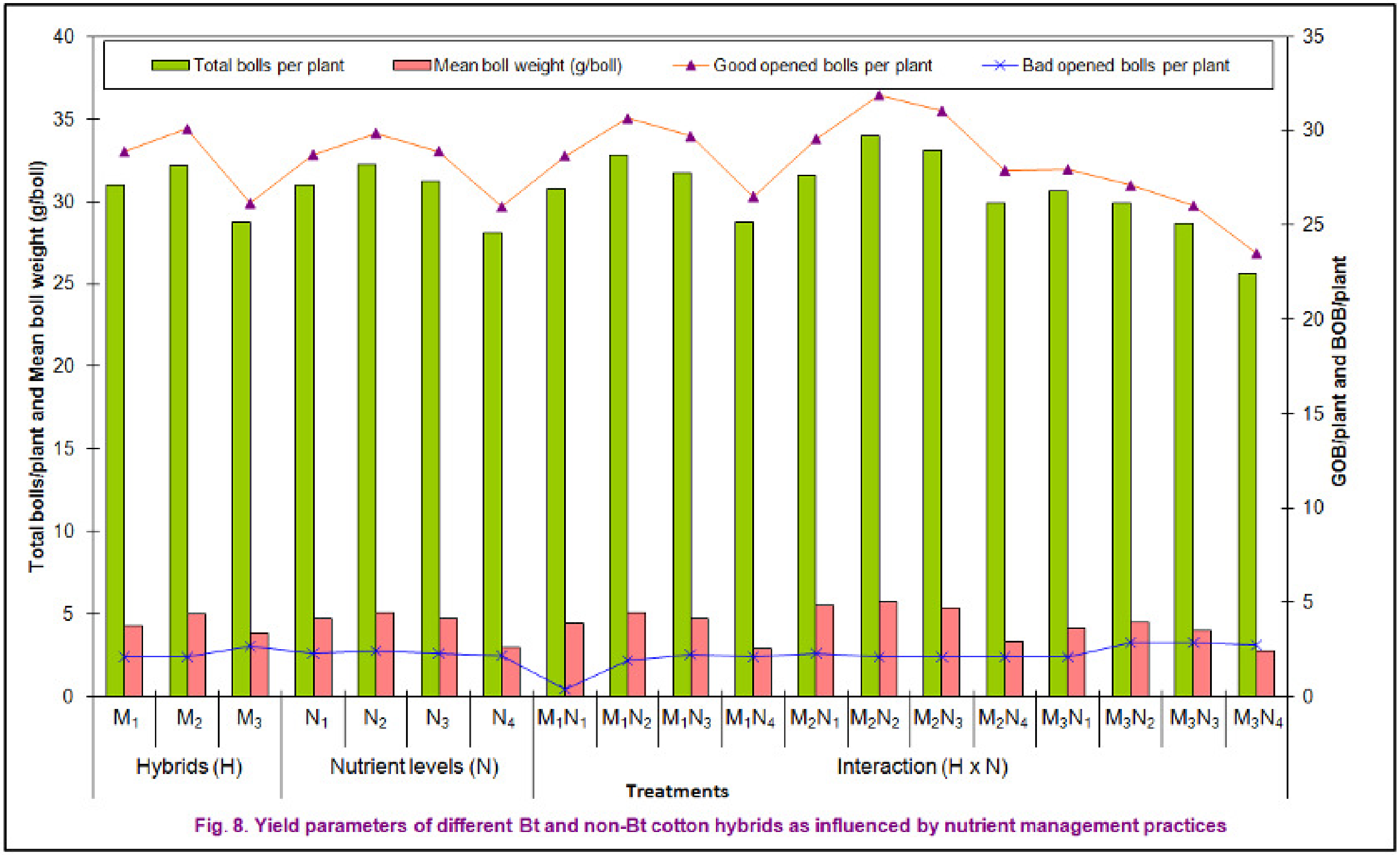


Fig. 8. Yield parameters of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

In interaction among the different treatment combinations, RCH-2 BG-I Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher total bolls per plant. The lowest total bolls per plant were recorded in NHH-44 non-Bt hybrid in control treatment.

4.2.1.6 Mean boll weight (g)

Mean boll weight of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 10 and Fig. 8.

Among the different genotypes Chiranjeevi BG-II Bt was recorded significantly higher mean boll weight (5.00) compared to other genotypes followed by RCH-2 Bt BG-I (4.27). The lowest mean boll weight was recorded in NHH-44 non-Bt genotype (3.85).

The application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher mean boll weight (5.11) followed by the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was (4.71). However, the lowest mean boll weight was recorded in absolute control (2.98).

In interaction among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher mean boll weight. The lowest mean boll weight was recorded in NHH-44 non-Bt hybrid in control treatment.

4.2.1.7 Number of good opened bolls per plant

Number of good opened bolls per plant of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 10 and Fig. 8.

Among the different genotypes, Chiranjeevi BG-II Bt hybrid recorded significantly higher good opened bolls per plant (30.07) compared to other genotypes followed by RCH-2 BG-I Bt hybrid (28.86). The lowest number of good opened bolls per plant were recorded in NHH-44 non-Bt genotype (26.12).

Application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher number of good opened bolls per plant (29.85) followed by the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was (28.90). However, the lowest good opened bolls per plant (25.94) were recorded in absolute control.

In interaction among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher number of good opened bolls per plant. However, the lowest number of good opened bolls per plant were recorded in NHH-44 non-Bt hybrid in control treatment.

4.2.1.8 Number of bad opened bolls per plant

Number of bad opened bolls per plant of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 10 and Fig. 8.

Table 11: Seed cotton yield, seed cotton yield, stalk yield and harvest index of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Treatment	Seed cotton yield (g plant^{-1})	Seed cotton yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	Harvest index
Hybrids (H)				
M_1-RCH-2 BG-I	419.05	1395.14	3130.28	29.25
M_2-Chiranjeevi BG-II	506.94	1693.49	3245.42	32.37
M_3- NHH-44 Non Bt	275.79	917.48	2696.80	24.86
S.Em.±	3.57	14.26	41.36	0.48
C. D. (P=0.05)	14.02	55.98	162.41	1.90
Nutrient levels (N)				
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM +(1%)$MgSO_4$)	382.41	1435.92	3248.45	30.16
N_2-RDF+Foliar application with KNO_3	494.84	1847.44	3544.71	33.66
N_3-RDF+19:19:19 (0.5%) +$MgSO_4$ (1 %) soil and foliar application	420.50	1567.22	3387.98	31.05
N_4-Absolute control	304.63	490.89	1915.53	20.42
S.Em.±	4.13	20.58	51.62	0.62
C. D. (P=0.05)	12.28	61.16	153.36	1.86
Interaction (H×N)				
M_1N_1	400.40	1482.95	3380.48	30.52
M_1N_2	530.16	1963.55	3726.81	34.51
M_1N_3	447.22	1656.38	3432.96	32.55
M_1N_4	298.41	477.66	1980.88	19.42
M_2N_1	484.13	1851.85	3502.59	34.60
M_2N_2	628.57	2372.13	3761.93	38.75
M_2N_3	538.49	2023.81	3730.16	35.20
M_2N_4	376.59	526.16	1986.98	20.92
M_3N_1	262.70	972.96	2862.28	25.37
M_3N_2	325.79	1206.64	3145.38	27.74
M_3N_3	275.79	1021.46	3000.81	25.39
M_3N_4	238.89	468.84	1778.72	20.92
S.Em.±	7.16	35.65	89.40	1.08
C. D. (P=0.05)	21.27	105.93	265.63	3.21

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton	:	RCH-2
M_2 - BG-II Bt cotton	:	Chiranjeevi
M_3 - Non-Bt cotton	:	NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

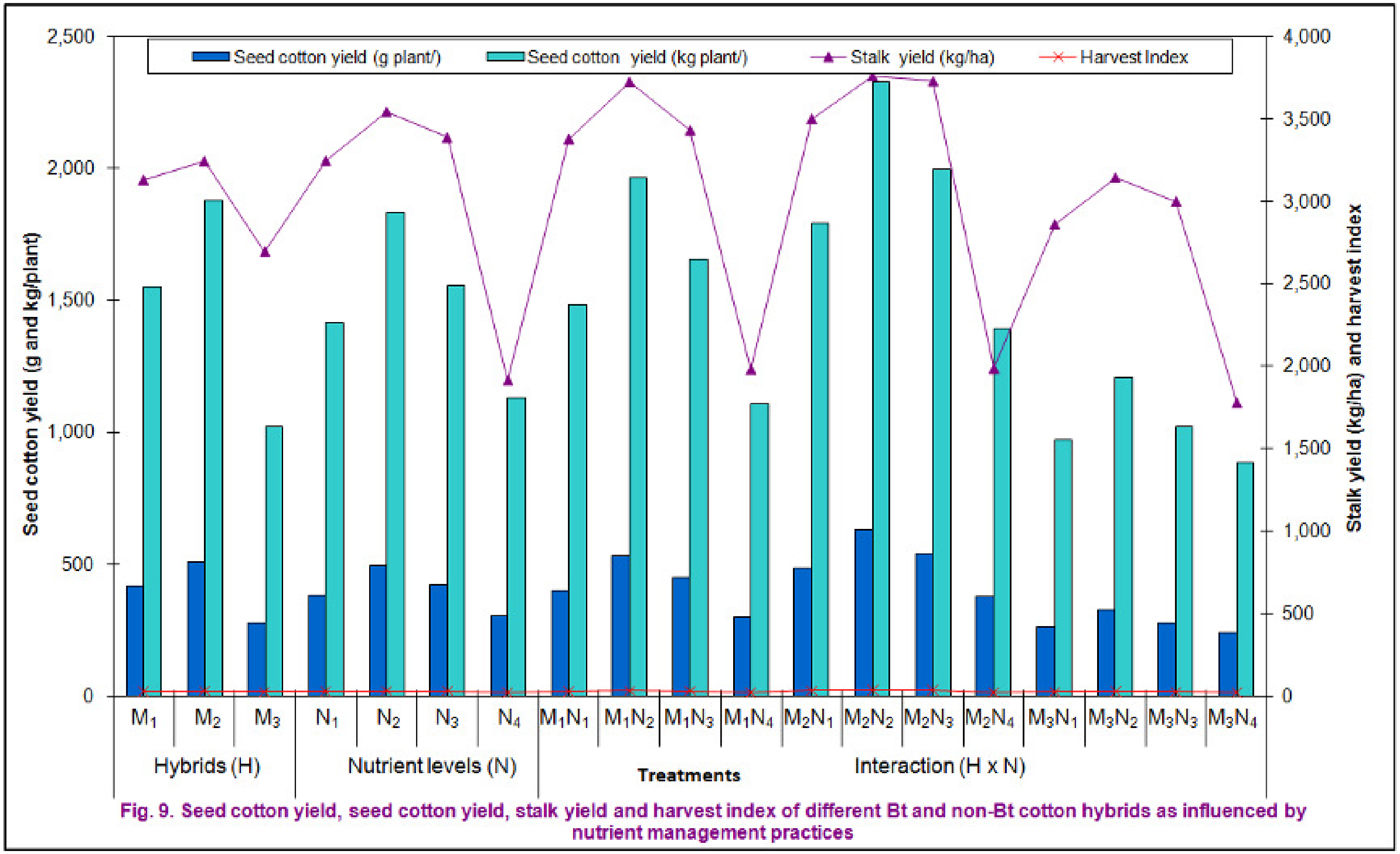


Fig. 9. Seed cotton yield, seed cotton yield, stalk yield and harvest index of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Among the different genotypes NHH-44 non-Bt hybrid registered significantly higher number of bad opened bolls per plant (2.63) compared to other genotypes.

Number of bad opened bolls per plant was found non-significant among the nutrient levels with respect to interaction effect.

4.2.1.9 Seed cotton yield

Seed cotton yield per plant of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 11 and Fig. 9.

Among the different genotypes, Chiranjeevi BG-II Bt hybrid recorded significantly higher seed cotton yield per plant (506.94 g) compared to other genotypes and was followed by RCH-2 BG-I Bt hybrid (419.05 g). The lowest seed cotton yield per plant was recorded in NHH-44 non-Bt genotype (275.79 g).

The application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher seed cotton yield per plant (494.84 g) compared to other nutrient levels. Next best treatment, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded (420.50 g). The lowest seed cotton yield per plant was recorded (304.63 g) in absolute control treatment.

Seed cotton yield per plant of Bt cotton hybrids and nutrient levels was found significant on seed cotton yield per plant. Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher seed cotton yield per plant. The lowest seed cotton yield per plant was recorded in NHH-44 non-Bt hybrid in absolute control treatment.

4.2.1.10 Seed cotton yield

Seed cotton yield of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 11 and Fig. 9.

Among the different genotypes Chiranjeevi BG-II Bt hybrid was recorded significantly higher seed cotton yield (1693 kg ha^{-1}) compared to other genotypes followed by RCH-2 BG-I Bt hybrid (1395 kg ha^{-1}). The lowest seed cotton yield was recorded in NHH-44 non-Bt genotype (917 kg ha^{-1}).

Application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher seed cotton yield (1847 kg ha^{-1}) compared to other nutrient levels. Next best treatment, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was recorded (1567 kg ha^{-1}). The lowest seed cotton yield was recorded in absolute control treatment (490 kg ha^{-1}).

Seed cotton yield of Bt cotton hybrids and nutrient levels was found significant on seed cotton yield. Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher seed cotton yield. The lowest seed cotton yield was recorded in NHH-44 non-Bt hybrid in absolute control treatment.

4.2.1.11 Stalk yield

Stalk yield of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 11 and Fig. 9.

Chiranjeevi BG-II Bt hybrid recorded significantly higher stalk yield (3,245 kg ha^{-1}). However, it was on par with RCH-2 BG-I Bt hybrid (3,130 kg ha^{-1}). Whereas, NHH-44 non-Bt registered significantly lower stalk yield (2,696 kg ha^{-1}).

Stalk yield differed significantly due to application of nutrients; Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher stalk yield (3,544 kg ha^{-1}) compared to other nutrient levels. However, the next best treatment was application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ (3,387 kg ha^{-1}). The lowest stalk yield was recorded in absolute control (1,915 kg ha^{-1}).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher stalk yield. The lowest stalk yield was recorded NHH-44 non-Bt hybrid in absolute control.

4.2.1.12 Harvest index (%)

Harvest index of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 11 and Fig. 9.

Chiranjeevi BG-II Bt hybrid recorded significantly higher harvest index (32.37) compared to other genotypes. However, NHH-44 non-Bt registered significantly lower harvest index (24.86) among the genotypes.

Harvest index differed significantly due to application of nutrients. Among the treatments application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher harvest index (33.66) compared to other nutrient levels. However, next best treatment was the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ (31.05). The lowest harvest index was recorded in absolute control (20.42).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid recorded significantly higher harvest index with application of nitrogen in seven splits and foliar application of KNO_3.

4.2.2 Quality parameters

4.2.2.1 Ginning out turn (%)

Ginning out turn (GOT) of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 12 and Fig. 10.

Data indicated that significantly higher GOT was recorded with Chiranjeevi BG-II Bt hybrid (34.50) as compared to other hybrids, However, lower GOT was recorded with NHH-44 non-Bt hybrid (31.52).

Table 12. Quality parameters of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Treatment	GOT (%)	Fibre length (mm)	Fibre strength (g/tax)	Uniformity ratio	Micronnaire (μg inch^{-1})
Hybrids (H)					
M_1-RCH-2 BG-I	33.02	31.51	20.61	49.47	4.35
M_2-Chiranjeevi BG-II	34.50	29.55	21.21	51.46	4.61
M_3- NHH-44 Non Bt	31.52	28.80	21.11	50.16	4.37
S.Em.±	0.23	0.10	0.05	0.17	0.04
C. D. (P=0.05)	0.89	0.40	0.22	0.66	0.17
Nutrient levels (N)					
N_1-RDF (100:50:50 NPK kg ha^{-1} +10 t FYM + 1% $MgSO_4$	32.82	29.84	21.03	50.21	4.44
N_2-RDF+Foliar application with KNO_3	33.34	30.16	21.11	50.71	4.64
N_3-RDF+19:19:19 (0.5%)+ $MgSO_4$ (1 %) soil and foliar application	33.22	30.11	21.09	50.54	4.54
N_4-Absolute control	32.67	29.70	20.66	49.99	4.15
S.Em.±	0.18	0.10	0.05	0.21	0.05
C. D. (P=0.05)	0.52	0.30	0.14	NS	0.14
Interaction (H×N)					
M_1N_1	32.86	31.40	20.66	20.62	4.28
M_1N_2	33.61	31.79	20.83	49.32	4.55
M_1N_3	32.95	31.57	20.75	49.72	4.41
M_1N_4	32.68	31.26	20.20	49.66	4.14
M_2N_1	34.06	29.50	21.31	49.18	4.64
M_2N_2	34.50	29.81	21.22	51.30	4.83
M_2N_3	34.92	29.78	21.22	51.80	4.76
M_2N_4	34.51	29.12	21.08	51.59	4.22
M_3N_1	31.55	28.61	21.12	51.14	4.40
M_3N_2	31.92	28.87	21.30	50.02	4.54
M_3N_3	31.78	28.98	21.31	50.59	4.45
M_3N_4	30.82	28.72	20.69	50.37	4.09
S.Em.±	0.30	0.18	0.08	49.64	0.08
C. D. (P=0.05)	NS	NS	0.24	NS	NS

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

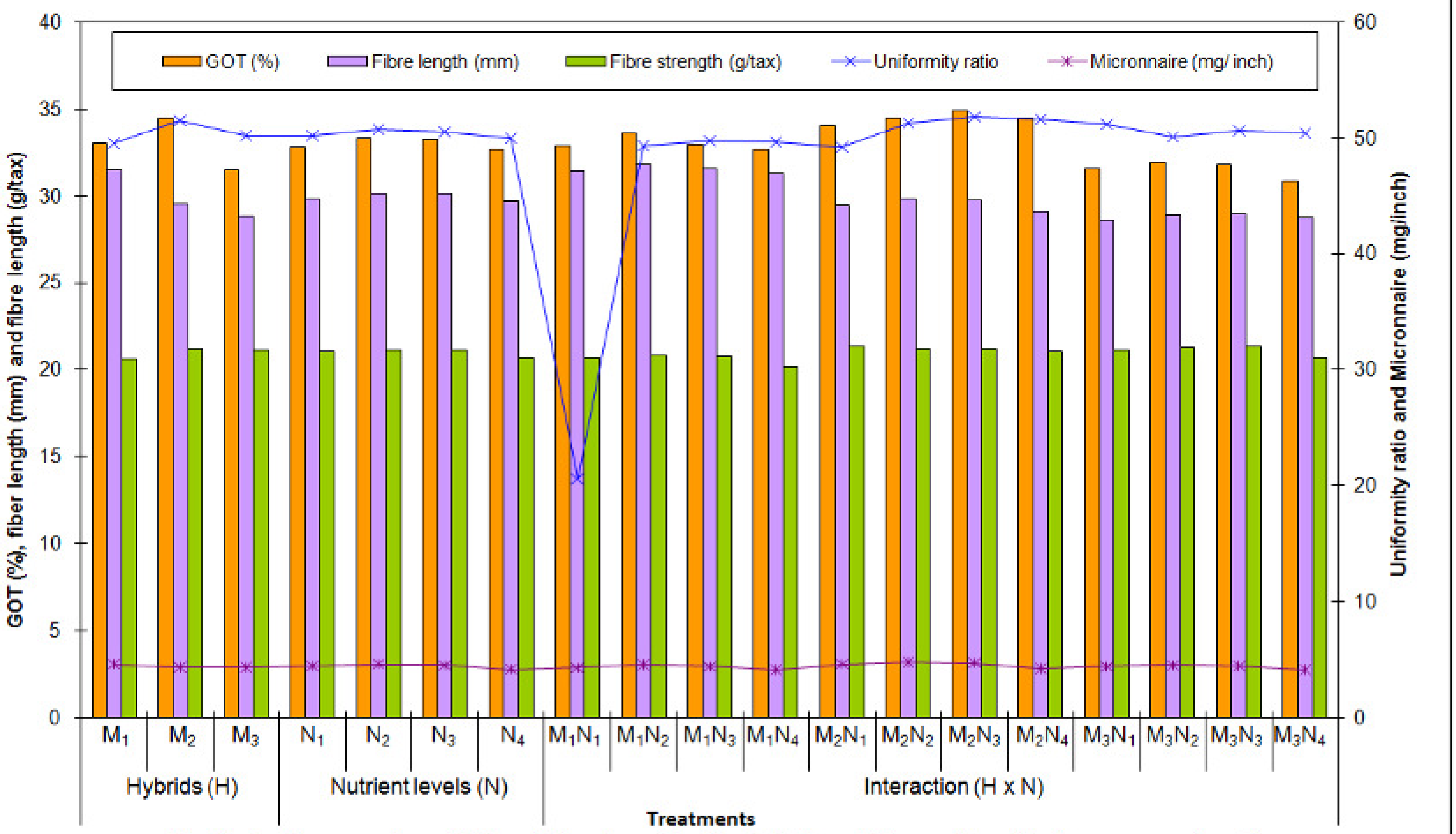


Fig. 10. Quality parameters of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Fig. 10. Quality parameters of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Ginning out turn differed significantly due to application of nutrients; Among the treatments application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher ginning out turn (33.34) compared to other nutrient levels. However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was at par (33.22). The lowest ginning out turn was recorded in absolute control (32.67).

Interaction was found non-significant on ginning out turn among the treatment combinations.

4.2.2.2 Fibre length (mm)

Fibre length of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 12 and Fig. 10.

RCH-2 BG-I Bt hybrid recorded significantly higher fibre length (31.51) compared to other genotypes. However, NH-44 non-Bt registered significantly lower fibre length (28.80) among the genotypes.

Fibre length differed significantly due to application of nutrients; among the treatments, the application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher fibre length (30.16) compared to other nutrient levels. However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was at par (30.11). The lowest fibre length was recorded in absolute control (29.70).

Interaction was found non-significant on fibre length among the different treatment combinations.

4.2.2.3 Fibre strength

Fibre strength of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 12 and Fig. 10.

Chiranjeevi BG-II Bt hybrid recorded significantly higher fibre strength (21.21 g tax^{-1}). However, NHH-44 non-Bt was on par (21.11 g tax^{-1}). The lowest fibre strength was recorded RCH-2 BG-I Bt hybrid (20.61 g tax^{-1}).

Fibre strength differed significantly due to application of nutrients; among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher fibre strength (21.11 g tax^{-1}). However, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and the application of recommended dose of fertilizer were on par (21.09 and 21.03 g tax^{-1}, respectively). The lowest fibre strength was recorded in absolute control (20.66 g tax^{-1}).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of recommended dose of fertilizer recorded higher fibre strength. However, application of nitrogen in seven splits with foliar application of KNO_3 and the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ were at par to above treatment combination.

4.2.2.4 Uniformity ratio (%)

Uniformity ratio of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 12 and Fig. 10.

Chiranjeevi BG-II Bt hybrid recorded significantly higher uniformity ratio (51.46). However, NHH-44 non-Bt hybrid was at par (50.16). The lowest uniformity ratio was recorded in RCH-2 BG-I Bt hybrid (49.47).

In interaction there is no significant difference was observed on uniformity ratio with respect to nutrient level.

4.2.2.5 Micronnaire value (µg $inch^{-1}$)

Micronnaire value of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 12 and Fig. 10.

Chiranjeevi BG-II Bt hybrid recorded significantly higher micronnaire value (4.61) followed by NHH-44 non-Bt hybrid (4.37). And lowest micronnaire value was recorded in RCH-2 BG-I Bt hybrid (4.35).

Micronnaire value differed significantly due to application of nutrients; among the treatments, the application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher micronnaire value (4.64). However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was at par (4.54). Lowest micronnaire value was recorded in absolute control (4.15).

Micronnaire value on interaction was found non-significant among the different treatment combinations.

4.2.3 *Cry* protein expression

4.2.3.1 *Cry1Ac* protein content (µg g^{-1} fresh weight)

Cry1Ac protein content of different Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 13 and Fig. 11.

There was no significant difference with respect to *Cry1Ac* protein content at 90 and 120 DAS among different Bt cotton varieties.

Cry1Ac protein content differed significantly due to application of nutrients: Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher *Cry1Ac* protein content at 90 and 120 DAS (1.26 and 0.97, respectively). However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and the application of recommended dose of fertilizer was on par at 90 and 120 DAS (1.25, 1.23, 0.94 and 0.95, respectively). Lower *Cry1Ac* protein content was registered at 90 and 120 DAS in absolute control (1.06 and 0.86, respectively).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits with foliar application of KNO_3 was recorded higher *Cry1Ac* protein compared to other combinations.

Table 13. ***Cry1Ac*** **protein content at 90 and 120 DAS of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices**

Treatment	Cry1Ac protein ($\mu g\ g^{-1}$ fresh weight)	
	90 DAS	**120 DAS**
Hybrids (H)		
M_1-RCH-2 BG-I Bt	1.17	0.93
M_2-Chiranjeevi BG-II Bt	1.23	0.93
S.Em.±	0.011	0.009
C. D. (P=0.05)	NS	NS
Nutrient levels (N)		
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + (1%) $MgSO_4$)	1.23	0.95
N_2-RDF+Foliar application with KNO_3	1.26	0.97
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	1.25	0.94
N_4-Absolute control	1.06	0.86
S.Em.±	0.012	0.011
C. D. (P=0.05)	0.04	0.03
Interaction (H×N)		
M_1N_1	1.20	0.96
M_1N_2	1.25	0.97
M_1N_3	1.23	0.96
M_1N_4	1.00	0.83
M_2N_1	1.25	0.93
M_2N_2	1.28	0.97
M_2N_3	1.27	0.92
M_2N_4	1.12	0.90
S.Em.±	0.017	0.016
C. D. (P=0.05)	0.05	0.04

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

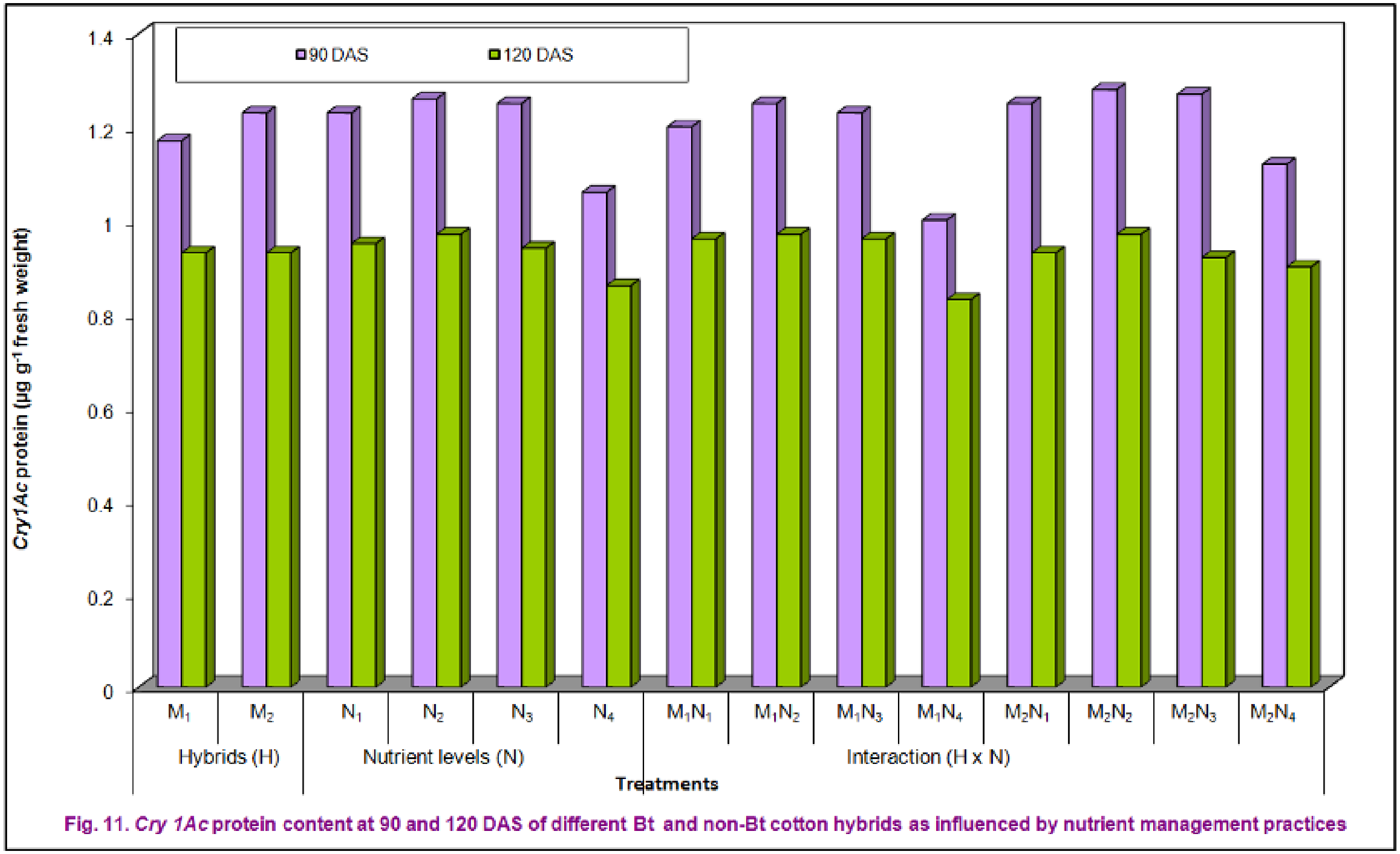


Fig. 11. ***Cry 1Ac*** **protein content at 90 and 120 DAS of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices**

4.2.3.2 *Cry 2Ab* protein content

Cry 2Ab protein content of Chiranjeevi BG-II Bt cotton hybrid as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 14 and Fig. 12.

Among the nutrient levels application of nitrogen in seven splits with foliar application of KNO_3 recorded nine per cent increase in *Cry 2Ab* protein content at 90 and 120 DAS compared to absolute control.

4.2.4 Soil enzyme activity

4.2.4.1 Dehydrogenase activity (µ TPF g soil d^{-1})

Dehydrogenase activity in soils of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 15 and Fig. 13.

In rhizosphere soil, irrespective of treatments dehydrogenase activity increased with increasing crop growth, reached peak at 90 DAS. Subsequently decline in dehydrogenase activity was observed.

Among the genotypes there was no significant effect on dehydrogenase activity at 90 and 120 DAS observed.

Dehydrogenase activity differed significantly due to application of nutrients; among the treatments, the application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher dehydrogenase activity at 90 and 120 DAS (8.96 and 4.82, respectively). However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and the application of recommended dose of fertilizer was at par at 90 DAS (8.65 and 8.34, respectively). However, at 120 DAS, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was at par (4.56) recorded. Lower dehydrogenase activity was recorded at 90 and 120 DAS in absolute control (6.80 and 3.48, respectively).

Among the different treatment combinations the interaction effect was found non-significant on dehydrogenase activity at 90 and 120 DAS.

4.2.4.2 Urease activity (µg NH_4^+ N g^{-1} soil d^{-1})

Urease activity in soils of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 15 and Fig. 13.

In rhizosphere soil higher urease activity was noticed at initial crop growth stages and declining trend was observed in subsequent growth stages.

Among the genotypes there was no significant effect on urease activity at 90 and 120 DAS.

Urease activity differed significantly due to application of nutrients; among the treatments, the application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher urease activity at 90 and 120 DAS (23.16 and 18.55, respectively). However, it was on par with the application of recommended dose of fertilizer at 90 DAS (23.01).

Table 14. *Cry2Ab* protein content at 90 and 120 DAS of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Treatment	Cry 2Ab protein content ($\mu g\ g^{-1}$ fresh weight)	
	90 DAS	120 DAS
M_2N_1	20.76	18.32
M_2N_2	21.02	18.78
M_2N_3	20.71	18.40
M_2N_4	18.97	16.96

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

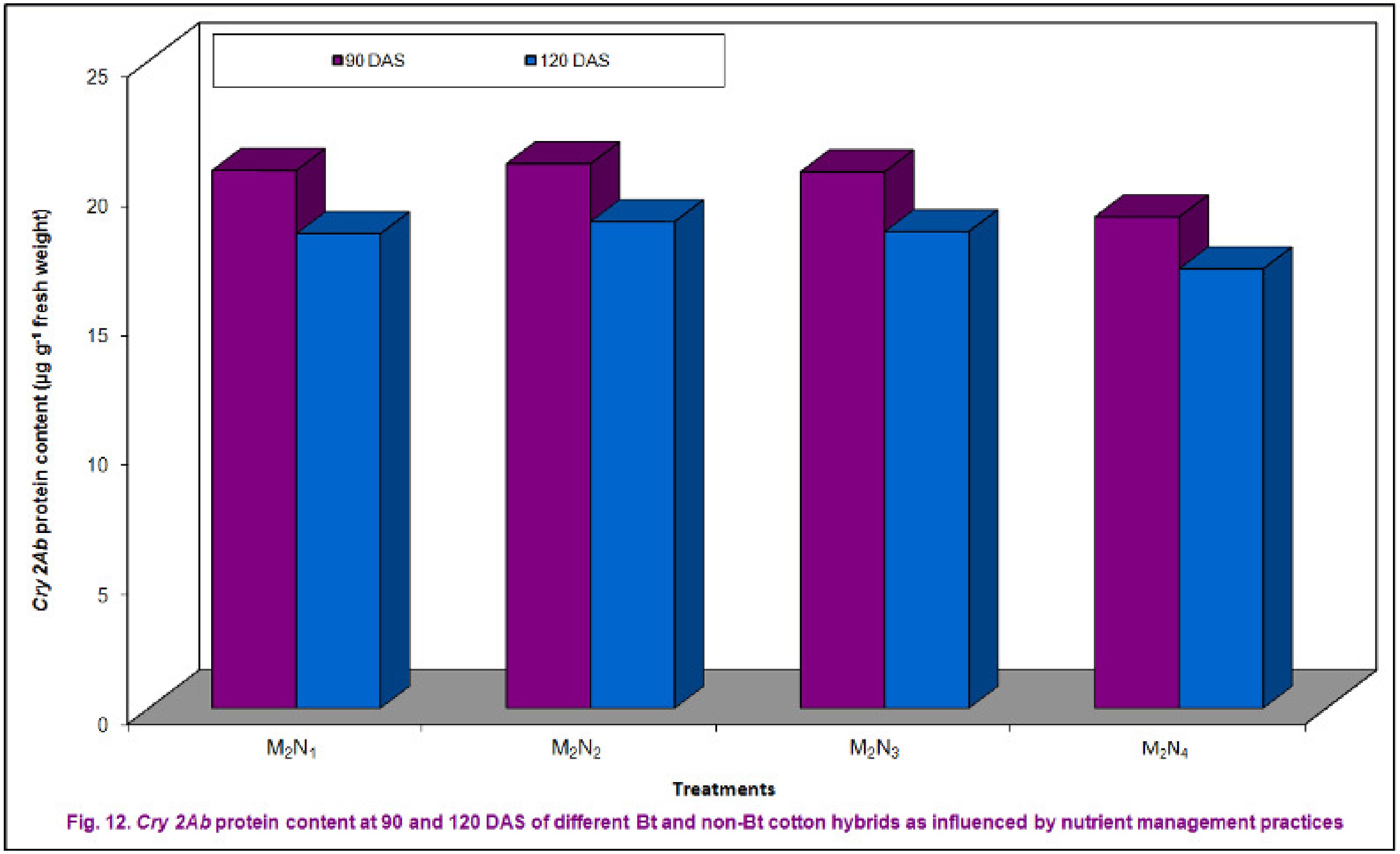


Fig. 12. ***Cry 2Ab*** **protein content at 90 and 120 DAS of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices**

Table 15: Dehydrogenase activity and urease activity of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

Treatment	Dehydrogenase activity (µg TPF g^{-1} soil d^{-1})		Urease activity (µg NH_4^+ N g^{-1} soil d^{-1})	
	90 DAS	120 DAS	90 DAS	120 DAS
Hybrids (H)				
M_1-RCH-2 BG-I	8.12	4.26	22.04	17.20
M_2-Chiranjeevi BG-II	8.29	4.36	22.25	18.42
M_3- NHH-44 Non Bt	8.16	4.30	21.60	17.23
S.Em.±	0.20	0.07	0.23	0.34
C. D. (P=0.05)	NS	NS	NS	NS
Nutrient levels (N)				
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + (1%) $MgSO_4$	8.34	4.38	23.01	17.80
N_2-RDF+Foliar application with KNO_3	8.96	4.82	23.16	18.55
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	8.65	4.56	22.29	18.15
N_4-Absolute control	6.80	3.48	19.39	15.98
S.Em.±	0.15	0.09	0.22	0.20
C. D. (P=0.05)	0.44	0.27	0.65	0.59
Interaction (H×N)				
M_1N_1	8.12	4.29	22.97	16.04
M_1N_2	8.96	4.78	23.36	18.52
M_1N_3	8.55	4.52	22.48	17.70
M_1N_4	6.86	3.45	19.36	16.55
M_2N_1	8.49	4.44	23.53	18.95
M_2N_2	9.09	4.97	23.45	18.53
M_2N_3	8.75	4.65	22.84	18.73
M_2N_4	6.80	3.38	19.17	17.48
M_3N_1	8.42	4.40	22.54	18.39
M_3N_2	8.83	4.70	22.66	18.58
M_3N_3	8.65	4.51	21.55	18.02
M_3N_4	6.72	3.61	19.65	13.91
S.Em.±	0.26	0.15	0.38	0.34
C. D. (P=0.05)	NS	NS	NS	1.02

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

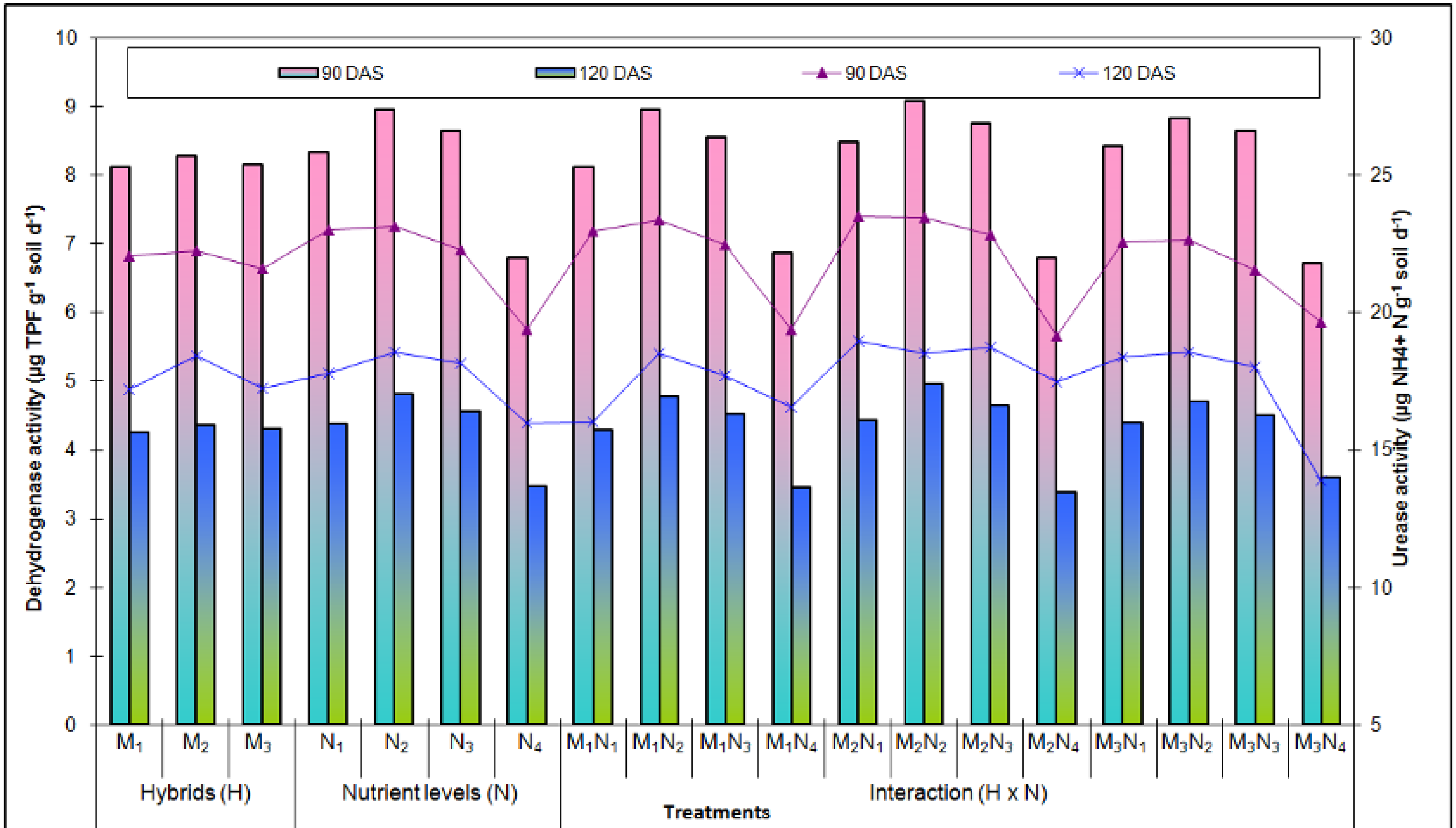


Fig. 13. Dehydrogenase activity and urease activity of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

Fig. 13. Dehydrogenase activity and urease activity of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

Whereas in 120 DAS, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par (18.15) with recommended dose of fertilizer application (18.55). Lower urease activity was recorded at 90 and 120 DAS in absolute control (19.39 and 15.98, respectively).Among the different treatment combinations there was no significant effect on urease activity at 90 and 120 DAS.

4.2.4.3 Phosphatase activity (µg pnp TPF g^{-1} soil h^{-1})

Phosphatase activity in soils of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 16 and Fig. 14.

Higher phosphatase activity was noticed at initial crop growth stages and declining trend was observed at subsequent growth stages.

Phosphatase activity differed non-significantly due to Bt cotton hybrids at all the growth stages.

Phosphatase activity differed significantly due to application of nutrients. Among the treatments, the application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher phosphatase activity at 90 and 120 DAS (19.36 and 15.58, respectively). However, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer was at par at 90 DAS (19.05 and18.90, respectively). Lower phosphatase activity was noticed in absolute control at 90 and 120 DAS (15.19 and 10.72. respectively).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in three splits and foliar application of 19:19:19 and $MgSO_4$ was recorded higher phosphatase activity at 90 DAS. However, at 120 DAS, there was no significant effect observed in different treatment combinations.

4.2.4.4 Arbuscular mycorrhizal fungi (AM fungi) root colonization

Arbuscular mycorrhizal fungal root colonization of Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 16 and Fig. 14.

Higher AM fungal root colonisation was noticed at initial crop growth stages and declining trend was observed at subsequent growth stages. AM fungal root colonization not differed significantly among cotton hybrids at all the growth stages.

AM fungal root colonization differed significantly due to application of nutrients; among the treatments, the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was recorded significantly higher AM fungal activity at 90 and 120 DAS (54.87 and 42.79, respectively). However, no significant difference observed between application of recommended dose of fertilizer and the application of nitrogen in seven splits with foliar application of KNO_3 was at 90 DAS (55.52 and 54.87, respectively). Lower AM fungal activity was noticed in absolute control at120 DAS.Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits with foliar application of KNO_3 recorded higher AM fungi root colonization compared to other combinations.

Table 16: Phosphatase activity and root colonization AM fungi at 90 and 120 DAS of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Treatment	Phosphatase activity (µg pnp TPF g^{-1} soil h^{-1})		AM fungi root colonization	
	90 DAS	120 DAS	90 DAS	120 DAS
Hybrids (H)				
M_1-RCH-2 BG-I	18.00	13.71	55.46	41.54
M_2-Chiranjeevi BG-II	18.58	13.81	55.53	41.12
M_3-NHH-44 Non Bt	17.79	13.33	54.16	40.04
S.Em.±	0.22	0.24	0.45	0.42
C. D. (P=0.05)	NS	NS	NS	NS
Nutrient levels (N)				
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM +$MgSO_4$	18.90	13.99	55.52	41.36
N_2-RDF+Foliar application with KNO_3	19.36	15.58	54.87	42.79
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	19.05	14.19	55.46	42.23
N_4-Absolute control	15.19	10.72	54.33	37.22
S.Em.±	0.22	0.22	0.27	0.29
C. D. (P=0.05)	0.66	0.65	0.81	0.87
Interaction (H×N)				
M_1N_1	19.17	14.21	55.65	42.06
M_1N_2	19.56	15.28	55.27	43.34
M_1N_3	19.20	14.82	56.21	42.61
M_1N_4	14.09	10.51	54.69	38.16
M_2N_1	19.17	14.48	56.45	41.92
M_2N_2	19.44	15.66	56.18	43.29
M_2N_3	19.69	13.89	55.81	42.70
M_2N_4	16.02	11.22	53.69	36.56
M_3N_1	18.38	13.27	54.47	40.12
M_3N_2	19.08	15.79	53.15	41.74
M_3N_3	18.26	13.85	54.38	41.38
M_3N_4	15.46	10.42	54.62	36.94
S.Em.±	0.38	0.38	0.47	0.51
C. D. (P=0.05)	1.14	NS	1.40	NS

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

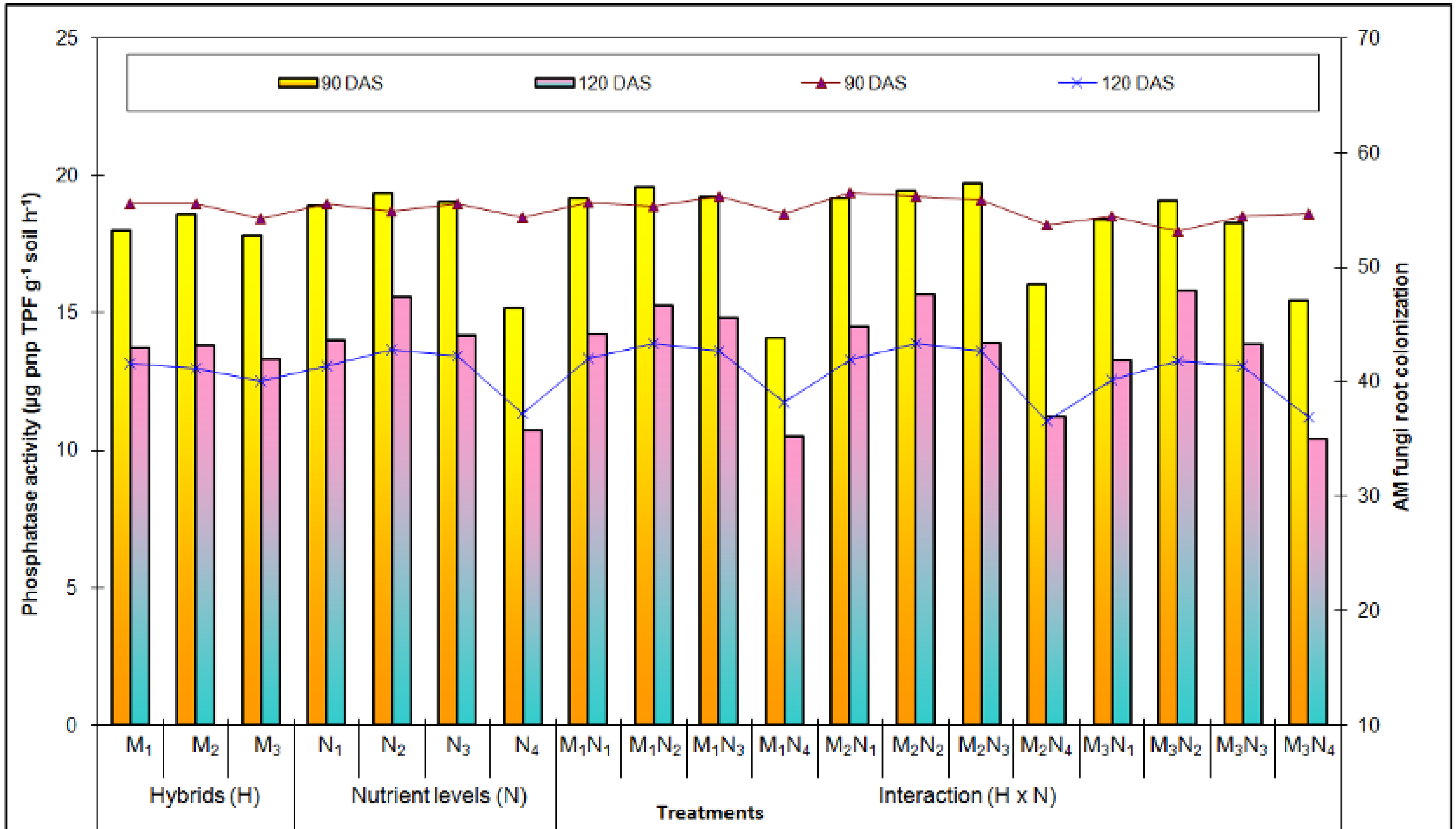


Fig. 14. Phosphatase activity and root colonization AM fungi at 90 and 120 DAS of different Bt and non Bt cotton hybrids as influenced by nutrient management practices

Fig. 14. Phosphatase activity and root colonization AM fungi at 90 and 120 DAS of different Bt and non Bt cotton hybrids as influenced by nutrient management practices

4.2.5 Nutrient uptake and available soil nutrient status

4.2.5.1 Nitrogen uptake

Nitrogen uptake of different Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 17 and Fig. 15.

Chiranjeevi BG-II Bt hybrid recorded significantly higher nitrogen uptake (37.57, 80.73 and 142.40 kg ha^{-1}, respectively) at 60, 90 and 120 DAS followed by RCH-2 BG-I Bt hybrid (33.11, 76.45 and 137.28, kg ha^{-1}, respectively). The lowest nitrogen uptake was recorded in NHH-44 non-Bt hybrid (31.68, 75.18 and 137.68 kg ha^{-1}, respectively).

Nitrogen uptake differed significantly due to application of nutrients. Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher nitrogen uptake (36.60, 81.60 and 146.60 kg ha^{-1}, respectively) at 60, 90 and 120 DAS. However, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par (35.30 and 80.30 kg ha^{-1}, respectively) at 60 and 90 DAS. Application of recommended dose of fertilizer was on par with above treatment (145.30 and 144.07 kg ha^{-1}). The lowest nitrogen uptake was recorded in absolute control (30.51, 68.84 and 120.51 kg ha^{-1}, respectively) at 60, 90 and 120 DAS.

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher nitrogen uptake at 60, 90 and 120 DAS. The lowest nitrogen uptake was recorded NHH-44 non-Bt hybrid in absolute control.

4.2.5.2 Phosphorus uptake

Phosphorus uptake of different Bt and non-Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 17 and Fig. 15.

Chiranjeevi BG-II Bt hybrid recorded significantly higher phosphorus uptake (9.69, 18.43 and 26.33 kg ha^{-1}, respectively) at 60, 90 and 120 DAS followed by RCH-2 BG-I Bt hybrid (7.36 and 14.86, kg ha^{-1}, respectively) at 60 and 90 DAS. Whereas in 120 DAS, phosphorus uptake was on par with Chiranjeevi BG-II Bt hybrid (23.61 kg ha^{-1}). Lowest phosphorus uptake recorded in NHH-44 non-Bt hybrid (6.96, 12.96 and 20.84 kg ha^{-1}, respectively) at 60, 90 and 120 DAS.

Phosphorus uptake differed significantly due to application of nutrients. Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher phosphorous uptake (9.31, 16.60 and 27.60 kg ha^{-1}, respectively) at 60, 90 and 120 DAS as compared to other nutrient levels. However, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer was on par at 60, 90 and 120 DAS. The lowest phosphorous uptake was recorded in absolute control at 60, 90 and 120 DAS (6.14, 13.70 and 15.41 kg ha^{-1}, respectively).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher phosphorous uptake at 60, 90 and 120 DAS. The lowest phosphorous uptake was recorded NHH-44 non-Bt hybrid in absolute control.

Table 17. Nutrient uptake status in crop of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

Treatment	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Hybrids (H)						
M_1-RCH-2 BG-I	33.11	76.45	137.28	7.36	14.86	23.61
M_2-Chiranjeevi BG-II	37.57	80.73	142.40	9.69	18.43	26.33
M_3-NHH-44 Non Bt	31.68	75.18	137.68	6.96	12.96	20.84
S.Em.±	0.41	0.74	0.87	0.68	0.51	1.04
C. D. (P=0.05)	1.61	2.91	3.41	2.66	2.02	4.09
Nutrient levels (N)						
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM +$MgSO_4$	34.07	79.07	144.07	8.19	15.07	25.07
N_2-RDF+Foliar application with KNO_3	36.60	81.60	146.60	9.31	16.60	27.60
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) so and foliar application	35.30	80.30	145.30	8.37	16.30	26.30
N_4-Absolute control	30.51	68.84	120.51	6.14	13.70	15.41
S.Em.±	0.57	0.74	1.18	0.42	0.64	0.96
C. D. (P=0.05)	1.68	2.19	3.50	1.26	1.91	2.84
Interaction (H×N)						
M_1N_1	32.32	77.32	142.32	7.65	13.32	23.32
M_1N_2	34.47	79.47	144.47	7.14	15.47	25.47
M_1N_3	34.45	79.45	144.45	8.45	15.45	25.45
M_1N_4	31.20	69.53	117.87	6.20	15.20	20.20
M_2N_1	36.52	81.52	146.52	9.52	17.52	27.52
M_2N_2	43.25	88.25	153.25	12.42	21.25	34.25
M_2N_3	39.05	84.05	149.05	9.58	20.05	30.05
M_2N_4	31.44	69.11	120.78	7.25	14.92	13.50
M_3N_1	33.38	78.38	143.38	7.39	14.38	24.38
M_3N_2	32.07	77.07	142.07	8.38	13.07	23.07
M_3N_3	32.39	77.39	142.39	7.07	13.39	23.39
M_3N_4	28.88	67.88	122.88	4.98	10.98	12.52
S.Em.±	0.98	1.28	2.04	0.73	1.11	1.65
C. D. (P=0.05)	2.92	3.79	6.06	2.18	3.30	4.92

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

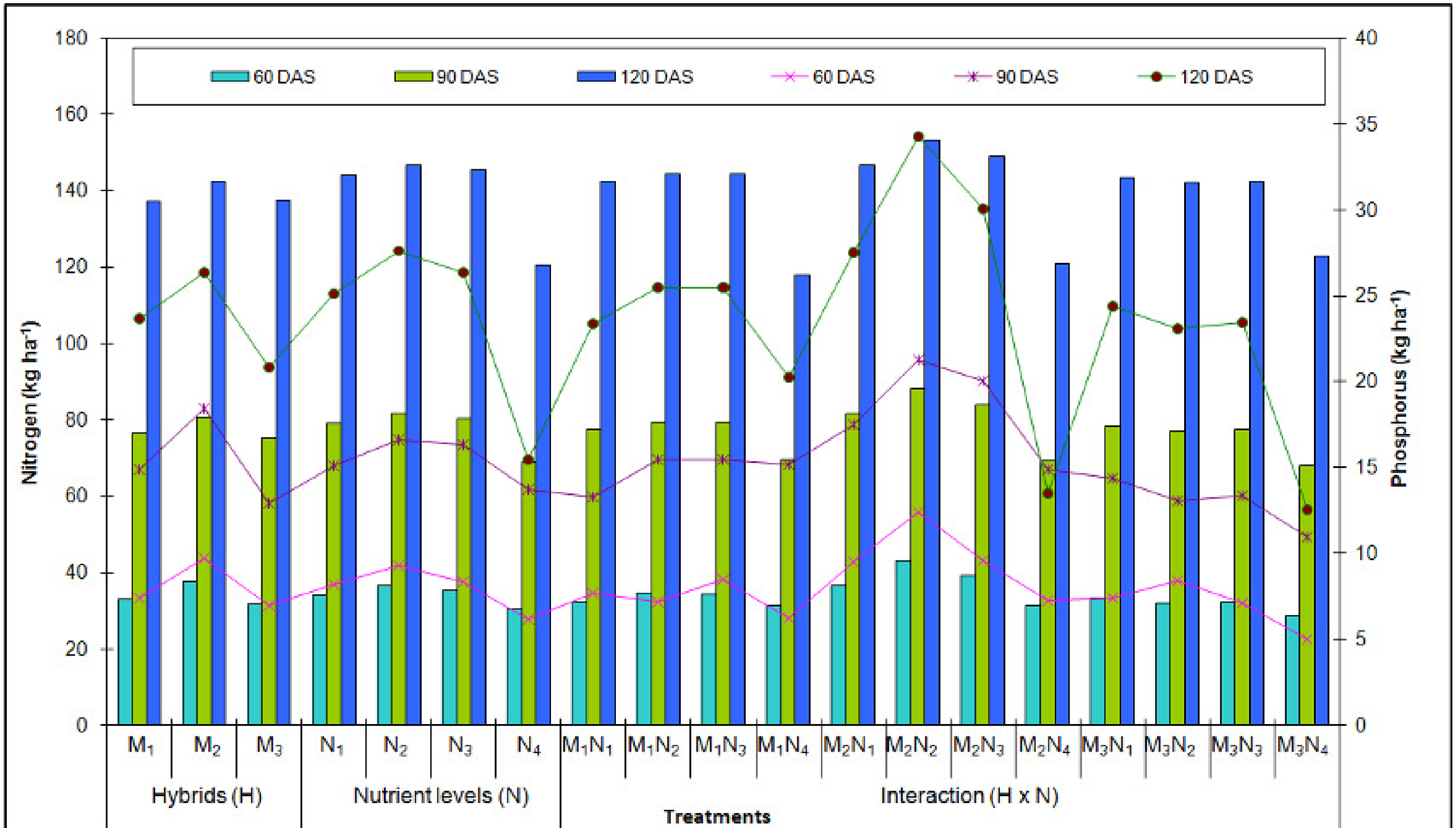


Fig. 15. Nutrient uptake status in crop of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

Fig. 15. Nutrient uptake status in crop of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

4.2.5.3 Potassium uptake

Potassium uptake of different Bt and non-Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 18 and Fig. 16.

Chiranjeevi BG-II Bt hybrid recorded significantly higher potassium uptake (32.32, 50.65 and 143.98 kg ha^{-1}, respectively) at 60, 90 and 120 DAS followed by RCH-2 BG-I Bt hybrid at 60, 90 and 120 DAS (27.70, 46.53 and 139.86, kg ha^{-1}, respectively). The lowest potassium uptake was recorded in NHH-44 non-Bt hybrid (26.18, 45.35 and 137.01 kg ha^{-1}, respectively) at 60, 90 and 120 DAS.

Potassium uptake differed significantly due to application of nutrients. Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher potassium uptake (32.60, 52.60 and 147.60 kg ha^{-1}, respectively) at 60, 90 and 120 DAS as compared to other nutrient levels. However, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par at 60, 90 and 120 DAS (31.30, 51.30 and 145.19 kg ha^{-1}, respectively). The lowest potassium uptake was recorded in absolute control at 60, 90 and 120 DAS (20.95, 36.06 and 126.62 kg ha^{-1}, respectively).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher potassium uptake at 60, 90 and 120 DAS. The lowest potassium uptake was recorded in NHH-44 non-Bt hybrid in absolute control

4.2.5.4 Magnesium uptake

Magnesium uptake by different Bt and non-Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients is presented in Table 18 and Fig. 16.

Chiranjeevi BG-II Bt hybrid recorded significantly higher magnesium uptake at 90 and 120 DAS (8.41 and 14.56 kg ha^{-1}, respectively). Whereas at 60 DAS, was found non-significant. Lowest magnesium uptake was recorded in NHH-44 non-Bt hybrid at 90 and 120 DAS (7.31 and 13.82 kg ha^{-1}, respectively).

Magnesium uptake was differed significantly due to application of nutrients. Among the treatments, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ (RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS) recorded significantly higher magnesium uptake at 60, 90 and 120 DAS (3.59, 9.72 and 16.46 kg ha^{-1}, respectively) as compared to other nutrient levels. The lowest magnesium uptake was recorded in absolute control at 60, 90 and 120 DAS (1.24, 5.38 and 11.57 kg ha^{-1}, respectively).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded significantly higher magnesium uptake at 60, 90 and 120 DAS. Lowest magnesium uptake was recorded in NHH-44 non-Bt hybrid in absolute control.

Table 18. Nutrient uptake status in crop of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

Treatment	Potassium (kg ha^{-1})			Magnesium (kg ha^{-1})		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Hybrids (H)						
M_1-RCH-2 BG-I	27.70	46.53	139.86	2.52	7.35	13.87
M_2-Chiranjeevi BG-II	32.32	50.65	143.98	2.66	8.41	14.56
M_3-NHH-44 Non Bt	26.18	45.35	137.01	2.38	7.31	13.82
S.Em.±	1.07	0.60	0.48	0.15	0.26	0.15
C. D. (P=0.05)	4.21	2.36	1.90	NS	1.04	0.61
Nutrient levels (N)						
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM +$MgSO_4$	30.07	50.07	141.74	2.81	8.63	15.31
N_2-RDF+Foliar application with KNO_3	32.60	52.60	147.60	2.42	7.03	13.00
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	31.30	51.30	145.19	3.59	9.72	16.46
N_4-Absolute control	20.95	36.06	126.62	1.24	5.38	11.57
S.Em.±	0.72	0.71	0.93	0.09	0.24	0.26
C. D. (P=0.05)	2.14	2.12	2.77	0.27	0.72	0.78
Interaction (H×N)						
M_1N_1	28.32	48.32	143.32	2.62	7.96	14.61
M_1N_2	30.47	50.47	145.47	2.43	6.68	13.19
M_1N_3	30.45	50.45	145.45	3.49	9.75	17.02
M_1N_4	21.53	36.87	125.20	1.54	4.95	10.68
M_2N_1	32.52	52.52	147.52	2.93	9.93	16.80
M_2N_2	39.25	59.25	154.25	2.64	7.31	12.08
M_2N_3	35.05	55.05	150.05	3.90	10.82	17.28
M_2N_4	22.44	35.78	124.11	1.16	5.58	12.07
M_3N_1	29.38	49.38	134.38	2.89	8.01	14.51
M_3N_2	28.07	48.07	143.07	2.21	7.11	13.73
M_3N_3	28.39	48.39	140.06	3.38	8.58	15.08
M_3N_4	18.88	35.54	130.54	1.03	5.62	11.95
S.Em.±	1.25	1.24	1.61	0.16	0.42	0.45
C. D. (P=0.05)	3.70	3.67	4.79	0.46	1.25	1.34

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

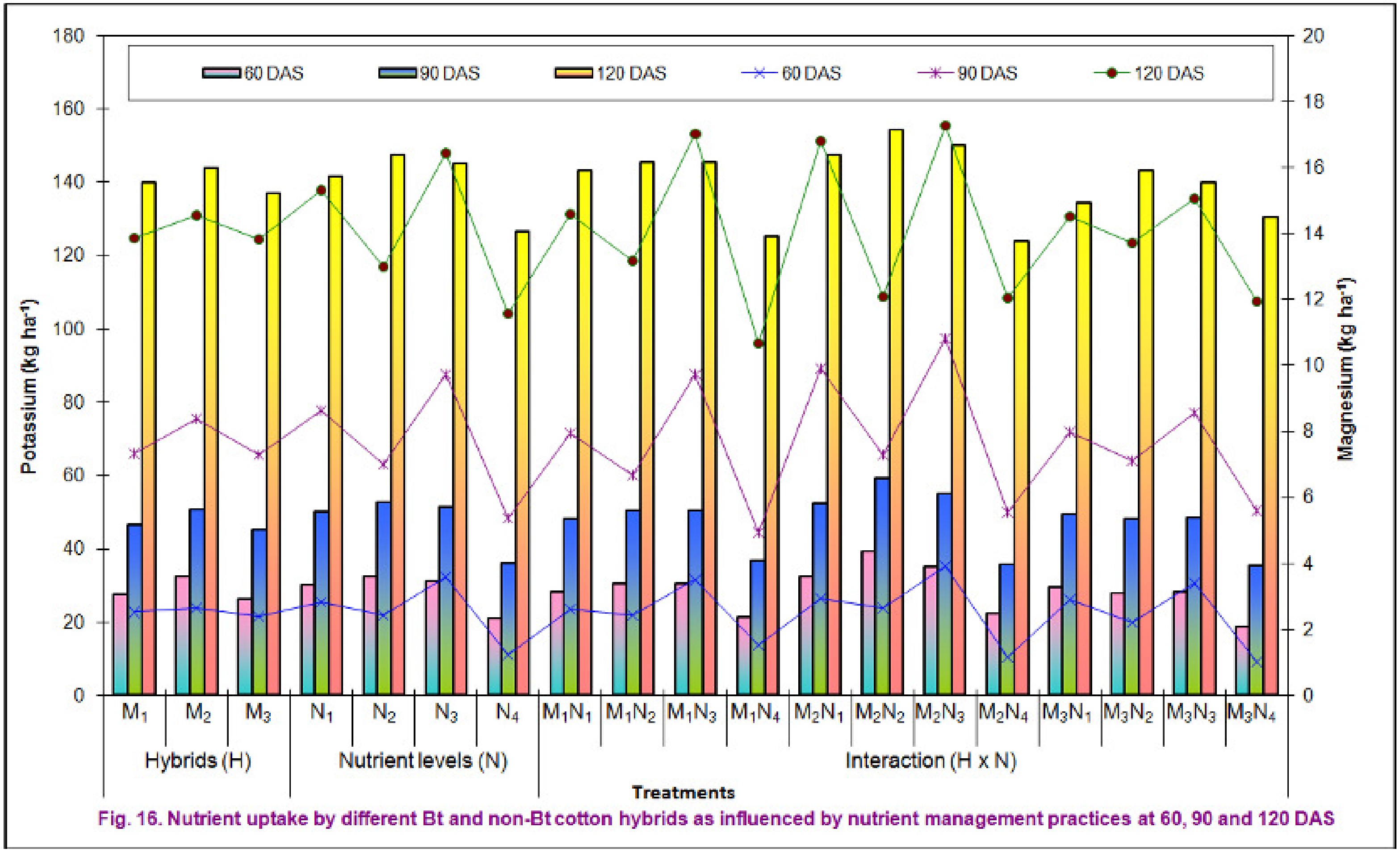


Fig. 16. Nutrient uptake by different Bt and non-Bt cotton hybrids as influenced by nutrient management practices at 60, 90 and 120 DAS

4.2.6 Available nutrient status in soil

4.2.6.1 Available nitrogen

Available nitrogen in soil after harvest of different Bt and non-Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 19.Available nitrogen in soil after harvest of different Bt and non-Bt cotton hybrids found to be non-significant.

Available nitrogen in soil after harvest was differed significantly due to application of nutrients; among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher available nitrogen in soil after harvest (303.45 kg ha^{-1}). The lowest available nitrogen in soil after harvest was recorded in absolute control treatment (124.39 kg ha^{-1})

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded significantly higher available nitrogen. However, lowest available nitrogen was recorded in NHH-44 non-Bt hybrid in absolute control.

4.2.6.2 Available phosphorous

Available phosphorous in soil after harvest of different Bt and non-Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 19.

Available phosphorous in soil after harvest of different Bt and non-Bt cotton hybrids found to be non-significant.

Available phosphorous in soil after harvest differed significantly due to application of nutrients. Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher available phosphorous in soil after harvest (32.29 kg ha^{-1}). However, it was on par with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ (31.45 kg ha^{-1}). The lowest available phosphorous in soil after harvest was recorded in absolute control treatment (12.48 kg ha^{-1}).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded significantly higher available phosphorous. However, lower available phosphorous was recorded in RCH-2 BG-I Bt hybrid in absolute control.

4.2.6.3 Available potassium

Available potassium in soil after harvest of different Bt and non-Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 19.

Available potassium in soil after harvest of different Bt and non-Bt cotton hybrids were found non-significant.

Available potassium in soil after harvest differed significantly due to application of nutrients; among the treatments, application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was recorded higher available potassium in soil after harvest (212.01 kg ha^{-1}).

Table 19: Available nutrient status in soil after harvest of different Bt cotton hybrids as influenced by nutrient management practices

Treatment	Nitrogen ($kg\ ha^{-1}$)	Phosphorous ($kg\ ha^{-1}$)	Potassium ($kg\ ha^{-1}$)	Magnesium (me/100 g)
Hybrids (H)				
M_1-RCH-2 BG-I	241.2	25.5	194.8	5.85
M_2-Chiranjeevi BG-II	243.1	28.7	193.1	4.99
M_3- NHH-44 Non Bt	242.1	25.2	195.5	5.89
S.Em.±	2.17	1.16	1.1	0.22
C. D. (P=0.05)	NS	NS	NS	0.86
Nutrient levels (N)				
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM + 1% $MgSO_4$)	272.2	31.4	210.6	4.44
N_2-RDF+Foliar application with KNO_3	303.4	32.2	210.7	5.74
N_3-RDF+19:19:19 (0.5 %)+$MgSO_4$ (1 %) soil and foliar application	268.5	29.6	212.0	5.68
N_4-Absolute control	124.3	12.4	144.6	6.45
S.Em.±	2.2	0.8	1.1	0.18
C. D. (P=0.05)	6.7	2.5	3.3	0.55
Interaction (H×N)				
M_1N_1	272.0	31.2	210.8	5.32
M_1N_2	295.1	33.1	212.3	5.38
M_1N_3	270.4	27.9	211.1	5.18
M_1N_4	127.3	19.5	144.8	7.52
M_2N_1	270.7	32.4	205.9	3.55
M_2N_2	306.6	34.8	206.3	6.62
M_2N_3	266.4	34.1	210.7	4.02
M_2N_4	128.5	13.4	149.6	5.78
M_3N_1	273.8	30.6	215.1	4.45
M_3N_2	306.5	28.8	213.3	5.23
M_3N_3	268.8	26.9	214.1	7.85
M_3N_4	117.3	14.4	143.5	6.05
S.Em.±	3.9	1.4	1.9	0.32
C. D. (P=0.05)	11.7	4.3	5.7	0.95

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

However, it was on par with the application of nitrogen in seven splits with foliar application of KNO_3 and application of recommended dose of fertilizer (210.70 and 210.68 kg ha^{-1}, respectively). Lower available potassium was recorded in absolute control (144.67 kg ha^{-1}).Among the different treatment combinations, NHH-44 non-Bt hybrid with application of recommended dose of fertilizer was recorded higher available potassium in soil after harvest. However, lowest available potassium was recorded in NHH-44 non-Bt hybrid in absolute control.

4.2.6.4 Exchangeable magnesium (me 100^{-1} g of soil)

Exchangeable magnesium in soil after harvest of different Bt and non-Bt cotton hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 18.

NHH-44 non-Bt hybrid recorded significantly higher exchangeable magnesium in soil after harvest (5.89) as compared to others. However, it was on par with RCH-2 BG-I Bt hybrid (5.85). The lower exchangeable magnesium was noticed in Chiranjeevi BG-II Bt hybrid (4.99).

Exchangeable magnesium in soil after harvest was differed significantly due to application of nutrients. Among the treatments, higher exchangeable magnesium was recorded in absolute control treatment (6.45) as compared to others. However, lower exchangeable magnesium was noticed in application of recommended dose of fertilizer treatment (4.44).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits with foliar application of KNO_3 was recorded higher exchangeable magnesium in soil after harvest (6.62). However, lower exchangeable magnesium was noticed in Chiranjeevi BG-II Bt hybrid with the application of recommended dose of fertilizer treatment combination.

4.2.7 Economics

4.2.7.1 Gross returns (₹ **ha^{-1}**)

Gross return of different Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 20 and Fig. 17.

Chiranjeevi BG-II Bt hybrid recorded significantly higher gross return (₹ 71,299) compared to other genotypes. However, NHH-44 non-Bt hybrid registered significantly lower gross return (₹ 38,582) among the genotypes.

Gross return differed significantly due to application of nutrients. Among the treatments, the application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher gross return (₹ 77,422) compared to other nutrient levels. However, the lowest gross return was registered in absolute control (₹ 21,370).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 was recorded higher gross return compared to other combinations.

4.2.7.2 Net return

Net return of different Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients are presented in Table 20 and Fig. 17.

Chiranjeevi BG-II Bt hybrid recorded significantly higher net return (₹ 40,533) compared to other genotypes. However, NHH-44 non-Bt hybrid registered significantly lower net return (₹ 8,395) among the genotypes.Net return differed significantly due to application of nutrients. Among the treatments, application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher net return (₹ 43,039) compared to other nutrient levels. However, the lowest net return was recorded in absolute control (₹ 2,234).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded higher net return compared to other combinations.

4.2.7.3 Benefit: cost ratio

Benefit: cost ratio of different Bt and non-Bt hybrids as influenced by different splits of nitrogen and foliar application of nutrients is presented in Table 20 and Fig. 17.

Chiranjeevi BG-II Bt hybrid registered significantly higher B: C ratio (2.19) compared to other genotypes. However, NHH-44 non-Bt registered significantly lower B: C ratio (1.26) among the genotypes.

Benefit: cost ratio differed significantly due to application of nutrients. Among the treatments, application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher B: C ratio (2.25) compared to other nutrient levels. However, the lowest B: C ratio was registered in absolute control (1.12).

Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 was recorded higher B: C ratio as compared to other treatment combinations.

Table 20: Gross return, net return and B: C ratio of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Treatment	Gross return (₹/ha)	Net return (₹/ha)	B: C ratio
Hybrids (H)			
M_1-RCH-2 BG-I	58,305	27,569	1.81
M_2-Chiranjeevi BG-II	71,299	40,533	2.19
M_3-NHH-44 Non Bt	38,582	8,395	1.26
S.Em.±	560.15	560.15	0.02
C. D. (P=0.05)	2199.42	2199.42	0.07
Nutrient levels (N)			
N_1-RDF (100:50:50 NPK kg ha^{-1}+10 t FYM +1 % $MgSO_4$)	60,096	25,454	1.73
N_2-RDF+Foliar application with KNO_3	77,422	43,039	2.25
N_3-RDF+19:19:19 (0.5%) +$MgSO_4$ (1 %) soil and foliar application	65,361	31,269	1.91
N_4-Absolute control	21370	2,234	1.12
S.Em.±	823.79	823.79	0.03
C. D. (P=0.05)	2447.60	2447.60	0.09
Interaction (H×N)			
M_1N_1	61,780	26,965	1.77
M_1N_2	81,848	47,292	2.37
M_1N_3	68,851	34,586	2.01
M_1N_4	20,742	1,432	1.07
M_2N_1	77,590	42,745	2.23
M_2N_2	99,957	65,371	2.89
M_2N_3	84,596	50,301	2.47
M_2N_4	23,054	3,714	1.19
M_3N_1	40,919	6,653	1.19
M_3N_2	50,460	16,453	1.48
M_3N_3	42,636	8,920	1.26
M_3N_4	20,315	1,555	1.08
S.Em.±	1426.84	1426.84	0.06
C. D. (P=0.05)	4239.37	4239.37	0.16

Note:

N_1- In RDF 50 (%) of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 (%) of N applied equally at 50, 80 and 110 DAS. And 1 (%) foliar spray of $MgSO_4$ at 50 and 80 DAS.

N_2- RDF 7 splits 10 (%) as basal, remaining 90 (%) is in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 (%) foliar application of KNO_3 three times from October onwards at 15 days interval.

N_3- RDF 3 splits 50 (%) of N and full dosage of P_2O_5 and K_2O as basal, remaining 50 (%) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application (1 %) at 70, 90, and 110 DAS.

N_4- Absolute control

RDF- Recommended Dose of Fertilizer

NS- Non-significant

LEGEND

Main plots: (Hybrids)

M_1 - BG-I Bt cotton : RCH-2

M_2 - BG-II Bt cotton : Chiranjeevi

M_3 - Non-Bt cotton : NHH-44

Sub plot: (Nutrients Schedule)

N_1 - RDF (100:50:50:N:P_2O_5:K_2O Kg/ha +10t FYM +1 % foliar application $MgSO_4$)

N_2 - RDF + Foliar application of KNO_3 2 per cent

N_3 - RDF+ 19:19:19 (0.5 %) + $MgSO_4$ (1 %) soil and foliar application

N_4 - Absolute control

Note: 1. In RDF 50 % of N and full dosage of P_2O_5 and K_2O as basal dosage and remaining 50 % of N was applied equally at 50, 80 and 110 DAS and 1 % foliar spray of $MgSO_4$ at 50 and 80 DAS.

2. RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS. 2 % foliar application of KNO_3 from October onwards at 15 days interval.

3. RDF 3 splits 50 % of N and full dosage of P_2O_5 and K_2O as basal, remaining (50 %) is in equal splits at 30 and 50 DAS + 19:19:19 (0.5 %) foliar spray and $MgSO_4$ @ 25 kg ha^{-1} as basal in soil application and foliar application 1 % at 70, 90, and 110 DAS.

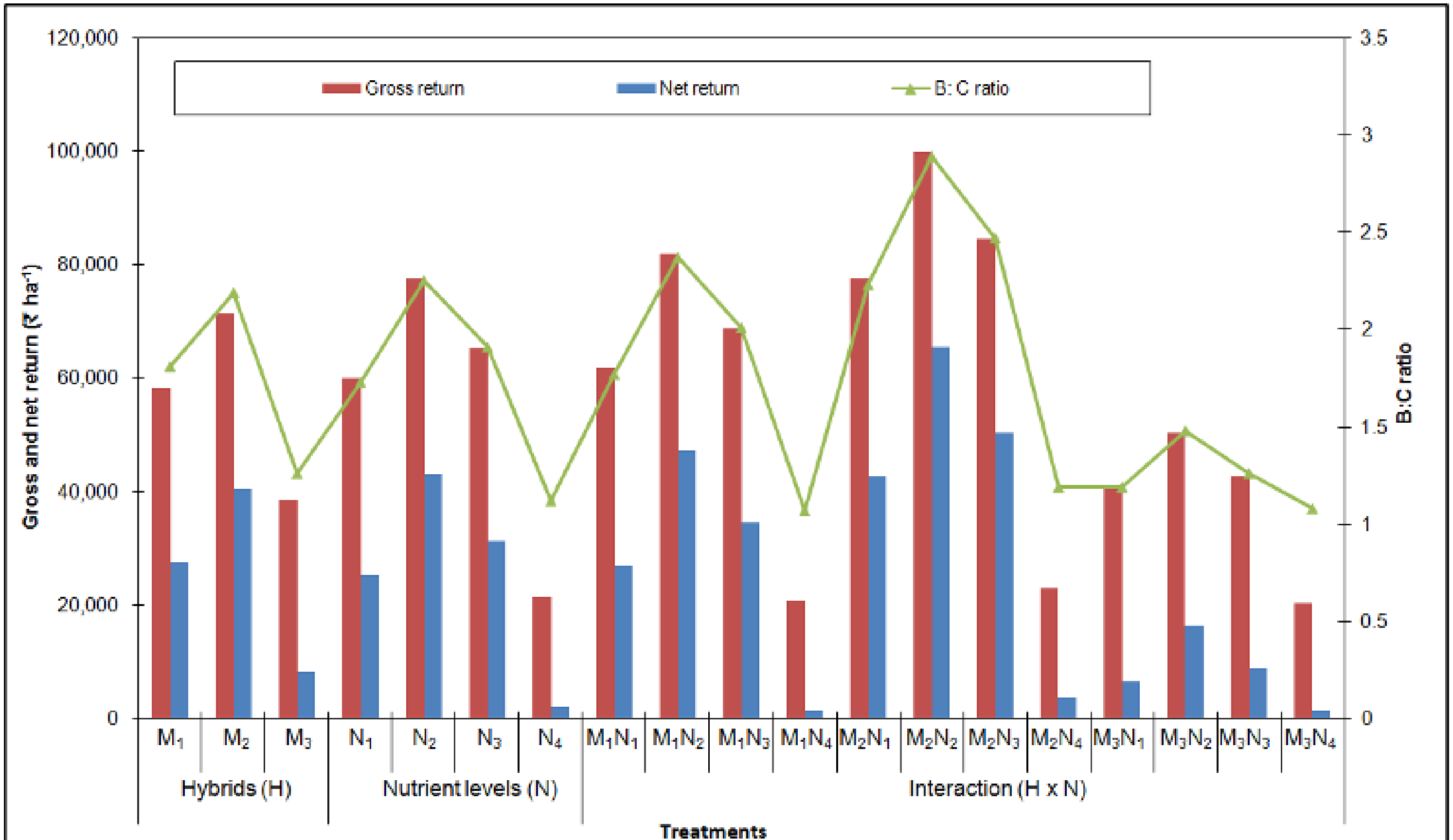


Fig. 17. Gross return, net return and B: C ratio of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

Fig. 17. Gross return, net return and B: C ratio of different Bt and non-Bt cotton hybrids as influenced by nutrient management practices

5. DISCUSSION

Cotton is one of the major crops in India and the country ranks second in world cotton production after China. India accounts for approximately 20 per cent of the world's total cotton area (15 m ha) and 12 per cent of the cotton production (350 m bales). Most of the cotton in India is grown under rainfed condition and only 35 per cent is grown under irrigation (Anon., 2014). The average lint yield of cotton in India is low (512 kg ha^{-1}) as compared to world average (725 kg ha^{-1}). It is documented that bollworm infestation is the major yield limiting parameter throughout the world. In this regard transgenic Bt cotton 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 cotton plants altered the source-sink relationship due to rapid translocation of saccharides and nutrients from leaves to the developing bolls.

Cotton is a deep rooted crop and voracious feeder of nutrients, responds well for nutrients. As it is a long duration crop it requires constant supply of nutrients. The response is more during flowering and boll development stage. Diversion of nutrients to the reproductive sympodial branches get disrupted leading to boll shedding and poor yield and compel the crop to exploit soil reserves for other nutrients. The optimal dose of nutrients builds up a favourable condition in increasing cotton productivity and improves the quality (Kalaichelvi, 2009). The yield potential of the crop can be exploited to the maximum only when the nutrient requirements are fully met with. Compared to desi, American cotton varieties and other hybrids, nutrient removal is higher in Bt cotton hybrids. In general, a rainfed crop removes about 6-7 kg N, 2-2.5 kg P, 7-8 kg K per 100 kg seed cotton (Blaise *et al.*, 2014). Balanced fertilization is a dynamic concept. Balanced dose of N, P and K is usually applied to the soil in the ratio of 2:1:1 ($N:P_2O_5:K_2O$) for obtaining greater efficiency instead of blanket recommendations. In view of the above facts, experiment was planned and executed at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during 2014-2015 and the results from investigations are discussed in this chapter.

5.1 Weather and crop performance

Crop growth is the net result of interplay of diverse metabolic activities taking place in different parts of a plant during its growth and development. The synthesis, accumulation and translocation of metabolites to the economic part are often influenced by environmental conditions. There by influencing the yield potential of the crop. More than 50 per cent of variation in yield of the crop is due to environment conditions. The most important climatic factors that influence growth, development and yield of crop are solar radiation, temperature, relative humidity, amount and distribution of rainfall. The mean annual rainfall for past 63 years at the Main agricultural Research Station, Dharwad was 711.44mm. The annual rainfall received during experimental period *kharif* 2014 was 633.5 mm, July to October was relatively wet and well distributed.

Monthly as well as weekly minimum and maximum temperatures and relative humidity did not deviate from the normal with no differential influence on crop growth and development. During 2014 the highest mean monthly maximum temperature (30.0 °C) and the lowest mean monthly minimum temperature (19.0 °C) were observed during the months of June and December, respectively. The mean monthly maximum relative humidity was 89.00 per cent in the month of July and mean monthly minimum relative humidity value was 42.00 per cent.

The sowing was delayed on account of recipient of rainfall after 15th July. Well distributed rainfall was observed throughout the cropping period. This facilitates attention of sufficient quantity of soil moisture (60.00 %), which favoured better attribution of growth parameters (plant height, number of monopodial branches, leaf area, leaf area index and total dry matter production *etc.*). The improved manifestation of growth parameters influenced positively on yield attributing traits like number of bolls per plant, mean boll weight and seed cotton yield. However, the crop experienced some physiological disorders during cold period.

5.2 Performance of genotypes

Genotypes play a vital role in determining yield of crops compared with environment in the expression of genetic potentiality. The genotypes varied in their yield potential depending on many factors and ultimately yield is the result of a complex process occurring in various spots of plant involve in many morphological changes controlled by both the genetic makeup and the environment. The crop experienced well distributed rainfall during the cropping period (July to October) in *kharif* season. There was no moisture limitation during grand growth period which helped the crop to express its full potential.

In the present investigations, among the Bt cotton hybrids Chiranjeevi BG-II Bt recorded significantly higher seed cotton yield (1693 kg ha^{-1}) compared to other cotton hybrids under investigation (Table 10). The lowest seed cotton yield was recorded in NHH-44 non-Bt hybrid (917 kg ha^{-1}). The magnitude of increase in seed cotton yield in Chiranjeevi BG-II Bt was to the extent of 45.6 per cent, in RCH-2 BG-I Bt 34.2 per cent over NHN-44 non-Bt hybrid. Stalk yield and harvest index (32.37) were higher in Chiranjeevi BG-II Bt hybrid and stalk yield and it was at par with RCH-2 BG-II Bt hybrid (3130 kg ha^{-1}) compared to others. The results are also in line with the findings in other hybrids. Hosmath (2011) reported that, Neeraj BG-II Bt cotton recorded significantly higher seed cotton yield compared to other Bt cotton genotypes. Similarly at Dharwad (Karnataka) Khadi *et al.*(2002 and 2008), Udikeri *et al.* (2003 and 2011), Hallikeri *et al.* (2004), Halemani *et al.* (2004), Yenagi (2006) and Anand (2005) have also reported that MECH-184 Bt, MECH-162 Bt, RCH-2 Bt (BG-II) produced significantly higher seed cotton yield compared to other Bt cotton genotypes Dharwad, at Bijapur, Raichur, Bheemarayanagudi and Siruguppa of Karnataka. Hegde *et al.* (2004), Patil *et al.* (2001), Krishnegowda (2004) and Venkateshalu *et al.* (2010) reported that, RCH-2 BG-II Bt, MECH-162 Bt and RCH-2 BG-II Bt were significantly superior with respect to seed cotton yield as compared to other Bt cotton hybrids

Chiranjeevi BG-2 Bt hybrid at 90 DAS

NHH-44 non-Bt hybrid

RCH-2 BG-1 hybrid at 90 DAS

Plate2. Crop view at 90 DAS

NHH-44 non-Bt hybrid control at 90 DAS

RCH-2 BG-1 hybrid at 90 DAS control

Chiranjeevi BG-2 Bt at 90 DAS control

Plate3. Treatment difference at 90 DAS

The increase of yield in any cotton hybrids depend on yield per plant, number of good opened bolls, bad opened bolls, boll weight, number of sympodia and monopodia (Table 3, 4, 9 and 10). In the present study results showed that, Chiranjeevi BG-II Bt recorded significantly higher seed cotton yield per plant (506.94 g plant^{-1}) compared to other Bt cotton hybrids, total opened bolls per plant (32.15), mean boll weight (5 g plant^{-1}), number of sympodia (10.17 and 16.23, respectively) at 90 and 120 DAS, and monopodia (2.82 and 3.76, respectively). At 90 and 120 DAS as compared to other tested Bt cotton hybrids. The reason for increase in yield components of these hybrids was due to higher dry matter accumulation, number of bolls per plant and mean boll weight. A similar variation in yield components among Bt cotton hybrids were also noticed by Sankaranarayanan *et al.* (2004), Hosmath *et al.*(2004a), Yenagi (2006) and Rajendran *et al*. (2009). Further, they reported that MECH-162 recorded significantly higher number of bolls per plant, number of sympodial branches and yield per plant as compared to other tested Bt cotton hybrids. Hosmath (2011) reported that Neeraj BG-II Bt produced significantly higher seed cotton yield per plant, bolls per plant, sympodial and monopodial branches per plant over the tested Bt cotton hybrids. Similar variation also observed by Giri *et al*. (2008) in NCS-145 Bt cotton, Bhalerao *et al*. (2008) in Bramha Bt at different locations of India.

The yield per plant in cotton is single most important yield attributing parameter that directly influences the productivity of a crop. The yield per plant is greatly influenced by number of good and bad opened bolls. In the present investigation the Chiranjeevi BG-II Bt cotton hybrid recorded significantly higher number of good opened bolls per plant (30.07) and less number of bad opened bolls per plant (2.08). Increased number of good opened bolls and reduced bad boll opening in this hybrid was due to better partitioning of dry matter and increased leaf area per plant. Similar findings were also observed by Kengegowda (2004) in RCH-2 BG-II Bt, Joshi (2007) in JKCH-99 Bt, Yenagi (2006) in RCH-20 BG-II Bt, MECH-184 Bt and Udikeri *et al*. (2011) in MRC-7201 (BG-II). They reported that these Bt cotton hybrids produced higher number of good opened and less bad opened bolls per plant as compared to other Bt cotton hybrids tested at different locations.

The seed cotton yield is an end product which depends on the plant height, dry matter production at different stages of the crop and its partitioning to economic part *viz.,* reproductive parts, leaf and for higher production. Plant height was increased in Chiranjeevi BG-II Bt at 60, 90 and 120 DAS (55.60, 77.69 and 104.16 cm, respectively), compared to RCH-2 BG-I Bt and NHH-44 non-Bt hybrid. Total dry matter production was higher at 60, 90 and 120 DAS (87.22, 206.60 and 248.23, respectively). as compared to others. The total dry matter produced by these hybrids was to the extent of 10.8, 10.5 and 9.9 per cent, respectively higher as compared to NHH-44 non-Bt cotton. The significant difference in the total dry matter production among different Bt cotton hybrids were also reported by Patil *et al*. (2011), Sankaranarayanan *et al.* (2009) in RCHB 708 Bt, Sudha (2011) in MRC 6918 Bt, Venugopalan *et al*. (2012) in RCH-2 Bt (BG-II) and Ramamurthy and Venugopalan *et al*. (2009) in MECH-184 Bt. These hybrids recorded significantly higher total dry matter production as compared to other Bt cotton hybrids tested at different locations. Partitioning of photosynthates to in economic part (boll) is a single most important factor contributing to the final yield. The data on dry matter accumulation in bolls indicated that, Chiranjeevi BG-II Bt was efficient in transportation and accumulation to in boll as compared to others.

General view at 90 DAS

General view at 135 DAS

Plate4. General view at 90 and 135 DAS

The total dry matter production and its accumulation in economic parts depends on the photosynthetic ability of the plant at various stages of growth and could be analyzed through leaf area, LAI and LAD and dry matter accumulation in leaves which express the photosynthetic ability or performance and final yield. Among the hybrids tested, Chiranjeevi BG-II Bt recorded significantly higher dry matter accumulation in leaves at 60, 90 and 120 DAS (37.34, 42.80 and 56.60 g plant^{-1}, respectively) as compared to others. Similar trend was followed with respect to dry matter accumulation in stem and reproductive parts. This increased dry matter accumulation in leaves was attributed to increased leaf area, LAI and LAD, which are an important part that determines the photosynthetic ability, growth and dry matter production. The data on leaf area, LAI and LAD at 60, 90 and 120 DAS, indicated that Chiranjeevi BG-II Bt recorded significantly higher leaf area (30.77, 83.26 and 133.05 dm^2 plant^{-1}, respectively), LAI (0.57, 1.54 and 2.46, respectively) and LAD (31.68 and 60.09, respectively) at 60-90 and 90-120 DAS as compared to others. The lowest leaf area, LAI and LAD were registered in NHH-44 Non hybrid. Significantly higher leaf area and LAI were noticed in MECH-162 Bt, RCH20 Bt (BG-II) and MRC 6918 compared to other Bt cotton hybrids which was also documented by Yenagi (2006), Ramamurthy and Venugopalan (2009) and Sudha (2011) at different locations. The reason for increase of leaf area in this hybrid is due to higher nutrient uptake and genetic makeup of hybrid.

The chlorophyll content is indirect indicator of relative content of chlorophyll. In the present study, SPAD meter values were taken at different growth stages at 60, 90 and 120 DAS. Chiranjeevi BG-II Bt recorded significantly higher chlorophyll content (34.23, 40.09 and 41.50, respectively). A higher SPAD reading was due to higher leaf chlorophyll content.

5.2.1 Effect on quality parameters

The data on quality parameters *viz.,* ginning out turn (GOT), fibre length, fibre strength, uniformity ratio and lower micronnaire values were found significant in Chiranjeevi BG-II Bt (34.50 %, 29.55 mm, 21.21 g tax^{-1}, 51.46 and 4.61 µ tax^{-1}, respectively) as compared to other cotton hybrids. With respect to fibre length noticed in RCH-2 BG-I Bt was higher (31.51mm) (Table 12). Similar observation in different Bt cotton hybrids were made by Halemani *et al*. (2004), Hallikeri *et al*. (2004), Yenagi (2006), Prasad and Rao (2008), Sarong *et al*. (2010) Manjunatha *et al*. (2010) and Phad *et al.* (2009a and 2009b) at different locations of cotton growing areas in India.

5.2.2 Effect on nutrient uptake and soil available nutrients

The nitrogen and magnesium content in leaves are more important and these are major indicators for diagnosing nutrient status. For harnessing the fullest production potentiality of any cotton genotype sufficiency range of nutrient has to be maintained (Anon., 2009).

The available soil nitrogen, phosphorous, potassium and magnesium are important for controlling growth and development in plant. Analysis of the results of the present study indicated that, Chiranjeevi BG-II Bt hybrid recorded significantly higher nitrogen uptake (37.57, 80.73 and 142.40 kg ha^{-1}, respectively), higher phosphorus uptake (9.69, 18.43 and 26.33 kg ha^{-1}, respectively) and higher potassium uptake (32.32, 50.65 and 143.98 kg ha^{-1}, respectively) at 60, 90 and 120 DAS.

Whereas, higher magnesium uptake of 8.41 and 14.56 kg ha^{-1}, respectively was observed at 90 and 120 DAS. It is may be due to higher dry matter production, leaf area per plant and yield per plant. The results are comparable with the findings of Police Patil (2007); Manjunatha *et al*. (2010) and Venugopalan *et al*. (2012).

5.2.3 Effect on economics

Economics is the ultimate criteria for acceptance and wider adoption of any technology and Bt technology is also no exception to this. Among different indicators of economic efficiency in any production system, net return has greater impact on the practical utility and acceptance of the technology by the farmers.

In the present study, same cultural practices and plant protection measures were adopted to all the treatments of Bt genotypes. Among the Bt cotton hybrids Chiranjeevi BG-II Bt recorded significantly higher gross return, net return and B: C ratio (₹ 71,299, ₹ 40,532 and 2.19, respectively) as compared to other hybrids. Lower gross return, net return and B:C ratio was recorded in NH-44 non-Bt hybrid (₹ 38,582, ₹ 8,395 and 1.26, respectively). The higher gross return, net return from cultivation of Chiranjeevi BG-II Bt was mainly due to higher economic yield associated with that hybrid. Similar economic benefits from Bt cotton cultivation were also reported by Venugopal *et al*. (2002), Hosmath *et al.* (2011), Yenagi (2006) in RCH-20 Bt; Police Patil (2007) in MRC-6322 Bt; Manjunatha *et al*. (2010b) in Bunny Bt, Sudha (2011) in MRC-6918 and Mallika Bt recorded significantly higher net return as compared to other Bt cotton hybrids tested at different locations.

5.3 Response of Bt cotton to different levels of nutrients on growth and yield

5.3.1 Effect of nutrients on growth and yield

Soil fertility and crop management are the two most important factors of modern agricultural system. Managing the balance of vegetative and reproductive growth is the essence of managing a cotton crop. 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 photosynthates supply to the sink sites or hormonal effects (Borowski, 2001). For a dynamic crop like cotton, excess N delay maturity, promote vegetative tendencies and usually result in lower yields (McConnell *et al*., 1996). Errors made in N management can impact the crop through either deficiencies or excesses. If deficiency of N develops in cotton, it is not difficult to diagnose and correct. But, excess N fertility levels, which can damage final crop productivity, are more difficult to detect and to correct (Sawan *et al*., 2006).

In the present investigation, seed cotton yield differed significantly due to application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher seed cotton yield of 1,847 kg ha^{-1} as compared to other levels (Table 10). Increase in yield was to the tune of 38.43 per cent over the control.

The lowest seed cotton yield (490 kg ha^{-1}) was recorded in absolute control. Increased number of splits might have helped for the increased availability of N by extending time and reducing the losses of N. Here N application was made up to 120 days through split application covering all stages of its requirements. Whereas, Hosmath (2011) observed that seed cotton yield advantage was more with foliar application of KNO_3 @ 2 per cent and Soil and foliar application of $MgSO_4$ @ 25 kg ha^{-1} and 1 per cent, respectively. Similarly Brar *et al*. (2004), Nehra and Kumawat (2003), Singh *et al*. (2004), Rajendran *et al*. (2011), Sharma and Singh (2007), Kaur *et al*. (2007 and 2011), Blaise *et al.* (2009), Aladakatti *et al.* (2011), Waraich *et al*. (2011) and Dewdar and Reddy (2013) also reported the increased seed cotton yield with KNO_3 @ 2 per cent foliar application along with RDF as compared to application of RDF alone.

The foliar nutrition plays an important role in physiology of cotton crop (Weir *et al*., 2001). Being a part of enzyme system or as a catalyst in enzymatic reactions, nutrients are required for plant metabolic activities such as respiration, meristmetic development, chlorophyll formation, energy system, protein and oil synthesis and helpful for growth and development of the plant. Magnesium occupies the centre part of the chlorophyll molecule and thus, playing vital role in photosynthesis. Further, it is also associated with maintenance of healthy green leaves as its deficiency causes red leaf diseases. The role of nitrogen and potassium in accelerating the meristem growth, cell multiplication and cell elongation, enzymatic activity for the conduct of cellular metabolism is well documented.

Higher seed cotton yield with different major nutrient and foliar sprays of KNO_3 combined with RDF was closely related to higher yield parameters such as harvested seed cotton yield per plant, bolls per plant, mean boll weight, monopodia $plant^{-1}$ and sympodia $plant^{-1}$ (Table 4, 5, 10 and 11). In the present investigation application of nitrogen in seven splits and foliar application of KNO_3 (RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS with 2 % foliar application of KNO_3 three times from October onwards at 15 days interval) recorded significantly higher seed cotton yield per plant (494.84 g), total bolls $plant^{-1}$ (32.24), mean boll weight (5.11) and monopodial branches $plant^{-1}$ (2.60, 3.13 and 3.90, respectively at 60, 90 and 120 DAS). The magnitudes of increase in application of nitrogen in seven splits and foliar application of KNO_3 was to the extent of seed cotton yield $plant^{-1}$ 38.33 %, total bolls $plant^{-1}$ 13 %, mean boll weight 41 per cent over the absolute control. Studies of Oostrehuis *et al*. (1990), Oostrehuis (1993), Brar and Brar (2001 and 2002), Sharma and Singh (2007), Blaise *et al*. (2009), Rajendran *et al*. (2011) and Kaur *et al*. (2001) also indicated that foliar application of 2 % KNO_3 resulted in increased yield per plant, monopodia per plant, sympodia per plant, boll weight and total bolls per plant. Increase of yield attributes in these treatments is due to the major nutrient and magnesium increased the photosynthetic activity, dry matter accumulation and increased the biochemical activity of the plant.

In cotton, yield per plant is more important to achieve maximum yield per unit area. Number of good opened bolls and bad opened bolls greatly influence the yield per plant. In present study of investigation on nutrient management treatment in cotton, application of nitrogen in seven splits and foliar application of KNO_3 (RDF 7 splits 10 % as basal, remaining 90 % in equal splits at 30, 60, 75, 90, 105 and 120 DAS with 2 % foliar application of KNO_3 three times from October onwards at 15 days interval) accounted significantly maximum number of good opened bolls (29.85) however, no significant effect was observed with respect to number of bad opened bolls.

The magnitudes of increase in application of nitrogen in seven splits and foliar application of KNO_3 were to the extent of good opened bolls per plant about 13 % over the absolute control. The lowest good opened bolls per plant in absolute control (25.94). Similar results was also obtained by Hosmath (2011).

The seed cotton yield is an end product which depends on the plant height, dry matter production at different stages of the crop and its partitioning to economic part *viz.,* reproductive parts, leaf and for higher production. Higher total dry matter production coupled with maximum translocation of dry matter into sink decides the yield of the crop (Krishnamurthy *et al*., 1973). Yield is the result of growth and development as indicated by plant height and total dry matter accumulation per plant, and its distribution in various parts. Many of the growth characters and yield attributes of the plants will have their contribution to the seed cotton yield of the cultivars. In the Present investigation the data on plant height indicated that application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher plant height at 60, 90 and 120 DAS (54.62, 77.96 and 104.63, respectively) as compared to other nutrient levels. Next treatments with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and RDF treatments were on par with each other. The total dry matter production (TDM) may depend on plant height. In the present study, TDM differed significantly, higher total dry production at 60, 90 and 120 DAS (90.14, 211.68 and 249.07 g plant^{-1}, respectively) compared to other treatments. Higher dry matter production in stem (50.74, 109.36 and 116.33 g plant^{-1} respectively), higher dry matter production in leaves (39.39, 44.46 and 58.40 g plant^{-1}, respectively and higher dry matter production in reproductive parts (57.86 and 74.33 g plant^{-1}, respectively) were noticed with the application of nitrogen in seven splits with foliar application of KNO_3 and application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was on par to above treatment at 90 and 120 DAS (206.21 and 246.07 g plant^{-1}, respectively) with respect to total dry matter production at 60 DAS, dry matter production in stem (49.40 and 48.96, respectively) was on par to the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application RDF. However, at 90 and 120 DAS the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ (Table 8 and 9), dry matter production in leaves was on par to the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ at 90 DAS (Table 9). The lowest dry matter is recorded in absolute control (Table 9). These results are in conformity with the findings of Srinivasan (2004), Sankaranarayanan *et al*. (2010) and Rajendran *et al*. (2011). They reported that, the foliar application of major and secondary nutrients along with RDF significantly increased the dry matter production and its accumulation in different parts *viz.,* leaves, stem and reproductive parts as compared to alone application of RDF.

The reason for increase in total dry matter production and its accumulation in different parts of plant are dependent on total photosynthetic area (leaf area, LAI and LAD) and rate of photosynthesis.

In the present investigation, the data on leaf area, LAI and LAD is recorded in application of nitrogen in seven splits with foliar application of KNO_3 at 60, 90 and 120 DAS (Table 6 and 7) as compared to other nutrient levels.

Application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer were on par at 60, 90 and 120 DAS (Table 6 and 7). The similar results were also observed by Nehra and Kumawat (2003).

5.3.2 Effect of nutrients on *Cry* protein concentration and SPAD value

The Bt-endotoxin is the *Cry* stalline proteins (*Cry* protein) that are only solubilised and activated in the highly alkaline midgut of bollworms (Hofte and Whitely, 1989). In the present investigation indicated that *Cry* protein (*Cry1Ac* and *Cry2Ab*) concentration was influenced by nutrient levels at all growth stages. Application of nitrogen in seven splits and foliar application of KNO_3 was recorded higher *Cry1Ac* protein at 90 and 120 DAS (1.26 and 0.97 μg^{-1}, respectively). The application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and the application of recommended dose of fertilizer was on par at 90 (1.25, 1.23, respectively) and 120 DAS (0.94 and 0.95 μg^{-1} respectively). Lower *Cry1Ac* protein content was registered at 90 and 120 DAS in absolute control (1.06 and 0.86, respectively). The magnitudes of increase in application of nitrogen in seven splits and foliar application of KNO_3 were to the extent of 15.87 per cent at 90 DAS and 11.34 per cent at 120 DAS over absolute control.

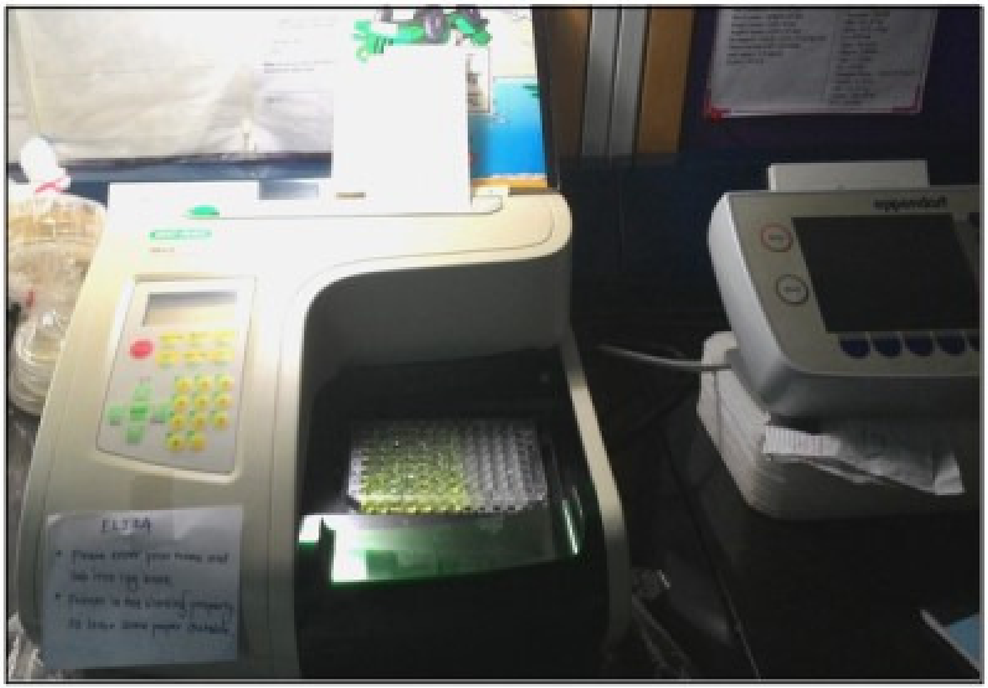
The application of nitrogen in seven splits with foliar application of KNO_3 recorded nine per cent increase in *Cry 2Ab* protein content at 90 and 120 DAS compared to absolute control. Similar results were also observed by Brown and Oosterhuis (2003) and Rochester Ian (2006). In the present study higher *Cry* protein concentration was noticed in crop growth stage at 90 DAS and declining trend was observed in subsequent growth stages. The results are in agreement with the findings of Pettigrew *et al*. (2000) and Adamczck and Summer (2001). They reported that declines in leaf *Cry* protein concentration as the cotton plants become aged. At particular stage of the crop *Cry* protein concentration changes with change in the nutrient levels. Further, studies of Sun *et al*. (2002), Hallikeri *et al*. (2011) and Wan *et al*. (2005) also confirmed the fact that expression pattern vary within the season with concentration at the beginning and least at the end.

5.3.3 Effect of nutrients on fiber quality parameters

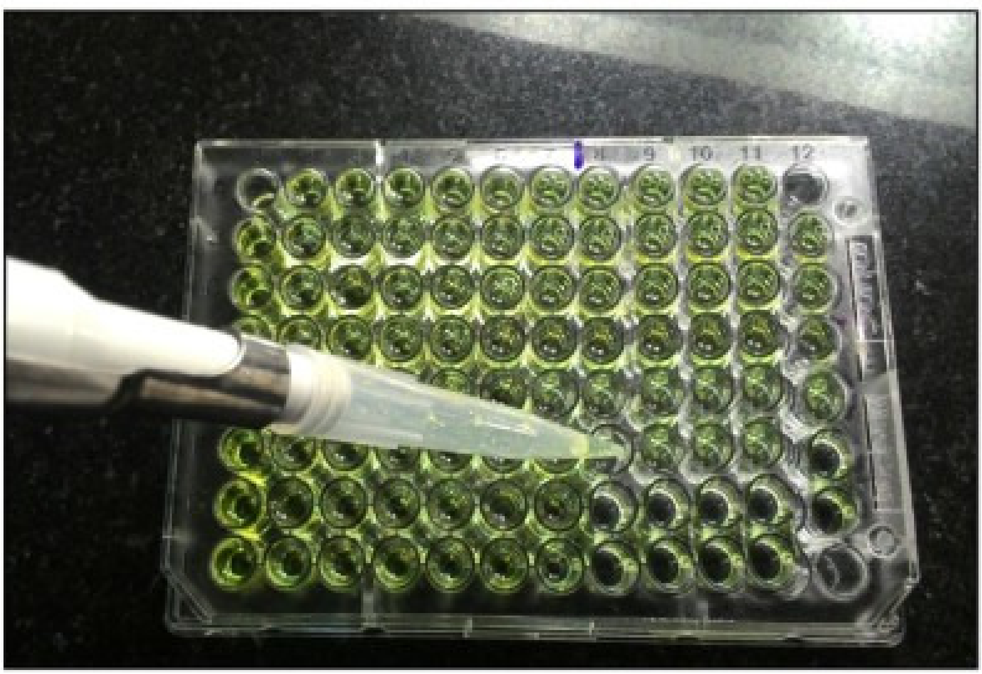
Bt cotton lint was tested for different fibre quality parameters *viz.,* fiber length, uniformity ratio, micronnaire value, fibre strength and ginning out turn. The experimental data on quality parameters showed that significantly higher ginning out turn, fiber length, fibre strength, uniformity ratio and micronnaire value were recorded with the application of nitrogen in seven splits with foliar application of KNO_3 (Table 12) and it was at par with the application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ par (Table 12). These results are in conformity with the observations on fibre properties in Bt hybrid cotton by Arun and Reddy (2009), Hosamani *et al*. (2013) and Thimmareddy *et al*. (2013b) who have reported that application of higher levels of fertilizers significantly influenced on fibre length, micronnaire value and ginning out turn.

5.3.4 Effect of nutrients on soil enzyme activity and AM fungi

Soil microorganisms are one of the main sources of soil enzymes, which play an essential role in energy transfer, environmental quality, organic matter decomposition, nutrient recycling and crop productivity. Dehydrogenase activity is only present in viable cells is a useful indicator of overall microbial activity in soil.



ELISA instrument for cry protein analysis



ELISA plate

Plate5. ELISA instrument for cry protein analysis

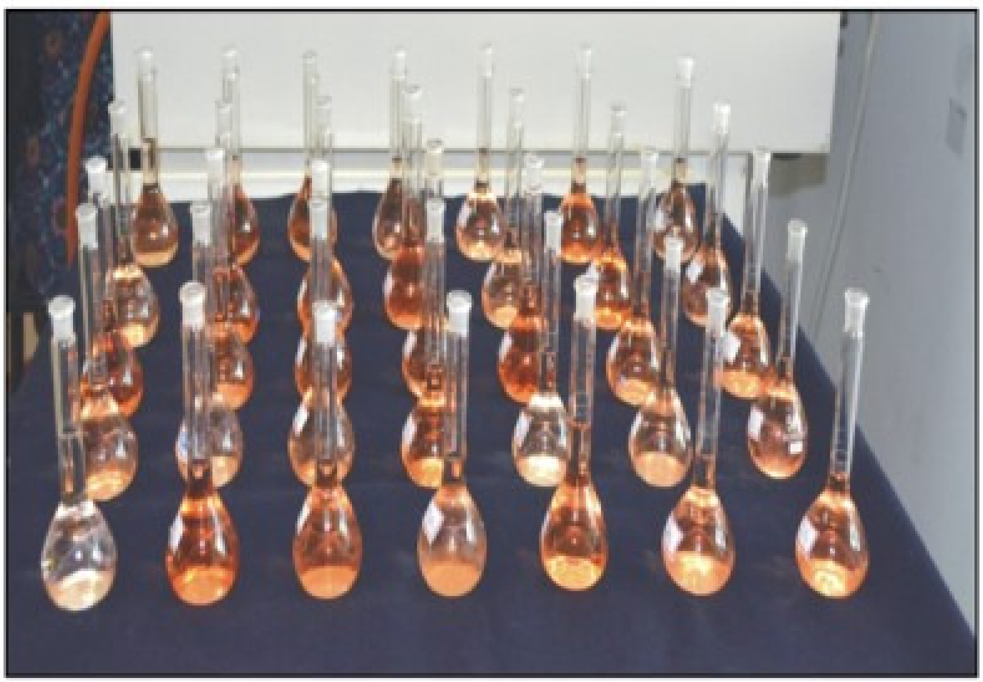
Phosphatase is believed to play critical role in phosphorus cycle by catalyzing hydrolysis of esters and anhydrides of phosphoric acid. Urease plays vital role in the hydrolysis of urea fertilizers and nitrogen availability to plants and Arbuscular mycorrhizal fungi play a crucial role for the growth, survival and development of plant species thus influencing plant secondary succession and community structure. Their benefits may involve better access to soil resources and enhancement of soil aggregation, stability and protection against phytopathogens. Therefore, an activity of soil enzymes acts as key biological indicator of changes occurring in soil.

In the present study, nutrient levels were mainly influenced on enhancement of enzyme activities. Application of nitrogen in seven splits with foliar application of KNO_3 was recorded higher dehydrogenase activity, urease activity, phosphatase activity and AM fungi root colonization at 90 and 120 DAS (Table 15 and 16) compared to absolute control. And application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was at par with respect to dehydrogenase activity at 90 and 120 DAS, urease activity was on par at 90 DAS. Similar trend observed in the application of recommended dose of fertilizer (Table 15). Higher phosphatase activity observed with the application of nitrogen in seven splits and foliar application of KNO_3 at 90 and 120 DAS (Table 16) and application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ and application of recommended dose of fertilizer was at par at 90 DAS and AM fungal root colonisation differed significantly due to application of nutrients. The application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was recorded significantly higher AM fungal activity at 90 and 120 DAS (Table 16). However, application of recommended dose of fertilizer and the application of nitrogen in seven splits with foliar application of KNO_3 was at par at 90 DAS (Table 16). All three enzyme activities were increased in rhizosphere soil with progressive crop growth, subsequently decline trend was observed. This might be due to increased as well as altered root exudates. The root exudates have a profound qualitative and quantitative effect on the rhizospheric microorganisms and increase in root exudation results in increase microbial activity. Yang *et al.* (2012) also reported that soil enzyme activity was increased with increase fertilizer levels.

5.3.5 Effect on nutrient uptake and soil available nutrients

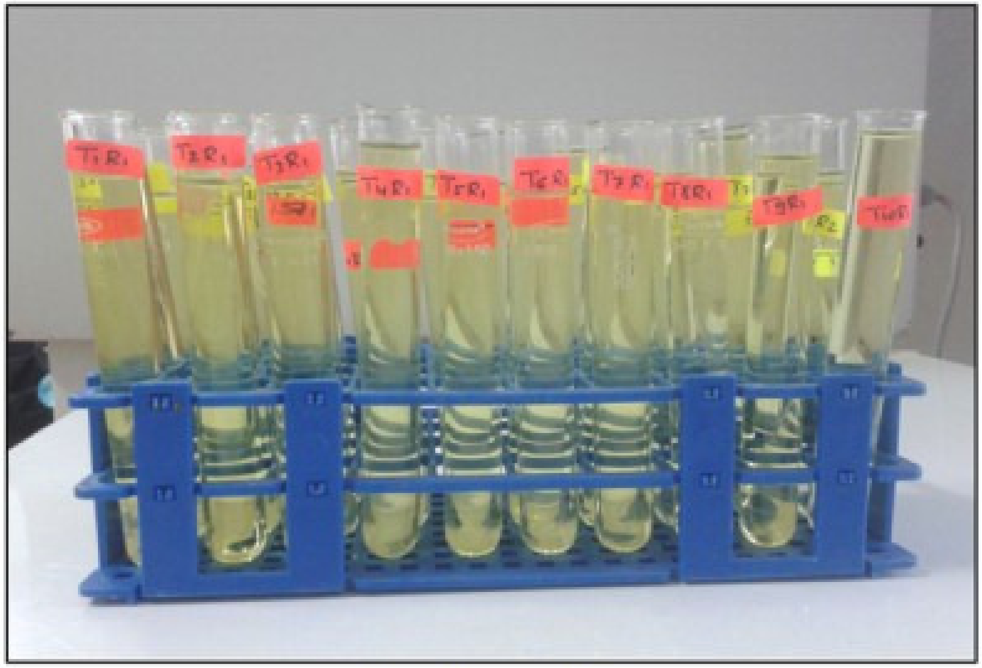
In the present investigation, nutrient uptake at different stages differed significantly due to application of nutrients. Results data indicated that, application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher nitrogen uptake (36.60, 81.60 and 146.60 kg ha^{-1}, respectively), higher phosphorous uptake (9.31, 16.60 and 27.60 kg ha^{-1}, respectively) and higher potassium uptake (32.60, 52.60 and 147.60 kg ha^{-1}, respectively) at 60, 90 and 120 DAS. Application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded higher magnesium uptake at 60, 90 and 120 DAS (3.59, 9.72 and 16.46 kg ha^{-1}, respectively). It may be due to higher dry matter accumulation. These results are in conformity with the finding of Nalayani (2010). Available nitrogen, phosphorus, potassium and magnesium in soil at harvest differed significantly due to application of nitrogen in seven splits with foliar application of KNO_3 recorded higher available nitrogen in soil after harvest (303.45 kg ha^{-1}) and available phosphorous in soil after harvest (32.29 kg ha^{-1}).

90 DAS

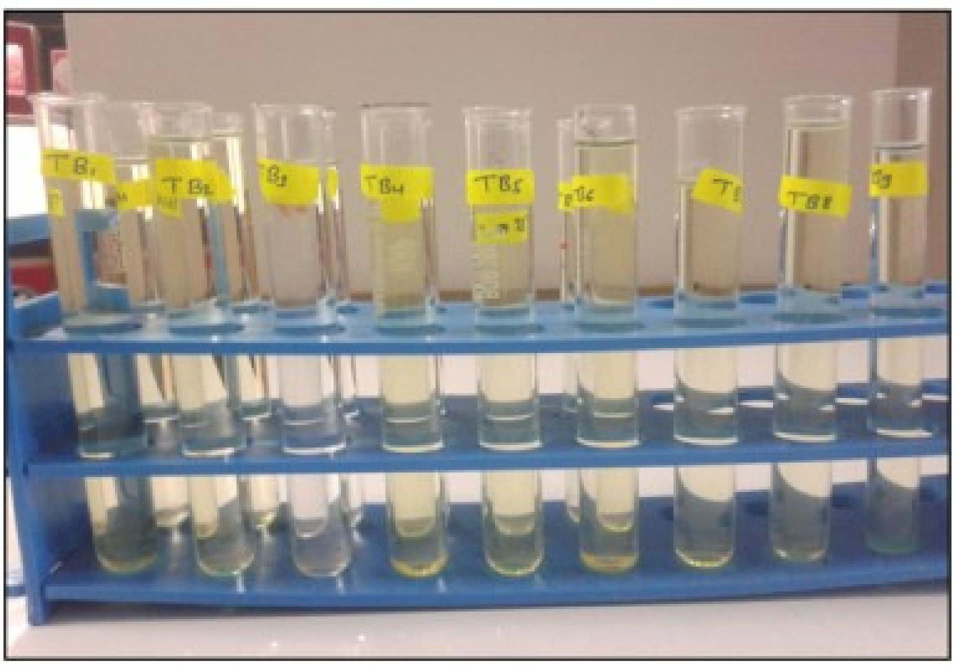


120 DAS

Plate6. Dehydrogenase activity



Phosphtase activity



Urease activity

Plate7. Phosphatase activity and urease activity

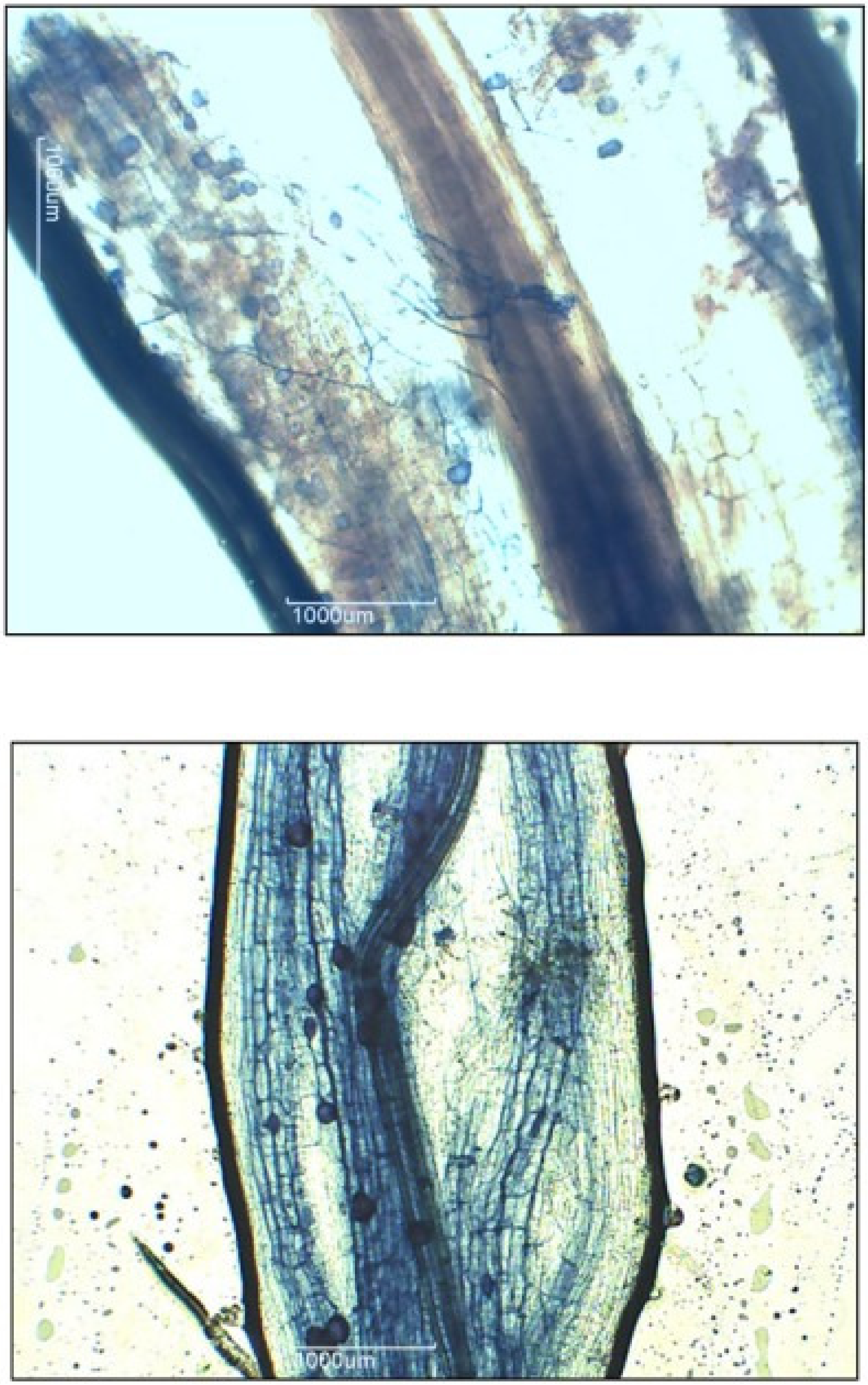


Plate8. AM fungi root colonization

Application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ was recorded higher available potassium in soil after harvest (212.01 kg ha^{-1}). Available magnesium was recorded in absolute control treatment (6.45 me $100g^{-1}$ of soil). Similar results reported by Police Patil (2007).

5.3.6 Effect on economics

In the present study, economics differed significantly due to application of different nutrient levels. Application of nitrogen in seven splits with foliar application of KNO_3 recorded higher gross return, net return and B:C ratio (₹ 77,421, 43,038 and 2.25, respectively) as compared to other levels. Lowest gross return, net return and B:C ratio recorded in absolute control (21,370.27, 2,233.60 and 1.12, respectively). Similar results were also reported by Hosmath *et al*. (2011), Yenagi *et al*. (2006), Solunke *et al*. (2009), Manjunatha *et al*. (2010b) and Patil *et al*. (2004).

5.4 Interaction effect of Bt cotton hybrids to nutrient levels

In the present investigation, Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher seed cotton yield and seed cotton yield $plant^{-1}$ (2372 kg ha^{-1} and 628 g $plant^{-1}$), respectively as compared to other treatment combinations. The increased yield in Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits and foliar application of KNO_3 to the tune of 62 per cent over NHH-44 non-Bt hybrid in absolute control. The increased seed cotton yield in this treatment an account of higher mean boll weight, bolls $plant^{-1}$, and good number of opened bolls $plant^{-1}$.

In cotton, yield in any hybrids is depend on yield attributing characters. In the present study interaction effect of Bt cotton hybrid and nutrient levels; Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher bolls $plant^{-1}$, mean boll weight $plant^{-1}$ and good number of opened bolls $plant^{-1}$ (Table 10) as compared to other treatment combinations.

The seed cotton yield is an end product, which obviously depends upon the total dry matter production at different stages of the crop growth and its partitioning to in different parts. In the present study total dry matter production was influenced by nutrient levels. Among the different treatment combinations, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher total dry matter production at 60 and 120 DAS (Table 9) as compared to other treatment combinations. The higher total dry matter production might be due to higher dry matter accumulation. At 120 DAS significantly higher dry matter production in stem and dry matter production in leaves in Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 (Table 9).

In cotton, yield per plant is more important to achieve maximum yield per unit area and plant growth *viz.,* plant height and number of monopodia $plant^{-1}$ indirectly contributes to the seed cotton yield. In the present study, Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher plant height and monopodia $plant^{-1}$ at 90 and 120 DAS as compared to other treatment combinations (Table 4).

Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher *Cry1Ac* and *Cry2Ab* at 90 and 120 DAS as compared to other treatment combinations (Table 13 and 14).

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits and foliar application of KNO_3 was recorded significantly higher nitrogen uptake, phosphorous uptake, potassium uptake and magnesium uptake at 60, 90 and 120 DAS (Table 17 and 18). Chiranjeevi BG-II Bt hybrid with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded significantly higher available nitrogen and higher available phosphorous (Table 17 and 18). Higher available potassium was recorded in NHH-44 non-Bt hybrid with application of recommended dose of fertilizer in soil after harvest and NHH-44 non-Bt hybrid with the application of nitrogen in seven splits and foliar application of KNO_3 was recorded higher available magnesium in soil after harvest (7.85 me 100^{-1} g of soil).

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher gross return, net return and B: C ratio as compared to other treatment combinations (Table 20).

Practical utility

Bollgard II Bt (Chiranjeevi BG II Bt) in the present study out yielded compared to Bollgard I Bt (RCH-2 BGI Bt) non-Bt (NHH-44 non-Bt). Hence, to get higher seed cotton yield Bollgard II Bt could be recommended under protective irrigation.

Application of recommended nitrogen in seven splits with foliar application of KNO_3 increased the seed cotton yield and also increased the soil microbial activity in the present investigation. Hence, instead of recommended nitrogen into three splits application of nitrogen, it is better to go for seven splits application of nitrogen to get higher yield under protective irrigation.

Based on the results of present investigation, cultivation of Bollgard II Bt hybrid with seven splits application of recommended nitrogen yield substantial seed cotton. Hence, the technology may be adopted by the farmers to get higher seed cotton yield.

Future line of work

- Micronutrient application through soil and foliar may be tried to get higher yield
- Various bioinoculants may be tried to maintain soil health.

6. SUMMARY AND CONCLUSIONS

The field experiment was conducted at Main Agricultural Research Station, University of Agricultural Science, Dharwad during *Kharif* 2014-15 to evaluate on soil and foliar nutrient management in Bt and non-Bt cotton genotypes under protective irrigation. The experiment was laid out in Split plot design with three replications. Experimental plot size of the experiment was 5.4 × 4.2 m with spacing 90 × 60 cm. The salient findings of field experiment are summarized as under.

The experiment comprised three main plots of Bt cotton hybrids M_1: RCH-2 BG-I Bt, M_2: Chiranjeevi BG-II Bt and M_3: NHH-44 non-Bt and sub plot consisted four nutrient levels S_1: RDF (100:50:50: NPK kg/ha + 10t FYM + 1% $MgSO_4$ foliar spray), S_2: RDF + Foliar application with KNO_3, S_3: RDF + 19:19:19(0.5 %) + $MgSO_4$ soil @ 25 kg ha^{-1} and foliar application (1 %) and S_4: Absolute control. The results are summarized under this chapter.

Performance of Chiranjeevi BG-II Bt hybrid recorded significantly higher seed cotton yield (1,693 kg ha^{-1}) compared to other genotypes followed by RCH-2 BG-I Bt hybrid (1,395 kg ha^{-1}). The lower seed cotton yield was registered significantly in NHH-44 non-Bt genotype (917 kg ha^{-1}).

Significantly higher yield and growth attributing characters *viz.,* seed cotton yield per plant, mean boll weight, TDM, sympodia per plant, monopodia per plant, leaf area, LAI, LAD and Chlorophyll content were observed in Chiranjeevi BG-II Bt hybrid as compared to other hybrids.

With respect to fibre quality, Ginning out turn (GOT), Fibre strength, Uniformity ratio and Micronnaire value values were recorded with Chiranjeevi BG-II Bt hybrid as compared to other hybrids.

Significantly higher nitrogen uptake, phosphorus uptake, potassium uptake and magnesium uptake was recorded Chiranjeevi BG-II Bt hybrid at 60, 90 and 120 DAS as compared to other hybrids.

Chiranjeevi BG-II Bt hybrid was recorded significantly higher gross return, net return and B: C ratio (₹ 71,299.49, ₹ 40,532.59 and 2.19, respectively) as compared to other hybrids.

Seed cotton yield differed significantly due to application of nutrients; application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher seed cotton yield of 1,847 kg ha^{-1} as compared to other levels. Lowest seed cotton yield was recorded in absolute control (490 kg ha^{-1}).

Significantly higher seed cotton yield per plant, total dry matter production, bolls per plant, mean boll weight, monopodia per plant and sympodia per plant, leaf area, LAD and Chlorophyll content were recorded with application of nitrogen in seven splits and foliar application of KNO_3 as compared to other nutrient levels.

Growth characters *viz.,* plant height which indirectly influences the seed cotton yield was recorded with application of nitrogen in seven splits and foliar application of KNO_3 as compared to other nutrient levels.

Cry1Ac protein content differed significantly due to application of nutrients: Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher *Cry1Ac* protein content at 90 and 120 DAS (1.26 and 0.97, respectively). And nine per cent increase in *Cry 2Ab* protein content at 90 and 120 DAS compared to absolute control.

Fibre quality differed significantly due to application of nutrients: Among the treatments, application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher ginning out turn (GOT), fibre length, fibre strength and micronnaire value as compared other nutrient levels.

Nutrient uptake was differed significantly due to application nutrient levels. Application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher nitrogen uptake, phosphorus uptake, potassium uptake and magnesium uptake at 60, 90 and 120 DAS as compared to absolute control.

Economics differed significantly due to application of different nutrient levels. Application of nitrogen in seven splits with foliar application of KNO_3 recorded higher gross return, net return and B:C ratio (₹ 77,421.93, 43,038.57 and 2.25, respectively) as compared to other levels.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher seed cotton yield, seed cotton yield plant^{-1} (2,372 kg ha^{-1} and 628 g plant^{-1}) as compared to other treatment combinations.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher bolls plant^{-1}, mean boll weight and good opened bolls plant^{-1} as compared to other treatment combinations.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher total dry matter production at 60 and 120 DAS as compared to other treatment combinations.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher plant height, monopodia plant^{-1} at 90 and 120 DAS as compared to other treatment combinations.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher *Cry1Ac* and *Cry2Ab* at 90 and 120 DAS (Table 13 and 14) as compared to other treatment combinations.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 was recorded significantly higher nitrogen uptake, phosphorous uptake, potassium uptake and magnesium uptake at 60, 90 and 120 DAS as compared to other treatment combinations.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in three splits with foliar application of 19:19:19 and $MgSO_4$ recorded significantly higher available nitrogen and available phosphorous. Whereas, higher available potassium was recorded in NHH-44 non-Bt hybrid with application of recommended dose of fertilizer in soil after harvest. Chiranjeevi BG-II Bt hybrid with the application of nitrogen in seven splits with foliar application of KNO_3 recorded higher available magnesium in soil after harvest as compared to other treatment combinations.

Chiranjeevi BG-II Bt hybrid with application of nitrogen in seven splits with foliar application of KNO_3 recorded significantly higher gross return, net return and B: C ratio as compared to other treatment combinations.

REFERENCES

Adamczyk, John, J. R. J. and Summer Ford Douglas, V., 2001, Potential factors impacting season long expression of *Cry1Ac* in 13 commercial varieties of Bollgard cotton. *J. Insect Sci.*, 1: 13: 1-6.

Aladkatti, Y. R., Hallikeri, S. S., Nandagvi, R. A., Naveen, N. E., Hugar, A. Y. and Blaise, D., 2011, Yield and fiber qualities of hybrid cotton (*Gossypium hirsutum* L.) as influenced by soil and foliar application of potassium. *Karnataka J. Agric. Sci.,* 24 (2): 133-136.

Aladkatti, Y. R., Shivamurthy, D., Nandagvi, R. A. and Hallikeri, S. S., 2012, Effect of integrated nutrient management practices on cotton. *National Seminar on Sustainable Agriculture and Food Security: Challenges in Challenging Climate*, 27-28, March, Haryana, p. 175.

Amandeep, S. B. and Sarlach, R. S., 2013, Response of American cotton (*Gossypium hirsutum* L.) genotypes to varying plant densities and graded levels of fertilizers. *Vegetos.,* 26(2):145-147.

Amboti, R. R. and Thakare, S. K., 2012, Effect of nutrient management on FUE, red leaf, fibre properties of *Bt* hybrid cotton. *Indian J. Agron.*, 57(4):390-396.

Amrutha, R., Shivkumar, T. and Anath Kumar, C. C., 2009, Foliar nutrition to reduce the shedding and square drain in cotton (*Gossypium hirsutum*). *National Symposium on Bt Cotton-Opportunities and prospects,* Nagpur*,* 2008-09, p.64.

Anand, S. R., 2005, Response of Bt cotton hybrids (*Gossypium hirsutum* L.) to different plant spacings under irrigation. *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad, Karnataka (India).

Anonymous, 1998, *Area and Production of Fibre Crops*. Directorate of Economics, Government of Indian Production, pp.1-10.

Anonymous, 2005, GM cotton's stride. *Pestology Biotech. Bulletin,* 29: 47.

Anonymous, 2006, *Project Coordinator Report, 2006-07*. Annual group meeting of AICCRP, Central Institute of Cotton Research (CICR), Coimbatore, pp. 81-86.

Anonymous, 2009, *Annual Report of the AICCIP 2009-10*, Central Institute of Cotton Research (CICR), Coimbatore, pp. 1-15.

Anonymous, 2010, Global Status of Commercialized Biotech Crops. *ISAAA Brief,* p.42.

Anonymous, 2011, Area, production and productivity of cotton in India, Cotton Advisory Board, Nagpur, pp. 75-82.

Anonymous, 2014, *Technical Report*, 2013-14, Directorate of Statistics, Ministry of Agriculture and Cotton Advisory Board, New Delhi, p. 77.

Arnold B. H. and Craig, A., 2006, Nitrogen fertility effects on *Bt* endotoxin and nitrogen concentrations of maize during early growth. *Agron. J.,* 92: 207–211.

Arnold, B. and Craig, A., 2003, Nitrogen fertility effects on Bt endotoxin and nitrogen concentrations of maize during early growth. *Agron. J.,* 89: 110-112.

Arnold, B. H. and Craig, A. A., 2005, Effect of nitrogen fertility on *Bt*-Endotoxin levels in *Bt* hybrids maize. *Agron. J.,* 91: 58-61.

Aruna, E and Reddy, B. S., 2009, Response of Bt cotton to plant geometry and nutrient combinations. *Indian J. Agric. Res*., 43(3): 206-210.

Asewar, B. V., Pawar, S. U., Bhosle, G. P. and Gokhale, D. N., 2013, Effect of spacing and fertilizer levels on seed cotton yield and economics of *Bt* cotton. *J. Cotton Res. Dev*., 27(1):63-65.

Ashaq H., Dinesh Kumar, B. S., Dwivedi, D., Rana, S. and Gangaiah, B., 2014, Relative response of *Bt* cotton *(Gossypium hirsutum*) to balanced fertilization in irrigated cotton-wheat cropping system. *African J. Agric. Res*., 9(1), pp. 21-33.

Bandhopadhyay, K. K., Prakash, A. H., Sankaranarayanan, K., Dharajyohi, B. and Gopalkrishnan, N., 2009, Effect of irrigation and nitrogen on soil water dynamics, productivity and input use efficiency of *Bt* cotton in Vertic Ustropept. *Indian J. Agric. Sci*., 79: 448-453.

Barathi, S. and Sira, R. K., 2013, *Cry1Ac, Cry 2Ab* expression in transgenic *Bt* cotton hybrids as influenced by nutrition and spacing in rainfed vertisols . *Inl. Res. J. Pharm.,* 4(9): 75-81.

Basavaneppa, 2012, Effect of nutrients on δ-endotoxin and management of refuge crops in *Bt* cotton under irrigated condition. *Ph. D. Thesis,* Univ. Agric. Sci., Dharwad, Karnataka (India).

Basavanneppa, M. A., Aladakatti, Y. R., Biradar, D. P., Ajay Kumar, M. Y. and Shivakumar, 2011, Influence of foliar nutrition on Bt cotton productivity and profitability in irrigated ecosystem. *World cotton Res. Conf. on Technologies for Prosperity-5*, Mumbai, 7-11 November 2011, Book of Abstracts, p.156.

Bastia, D. K., 2000, Response of cotton hybrid Savitha to spacing and nitrogen, phosphorus and potassium levels treatments under rainfed conditions of Orissa. *Indian J. Agric. Assess*, 185:485–495.

Bhalerao, P. D. and Gaikwad, G. S., 2010, Productivity and profitability of *Bt* cotton under various plant geometry and fertilizer levels. *Indian J. Agron*., 55(1):60-63.

Bhalerao, P. D., Deshmuk, P. W., Godavari, Gaikwad, G. and Imade, S. R., 2012, Response of *Bt* cotton to spacing and fertilizer levels under rainfed condition. *Indian J. Agron*., 57(2):176-179.

Bhalerao, P. D., Gawande, P. P., Ghatol, P. U. and Patiol, B. R., 2008, Performance of Bt cotton hybrids for various spacing under rainfed conditions. *Agric. Sci. Digest*, 28 (1):54-56.

Bhatade, S. S., Ansingkar, A. S., Deshmukh, L. S., More, S. S. and Kurkhade, N. G., 2008, Identification of suitable cotton species and genotypes for different rainfed agro-ecological situations of Marathwada region of Maharashtra state. *J. Cotton Res. Dev.*, 22(1): 1-4.

Bhati, A. S. and Singh, M., 2015, Effect of split application of nitrogen and potassium on yield, nutrient uptake and nutrient use efficiency in Bt cotton. *Ann. Pl. Soil Res.,* 17 (1): 71-73.

Biradar, D. P., Alagawadi, A. R., Basavanneppa, M. A. and Udikeri S. S., 2012, Soil microflora and enzyme activities in rhizosphere of Transgenic *Bt* cotton hybrid under different intercropping systems and plant protection schedules, *Geophysic Res.*, 14:793-802.

Black, C. A., 1965, Methods of Soil Analysis (part-2), Agronomy monograph-9, American Society of Agronomy, Medison, Wisconsin, USA, pp. 149-157.

Blaise, D., Singh, J. V. and Bande, A. N., 2009, Response of rainfed cotton (*Gossypium hirsutum* L.) to foliar application of potassium. *Indian J. Agron.*, 54(4):50-55.

Blaise, D., Venugopalan, M. V. and Raju, A. R., 2014, Introduction of Bt Cotton hybrids in India: Did it change the agronomy? *Indian J. Agron.*, 59(1):1-20.

Borowski, E., 2001, The effect of nitrogenous compounds on the growth, photosynthesis and phosphorus uptake of sunflower. *Annales Universitatis Mariae Curie Skiodowska. Sectio EEE*, *Horticultura*, 9: 23-31.

Brar, A. S., Singh, N. and Deol, J. S., 2002, Influence of plant spacing and growth modification practices in yield and its attributing characters of two cotton cultivars (*G. hirsutum*). *J. Res. Panjab Agric. Uni.*, 39 (2): 181-183.

Brar, M. S. and Brar, A. S., 2001, Effect of foliar application of nutrients on yield of hirstum cotton. *In: Proceedings of National Symposium on Cotton Research Strategies of New Millenium,* 16 April 2001, *CCS Harayana Agric. Uni*, Hisar, p. 24.

Brar, M. S. and Brar, A. S., 2004, Foliar nutrition as supplementation to soil fertilizer application to increase yield of upland cotton. *Indian J. Agric.*, 74: 472-475.

Brar, M. S., Gill, M. S., Sekhon, K. S., Sandhu, B. S., Sharma, P. and Singh, A., 2008, Effect of soil and foliar application of nutrients on yield and nutrient concentration in *Bt* cotton. *J. Res. Punjab Agric. Univ.*, 45(3&4): 89-91.

Brown, R. S. and Oosterhuis, D. M., 2003, Effect of foliar Chaperone applications under elevated temperatures on the protein concentrations and physiological responses of cotton. *Summaries of Arkansas Cotton Research 2003*, *AAES Res. Series* 521, pp. 108-113

Buttar, G. S., Sekhon, K. S. and Sudeep Singh., 2010, Effect of different spacings and nitrogen levels on growth and yield attributes of American cotton Bt hybrids under irrigated conditions. *J. Cotton Res. Dev.*, 24(1):73-75.

Casida, L. E., Klein, D. A. and Santoro, T., 1964, Soil dehydrogenase activity. *Soil Sci.* 98:371-376.

Chang, Q. Y., Li-hua, X. and De-yin, Y., 2005, Effect of nitrogen fertilizer on the *Bt* protein content in transgenic cotton and nitrogen metabolism mechanism. *Cotton Sci.*, 17 (4): 227-231.

Chinnu Babu V., Prasad, N. V. S. D., Krishana, M. S. R. and Ramachandra Rao, G., 2013, Spatial and temporal expression of *Bt* toxin on commercial *Bt* cotton hybrids. *J. Cotton Res. Dev.*, 27(1) 80-84.

Chitdeshwari, T., Sankaran, K. and Krishna, D. D., 1997, Role of magnesium sulphate in controlling shedding of leaves in cotton. *Madras Agric. J.,* 84:386-387.

Choudhary, B. and Gaur, K., 2010, Bt cotton in India: *A country profile. ISAAA Series of biotech crop profiles.* International Service for Acquisition of Agri-Biotech Applications (ISAAA), Ithaca, New York, p. 4.

Clive, J., 2009, Global Status of Commercialized Biotech/GM Crops: 20O6. *ISAAA Briefs* No. 35, ISAAA (International Service for Acquisition of Agri-Biotech Applications), Ithaca, New York, USA.

Devaraj, M. S., Bhattoo, B. S. Duhan, Promila Kumari and Jain, P. P., 2011, Effect of crop geometry and fertilizer levels on seed cotton yield and nutrient uptake of *Bt* cotton under irrigated conditions. *J. Cotton Res. Dev.*, 25(2): 176-180.

Dewdar, M. D. H. and Reddy, M. M., 2013, Influence of soil and foliar application of potassium fertilization on growth, yield and fiber quality traits in two *Gossypium barbadense* L. Varieties. *African J. Agric. Res.*, 8 (9): 2211-2215.

Doli, A. M. G. Umate, G. L. Sawargaonkar, M. G. Patil, 2009, Effect of different fertilizer doses and green manuring treatments on growth and yield of rainfed *Bt* cotton. *National Symposium on Bt cotton: Opportunities and Prospects*, 17-19, November, CICR, Nagpur, p.60.

Donald, L.M., 1962, Competition among crop and pasture plants. *Advances in Agronomy*, 10: 435-473.

Dong, H., Li, W., Li, Z., Tang, W. and Zhang, D., 2010, Evaluation of production systems in China that uses reduced plant densities and retention of vegetative branches. *J. Cotton Sci.,* 9 : 1-9.

Evazi, Z. and Tabatabai, M. A., 1979, Phosphatase activity in soil. *Soil Biol. Biochem.*, 9: 167-172.

Fitt, G., 1998, A future for IPM in cotton : the challenge of integrating new tools to minimize pesticide dependence. *Proceedings of World Cotton Research Conference-2*, held at Athens, Greece, pp. 75-84.

Gadhiya, S. S., Patil, B. B., Jadav, N. J., Pavaya, R. H., Patil, M. V. and Patil, V. R., 2009, Effect of different levels of nitrogen, phosphorus and potassium on growth, yield and quality of *Bt* cotton. *An Asian J. Soil Sci.*, 4(1):37-42.

Gangaiah, B. and Ahlawat, I. P. S., 2014, Nitrogen fertilization of *Bt* cotton-wheat cropping system. *Indian J. Agron.*, 54(2):235-241.

Gawade, R. T. and Bhalerao, P. D., 2012, Effect of fertilizer application on leaf reddening and yield of Bt. cotton. *Bioinfolet.*, 9 (3) : 382 – 384.

Ghongane, S. B., Yeledhalli, N. A., Patil, B. V., Desai, B. K., Beledhadi, R. V., 2009, Effect of fertilizer and irrigation levels on *Cry* protein, soil moisture depletion pattern, yield and nutrient uptake of transgenic *Bt* cotton in deep vertisols*, Karnataka J. Agric. Sci.,* 22 (4) : 901-904.

Giri, A. N., Aundhekar, R. L., Kapse, P. S. and Suryavanshi, S. B., 2008, Response of Bt cotton hybrids to plant densities and fertilizer levels. *J. Cotton Res. Dev.*, 22(1): 45-47.

Giri, M. D., Dhonde, M. B. and Tekale, C. D., 2014, Split application of nitrogen and foliar nutrition in Bt cotton (*Gossypium hirsutum*). *Bioinfolet.*, 11 (2):599-602.

Gomez, K. A. and Gomez, A. A., 1984, *Statistical Procedures for Agricultural Research. 2nd Edn., A Willey Interscience Publication*, New York (USA), p.680.

Greenplate, J. T, 1999, Quantification of *Bacillus thuringiensis* insect control protein cry1Ac over time in Bollgard cotton fruit and terminal. *J. Econ Entomol.*, 92(6): 1377-1383.

Gundlur, S. S., Rajkumar, S., Neelakanth, J. K., Ashok, P. and Khot, A. B., 2013, Water and nutrient requirement of *Bt* cotton under vertisols of Malaprabha command. *Karnataka J. Agric. Sci.*, 26 (3):368-371.

Halemani, H. L., Hallikeri, S. S., Nandagavi, R. A. and Nooli, S. S., 2004, Performance of Bt cotton hybrids at different levels of fertilizers under protective irrigation. *Int. Symp. on 'Strategies for Sustainable Cotton Production–A Global Vision 2, Crop Production,* 23-25 Nov., UAS, Dharwad, Karnataka (India), pp. 153-155.

Hallikeri, S. S., 2008, Studies on the effect of time of sowing, nitrogen and irrigation levels on growth, yield, fibre quality and endotoxin concentration of *Bt* cotton. *Ph. D. Thesis, Univ. Agric. Sci.,* Dharwad, Karnataka (India).

Hallikeri, S. S., Halemani, H. L., Nandagavi, R. A. and Nooli, S. S., 2004, Response of Mahyco *Bt* cotton hybrids to levels of fertilizer under protective irrigation. *International. Symposium on 'Strategies for Sustainable Cotton Production – A Global Vision 2,* Crop Production, 23-25 Nov., UAS, Dharwad, Karnataka (India), pp. 139-141.

Hallikeri, S. S., Halemani, H. L., Patil, V. C. Palled, Y. B., Patil, B. C. and Katageri, I. S., 2010, Effect of nitrogen levels, split application of nitrogen and detopping on seed cotton yield and fibre quality in Bt cotton. *Karnataka J. Agric. Sci.*, 23(3):418-422.

Hallikeri, S.S. and Halemani, H. L., 2011, Influence of nitrogen management on expression of *Cry* protein in *Bt*-cotton (*Gossypium hirsutum*). *Indian J. Agron.,* 56 (1): 62-67.

Hallikeri, S.S. Halemani, H.L. Patil B.C. and Nandagavi., R.A., 2011, Influence of nitrogen management on expression of cry protein in Bt-cotton (*Gossypium hirsutum*) *Indian J. Agron.* 56 (1): 62-67.

Hanumantha, L. P., 1999, Impact of nutrients and growth regulators on drying of reproductive structures in Bt cotton (*Gossypium hirsutum*). *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad (India).

Hegde, M., Nidagundi, J. M., Biradar, D. P., Udikeri, S. S. and Khadi, B. M., 2004, Performance of Bt and non-Bt cotton hybrids against insect pests under irrigated condition. *International Symposium on Strategies for Sustainable Cotton Production – A Global Vision 2, Crop Production,* 23-25 Nov., UAS, Dharwad, Karnataka (India), pp. 143-145.

Hill, C. A. and Pinnock, D. E., 1998, Histopathological effects of *Bacillus thuringiensis* on the Alimentary canal of the sheep house. Bovicola Ovis. *J. Inver. Patho*, 72 (1): 9-20.

Hofte, H. and Whitely, H.R., 1989, Insecticidal *Cry*stal proteins of *Bacillus thuringiensis*. *Microbial Rev.*, 53: 242-255.

Holt, H., 1998, Season long monitoring of transgenic cotton plants development of assay for the quantification of *Bacillus thuringiensis* insecticidal protein, the ninth Australian cotton Conference. *Proceedings Cotton Res. Dev.*, Australia, pp.331-335.

Hosamani, V., Halepyati, A. S., Chowdry, R., Manu, T. G., Santhosh, U. N. and Nataraj, N., 2013, Response of *Bt* cotton to macro nutrients and liquid fertilizers. *Bioinfolet.*, 10(4B): 1319-1323.

Hosmani, V., Halepyati, A.S., Shashikumar, M., Santhosh, U. N., Nataraja, M. and Manu, T. J., 2013, Quality, uptake of nutrients and economics of irrigated Bt cotton (*Gossypium Hirsutum* L.) as influenced by macronutrient and liquid fertilizers. G.B.A.H.S., 2 (1): 29-32.

Hosmath, J. A., 2011, Evaluation of Bt cotton genotypes and nutrient management to leaf reddening. *Ph. D. Thesis,* Univ. Agric. Sci., Dharwad, Karnataka (India).

Hosmath, J. A., Biradar, D. P., Deshpande, S. K., Dodamani, S. V. and Rizwan Haris, M. D., 2004, Analysis of *Bt* toxin (*Cry1Ac* protein) under organics. In: *The proc. International Symposium on Sustainable Cotton Production -A global vision. Crop Production, 23 25 Nov., UAS, Dharwad,* Karnataka (India), pp. 135-137.

Hosmath, J. A., Biradar, D. P., Patil, V. C., Palled, Y. B. and Malligawad, L. H., 2015, Nutrient requirement of Bt. cotton (*Gossypium hirsutum*). *Indian J. Agron.,* 59 (1): 133-138.

Isik, I. and Guenther S., 2007, Fate and effects of insect-resistant *Bt* crops in soil ecosystems, *Soil Biol. Biochem.,* 40: 559–586.

Jackson, M. L., 1967, Soil Chemical Analysis Prentice Hall, India, Private Limited, New Delhi, p.498.

Jackson, M. L., 1973, Soil Chemical Analysis Prentice Hall of India Pvt. Ltd., New Delhi (India), p. 187.

Jiang, L., Duan, L., Tian, X., Wang, B., Zhang, H., Zhang, M. and Lizhaohu, 2004, NaCl salinity stress decreased *Bacillus thuringiensis* (*Bt*) protein content of transgenic *Bt*-cotton (*G. hirsutum*) seedlings. *Environ. Botany*, 55 (3): 315-320.

Jikun, H., Jianwei, M., Ruijian, C., Honghua, S., Kongming, W., Fangbin, Q. and Ruifa, H., 2014, Effect of farm management practices in the Bt toxin production by Bt cotton: evidence from farm fields in China. *Transgenic Res.*, 23:397–406.

Joshi, P. N., 2007, Agronomic performance, δ-endotoxin quantification and molecular characterization of *Bt* cotton genotypes. *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad, Karnataka (India).

Kalaichelvi, K., 2009, Bt cotton response to plant geometry and fertilizer levels. *J. Cotton Res. Dev.*, 23:96-99.

Kasturikasen, B. and Amitava, R., 2013, *Bt* cotton influencing enzymatic activities varied soils. *J. Ecol.* 3(8): 505-509.

Katkar, T. A. B., Wankhede, S. T. and Lambe, S. P., 2005, Effect of foliar application of nutrients on production of cotton. *J. Cotton Res. Dev.*, 16(1):89-92.

Kaur, M., Kaur, M. and Brar, A. S., 2007. Effect of potassium on the growth and yield of American cotton (*Gossypium hirsutum* L.). *J. Cotton Res. Dev.*, 21(2): 187–190.

Kaur, P., Buttar, G. S., Kaur, M., Gilli, M. S. and Sohu, R. S., 2011, Effect of foliar and split application of potassium on seed cotton yield and fibre quality of American cotton (*Gossypium hirsutum* L.). *Indian J. Agric. Sci.*, 81 (9): 838-842.

Kaur, P., Maninder, Kaur, Gill, M. S. and Buttar, G. S., 2010, Response of *Bt* cotton hybrid RCH 134 to varied spacing and fertility levels under Punjab conditions. *J. Cotton Res. Dev.*, 24(2):189-192.

Khadi, B. M., 2009, Biotech cotton: Issues for consideration. *J. Cotton Res. Dev.*, 23(4) : 27-31.

Khadi, B. M., Katageri, I. S. and Mogali, S. C., 2008, Performance of Bt cotton hybrids for yield and fiber quality in transitional tract of Karnataka. *Indian Agric. Sci. Digest*, 28 (4): 283-285.

Khadi, B. M., Katageri, I. S., Kulkarni, V. N. and Adigannavar, A. M., 2002, Evaluation of Bt cotton hybrids in transitional tract of Karnataka. *National Seminar on Bt cotton Scenario with special reference to India,* Dharwad 23rd May, 2002, p. 87.

Khan, M. A., 1996, Response of mustard to ethrel spray and basal and foliar application of nitrogen. *J. Agron Crop Sci*, 175: 331-334.

Kranthi, K. R., Dhawad, C. S., Naidu, S., Mate, K., Patil, E. and Kranthi, S., 2005, *Bt* cotton seed as source of *Bacillus thuringiensis* insecticidal *Cry1Ac* toxin for bioassays to detect and monitor bollworm resistance to *Bt* cotton. *Curr. Sci.,* 88(5): 796-800.

Kranthi, K. R., Kranthi, S., Banerjee, S., K. and Mayee, C., D., 2005, Perspectives on Resistance Management Strategies for *Bt* cotton in India. *World Cotton Research Conference-3*, Cape Town, South Africa, pp. 1254-1262.

Kranthi, K. R., Naidu, S., Dhawad, C. S., Tatwawadi, A., Mate, K., Patil, E., Bharose, A. A., Behere, G. T., Wadaskar, R. M. and Kranthi, S., 2005, Temporal and intra-plant variability of *Cry1Ac* expression in *Bt*-cotton and its influence on the survival of the cotton bollworm, *Helicoverpa armigera* (Hubner) (Noctuidae : Lepidoptera). *Curr. Sci*., 89(2): 291-298.

Krishnamurthy, K., Bommegowda, A., Raghunath, G., Rajasekhar, B. G., Venugopal, N., Jagannatha, M. R., Jayaram, G. and Prasad R.T.V., 1973, Investigations on the structure of yield in Cereals (maize and sorghum). *Final Tecnol. Rep*., 480: 373.

Krishnegowda, 2004, Response of *Bt* cotton hybrids to fertilizer levels under irrigated condition in Tungabhadra Project (TBP) area. *M. Sc. (Agri.) Thesis, Univ. Agric. Sci*., Dharwad, Karnataka (India).

Majid, R. and Mohammad, G., 2011, Response of yield and yield components of cotton to different rates of boron fertilizer. *American-Eurasian J. Agron*., 4(1):13-16.

Manjunatha, M. J., Halepyati, A. S., Koppaikar, B. G. and Pujari, B. T., 2010a, Yield and yield components, uptake of nutrients, quality parameters and economics of Bt cotton (*Gossypium hirsutum* L.) genotypes influenced by different plant densities. *Karnataka J. Agric. Sci*., 23 (3): 423-425.

Manjunatha, M. J., Halepyati, A.S., Koppaikar, B.G. and Pujari, B.T., 2010b, Influence of different plant densities on the growth, yield and economics of Bt cotton (*Gossypium hirsutum* L.) genotypes under dry land condition. *Karnataka J. Agric. Sci*., 23 (4): 580-583.

Manjunatha, R., Pradeep, S., Sridhara, S., Manjunatha, M., Mohan, I. N., Shivanna, B. K. and Hosamani, V., 2009, Quantification of *Cry1Ac* protein overtime in different tissues of *Bt* cotton Hybrids. *Karnataka J. Agric. Sci*., 22(3): 609-610.

Manjunatha, S. B., 2014, Nutrient management studies for higher productivity of Bt cotton. *Ph. D. Thesis,* Univ. Agric. Sci. Dharwad, Karnataka (India).

McConnell, J. S., Baker, W. H. and Frizzell, B. S., 1996, Distribution of residual nitrate-N in long term fertilization studies of an alfisol cropped for cotton. *J. Environ. Quart*., 25: 1389-1394.

Modhvadia, J. M., Solanki, R. M., Nariya, J. N., Vadaria, K. N. and Rathod, A. D., 2012, effect of different levels of nitrogen, phosphorus and potassium on growth, yield and quality of *Bt* cotton hybrid under irrigated conditions*. J. Cotton Res. Dev*., 26(1):47-51.

Muhr, G. R., Datta, N. P., Shankarambramoney, R., Lelley, V. R. and Donahue, R. L., 1965, *Soil Testing in India*. USAID, New Delhi, pp. 47-77.

Nalayani, P., Sankaranarayanan, K. and Anandham, R., 2010, Bio inoculants for enhancing the productivity and nutrient uptake of winter irrigated cotton under graded levels of nitrogen and phosphatic fertilizers. *Indian J. Agron*. 58(3):391-395.

Narayan, E., Hema, K., Srinivasulu, K., Prasad, N. V. V. S. D. and Rao, N. H. P., 2008, Performance of *Bt* cotton hybrid (NCS-145 *Bt*) to varied spacings and fertilizer levels in vertisol under rainfed condition. *J. Indian Soc. Cotton Improv*. April, pp. 33-36.

Nehra, P. L. and Godara, S. P., 2009, Agronomic evaluation of *Bt* cotton hybrid under varied crop geometry and NPK levels. *National Symposium on Bt cotton: Opportunities and Prospects*, 17-19, November, CICR, Nagpur, p.52.

Nehra, P. L. and Kumawat, P. D., 2003, Effect of foliar nutrition on productivity of American cotton (*Gossypium hirsutum* L.). *J. Cotton Res. Dev*., 17 (1): 32-40.

Nehra, P. L. and Yadav, P. S., 2011, Agronomic evaluation of *Bt* cotton hybrid (RCH-134 *Bt* I) under varied crop geometries and fertilizer levels in canal command area of north- west Rajasthan*. Cotton Res. J*. 2: 77-80.

Olsen, K. M., Daly, J. C., Finnegan, E., J. and Mahon, R., J., 2005, Changes in *Cry1Ac Bt* transgenic cotton in response to two environmental factors: Temperature and insect damage. *J. Econ. Ent.,* 98 (4): 1382-1390.

Oosterhuis, D. M., 1993, Growth and development of cotton plant. In : *Nitrogen Nutrition of Cotton* : Practical Issues, 1-24 (Ed.) : W. N. Miley and D. M. Oosterhuis, ASA, Madison, WI.

Oosterhuis, D.M., Wullschleger, S.D., Maples, R.L. and Miley, W.N., 1990, Foliar feeding of potassium nitrate on cotton. *Better Crops and Plant Food : Practical Issues*, 74: 8-9.

Pancholy, S. K. and Rice, E. L., 1973, Soil enzymes in relation to old field succession: Amylase, invertase, cellulose, dehydrogenase and urease. *Soil Sci. Soc. America*., 37:47-50.

Patil, S., Patil, B., Kademani, S. and Pawar, K. N., 2011, Studies on change in the gas exchange and phonological parameters under water stress condition in Bt cotton hybrid. *World Cotton Res. Conf. on Technologies for Prosperity-5*, Mumbai, 7-11, November 2011, p. 169.

Patil, V. C., Halemani, H. L., Girijesh, G. K., Chandrashekhar, C. P., Kalibhavi, C. M., Hallikeri, S. S. and Yenagi, B. S., 2004, Scheduling of drip irrigation for hybrid cotton (*Gossypium hirsutum* L.) in northern dry zone of Karnataka. International Symposium on *"Strategies for Sustainable Cotton Production – A Global Vision" 2*. Crop Production, 23-25 November 2004, UAS, Dharwad, pp. 207-212.

Patil, V. C., Halemani, H. L., Hallikeri, S. S., Nooli, S. S. and Bandiwadder, T. T., 2004, Response of hybrid cotton to drip irrigation and fertrigation. International Symposium on *"Strategies for Sustainable Cotton Production – A Global Vision" 2*. Crop Production, 23-25 November 2004, UAS, Dharwad, pp. 145-147.

Pawar, S. U., Gitte, A. N., Bhosle, G. P., and Suryawanshi, S. B., 2010, Effect of fertilizer levels and plant densities on yield, gross and net monetary returns of *Bt* cotton hybrid *J.Cotton Res. Dev*., 24 (2): 182-185.

Pettigrew, W. T. and Adamczyk, J. J., 2006, Nitrogen fertility and planting date effects on lint yield and *Cry1Ac* (*Bt*) endotoxin production. *Agron J.*, 98: 691-697.

Pettigrew, W. T., McCarty, J. C. and Vaughn, K. C., 2000, Leaf senescence like characteristics contributes to cotton's premature photosynthetic decline. *Photosynt. Res.*, 65: 187-195.

Phad, D. S., Bhatade, S. S. and Deosarkar, D. B., 2009, Identification of suitable Bt cotton hybrids under rainfed conditions of Marthwada region. *National. Symposium on Bt Cotton :Opportunities and Prospects.* 17-19, November, CICR, Nagpur, Maharashtra, p. 24.

Phad, D. S., Bhatade, S. S. and Deosarkar, D. B., 2010, Identification of suitable Bt cotton hybrids under rainfed condition of Marathwada region. *J. Cotton Res. Dev.,* 24(1): 5-8.

Piper, C. S., 1966, *Soil and Plant Analysis.* Hans Publishers, Bombay, p.236.

Police Patil, A. S., 2007, Performance of *Bt* cotton hybrids as influenced by site specific nutrient management approach for realizing target yields. *M. Sc. (Agri.) Thesis,* Univ. Agric. Sci., Dharwad, Karnataka (India).

Power, J. F., Wills, W. O. and Reilman, G. A., 1967, Effect of soil temperature, phosphorus and plant age on growth analysis in maize. *Agron. J.*, 57: 113-119.

Power, J. F., Wills, W. O., Grains, D. L. and Reilman, G. A., 1969, Effect of soil temperature, phosphorus and plant age on growth analysis in barley. *Agron. J.,* 59: 231-234.

Rajendran, K., Mohamed, M. A. and Vaiyapuri, K., 2009, Influence on growth, yield attributes and yield of Bt cotton by soil and foliar application of nutrients. *Madras Agric. J.*, 98 (1-3): 67-68.

Rajendran, K., Mohamed, M.A. and Vaiyapuri, K., 2009, Agronomic performance of Bt and non-Bt cotton hybrids. *Madras Agric. J.*, 96 (7-12): 378-379.

Ramamurthy, V. and Venugopalan, M. V., 2009, Performance of Bt cotton (*Gossypium hirsutum*) hybrid on shrink swell soils of Central India. *Indian J. Agric. Sci.,* 79(12) : 1026-1029.

Raman, J. S., Ahlawat, I. P. S. and Surender, S., 2012, Effects of transgenic *Bt* cotton on soil fertility and biology under field conditions in subtropical inceptisol, *Environ Monit Assess*, 185:485–495.

Ranjithkumar, L., Patil, B. V. and Vijaykumar, N. G., 2011, Impact of irrigation and fertilizer levels on *Cry1Ac* protein content in *Bt* cotton. *Res. J. Agric. Sci.*, 2(1): 33-35.

Reddy, P. R. and Kumar, B. D., 2010, Fertilizer response studies in *Bt* cotton hybrid. *J. Cotton Res. Dev.,* 24(1) 76-77.

Reddy, R. P. and Kumar, D. B., 2010, Fertilizer response studies in *Bt* cotton hybrid. *J. Cotton Res. Dev.,* 24(1): 76-77.

Ren, F. S., Hong C and Wan, H. G., 2006, Transgenic *Bt* cotton has no apparent effect on enzymatic activities or functional diversity of microbial communities in rhizosphere soil. *Plant and Soil*, 285:149–159.

Rochester, I. J., 2006, Effect of genotype, edaphic, environmental conditions and agronomic practices on *Cry1Ac* protein expression in transgenic cotton. *J. Cotton Sci.,* 10: 252–262.

Sachs, E. S., Benedict, J. H., Stelly, D. M., Taylor, J. F, Altmon, D. W., Berberich, S. A. and Davis, S. K, 1998, Expression and segregation of genes encoding *Cry1Ac* insecticidal proteins in cotton. *Crop Sci.,* 38: 1-11.

Sagar, D., Patil, B. V. and Bheemanna, M., 2011, Pest status and *Cry* protein content in transgenic cotton*. J. Cotton Res., Dev*., 25(2):258-262.

Sakarvadia, H. L., Polara, K. B., Parmar, K. B., Babariya, N. B. and Kunjadia, B. B., 2009, Effect of potassium and zinc on growth, yield, quality parameters and nutrient uptake by *Bt* cotton. *Asian J. Soil Sci*., 4(1):24-26.

Saleem, M. F., Bilal, M, F., Awais, M., Shahid, M, Q. and Anjum, S. A., 2010, Effect of nitrogen on seed cotton yield and fiber qualities of *Bt* cotton cultivars*. J. Animal Plant Sci*., 20(1):23-27.

Sankaranarayan, K., Nalayini, P., Praharaj, C. S. and Dharajyothi, 2004, Effects of dates of sowing on the productivity of *Bt* cotton hybrid. *International. Symposium on 'Strategies for Sustainable Cotton Production – A Global Vision 2,* Crop Production, 23-25 Nov., UAS, Dharwad, Karnataka (India), pp. 103-104.

Sankaranarayanan, K., Praharaj, C. S., Nalyini, P., Bandopadhyay, K. K. and Gopalakrishnan, N., 2010, Effect of magnesium, zinc, iron and boron application on yield and quality of cotton (*Gossypium hirsutum*). *Indian J. Agric. Sci.,* 80(8) : 699-703

Sarang, D. H., Bhatade, S. S. and Deosarkar, D. B., 2010, Evaluation of some new *Bt* cottonhybrids for seed cotton yield and fibre quality traits under rainfed conditions. *J. Cotton Res. Dev*., 24(2): 149-154.

Sarkar, B., Patra, A. K. and Purakayasth T. J., 2009, Transgenic *Bt*-cotton affects enzyme activity and nutrient availability in a sub-tropical inceptisol. *J. Agron. Crop Sci*., 194(4): 289-296.

Sasthri, G., Thiagarajan, C. P., Srimathi, P., Malarkodi, K. and Venkatasalam, E. P., 2001, Influence of higher levels of NPK on seed cotton yield, seed yield and seed quality characters of cotton cv. MCU-5 and hybrid TCHB 213. *Madras Agric. J.,* 88 (1-3): 60-63

Sawan, Z. M., Mahmoud, H. and Guibali, A. H., 2006, Response of yield,yield components and fibre properties of Egyptian cotton (*Gossypium barbadense* L.) to nitrogen fertilization and foliar applied potassium and mepiquat chloride. *J. Cotton Sci*., 10: 224-234.

Saxena, D. and Stotzky, G., 2001, *Bacillus thuringiensis* (*Bt*) toxin released from root exudates and biomass of *Bt* corn has no apparent effect on earthworms, nematodes, protozoa, bacteria and fungi in soil. *Soil. Biol. Bioc.* 33: 1225-1230.

Sestak, Z., Catasky, J. and Jarvis, P. G., 1971, *Plant Photosynthetic Production : Manual of Methods* (Ed. Junk N. V.), The Haque Publishers, New York, pp. 72-78.

Sestak, Z., Regar, P. L., and Jarvis, P.G., 1997, Plant Photosynthetic Production, *Water Res.,* 7(8): 1219-1224.

Setty, R. A., Satyanarayana Rao and Koppalkar, B. G., 2002, Integrated foliar nutrition studies for yield maximization in hybrid cotton under. *J. Cotton Res. Dev.*, 16(2):196-198.

Sharma, S. K. and Singh, S., 2007, Yield, yield attributes and quality of cotton as influenced by foliar application of potassium. *J. Cotton Res. Dev.,* 21 (1):51-54.

Shivamurthy, D. and Biradar, D. P., 2014, Effect of foliar nutrition on growth, yield attributes and seed cotton yield of *Bt* cotton. *Karnataka J. Agric. Sci.,* 27 (1):5-8.

Singh, A., Rathore, P. and Pathak, D., 2004, Effect of foliar application of inorganic nutrients on yield of American cotton. *J. Cotton Res. Dev.*, 18 (2):172-174.

Singh, C., Joshi, R. C. and Katti, C. V., 1970, Soil and foliar application of nitrogen to rainfed cotton. *Indian J. Agron*, 15: 269-271.

Singh, Y., Rao, S. S. and Regar, P. L., 2010, Deficit irrigation and nitrogen effects on seed cotton yield, water productivity and yield response factor in shallow soil of semi arid environment. *Agril. Water Manag.*, 97: 965-970.

Solaiappan, U. and Sherif M. N., 1994, Effect of tillage practices and nitrogen application in cotton (*Gossypium* spp.) grown after rice. *Indian J. Agron.*, 39 (2): 302-304.

Solunke, P. S., Thokale, J. G. and Barve, U. S., 2009, Influence of foliar feeding of different micronutrients on yield and economics of hybrid cotton. *National Symposium on Bt Cotton: Opportunities and Prospects,* 17-19, November, CICR, Nagpur, Maharashtra, p. 59.

SreeRekha, M. and Pradeep, T., 2012, Agronomic management for *Bt* cotton under rainfed conditions*, Indian J. Agric. Res.,* 46(1):80-83

SreeRekha, J., Arjuna Rao, P. and Usha, S., 2009, Management of aphids on bhendi with organic sources of NPK and certain insecticides. *The Andhra Agric. J.*, (1&2): 56-60.

Srinivasan, G., 2003, Response of cotton (*Gossypium hirsutum*) to split application of major nutrients. *Indian J. Agron*, 48:59-61.

Srinivasan, G., 2004, Response of cotton (*Gossypium hirsutum* L.) to foliar nutrition and canopy management practices. *Madras Agric. J.*, 91 (7-12): 370-373.

Srinivasan, G., 2006, Agronomic evaluation of *Bt* cotton hybrids in season irrigated trait of Tamil Nadu. *J. Cotton Res. Dev.,* 20: 224-225.

Subbaiah, B. V. and Asija, G. L., 1956, Rapid procedure for estimation of available nitrogen in soil. *Curr. Sci.,* 25: 259-260.

Sudha, T., 2011, Studies on performance of Bt cotton genotypes in different soils of northern transition zone of Karnataka under rainfed situation through farmers participatory approach. *Ph. D. Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Sun, H. W., Bai-Li, Xin Sun-Yi Wen, Sun, H. W., Bai-L. X. and Sun, Y. W., 2002, A preliminary research report on the effect of three Bt transgenic cotton verities in the field against bollworms. *China Cottons*, 26(3):13-15.

Sundaram, V., 1979, Hand Book of Methods of Test for Fibres, Yarn and Fabrics. *Cotton Tech. Res. Lab*., Bombay, pp. 12-38.

Sunitha, V., Chandrashekhar, K. and Veeraraghavaiah, 2010, Performance of *Bt* cotton hybrids at different nitrogen levels. *J. Cotton Res. Dev.,* 24 (1): 52-55.

Tandon, H. L. S. and Narayan, P., 1998, *Fertilizer in Indian Agriculture: Past, Present and Future (1950-2000)*, FDCO, New Delhi, India, p. 160.

Tayade, A. S. and Dhoble, M. V., 2010, Effect of transgenic Bt cotton hybrid, nutrient and pest management on seed cotton yield, nutrient uptake and status of available nutrient in soil. *Indian J. Fert*., 6(8) : 34-40.

Teng, S., Quian, Q., Zheng, D., Kunihiro, Y., Fujimoto, K., Huang, D. and Zhu, L., 2004, Quality analysis of leaf photosynthetic rate and related traits in rice (*Oryza sativa* L.). *Euphytica*, 135: 1-7.

Thimmareddy, K., Desai, B. K. and Vinoda Kumar, S. N., 2013a, Seed cotton yield, Uptake of NPK, and economics of *Bt* cotton as in (*Gossypium hirsutum L*) as influenced by different bio-fertilizers and *in-situ* green manuring under irrigation. *Trends in Biosci*., 6(6):838-841.

Thimmareddy, K., Desai, B. K. and Vinoda Kumar, S. N., 2013b, Uptake of NPK, availability of NPK and quality parameters of *Bt* cotton as in (*Gossypium hirsutum L*) as influenced by different bio-fertilizers and *in-situ* green manuring under irrigation. *Inl. J. Agric., Envir. Biotechol*., 6(4):623-628.

Tuteja, O. P., Anil Metha and Hamid Hasa, 2008, Impact of plant densities and nitrogen levels on seed cotton yield and fibre quality on promising Bt cotton hybrids, *J. Indian Soc. Cotton Improv*., 1:54-56.

Udikeri, S. S., Patil, B.V., Khadi, B. M., Basavangoud, K., Kulkarni, K. A. and Vamadevaih, H. M., 2011, Field evaluation of selected first and second generation Bt transgenic cotton hybrids in rainfed situation, *Karnataka J. Agric. Sci*., 24 (5) :654-660.

Udikeri, S. S., Patil, S. B., Hegde, R., Kulkarni, V. and Patil, S. S., 2003, Performance of Bt cotton genotypes under unprotected conditions. In : *Proc. World Cotton Conf.* 3, 9-13 March, 2003, Cape Town, South Africa, pp. 1282-1286.

Usha, M., Anita Chaudhary and Anju Kamra., 2008, Effect of Bt cotton on enzymes activity and microorganisms in rhizosphere, *J. Agric. Sci.*, 3(1):50-55.

Venugopal, K., 2004, Changing paradigms (avenues/approaches) in cotton production technologies for improving productivity and fibre quality of cotton. *International Symposium on "Strategies for Sustainable Cotton Production – A Global Vision"2.* Crop Production, 23-25 November 2004, UAS, Dharwad. pp. 1-6.

Venugopal, K., Ramasami, M. and Thigarajan, C. P., 2002, Risk assessment and its management in Bt cotton in India. In : *National Seminar on Bt Cotton Scenario with Special Reference to India*, 23rd May, 2002, UAS, Dharwad, Karnataka (India), pp. 70-84.

Venugopalan, M., V. and Blaise, D., 2007, Effect of planting density and nitrogen levels on productivity and N-use efficiency of rainfed upland cotton. *Indian J. Agron.*, 46 (2): 346-353.

Verma, V., 1973, *A Text Book of Plant Physiology*, S. Chand Publisher, New Delhi, pp.250-275.

Vivekanandan, A.S., Gounasena, H.P.M. and Sivanyagan, T., 1972, Statistical evaluation of the accuracy of three techniques used in the estimation of leaf area of crop plant. *Indian J. Agric. Sci.*, 42: 857-860.

Wan, P., Zhang, Y., J., Wu, K., M. and Huang, M., S., 2005, Seasonal expression profiles of insecticidal protein and control efficacy against *Helicoverpa armigera*. *J. Econ, Ent,* 98 (1): 195-201.

Waraich, E. A., Ahmad, R., Hur, R.G. M., Ehasnullah, Ahmad, A. and Mahmood, N., 2011, Response of foliar application of KNO3 on yield, yield components and lint quality of cotton (*Gossypium hirsutum* L.). *African J. Agric. Res.*, 6(24):5457-5463.

Weir, B. L., Roberts, B. A. and Stoddard, S., 2001, Effect of foliar applid K on California cotton. 14th Int. Plant Nutrition Colloquium, Hanover, Germany, pp. 792-793.

Wude Y. A., Meijun Z. and Guangwei D., 2012, Effect of transgenic *Bt* cotton on bioactivities and nutrients in rhizosphere soil, *Communications in Soil Science and Plant Analysis,* 43:689–700.

Yang, C., Xu, L. and Yang, D., 2005, Effects of nitrogen fertilizer on the Bt-protein content in transgenic cotton and nitrogen metabolism mechanism. *Cotton Sci.* 17(4): 227–231.

Yenagi, B. S., 2006, Studies on performance of Bt cotton genotypes and evaluation of refuge crops/cropping system. *Ph. D. Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

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

Items		Units	Prices (₹)
A. Inputs			
Seeds	Chiranjeevi BG-II	Pkt 450 g	930.00
	RCH-2 BG-I	Pkt 450 g	960.00
	NHH-44 Non Bt	Pkt 450 g	350.00
Fertilizers	DAP	Qtl.	2,540.00
	Urea	Qtl.	571.00
	MOP	Qtl.	1,774.00
	19:19:19	kg	60.00
	$MgSO_4$	kg	40.00
	KNO_3	kg	60.00
Manure	FYM	Tonne	750.00
Pesticides	Confidar	100 ml	310.00
	Regent	100 ml	150.00
	Monocrotophos	Lit	450.00
	Acephate	250 g	210.00
Labour	Men	Day	236.00
	Women	Day	236.00
	Bullock pair	1	650.00
Irrigation	Man power	4	2,000.00
Others	Tractor (Transport)	Day	800.00
B. Output			
	Seed cotton cost (₹)	Qtl.	4,050.00

Appendix II: Cost of cultivation of experiment of soil and foliar nutrient management in Bt and non-Bt cotton genotypes under protected irrigation

Tr. No	Combination	Cost of cultivation (₹)
T_1	M_1N_1	34,815
T_2	M_1N_2	34,557
T_3	M_1N_3	34,265
T_4	M_1N_4	19,310
T_5	M_2N_1	34,845
T_6	M_2N_2	34,587
T_7	M_2N_3	34,295
T_8	M_2N_4	19,340
T_9	M_3N_1	34,265
T_{10}	M_3N_2	34,007
T_{11}	M_3N_3	33,715
T_{12}	M_3N_4	18,760

Main plots: (Hybrids)

1. RCH-2 BG-I Bt cotton
2. Chiranjeevi BG-II Bt cotton
3. NHH-44 Non-Bt cotton

Sub plot: (Nutrients Schedule)

1. RDF (100:50:50:NPK Kg/ha +10t FYM +1 % foliar application $MgSO_4$)
2. RDF + Foliar application with KNO_3
3. RDF+ 19:19:19 (0.5%) + $MgSO_4$ (1%) soil and foliar application
4. Absolute control

SOIL AND FOLIAR NUTRIENT MANAGEMENT IN Bt AND NON-Bt COTTON GENOTYPES UNDER PROTECTIVE IRRIGATION

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ABSTRACT

A field experiment on "Soil and foliar nutrient management in Bt and non-Bt cotton genotypes under protective irrigation" was conducted at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2014. The experiment was replicated thrice in split plot design and executed on black vertisols. The treatments comprised of three main plots of Bt cotton hybrids; RCH-2 (BG-I) Bt, Chiranjeevi (BG-II) Bt and NHH-44 non-Bt and sub-plots consisted four nutrient levels; RDF (100:50:50: NPK kg ha^{-1} + 10t FYM + 1% $MgSO_4$ foliar spray), RDF + Foliar application with KNO_3, RDF + 19:19:19 (0.5 %) + $MgSO_4$ soil @ 25 kg ha^{-1} and foliar application (1 %) and Absolute control. Chiranjeevi BG-II Bt hybrid recorded significantly higher seed cotton yield (1,693 kg ha^{-1}) compared to other genotypes followed by RCH-2 BG-I Bt hybrid (1,395 kg ha^{-1}). The lower seed cotton yield is registered significantly in NHH-44 non-Bt hybrids (917 kg ha^{-1}). Among different nutrient levels, application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher seed cotton yield (1,847 kg ha^{-1}), *Cry1Ac* protein (1.26 and 0.97 μg^{-1}, respectively) at 90 and 120 DAS, net return (₹ 43,532) and B: C ratio (2.19) compared to other nutrient levels. Among nutrient levels, application of nitrogen in seven splits along with foliar application of KNO_3 recorded the highest dehydrogenase, phosphatase, urease activity and AM fungal root colonization at 90 and 120 DAS. However, the results obtained with different hybrids with respect to soil enzymes and AMF root colonization was at par with each other. In Chiranjeevi BG-II Bt hybrid application of nitrogen in seven splits and foliar application of KNO_3 recorded significantly higher seed cotton yield (2,328 kg ha^{-1}), *Cry1Ac* protein (1.26 and 0.97 μg^{-1}, respectively) at 90 and 120 DAS compared to other treatments. Net return (₹ 43,532) and B:C ratio (2.25) followed the similar trend.