STUDIES ON PERFORMANCE OF Bt COTTON GENOTYPES IN DIFFERENT SOILS OF NORTHERN TRANSITION ZONE OF KARNATAKA UNDER RAINFED SITUATION THROUGH FARMERS PARTICIPATORY APPROACH

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1. INTRODUCTION

Cotton (*Gossypium hirsutum*) is an important fiber yielding crop of global importance, which is grown in tropical and sub tropical regions of more than 80 countries the world over. India is the only country where all the cultivated species and some of their hybrid combinations are commercially grown. The diversity of cotton cultivars and cotton agro climatic zones in India is considerably larger when compared to other major cotton growing countries in the world.

The rapid adoption of biotech crops during the initial 13 years of commercialization, 1996 to 2008, reflects the substantial multiple benefits realized by both large and small farmers in industrial and developing countries. A total of 762 approvals have been granted for 155 events in 24 crops in 2009. As predicted by ISAAA (International Service for the Acquisition of Agri-Biotech Applications) in 2005, there will be 40 biotech countries by 2015, 20 million biotech crop farmers and 200 million hectares of biotech crops. There will be a continuing and expanding supply of appropriate new biotech crops to meet the priority needs of global society, particularly the developing countries of Asia, Latin America and Africa (James Clive, 2009).

Updated global impact assessments for biotech crops indicate that for the period 1996 to 2008 economic gains of US $51.9 billion were generated from two sources, firstly, reduced production costs (50%) and secondly, substantial yield gains (50%) of 167 million tonnes. The latter would have required 62.6 million additional hectares had biotech crops not been deployed, hence biotech crops are an important land saving technology. During the 14 years of commercialization 1996 to 2009, the global area of biotech crops increased almost 89 fold increase from 1.7 million hectares in 1996 to 13.4 million hectares in 2009. This rate of adoption is the highest rate of crop technology adoption for any crop technology and reflects the continuing and growing acceptance of biotech crops by farmers. The number of countries growing biotech crops quadrupled increasing from 6 in 1996 to 12 countries in 1997, 17 in 2004, 21 countries in 2005 and 25 in 2009 (James Clive, 2009). In 2009, developing countries continued to outnumber industrial countries by 16 to 9 and closed the gap with industrial countries to only 4.

The genetically modified Bt cotton, containing the cry gene sourced from the soil bacterium *Bacillus thuringiensis* sub species *kurstaki*, confer resistance to bollworms of cotton was first adopted as hybrids in 2002 in India. India, the largest cotton grower in the world, has benefited from 8 years (2002 to 2009) of spectacular success with Bt cotton. Bt cotton contributed to increased productivity and reduced requirements for pesticides while, contributing to a better and most sustainable environment in the face of climate change. Remarkably, for the eighth consecutive year the hectarage, adoption rate and the number of farmers using Bt cotton hybrids in India in 2009, all continued to soar to record highs. The increase in area from 50,000 hectares in 2002, to 8.4 million hectares in 2009 represents an unprecedented 168 fold increase in eight years. 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. The major states growing Bt cotton in 2009 are Maharashtra (3.39 million hectares) representing 40 per cent area of Bt cotton in India followed by Gujarat (1.68 million hectares / 20%), Andhra Pradesh (1.04 million hectares / 16%) and Karnataka (0.27 million hectares / 4%).

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%) than single gene Bt cotton hybrids 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 (BG 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 for *Spodoptera* control as well as increasing yields by 8-10 per cent over single gene Bt cotton hybrids (James Clive, 2009).

Cotton production increased from 15.5 million bales in 2001-02, to 24.4 million bales in 2005-06, 28 million bales in 2006-07 and 31.5 million bales in 2007-08 projection of 30.5 million bales of production in 2009-10 (Cotton Advisory Board, 2008), despite the fact that there was a delayed monsoon with erratic rainfall and flooding at the time of boll maturity and cotton picking (James Clive, 2009). With the boom in cotton production in the last eight years, exports of cotton have registered a sharp increase from a meagre 0.05 million bales in 2001-02 to 5.8 million bales in 2006-07 before touching a high of 8.8 million bales in 2007-08. The step-wise increase in adoption of Bt cotton between 2002 and 2009, the average yield of cotton in India, which used to have one of the lowest yields in the world, increased from 308 kg per hectare in 2001-02 to 526 kg per hectare in 2008-09 and projected to increase to 568 kg/ha in the 2009-10 with 50 per cent increase in yield, attributed to Bt cotton.

Subsequent to the introduction of Bt cotton, the pesticide consumption decreased from 48,350 metric tonnes in 2002, the year of Bt cotton was first introduced, to 37,959 metric tonnes in 2006. The decrease in pesticide usage is equivalent to a 22 per cent reduction over a short period of five years (James Clive, 2009).

In the present investigation to verify the performance of commercially approved transgenic Bt cotton genotypes through participatory approach and to have widespread and quick adoption of the genotypes, the experiment was undertaken in farmers field with mother and baby trial design. Farmer participatory research is the collaboration of farmers and scientists in agricultural research and development. The farmer participatory mode of research has been regarded as ideal tool to verify the hypotheses of the researcher and also helps in quick adoption of the technology. The benefits derived by the farmers with a new technology could be easily assessed through farmer participatory approach and the reliability is of high order. The mother and baby trial design concept is recent in origin among farmer participatory research methodologies, wherein biological performance of the new techniques are compared through a research managed experiment (mother trial) and farmers managed trials (baby trials). The mother and baby trial is reported to and ideal design in evaluating the new genotypes of various crops at farmers field (Snapp, 2003). In the present study, the principles of mother and baby trial have been adopted to verify the performance of commercially approved transgenic Bt cotton genotypes in red and black soils separately.

Cotton production is affected by genetic potentiality, soil, climatic conditions and management factors. Among them, soil type is the major factor influencing on the yield. The soil properties and crop yield are spatially dependent and soil variability is usually the primary factor for the variation of crop yield (Forcella, 1993; Johnson *et al*., 2002; Buscaglia and Varco, 2003; Bronson *et al*., 2003; Ping *et al*., 2004). Cotton yield has usually exhibited spatial and temporal variability. Poor inherent fertility status of the soils is one of the major reasons for the low productivity of cotton in both irrigated as well as rainfed ecosystems. The soils of the cotton growing are low in organic carbon, nitrogen and phosphorus. Among secondary and micronutrients, sulphur and zinc deficiency is widespread and boron deficiency is on the rise (Rattan *et al*., 1999).

Improved understanding of factors that limit yield on farmers field is necessary to reduce environmental impacts of agriculture. Quantifying spatial variability of crop yield and soil properties is important for decision making in site specific crop management. There is need to identify soil characteristics that are important and useful in crop yield pattern description and to explore the nature of important soil variate interactions that may significantly influence yield prediction and to harness the benefits of the Bt cotton and to sustain its yield potential, the present study was planned with following objectives.

1. To evaluate the performance of Bt cotton genotypes in different soils of northern transition zone (Zone-8) of Karnataka under rainfed situation.
2. To prepare the fertility map of soils and yield map of Bt cotton growing areas in a selected taluk of northern transition zone (Zone-8) of Karnataka.
3. To document the existing cultivation practices of Bt cotton cultivars grown in different soils of northern transition zone (Zone-8) of Karnataka under rainfed situation.

2. REVIEW OF LITERATURE

The literature pertaining to the following heads is presented in this chapter.

2.1 Performance of Bt and non-Bt genotypes in different soil types

2.2 Soil fertility status in different soil types

2.3 Physico-chemical and biological properties of cotton grown soils and its performance on yield and quality of fibre

2.4 Cultivation practices of Bt cotton in different soil types on growth and yield performance

2.1 Performance of Bt and non-Bt genotypes in different soil types

The development of Bt cotton represents a significant technological landmark in the global cotton research. India adopted this technology in 2002-03.

Commercial cultivation of Bt cotton in India began in 2002-03 with three hybrids *viz.*, MECH-12 Bt, MECH-162 Bt and MECH-184 Bt (APCOAB, 2006) and in 2008 there were 274 hybrids officially approved by the GEAC. The national cotton productivity increased by over 85 per cent in the last five years from 302 kg lint per ha in 2002-03 to 560 kg lint per ha in 2007-08 (ICAC, 2009).

Several studies have been made on the field performance of Bt hybrids. Initial multi-location 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 and national checks in the magnitude of 62 to 92 per cent and an average increase in the gross income to the tune of 67 per cent (ISAAA, 2002) and 14.7 per cent reduction in the pesticide costs through the adoption of Bt cotton (Naik, 2001).

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 (2095 kg/ha) and Ajeet-II BG-II (1928 kg/ha) recorded 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), boll weight (4.7 g/boll) and total dry matter production (502 g/plant) 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) as against Bt hybrid RCH-2 with lower sympodial per plant (16.7) and seed cotton yield per plant (127.17 g/plant).

Assessment of agronomic efficiency of Bt cotton hybrids was made in rainfed Vertisol revealed that higher seed cotton yield was obtained in MECH-184 Bt and MECH-162 Bt, whereas non-Bt counterparts yielded 2 to 3.5 q per ha less. Bt hybrids MECH-184 and MECH-162 were found agronomically more efficiency primarily through the inbuilt resistance to *H. armigera* and consequent early builtup and efficient resistance of reproductive activity (Singh *et al*., 2003).

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 (sandy loam) (Raghu Rami Reddy and Dileep 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.

The cotton hybrid Savitha grown on Vertisol under rainfed condition recorded the higher number of bolls per plant (49.4) and seed cotton yield per plant (154.5 g) with wider spacing of 120 cm $\times$ 60 cm and 120-60-60 kg NPK per ha (Bastia, 2000).

Dhoble *et al.* (1990) studied the productivity of cotton varieties as influenced by different soil types. Growing of cotton on heavy soils had recorded higher seed cotton yield (1560 kg/ha) over medium and shallow soils. Variety Eknath produced the higher seed cotton yield (948 kg/ha) over the other varieties Purnima and SRT-1. All the cotton varieties produced higher seed cotton on heavy soils followed by medium soils and low yields on shallow soils.

The impact of different soil types *viz*., clay loam and sandy clay loam on the root growth and yield of cotton was undertaken at coastal region of Karaikal by Suresh *et al.* (2005). The root length of cotton cultivars was longer in clay loam soil and sandy clay loam being 40.6 and 41.6 cm, respectively. Clay loam registered the highest seed cotton yield (17.59 q/ha). Net income and benefit:cost ratio were higher in MCU-7 variety than other genotypes at 80-40-40 kg NPK per ha.

Venugopalan *et al.* (2007) studied the effect of soil types and N levels on rainfed AKH-4 cotton. Shallow soil gave higher yield of cotton (1476 kg/ha) at deficit as well as excess rainfall than in deep soil (933 kg/ha). The mean earliness index was 0.65 on shallow and 0.40 on deep soil. Cotton on shallow soil (well drained Inceptisols) 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 and moderately well drained Vertisols.

Suresh and Chellamuthu (2004) evaluated the relative performance of seven *Gossypium hirsutum* cotton varieties in clay loam soil (Ustic Quartipsamments). The variety ADT-1 registered the highest seed cotton yield (1550 kg/ha) which was on par with that of MCU-7 (1370 kg/ha). The lowest seed cotton yield was recorded in LRA-5166 (933 kg/ha).

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, number of bolls over non-Bt hybrids.

Mayee *et al.* (2004) evaluated the Bt transgenic intra *hirsutum* hybrids for yield and fibre properties. The results indicated that Bt hybrid MECH-162 recorded 2.13 t per ha of yield followed by MECH-184 (2.01 t/ha) and MECH-12 (1.77 t/ha). The Bt hybrids exhibited superiority in bolls per plant and matured 20 to 30 days earlier than non-Bt hybrids. Non-Bt hybrids exhibited 1 to 2 mm superiority of span length over 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 reveals that Bt cotton hybrids depicted wide range for seed cotton yield (855-2397 kg/ha), 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), micronaire value between fine (2.9) to medium (4.78).

The performance of Bt cotton hybrids at farmers field in Haryana was carried out by Mehta *et al.* (2009). The results indicated that pooled average of seed cotton yield over three years was to the extent of 24.06 q per ha in Bt cotton against 18.09 q per ha in non-Bt cotton. The average additional net returns from Bt over non-Bt cotton were Rs. 8959 per ha.

The performance of eight hybrids of *hirsutum* cotton (*Gossypium hirsutum* L.) were studied in the field experiment at Research and Demonstration Farm of Pachora by Lalage *et al.* (2004). The study indicated that NCH-744 recorded significantly higher seed cotton yield (2602 kg/ha) followed by NCH-996 (2551 kg/ha), MCH-711 (2418 kg/ha) and NHH-44 (2202 kg/ha).

The field experiment was carried out to study the influence of time and method of sowing on yield potentiality of cotton genotypes under rainfed condition on medium black soil (Lamani *et al.*, 2004). The results indicated that among the cotton genotypes, DHB-290 an inter-specific cotton hybrid registered significantly higher seed cotton yield of 1692 kg per ha with 13 to 42 per cent, yield advantage over rest of the genotypes which were attributed to more number of monopodial/sympodial branches per plant, bolls per plant (34.27) and higher boll weight (5.64 g).

Jayadhar produced higher seed cotton yield which was 14 per cent and 14.8 per cent more than DDhc-11 and RAHS-14, respectively in deep black (Vertisol) under rainfed conditions (Kubsad *et al.*, 2004).

Seed cotton yield was significantly higher in MECH-162 Bt (1172.39 kg/ha) than DHH-11 (875.96 kg/ha) and non-Bt MECH-162 (719.31 kg/ha) 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 (2183 kg/ha) and recorded 1468 and 1053 kg per ha more yield than MECH-184 non-Bt (715 kg/ha) and DHH-11 (1130 kg/ha). 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).

Suresh *et al.* (2004) studied the relative performance of desi cotton hybrids and cotton cultivars in clay soil at Karaikal. The results indicated that the seed cotton yield of G. Cot DH-7 was 34.71 q per ha and that of G. Cot DH-9 was 34.77 q per ha. Among the desi varieties, DB-3-12 recorded highest yield of 26.76 q per ha than MCU-7 (21.73 q/ha).

RCH-2 Bt recorded 2857 kg per ha of seed cotton yield followed by RCH-144 Bt (2794 kg/ha) and superior to RCH-20 Bt hybrid (2585 kg/ha) as well as MECH-184 Bt hybrid (2575 kg/ha) in medium deep black soil. RCH-2 Bt cotton hybrid recorded higher 2.5 per cent staple length, micronaire value, maturity percentage and tenacity (Halemani *et al.*, 2004a).

The production potential of GTHH-49 was higher than the newly released hybrid G. Cot Hy-10 on sandy loam soil at Talod, Gujarat (Patel *et al.*, 2004). DHH-11 cotton hybrid recorded higher yield (2372 kg/ha) than the other genotypes in medium black soil at Agricultural Research Station, Dharwad.

Hirsutum variety Sahana (2202 kg/ha) also performed better and it produced 61 and 19 per cent higher yield than interspecific hybrids DCH-32 (1369 kg/ha) and DHB-105 (1858 kg/ha) (Patil *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.

Kerby (1996) in a 75 field comparison study of three Bt cotton varieties and their non-Bt near isogenic parents, reported a lint yield increase as much as 207.2 kg per ha which represented a 20 per cent improvement in yield. Benedict and Altman (2001) showed yield increase of approximately 4 per cent (174.8 kg/ha) with Bt cotton. Udikeri *et al.* (2003a) found that among the MECH Bt hybrids, higher seed cotton yield of 21.75 q per ha was recorded in MECH-184 Bt which was on par with MECH-12 Bt (21.53 q/ha) and MECH-162 Bt (18.58 q/ha) in medium black soil.

Udikeri *et al.* (2003b) found that under unprotected rainfed condition in medium black soil damage to fruiting bodies was significantly lower in MECH-184 Bt (4.04%) followed by MECH-162 Bt (5.02%) and MECH-12 Bt (6.84%). Highest seed cotton yield was recorded in MECH-184 Bt (12.13 q/ha) followed by MECH-162 Bt (8.44 q/ha) and MECH-12 Bt (6.77 q/ha).

Venugopal *et al.* (2002) showed that among the Bt hybrids, MECH-162 Bt was superior in central zone (13.3 q/ha) and MECH-184 Bt in south zone (20.09 q/ha). MECH-184 Bt and MECH-12 Bt recorded significantly lower boll damage compared to non-Bt check. Vennila *et al.* (2004) showed that among the cotton hybrids, RCH-20, RCH-134, RCH-138 and RCH-144 Bt hybrids recorded significantly lower damage levels and significant differences in yield were not observed.

Venugopal *et al.* (2002) reported that Bt cotton (MECH-184 Bt, MECH-162 Bt and MECH-12 Bt) required less insecticidal sprays, thus saving in plant protection and increased the total economic benefit from Bt cotton hybrids.

Hegde *et al.* (2004) reported that boll damage was significantly lower in MECH-162 Bt (15.67%) and it was on par with MECH-184 Bt (19.12%) and MECH-12 Bt (20.18%) and significantly lower than the rest of the hybrids. MECH-184 Bt recorded significantly higher yield (782 kg/ha) than NHH-44, MECH-12 Bt and MECH-162 Bt.

Radhika *et al.* (2004) recorded the highest yield of 14.89 q per ha in MECH-184 Bt which was on par with other Bt hybrids but, significantly higher than in non-Bt versions of same genotypes and checks.

Bhosle *et al.* (2004) reported that MECH-184 Bt recorded the highest seed cotton yield (1148 kg/ha) and found on par with MECH-162 Bt (1001 kg/ha). Both of the hybrids were significantly superior over MECH-12 Bt (570 kg/ha) and NHH-44 (541 kg/ha). Bhosle *et al.* (2004a) found that the percentage of boll damage in Bt cultivars ranged between 14.61 to 17.26 per cent. MECH-184 recorded the highest seed cotton yield of 1651 kg per ha with the lower cost of protection due to lower damage in open boll of 14.61 per cent compared to non-Bt version (35.54%).

Surulivelu *et al.* (2004) evaluated Bt cotton hybrids and found that RCH-2 Bt and RCH-20 Bt recorded significantly higher yield of 19.3 and 20.5 per cent, respectively over their non-Bt counterparts and 33.3 and 55.5 per cent, respectively over Savita due to the bollworm damage reduction in Bt entries to the extent of 73.8 and 72.9 per cent over their non-Bt counterparts.

In USA, Bt cotton growers produced 11.4 per cent higher yield than conventional cotton growers. In addition, Bt cotton plots required 75 per cent less insecticides and resulted in 155 per cent higher returns (Carlson *et al*., 1998).

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

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

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

Patil *et al.* (2004) studied the performance and economics of Bt cultivation in irrigated ecosystem at Regional Agricultural Research Station, Raichur and in farmers field. MECH-102 Bt and its non-Bt during 2002-03 and MECH-184 and its non-Bt during 2003-04 and local hybrids (NHH-44 and NCS-145) were cultivated and compared. Incidence of bollworms in MECH-162 Bt and MECH-184 Bt cotton hybrids was negligible. During 2002-03, MECH-162

Bt recorded significantly higher yield of 25.58 q per ha with a net profit of Rs. 33,802 in the farmers field than non-Bt and local hybrid. Similarly, during 2003-04, MECH-184 Bt recorded cotton yield of 24.38 q per ha with a net profit of Rs. 41,332 in research station and 24.65 q per ha with a net profit of Rs. 40,090 in the farmers field. Bt cotton hybrids recorded 35.45 per cent increase in net profit over local hybrids making it commercially viable and profitable under irrigated ecosystem.

Farmers participatory field trial was conducted in rainfed cotton growing region of Nanded district in central zone of Maharashtra to evaluate the performance of Bt cotton hybrid. MECH-162 under Integrated Pest Management (IPM) the result obtained that 11.5 per cent less fruiting bodies were damaged in Bt MECH-162. Seed cotton yield (12.49 q/ha) and net return (Rs. 16231/ha) were highest with Bt MECH-162 whereas conventional cotton with a yield of 7.1 q per ha and net returns of Rs. 10,507 per ha (Bambawale *et al.*, 2004).

Joshi (2007) observed that in field experiment of medium deep black soil at UAS, Dharwad, genotype JK-CH 99 Bt recorded significantly higher yield (3323 kg/ha) which was on par with JK-Durga Bt (3302 kg/ha). MRC-6322 Bt (3230 kg/ha) and NCS-207 Bt (2963 kg/ha). The two non-Bt cotton hybrids DHH-11 and DCH-32 recorded 2335 and 2122 kg per ha of seed cotton yield, respectively. The highest net profit was found with JKCH-99 Bt (Rs. 59,766/ha).

Bennet *et al.* (2001) in a set of four trials, yields were compared between the Bt variety and its non-transgenic isoline. A mean yield increase of 27.3 per cent was observed with Bt variety and on an average the Bt cotton compared to non-transgenic isoline recorded less number of sprays.

Sharma (2002) reported that Bt cotton hybrids showed a marginal improvement in ginning outturn over their respective non-Bt. But, there was no difference in lint index between Bt and non-Bt counterparts.

Khadi *et al.* (2002) noticed among Bt cotton hybrids only MECH-184 Bt recorded significantly higher seed cotton yield than the commercial hybrids and zonal check hybrids.

Anilkumar (2004) reported that in clay soil Bt cotton hybrid recorded significantly higher seed cotton yield (2304 kg/ha) as compared to non-Bt hybrid (1552 kg/ha). The increase in yield mainly attributed to more number of bolls per plant and seed cotton weight per plant.

Kristen *et al.* (2002) showed the yield advantage of Bt cotton (14.19%) over non-Bt cotton and check.

Kengegowda (2003) reported that Bt cotton hybrids produced significantly more good opened bolls and less bad opened bolls as against NHH-44 hybrid. Higher seed cotton yield was obtained in RCH-2 Bt (25.62 q/ha) as compared to NHH-44 under unprotected conditions at Raichur, Karnataka.

Anand (2005) reported that in medium soil MECH-184 Bt recorded significantly higher dry matter production (464.4 g/plant), nutrient uptake and seed cotton yield (2615 kg/ha) over RCH-2 Bt (2389 kg/ha) and Bunny Bt (1659 kg/ha). Cotton hybrid MECH-184 Bt recorded higher gross returns (Rs. 47,793/ha) and net returns (Rs. 27,558/ha).

Sangshetty (2006) reported that Jayadhar recorded higher LAI (0.54 dm/m2), higher number of monopodials and sympodial branches, higher kapas yield with higher returns and B:C ratio. Sahana recorded significantly higher fibre strength, fineness and maturity ratio.

Krishnegowda (2004) reported that in medium black soils at Raichur RCH-2 Bt recorded significantly higher dry matter production, nutrient uptake and seed cotton yield (2720 kg/ha) over NHH-44 hybrid (1264 q/ha) followed by MECH-184 Bt (2364 kg/ha).

Judy and Howell (2010) reported that the cotton lint yields in the coarse textured Vingo and Amarillo soils tended to be larger compared with cotton lint yields in the fine textured Pullman and Vlysses soil in 2005 and 2007. Early season meteorological conditions which influenced square shedding and boll development might have affected lint yields interactively with soil texture and irrigation.

2.2 Soil fertility status in different soil types

Soils are characterized by high degree of spatial variability due to the combined effect of physical, chemical or biological processes that operate with different intensities and at different scales. The pattern and magnitude of cotton crop yield variability in a field reflect soil conditions that influence yield to varying degree. In many instances, rather larger differences in yield of cotton have been observed over short distances (McBratney and Pringe, 1997; Cowrin *et al*., 2003a and Bruce *et al*., 1990).

Soil spatial variability can be caused by geological and pedological processes as well as management practices (Bouma and Finks, 1993). Consequently, variations of soil physical, chemical and biological properties can appear both horizontally and vertically. The majority of the total variation of soil morphological and physical properties resided within the map units and not between them (Agbu and Olson, 1990).

Field variability of crop yield is a consequence of variation in the genetic properties of the plants and of environmental factors (Bresler *et al*., 1981). The environmental factors in a single field that result in a certain spatial crop yield may be viewed as stemming from soil properties and soil variables (Bresler and Laufer, 1988; Berndtsson and Bahri, 1995).

Generally, it is thought that spatial yield variability is primarily controlled by soil properties (Forcella, 1993). Soil factors other than the soil fertility influence yield (Ciha, 1984; Jaynes and Colven, 1997; Manu *et al*., 1996; Miller *et al*., 1988; Wright *et al*., 1990).

Soil variability is caused by an assortment of different factors. Interactions among parent materials, topography, vegetation, tillage, fertilization, cropping history and so on influence the variability of the physical and chemical properties (Cox *et al.,* 2005).

The organic carbon content was less in black soils compared to that of associated red soils. The values of electrical conductivity in red soils ranged from less than 0.15 to 0.25 dS per m and did not show any trend with depth of soil while, in black soil it ranged from 0.15 to 0.8 dS per m and showed increased trend with depth in Andhra Pradesh (Krishnamoorthy and Govindarajan, 1977). Singh *et al.* (2000) reported that the electrical conductivity of soils varied from 2.0 to 9.6 dS per m in old alluvial soils of Sone basin area.

Organic carbon content in the surface soil was found to be higher as compared to the lower layers in different treatments and the highest and significantly higher values at different depths were noticed in the treatment that received recommended dose of fertilizer along with FYM. $CaCO_3$ content values were found to be low in surface layer (0 – 20 cm) and continued to increase with increasing depth upto 100 cm depth (Thakur *et al*., 2009).

In Karnataka, about 10.3 per cent soils fall under low category, 35.87 per cent under medium and 53.9 per cent under high category of available nitrogen status. In case of available phosphorus status, about 83 per cent of the soils were low and 17 per cent area under medium category while, available potassium was medium to high in most of the soils except in lateritic soils of coastal plain and Western Ghats and in shallow red and black soils (Shivaprasad *et al*., 1998).

Girish and Badrinath (1996) studied the potassium status in 11 surface soils of Dakshina Kannada in Karnataka under different agricultural situations. The soils were highly acidic in reaction, medium in carbon and available potassium status.

Nanjundaswamy (1996) observed that the black soils were clayey in nature and neutral to alkaline in reaction. The soluble salts were low in all the soils while, available sulphur, calcium and magnesium were sufficient.

Motsara (2002) depicted soil fertility maps of Indian soils. Majority of soils in Karnataka state were medium in available nitrogen status. Similarly, phosphorus content also showed medium status and high in potassium.

Micronutrients (Fe, Zn, Cu and Mn)

Total content of micronutrients vary with soil types and depth of soil. The amount of micronutrients decreased sharply from the surface to sub-surface beyond which the decline was gradual to the lower depths (Kanwar and Randhawa, 1979). The total Zn was 10 to 300 ppm, total Cu was 1.0 to 2.85 ppm. The distribution of micronutrients was more in surface and decreased with depth (Yaduvanshi *et al.*, 1988).

Mayalagu and Peermohamed (1992) reported that micronutrient status of Subraminapuram soil series and it was found that it had less than the critical minimum level of available micronutrient (Fe, Mn, Zn and Cu).

Tripathi *et al.* (1994) reported that Zn content decreased with depth and coincided with the distribution pattern of organic carbon in the profiles. Study suggested that organic matter is more predominant factor which appear to control the availability of micronutrients.

Dhane and Shukla (1995) reported the deficiency of Zn and Fe in a large number of soil series of Maharashtra. The deficiency of Mn was limited, while Cu was found to be adequate in all soil series of Maharashtra. The distribution of micronutrients correlated with organic carbon and clay content of soil.

Micronutrients status of soils of Katol Tahasil in Nagpur district indicated that in all 11 soil series, available Fe, Mn, Cu and Zn were marginal, adequate, high and low to marginal respectively (Jibhakate *et al.*, 2009b). Dhane and Shukla (1995) reported that available copper content in some series of Maharashtra ranged from 0.9 to 2.1 mg per ha soil.

The availability of Zn ranged 0.07 to 3.06 mg per kg in soils of Punjab. Organic carbon, silt, EC and pH were the important factors in controlling the Zn availability (Bali *et al.*, 2010).

Naik and Das (1964) analysed 64 surface soil samples belonging to black, alluvial, red and laterite soils of India and reported that a large number of laterite, red and alluvial soils were found to contain less than 10 ppm of available sulphur. Black and coastal alluvial soils were rich in sulphur whereas saline and alkali soils have extremely high in sulphur.

Basappa (1990) observed that the concentration of available iron ranged from 3.82 to 14.26 mg per kg in the soils studied. A general increase with depth in some profiles was observed and indicated wide variation in the parent material. Rajkumar *et al.* (1990) reported that the soils derived from basalt parent rocks exhibited lesser concentrations of DTPA extractable iron (7.5 ppm) than those derived from ferruginous and sand stone or shale parent materials (18 ppm). Soils derived from granite gneiss parent rocks exhibited medium values for available iron (8.2 ppm).

Arvind Kumar *et al.* (1994) observed that the available iron in dominant soil series of South Chotanagpur in Bihar varied from 14.2 to 148.8 ppm. Tripathi *et al.* (1994) reported that the available Fe in 10 typical pedons of Himachal Pradesh were >4.5 ppm and is found to decrease with depth. Dhane and Shukla (1995) reported that the DTPA-Fe varied from 2.6 to 8.3 ppm in some soil series of Maharashtra. Sahoo *et al.* (1995) found that the DTPA-Fe varied from 5.58 to 33.80 ppm in the soils of Malwa plateau in Rajasthan.

Vadivelin and Bandyopadhyay (1995) observed that the DTPA-Fe ranged from 1.7 and 21.1 ppm in the surface of Mincoy Island, Lakshdweep and decreased with the depth.

Prasad (1991) reported that the available Mn in old alluvial soils of Bihar ranged from 5.9 to 75.8 ppm. Surface soils had more available manganese than sub-surface soils. Vijaykumar *et al.* (1996) reported that the available Mn content in some soil profiles in Northern Telangana of Andhra Pradesh varied from 15 to 86 ppm. The available Mn in all the profiles decreased regularly with depth. Srinivasarao *et al.* (1995) observed that the available Mn were above the critical limits of 2.0 ppm in the Nellore district black soils of Andhra Pradesh. Similarly, Barua *et al.* (1993) reported that there was no deficiency of available Mn in some acidic soils of Assam. Bhogal *et al.* (1993) observed that the available Mn in some aquic Ustifluvents and Udifluvents of Bihar varied from 0.7 to 92.1 ppm. Muneshwar Singh and Sekhon (1993) found that the DTPA-Mn in some benchmark soil series of India ranged from 13.4 to 30.5 ppm. Paul *et al.* (1993) reported that the alluvial and reddish brown sandy soils of Uttar Pradesh were rich in available Mn.

Pradeep Kumar *et al.* (1996) observed that the average values of DTPA-Mn in Soan river valley soils of lower Shiwaliks were 10.7 ± 8.4, 7.9 ± 4.8 and 13.7 mg per kg in the soils of hills, piedmonts and flood plains, respectively.

Mayalagu and Peermohamed (1992) reported that available copper ranged from 0.7 to 1.0 ppm in the Andjhra Pradesh horizons. Available copper status was positively and negatively correlated with pH and organic carbon of the soils, respectively. Sangwan and Kuldeep Singh (1993) found that available copper content in Southern semi-arid soils of Haryana ranged from 0.3 to 1.9 ppm with mean value of 0.9 ppm. Tripathi *et al.* (1994) reported that the content of available copper in soil profiles of Himachal Pradesh was 0.4 to 4.8 mg per kg soil with an average value of 1.7 mg per kg soil. The content of copper in these soils is considered to be adequate in the light of critical limit of 0.4 mg per kg soil.

The distribution of micronutrients is mainly governed by the clay content (Katyal and Sharma, 1991) and organic matter (Frank *et al.*, 1976).

Katyal and Sharma (1991) reported that the DTPA zinc varied between 0.12 and 2.8 mg per kg soil. The correlation between DTPA zinc and pH, $CaCO_3$ and organic matter pointed out that zinc availability in soils would fall with a rise in pH and lime content and increase with an increase in organic matter content.

Kuldeep Singh and Hans Raj (1996) reported that the available zinc content which varied between 0.12 to 2.08 ppm with a mean value of 0.29 ppm in the range of alluvial soils of Haryana.

Katyal and Rattan (1993) found that the available Zn contents in Indian soils range between <0.1 and >10.0 mg per kg soil. On an average, Indian soils contain around 0.6 mg available Zn per kg soil which is only one hundredth of total zinc.

Tripathi *et al.* (1994) reported that the available zinc content in Himachal Pradesh ranged from 0.1 to 2.8 mg per kg soil content of DTPA extractable zinc, by and large decreased with depth. The DTPA zinc was significantly and positively correlated with organic carbon.

2.3 Physico-chemical and biological properties of cotton grown soils and its performance on yield and quality of fibre

Field experiments conducted in Florence USA on investigation of the influence of soil spatial variability on cotton, fibre yield and quality. The result indicated the range of spatial correlation varied from 33 to 99 m. The soil properties with the greatest range included soil pH, Na, P and organic matter. Soil Ca, Mg and K exhibited the least variability. Soil pH, soil P and soil organic matter were found to be correlated with fibre yield, AFIs shape and maturity indices, micronaire, length and HVI color indices (Johnson *et al.*, 2002).

Crop yield inconsistently correlates with apparent soil electric conductivity because of the influence of soil properties (salinity, water content, texture *etc.*) that may or may not influence yield within a particular field and because of a temporal component of yield variability that is poorly captured by electrical conductivity. The study in San Joaquin valley in Central California indicated that salinity, plant available water, leaching fraction and pH were the most significant properties influencing cotton yield (Corwin *et al.*, 2003a).

Li *et al.* (2001, 2002) reported that N accumulation and cotton lint yields were negatively correlated with elevation. Besides landscape position, soil series is an important factor that affects crop yields and fertilizer response. The study at Lamesa and Ropesville at Lubbock indicated that landscape position and slope had significance impact on cotton yields but not on P fertilizer response. Calcareous Vs non-calcareous soil series affected early season growth and P accumulation and yield response to added P (Bronson *et al.*, 2003).

The study conducted near New Deal on the southern high plains of Texas indicated that sand and clay content, exchangeable Ca^{2+} and Mg^{2+}, NO_3^-, Olsen-O, pH, relative elevation and slope were important factors affecting lint yield and high fibre quality (Ping *et al.*, 2004).

Soil properties and cotton yield varied widely within relatively small fields and the amounts of variability were field specific. In general, pH was the least variable of the soil chemical property. Yield in the north field was related to K, Mg and P levels and indicated that management zones on these nutrients would prove beneficial. Whereas, the management zones in the south field based on the elevation, sand content, pH and Ca. The research conducted on cotton field in Texas indicated that soil properties, except nitrate (NO_3^-), nitrogen (N) and Olsen phosphorus (P) were strong spatially dependent, whereas lint yield was moderately to strongly spatially dependent. Fiber quality was moderately spatially dependent. Spatial appearance of higher yield in drier years was associated with the distribution of soil properties favouring cotton growth including lower pH and calcium and higher P and sand content (Cox *et al.*, 2005).

Organic residue was beneficial to enhance moisture retention, availability of nutrients and their mineralization in soil to explain maximum production potentiality of crops in cotton + soybean intercropping system under better physical condition of soils (Bonde *et al.*, 2004a).

Satyanarayana Rao and Janawade (2009) reported that sunnhemp green manuring was found beneficial in improving the fertility status of soil organic carbon, available N, P_2O_5 and K_2O, while FYM showed similar trend. Combination of green manures, organic manures and chemical fertilizers showed higher improvement in soil physical, chemical properties as compared to application of organics or inorganics alone.

Praharaj *et al.* (2010) observed that plant wastes amended plots influenced organic carbon, available N and K in soil leading to higher residual fertility although a crop of sorghum grown after cotton in its residual fertility was not influenced by the treatments. Maximum economic benefits were obtained with decomposable bio-wastes.

Application of FYM (10 t/ha) decreased bulk density (1.21 g/cc) of soil but increased maximum water holding capacity (74.67%), aggregate stability (78.62%) and infiltration rate (1.22 cm/hr) of soil. Soil organic carbon content was also increased from 0.97 to 1.01 per cent (Hallikeri *et al.*, 2004).

Higher bacteria, fungi and actinomycetes population were recorded in the treatment receiving combined application of FYM (10 t/ha) and recommended level of chemical fertilizers. FYM (10 t/ha) in combination with RDF (40-25-25 N, P_2O_5 and K_2O) improved the available nutrient status of N, P, K, Zn and Fe of soil, but pH and EC of soil were not significantly influenced (Mohan Kumar, 2002).

Malewar *et al.* (2000) at Parbhani under Vertisols showed that available P_2O_5, N, K_2O were significantly higher in soil receiving FYM 10 t per ha + RDF. Organic carbon, bulk density, porosity, water holding capacity and infiltration rate of soil improved significantly with the application of organic manures and integrated nutrient supply system. Ravankar (2000) reported that the uptake of nutrients was significantly higher (49.7 N, 15.2 kg P_2O_5 and 48.6 K_2O kg/ha) under 50 per cent recommended dose of nitrogen through organics + 50 per cent recommended dose of nitrogen fertilizer.

The combined application of inorganic fertilizer and organic manures for two years recorded higher mean value of soil N, P, K and organic carbon content. The continuous addition of inorganic fertilizer and FYM might have improved the microbial activity and enhanced the availability of native and applied nutrients which inturn increased the yield (Solaiappan, 2002).

Bonde *et al.* (2004a) at Nagpur on Vertisols showed that application of FYM recorded significantly higher phosphorus uptake by cotton-soybean over control. Halemani *et al.* (2004a) reported that in Vertisol at Dharwad, application of FYM @ 10 t per ha decreased the bulk density (1.21 g/cc) increased the infiltration rate (1.32 cm/hr), water holding capacity (66.93%) soil organic carbon content from 0.60 to 0.87 per cent and available N (249.10 kg/ha), P_2O_5 (35.4 kg/ha) and K_2O (372.80 kg/ha) of soil as compared to rest of the treatments.

Sangashetty (2006) reported that integrated manurial treatment (RDF + FYM) recorded significantly higher N, P_2O_5 and K_2O content after the harvest of the cotton crop. Organic carbon content in soil was higher with RDF + FYM and FYM 100% + glyricidia 100% recorded higher population of bacterial, fungal and actinomycetes.

Reduction in bulk density and increase in porosity was observed with the application of Agridev + Glyricidia. The application of Agridev + pressmud cake recorded significantly higher organic carbon content in soil and showed maximum decline in $CaCO_3$ content in soil. The availability of nitrogen and potassium in soil was significantly increased with the application of Agridev + neem seed cake. Whereas, maximum availability of phosphorus was recorded with the application of Agridev + PMC (Kide *et al.*, 2008).

Tayade and Dhoble (2010) reported that status of available N, P and K in soil at harvest was significantly higher in graded levels of fertilizers as compared to FYM 10 t per ha. 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 10 t FYM per ha.

Badole and More (2002) observed that maximum build up of available N and K was recorded with Integrated Nutrient Management (INM), 3.6, 3.0 and 4.5 times more N, P and K build up in cotton. Organic sources recorded greater build up of N, P and K build up in soil.

Integrated management treatments both at optimal and super-optimal levels of nutrients applications as against application of nutrients through chemical fertilizer alone recorded higher seed yield as well as higher organic carbon, available N and available P at periodic intervals. Higher nutrient recovery, partial factor productivity and agronomic efficiency of applied nutrients (Dhawan *et al.*, 2005).

Cotton yield and all fiber quality properties measured displayed spatial correlation, fiber quality was correlated with soil organic matter, B, Cu, Fe, Mn and Zn (Johnson *et al.*, 1999). Fibre quality was correlated with soil Mg, K, Cu (Elms *et al.*, 1997).

Influence of micronutrient fertilization ($MgSO_4$, $FeSO_4$, $ZnSO_4$ and borax) on post-harvest assessment of soil pH, EC, available N, P and K status revealed that none of the nutrients and their method of application (soil and foliar) influenced soil pH, EC, available nutrients N, P except K. Foliar application of borax @ 0.5% on 60, 75 and 90 days after planting registered the highest available K in post-harvest soil and might be due to production of less seed cotton yield, less demand for K that the soil K at relatively high soil available K (Sankaranarayan *et al.*, 2010). Negative balance of K is reported with high yield of cotton and external application through fertilizer is far lesser than what is removed (Blaise *et al.*, 2005b).

Badole and More (2001) reported that fungi population was significantly affected by organic and inorganic treatments. Maximum saprophytic fungal population was recorded with the treatment received organic sources, after harvest of cotton. The fungal population was high with integrated nutrient supply system due to combined effect of organic and inorganic sources. Rhizobium, Azotobacter, fungi, actinomycetes, bacteria and phosphates solubilizing bacterial population were maximum with combination of different organic sources and integrated nutrient supply.

2.4 Cultivation practices of Bt and non-Bt cotton in different soil types on growth and yield

a) Tillage and crop residue management

Development of mouldboard and disc plough led to intensive tillage and these were recommended for cotton owing to its deep rooting nature (Kairon *et al.*, 2002). Tillage practices vary according to region and soil type. In rainfed Vertisols of central and south India, conventional tillage (CT) practice involves deep ploughing once in 2 to 3 years followed by harrowing and planting (Blaise and Ravindran, 2003). Inter-row cultivation is also done 4 to 6 times, with a bullock drawn hoe. In sandy loams of North India, seed bed is prepared by disking twice followed by two cultivator passes and planking (Jalota *et al.*, 2008). Tillage practices are not likely to be different for Bt hybrids.

In the rainfed regions of Central India, reduced tillage (RT) have been found to be equal or better than conventional tillage systems in yield (Blaise and Ravindran, 2003 and Blaise *et al.*, 2005a). The upland Bt hybrid performed better with the reduced tillage than conventional tillage (Blaise, 2008).

In the sandy loams of North India (Sirsa, Haryana), incorporation of shredded cotton status and wheat straw resulted in a 0.2 t per ha higher yield than their removal (Bhaskar *et al.*, 2002). Decomposition of the wide C/N ratio material can be hastened by incorporating microbial cultures like *Trichoderma viride* (Babou *et al.*, 2005).

b) Crop establishment

Proper crop establishment and a good crop stand is a pre-requisite for realizing good yield. Crop geometry and inturn seed rate depends on the nature of the cultivar, soil its depth, fertility and implement available *etc.* (Venugopalan and Blaise, 2001).

The early maturity and resistance to bollworms should offer more flexibility in planting time and make Bt cotton hybrids suitable for delayed planting under delayed sowing condition (1 October), Bt hybrid MECH-162 performed better with enhanced yield (42.3%) over non-Bt hybrid (Sankaranarayan *et al.*, 2004).

In south zone, second fortnight of April to first fortnight of May and second fortnight of July to first fortnight of August is recommended for sowing in Ghataprabha and Tungabhadra tracts of Karnataka, respectively. Seed cotton yield recorded under normal sown crop (1130 kg/ha) was significantly more over late sown crop (1058 kg/ha). The sowing invariably influenced number of sympodia, number of bolls, yield per plant, 100 seed weight, GOT (%). Normal sown crop showed superiority over late sown crop in staple elongation and micronaire value (Patil *et al.*, 2009).

Normal sown (May 1) crop recorded more plant height, LAI and total dry matter than late sown (May 29) crop. Normal sown crop produced maximum (18.6%) reproductive dry matter, while late sown crop produced maximum 18.7 per cent at 140 DAS. Root dry matter at 140 was accumulated significantly higher under normal sown crop than late sown crop (Shamim Ansari and Mahey, 2003).

Pettigrew (2002) reported that early June leaf area index of the early planted plants was 172 per cent greater than plants in the normal planting, which contributed to a 55 per cent greater canopy light interception for the early planting. Early planted cotton demonstrated a 10 per cent yield improvement over the normal planted.

Sowing of cotton on 1 May gave the highest plant height, bolls per plant and boll weight. Delay in sowing by every 15 days not only significantly increased the boll shedding intensity but also decreased the seed cotton yield. Sowing of cotton on 16th and 31st May reduced the yield by 13.1 and 31.9 per cent, respectively as compared with that sown on 1 May (Iswar Singh and Chouhan, 1993). Early planted cotton had 136 per cent greater LAI and 68 per cent taller plants than the normal planted cotton in June (Pettigrew and Adamczy, 2006).

Hanuman Prasad *et al.* (2000) reported that three dates of sowing beginning from 15th May to 30th May and 15th June has proved that sowing of cotton on 15th May has produced significantly higher yield over other dates of sowing in Rajasthan. Boll weight, number of bolls per plant and plant height were increased on early sowing with gradual decrease in the observations with delayed sowing.

Under North Indian conditions, Nehra and Matish Chandra (2001) observed that sowing of cotton during 1 May produced significantly higher yield over 15th and 30th May. The reduction in the yield due to late planting may be because of shortening of total crop duration which affected vegetative and reproductive process of the crop adversely.

The best yield response of cotton to planting date was obtained when the crop was sown early. Lint yield was 11.2 per cent higher for the early planting date than for the late planting date. Late planting caused reduction in yield (Gormus and Yucel, 2002).

Experiment conducted with four dates of sowing from 1 May to 16th June at 15 days revealed that 16th May sown crop yielded highest at Bhawalpur in Punjab. Sowing before or after this date decreased seed cotton yield significantly (Akhtar *et al.*, 2002). Hutmacher *et al.* (2003) showed the benefit of April planting dates over early May planting dates. Studies made at Surat revealed that advanced sowing of cotton in June produced 63.5 per cent and 101.7 per cent higher yield over July and August sowing (Subramanyam *et al.*, 2004). In Punjab early sowing in March or April produced higher yield of cotton due to more boll size, boll weight and higher number of sympodials (Buttar *et al.*, 2005).

Summer sowing of cotton from 15th February to 15th April at fortnight intervals shown that early sowing. On 15th February registered the highest number of bolls per plant and found compare with 1st March. There was decline in number of bolls due to delayed sowing. Similar trend was recorded with yield per ha and benefit:cost ratio (Srinivasan, 2001). In comparison with four dates of planting from 22nd April to 6th June early sowing of cotton recorded higher seed cotton yield over late sowing (Jalsingh and Bishnoi, 2000).

c) Plant density

Basawaid *et al.* (2002) observed higher dry matter in leaves, stems and fruits with increase in plant density from 14,000 to 16,000 plants per hectare.

Rout and Satapathy (2001) reported significantly higher seed cotton yield of 19.58 q per ha with 90 × 60 cm spacing followed by 105 × 60 cm spacing. Anand (2005) reported that seed cotton yield increased significantly with decrease in the plant spacing from 90 × 60 cm to 75 × 30 cm (2417 to 2021 kg/ha). MECH-184 Bt with 90 × 45 cm spacing gave significantly higher net returns.

Bastia (2000) reported that seed cotton yield per ha (1940 kg/ha) and the harvest index (28.9%) were the highest for the spacing 90 cm × 90 cm followed by (1795 kg/ha and 27.44%) in 120 cm × 60 cm spacing. The spacing of 90 cm × 90 cm also registered the highest return (Rs. 2.47) per rupee invested.

Buttar and Singh (2006) also reported that closer plant geometry gave higher seed cotton yield than wider spacing.

Study at George Experiment Station illustrates that lint yields were greater at 12.6 plants per m2 and lowest at 3.6 plants per m2. Of the fiber properties investigated, micronaire and fineness were most affected by plant density (Bednarz *et al.*, 2005). Under irrigation, UNR (Ultra Narrow Row Cotton) averaged 771 kg lint per ha and wide row cotton averaged 1069 kg lint per ha, without irrigation, UNR cotton averaged 377 kg per lint per ha and wide row cotton averaged 586 kg lint per ha. Maximum yields of UNR cotton were attained from plant densities in the range of 128000 to 256000 per ha (Boquet, 2005).

Higher plant density of 27777 plants per ha (60 × 60 cm) plant spacing performed better than lower plant densities (18518 and 12345 plants/ha) for Bt cotton hybrids (Giri *et al.*, 2008) at Marathwada under rainfed conditions.

Field experiment at Punjab Agricultural University, Regional Station, Bathinda indicated that spacing of 90 × 90 cm recorded higher number of sympodia and boll weight (Brar *et al.*, 2008).

The results from the experiment at Akola indicated that 90 × 45 cm spacing recorded 50.5 and 17.7 per cent higher seed cotton yield than 90 cm × 90 cm and 90 cm × 60 cm spacing (Bhalerao *et al.*, 2010). Hybrid NCS-145 (Bunny Bt) planted at higher plant density of 27777 plants per ha with higher fertilizer dose of 100-50-50 kg NPk per ha recorded more seed cotton yield compared to RCH-2 Bt in the experiment conducted at Parbhani (Pawar *et al.*, 2010).

d) Nutrient management

The large scale cultivation of Bt cotton is likely to usher in an era of ecofriendly cotton cultivation with reduction in the number of ecofriendly cotton cultivation with reduction in the number of insecticidal applications. However, to sustain the benefits of Bt cotton, a sound nutrient management programme is essential. Bt cotton had a higher N content than non-Bt cotton suggesting that they may have a greater N uptake and metabolism than non-Bt cotton.

Application of 150 per cent of the RDF *i.e.*, 135-29.5-56.0 kg NPK per ha was on par with 125 per cent RDF (Sankaranarayanan *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). Vishwanath (2007) reported significantly higher seed cotton yield with 150 per cent RDF (2.42 t/ha) as compared to RDF (2.14 t/ha). In MECH-162 and RCH-2 BT hybrids, 125 per cent RDF recorded significantly higher seed cotton yield as compared to RDF of 120-26.4-50 kg NPK per ha (Kalaichelvi, 2009). On the contrary, field trials at Guntur in Andhra Pradesh (Narayana *et al.*, 2008), Dharwad in Karnataka (Hallikeri *et al.*, 2004) and Warangal in Andhra Pradesh (Reddy and Gopinath, 2008) did not indicate any significant yield increase by applying nutrients beyond RDF on Vertic Ustropepts of Coimbatore, Bandopadhyay *et al.* (2009) observed 60 kg N per ha as optimum dose for high yield and N use efficiency in RCH-2 Bt. For Bt cotton on sandy loam soils of north zones, Brar *et al.* (2008) recommended a dose of $N_{150}P_{22}K_{25}$ + Zn_3 kg per ha 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 (Ramanjeet Singh *et al.*, 2009). For summer irrigated tract of Sirivilliputtur, 100-22-41.6 kg N-P-K per ha was the optimum dose for MECH-162 and MECH-184 hybrids (Srinivasan, 2006). In northern transitional zone of Karnataka, to obtain a targeted seed cotton yield of 3 t per ha in MRC-6322 Bt cotton, 217-59-148 kg N-P-K per ha was found optimum (Patil *et al.*, 2009).

In North China, the transgenic cultivars were more sensitive to K deficiency than the conventional cultivars (Zhang *et al.*, 2007). 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). Late application of N and K may delay the senescence (Dong *et al.*, 2005) and reduce the yield of Bt cotton. Higher seed cotton yield was obtained due to foliar application of $MnSO_4$ @ 0.2 per cent followed by $MgSO_4$ @ 0.1 per cent, boric acid @ 0.2 per cent, $FeSO_4$ @ 0.2 per cent and $ZnSO_4$ @ 0.2 per cent. Significant variation was noticed in fibre length and strength due to foliar spray but not in micronaire and uniformity ratio (Ratnakumari and Hema, 2009).

Soil applied with $FeSO_4$ @ 50 kg per ha registered highest ginning percentage of 39.2 per cent and uniformity ratio of 50.2. Fibre length was also significantly improved by soil application of borax @ 5 kg per ha. Foliar sprays of $MgSO_4$ @ 0.5 per cent and soil applied borax @ 5 kg per ha also raised the seed cotton yield by more than 18 per cent (Sankaranarayan *et al.*, 2010).

The continuous addition of inorganic fertilizers and FYM improved the microbial activity and enhanced the availability of native and applied nutrients which inturn increased the yield of cotton (Solaiappan, 2002). Integrated nutrient supply system with 50 per cent NPK through chemical fertilizer and 50 per cent NPK through farmyard manure (FYM) + Azospirillum + cow dung urine slurry + phosphorus solubilizing bacteria recorded the highest cotton yield of 1675 kg per ha (Badole and More, 2002). 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).

Anilkumar (2004) reported that combined application of 150 per cent RDF and vermicompost @ 1 t per ha gave significantly higher seed cotton yield (2262 kg/ha) over the other treatments and found on par with the application of 150 per cent RDF and farmyard manure (2107 kg/ha).

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.

Mamatha (2007) reported that combined application of sulphur, iron and zinc each at 50 kg per ha recorded the highest seed cotton yield, ginning percentage and seed index.

Venugopalan *et al.* (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 upto 80 kg N per ha on shallow but only upto 40 kg N per ha on deep soil. The N yield applied relationship was quadratic during both years in deep soil and linear in shallow soil.

Bastia (2000) reported that number of bolls per plant showed highest number (48.1) for 140-70-70 kg 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 (Rs. 2.61) was realized from the fertilizer dose of 120-60-60 kg NPK per ha.

Sunitha *et al.* (2010) reported that maximum plant height and the highest dry matter accumulation were recorded with the application of 240 kg N per ha. In case of Bunny Bt and non-Bt Bunny hybrids, the difference between 180 and 240 kg N per ha were not significant with respect to number of monopodial and sympodial branches per plant. Application of 240 kg N per ha recorded significantly higher yield and yield attributes.

Among the three levels of fertilizers tried, recommended dose (90-45-45 kg NPK/ha) in Vertisol under rainfed condition was found to be the optimum and the differences amongst the levels for almost all the parameters were non-significant including seed cotton yield (Singh *et al.*, 2003). In Bt cotton hybrid (Brahma), nitrogen response was observed upto 150 kg per ha only (2928 kg/ha) with further increase in N level cotton yields was reduced. Application of 60 kg P_2O_5 and K_2O per ha significantly recorded higher seed cotton yield over 30 kg per ha in Alfisols under irrigation (Raghu Rami Reddy and Dileep Kumar, 2010).

Bikaneri Nerma recorded more number of nodes per plant. The yield response differed among the cultivars and was noticed upto 60 kg N per ha in AKH081, 90 kg N in Bikaneri Nerma LRA-5166 and 120 kg N level in LRK-516. The tendency for yield reduction at 120 kg N level (Kumara Perumal, 1999).

Crop responded favourably upto 80 kg N per ha increasing plant height, total leaf, root and reproductive dry matter production and seed cotton yield. But, LAI, stem dry matter and chlorophyll content increased significantly upto the application of 160 kg N per ha (Shamim Ansari and Mahey, 2003).

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

Pawar *et al.* (2010) revealed that application of 100-50-50 kg NPK per ha recorded significantly more seed cotton yield (2214 kg/ha), gross monetary returns (Rs. 46865/ha) and net monetary returns (Rs. 31131/ha) than both the lower levels of fertilizer application 80-40-40 and 60-30-30 kg NPK per ha. Srinivasulu *et al.* (2006) also reported that yield, net monetary returns and benefit:cost ratio increased with increasing nitrogen level. 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 per ha.

Increased yield was due to improvement in bolls per plant (Bhalerao and Godavari, 2010). 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.

Boquet (2005) reported that increasing fertilizer N rate from 90 to 157 kg per ha had no effect on boll number or boll weight and yield or yield components of irrigated or rainfed cotton. Maximum yields of 377 kg lint per ha with UNR cotton and wide row cotton averaged 586 kg lint per ha were attained from N rate of 90 kg per ha.

Meena *et al.* (2009) observed that nutrient management with each successive increase in nitrogen levels with basal application of 40 kg phosphorus per ha, the seed cotton yield increased significantly upto 80 kg N per ha though the highest seed cotton yields were obtained with 100 kg N per ha.

Pettigrew (2003) reported that early season flowering rates briefly increased 11 per cent when plants were grown without supplemental K. Late season leaf area under (LAI) was 23 per cent lower without supplemental K compared with plants fertilized with 112 kg per ha. The increased LAI of the K fertilized plants allowed them to intercept 6 per cent more of the late season sunlight than the 0 kg per ha. Potassium fertilization increased yield 9 per cent low K had only minor effects on fibre quality.

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

Satyanarayana Rao and Janawade (2009) reported that green manuring with sunnhemp and Lucerne recorded significantly higher NPK uptake over no green manuring practice. Increase in fertilizer levels increased NPK uptake by cotton. Fibre quality parameters (fibre length, fineness, fibre strength and fibre quality index were not significantly influenced by either green manure or organic manures or chemical fertilizers application).

e) Weed management

Cotton crop is highly susceptible to competition from weeds from sowing to about 60 days, when the canopy covers the inter-row space. Cotton yields were reduced by 50 to 85 per cent with unchecked weed growth or ineffective weed control. Fluchloralin at 1.0 kg a.i. per ha or pendimethalin @ 1.5 kg a.i. per ha as pre-planting application along with one interculture at 35 DAS consistently performed better in the control of weeds (Rajendran and Jain, 2004). Glyphosate @ 1.0 kg per ha as directed spray at 20 DAS followed by one hand weeding at 45 DAS recorded the lowest weed dry matter and nutrient uptake by weeds (Nalayani *et al.,* 1999).

3. MATERIAL AND METHODS

The field experiments were conducted under rainfed condition during *kharif* 2008-09 and 2009-10 at two villages *viz.*, Govankoppa and Budarkatti, Bailhongal taluk in farmers field which represented black and red soils, respectively as mother trials. The details of materials and techniques adopted during the course of investigation are presented in this chapter.

3.1 Experimental details

3.1.1 Experimental sites

Two field experiments were conducted in farmers field representing black and red soils during *kharif* 2008-09 and 2009-10 at Govankoppa and Budarkatti villages (mother trial) of Bailhongal taluk, Belgaum district, which is situated in northern transition zone of Karnataka (Zone-8) and baby trials in Govankoppa, Chikkabellikatti and Budarkatti villages.

3.1.2 Soil and soil profile characteristics

The soil of the experimental site was clay texture in black soil at Govankoppa village and at Budarkatti village, the soil texture was sandy clay loam in red soil.

Composite soil samples were drawn from each experimental area before sowing to a depth of 0 to 30 cm and was analyzed for physical and chemical properties and the values obtained are furnished in Table 1 and 2.

Soil samples were drawn from each experimental areas before sowing to a depth of 0-30 cm, 30-60 cm, 60-90 cm and >90 cm and were analyzed for physical and chemical properties and the values obtained are furnished in Table 3 and Plate 1.

3.1.3 Climatic conditions

The data on rainfall for the years 1999 to 2009 and average of ten years recorded at Bailhongal taluk are presented in Table 4 and depicted in Fig. 1.

The mean annual rainfall for the last 10 years was 659.6 mm well distributed from March to November. Maximum rainfall (117.2 mm) was received in the month of October followed by June (116.7 mm). The rainfall received during 2008-09 (April 2008 to March, 2009) was 589.4 mm. Two protective irrigations were given in black soil and three protective irrigations were given in red soil during 2009-10. The rainfall recorded during 2009-10 (April 2009 to March, 2010) was 736.4 mm.

3.1.4 Previous crop in the experimental area

In red soil, chilli was grown in *kharif* and sorghum during *rabi* season, whereas in black soil, soybean was grown in *kharif* and chickpea during *rabi* season.

Field experiments

3.1.5 Treatment details

The experiment consisted of nine commercially available Bt cotton genotypes (hybrids) and one conventional non-Bt hybrid as treatment as below.

Table 1: Physical and chemical properties of experimental field representing black soil

Sl. No.	Properties	Value		Method employed
I.	**Physical properties**			
A.	**Particle size analysis**			
	Coarse sand (%)	7.8		Hydrometer method (Piper, 1966)
	Fine sand (%)	12.3		
	Silt (%)	18.0		
	Clay (%)	60.4		
	Soil texture	Clay		
B.	**Bulk density (Mg/m^3)**	**1.32**		**Core sampler method (Dastane, 1967)**
II.	**Chemical properties**	**Value**	**Rating**	
	Available nitrogen (kg/ha)	265.0	Low	Alkaline permanganate method (Subbaiah and Asija, 1956)
	Available phosphorus (P_2O_5) (kg/ha)	32.4	Medium	Olsen's method (Jackson, 1973)
	Available potassium (K_2O) (kg/ha)	420.0	High	Flame photometer method (Jackson, 1973)
	Organic carbon (%)	0.55	Medium	Walkley and Black wet oxidation method (Jackson, 1967)
	Soil pH (1:2.5 soil:water suspension)	7.2	Neutral	Potentiometric method (Piper, 1966)

Table 2: Physical and chemical properties of experimental field representing red soil

Sl. No.	Properties	Value		Method employed
I.	**Physical properties**			
A.	**Particle size analysis**			
	Coarse sand (%)	32.1		Hydrometer method (Piper, 1966)
	Fine sand (%)	13.9		
	Silt (%)	22.8		
	Clay (%)	31.2		
	Soil texture	Sandy clay loam		
B.	**Bulk density (Mg/m^3)**	**1.42**		**Core sampler method (Dastane, 1967)**
II.	**Chemical properties**	**Value**	**Rating**	
	Available nitrogen (kg/ha)	234.0	Low	Alkaline permanganate method (Subbaiah and Asija, 1956)
	Available phosphorus (P_2O_5) (kg/ha)	21.6	Medium	Olsen's method (Jackson, 1973)
	Available potassium (K_2O) (kg/ha)	283.0	High	Flame photometer method (Jackson, 1973)
	Organic carbon (%)	0.40	Low	Walkley and Black wet oxidation method (Jackson, 1967)
	Soil pH (1:2.5 soil:water suspension)	6.81	Neutral	Potentiometric method (Piper, 1966)

Table 3: Chemical properties of soil profiles in black and red soils (mother trial)

Depth (cm)	pH	Electrical conductivity (dS/m)	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Magnesium (Meq/ 100 g)	Zinc (ppm)	Copper (ppm)	Iron (ppm)	Manganese (ppm)
Black soil											
0 – 30	7.20	0.18	0.55	265	32.4	420	17.9	0.45	1.20	4.40	16.01
30 – 60	7.40	0.15	0.48	253	30.1	418	12.3	0.31	1.16	3.41	9.76
60 – 90	7.41	0.26	0.37	249	29.8	412	10.8	0.30	0.69	3.38	8.31
>90	7.50	0.30	0.35	246	27.6	410	10.2	0.26	0.63	3.32	6.97
Red soil											
0 – 30	6.81	0.14	0.40	234	21.6	283	3.73	0.96	2.66	10.07	20.75
30 – 60	6.90	0.18	0.37	229	20.1	276	2.43	0.40	1.97	8.12	13.40
60 – 90	7.00	0.17	0.32	235	19.8	270	2.31	0.33	1.65	5.22	9.94
>90	7.10	0.23	0.30	231	16.3	268	1.73	0.23	1.39	5.00	8.81

Black soil (Govanakoppa village)

Red soil (Budarkatti village)

Plate 1: Soil profiles of the experimental sites (Mother trials)

Table 4: Rainfall data of Bailhongal taluk (mm)

Month / Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean of ten years
January	-	-	-	-	-	-	-	-	-	-	-	-
February	5.7	-	-	10.4	-	-	-	-	-	-	-	8.05
March	-	-	-	-	40.3	-	-	3.6	-	147.9	4.8	49.20
April	-	2.3	29.6	44.0	40.9	5.0	35.8	4.4	49.7	47.6	17.7	30.80
May	82.2	85.0	23.0	38.3	4.4	100.9	11.8	98.0	60.4	66.0	130.6	70.06
June	77.3	56.9	59.6	45.4	52.1	116.5	148.6	170.8	229.2	39.0	171.7	116.7
July	154.3	95.2	41.8	13.4	26.0	12.8	235.0	132.8	131.3	55.1	17.6	91.50
August	26.7	90.1	49.3	73.5	24.8	72.4	105.0	94.6	112.7	171.4	74.9	89.50
September	15.2	157.7	99.9	6.0	27.6	130.9	184.6	57.9	218.6	99.0	116.2	111.40
October	146.4	135.9	14.6	165.1	181.5	45.4	225.2	25.0	25.9	55.4	152.2	117.20
November	-	7.3	19.0	-	-	18.8	6.4	25.6	10.8	51.1	42.4	18.20
December	-	-	-	-	-	-	-	-	-	-	13.1	13.10
Total	**507.8**	**630.4**	**336.3**	**376.1**	**397.0**	**502.7**	**952.4**	**581.5**	**838.6**	**732.5**	**741.2**	**659.60**
No. of rainy days	**60**	**67**	**58**	**45**	**28**	**42**	**63**	**67**	**88**	**91**	**98**	**64**

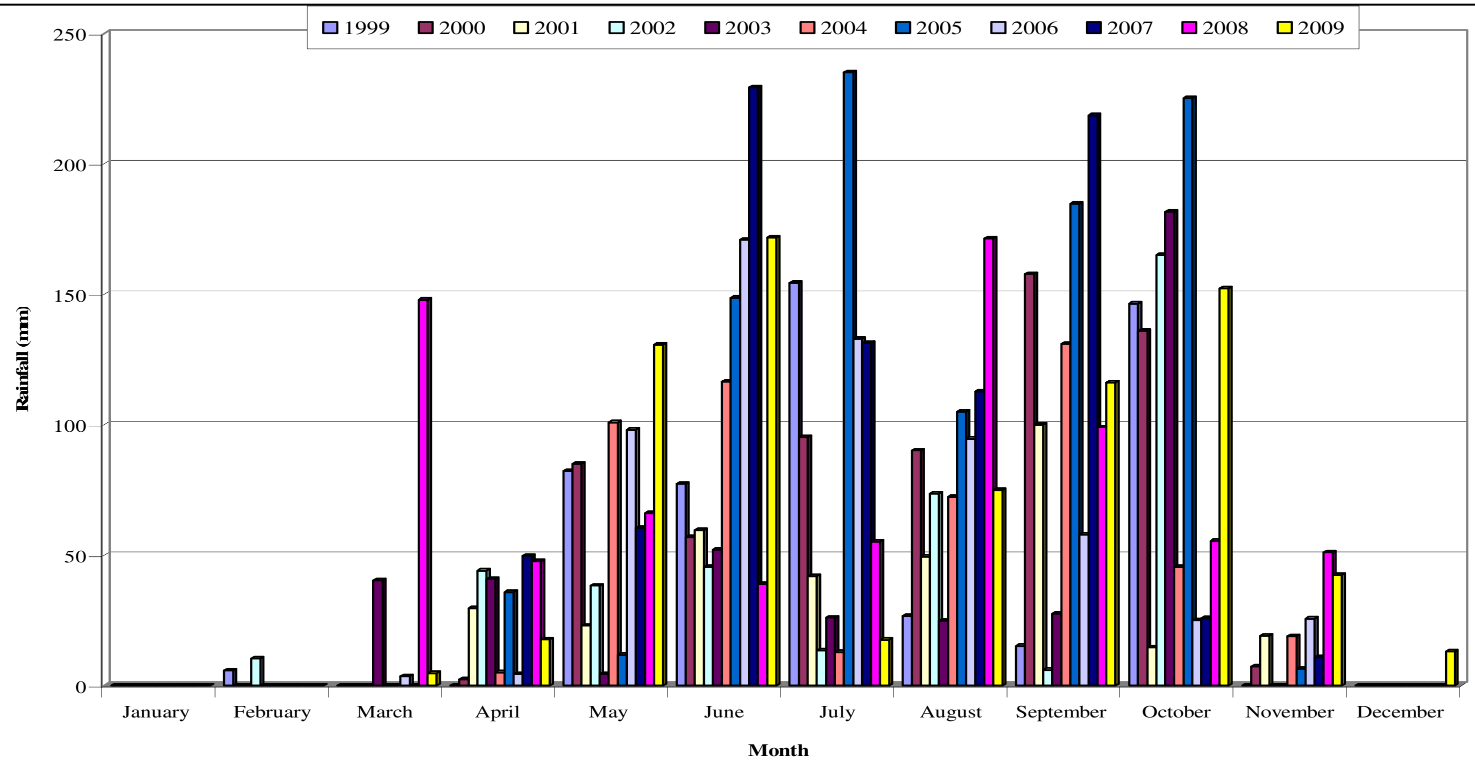

Fig. 1: Rainfall data of Bailhongal taluk (mm)

Fig. 1: Rainfall data of Bailhongal taluk (mm)

Genotypes	Cotton hybrids	Source of supply
T_1	RCH-2 Bt I	: M/s. Rasi Seeds Co. Ltd., Atur, (Tamil Nadu)
T_2	RCH-2 BG-II Bt	: M/s. Rasi Seeds Co. Ltd., Atur, (Tamil Nadu)
T_3	NCS-145 Bunny BG-II Bt	: M/s. Nuziveedu Seeds Ltd., Hyderabad (Andhra Pradesh)
T_4	JK-99 Bt	: M/s. JK Agri Genetics Ltd., Hyderabad (Andhra Pradesh)
T_5	NCS-207 Mallika Bt	: M/s. Nuziveedu Seeds Ltd., Hyderabad (Andhra Pradesh)
T_6	MRC-6918 Bt	: M/s. Mahyco Seeds Ltd., Jalna (Maharashtra)
T_7	Brahma Bt	: M/s. Monsanto India Ltd., Bangalore (Karnataka)
T_8	RCH-708 Bt	: M/s. Rasi Seeds Co. Ltd., Atur, Coimbatore (Tamil Nadu)
T_9	NCS-145 Bunny Bt	: M/s. Nuziveedu Seeds Ltd., Hyderabad (Andhra Pradesh)
T_{10}	DHH-11*	: Agricultural Research Station, Dharwad Farm, Dharwad

* Conventional (non-Bt cotton hybrid)

3.1.6 Design and layout

The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The detail plan of layout of the experiments (mother trial) is shown in Fig. 2 and 3 and baby trials in Fig. 4. The general view of the experiment is shown in Plate 2.

3.1.7 Plot size

Gross plot size : 10.8 m × 7.8 m

Net plot size : 9.0 m × 6.6 m

3.1.8 Cultural practices

3.1.8.1 Land preparation

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

3.1.8.2 Sowing

The different cotton genotypes were dibbled 90 cm apart in rows with intra row spacing of 60 cm on 27-06-2008 (black soil) and 29-06-2008 (red soil) and 29-06-2009 (black soil) and 01-07-2009 (red soil) during 2008 and 2009, respectively on flat bed at the rate of two seeds per hill to a depth of 4 cm on flat bed. Gap filling was done 10 days after sowing.

3.1.8.3 Fertilizer application

The 50 per cent of recommended dose of nitrogen and full dose of P_2O_5 and K_2O were applied (100-50-50 N:P_2O_5:K_2O/ha) at the time of sowing and the remaining 50 per cent of N was applied at 30 days after sowing (DAS).

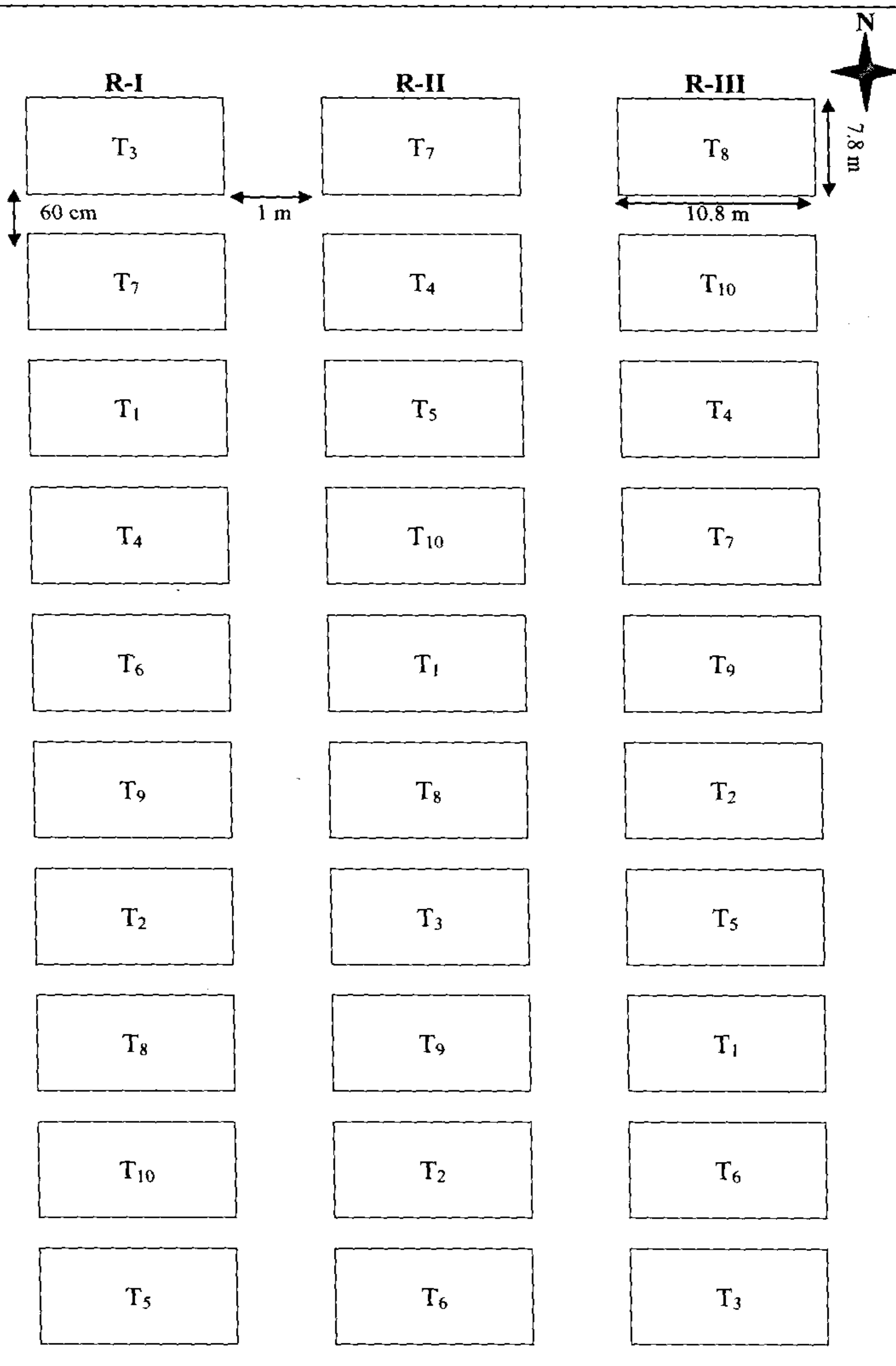

Fig. 2: Field layout of experiment (black soil of Govankoppa)

Fig. 2: Field layout of experiment (black soil of Govankoppa)

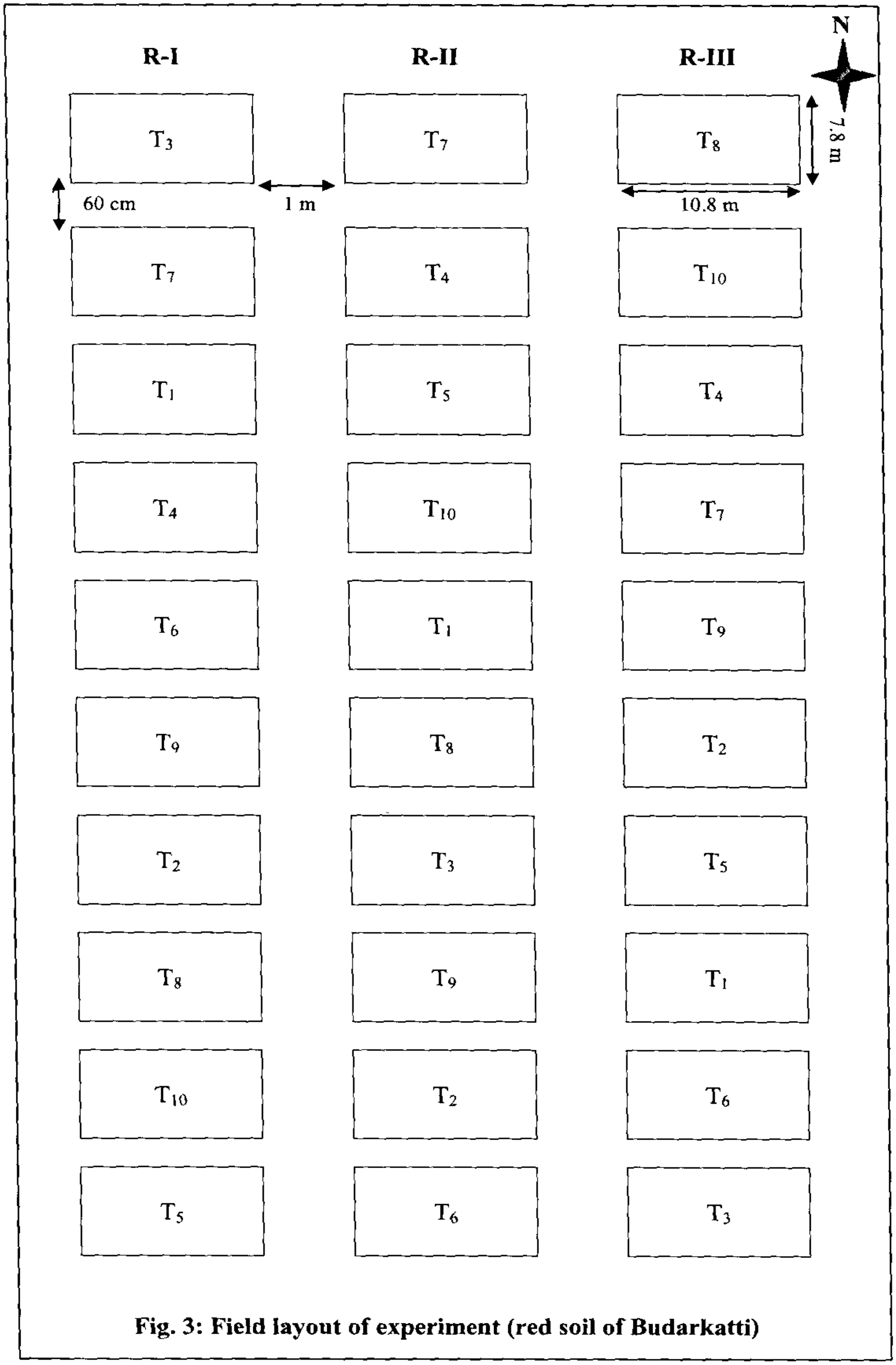

Fig. 3: Field layout of experiment (red soil of Budarkatti)

	R-I	R-II	R-III
T_1	RCH-2 BG-I	RCH-2 BG-I	RCH-2 BG-I
T_2	RCH-2 BG-II	RCH-2 BG-II	RCH-2 BG-II
T_3	Bunny BG-II	Bunny BG-II	Bunny BG-II
T_4	JK-99 Bt	JK-99 Bt	JK-99 Bt
T_5	Mallika Bt	Mallika Bt	Mallika Bt
T_6	MRC-6918 Bt	MRC-6918 Bt	MRC-6918 Bt
T_7	Brahma Bt	Brahma Bt	Brahma Bt
T_8	RCH-708 Bt	RCH-708 Bt	RCH-708 Bt
T_9	Bunny BG-I	Bunny BG-I	Bunny BG-I
T_{10}	DHH-11	DHH-11	DHH-11

Each treatment and each replication represents one farmer

Total number of farmers – 30 in black and 30 in red soils

Fig. 4: Plan of layout of baby trials on different farmers fields in black soil (Govankoppa and Chikkabellikatti villages) and red soil (Budarkatti village) in Bailhongal taluk of Belgaum district

Fig. 4: Plan of layout of baby trials on different farmers fields in black soil (Govankoppa and Chikkabellikatti villages) and red soil (Budarkatti village) in Bailhongal taluk of Belgaum district

Black soil (Govanakoppa village)

Red soil (Budarkatti village)

Plate 2: General view of the experimental sites

3.1.8.4 After care

Three hand weedings of 25, 45 and 65 DAS and three intercultivations at 55, 75 and 85 DAS were carried out to keep the plots free from weeds and to close the cracks developed during the crop growth period to reduce evaporation losses in both the years.

In red soil, three hand weedings at 25, 45 and 65 DAS and three cultivations at 55, 75 and 85 DAS were carried out to keep the plots free from weeds. Two protective irrigations were given in black soil and three protective irrigations were given in red soil during 2009-10.

3.1.8.5 Plant protection schedule

All Bt cotton seeds were treated with imidacloprid at 7.5 ml per kg at the source of packing. The seeds of DHH-11 were treated with imidacloprid at the same rate. The crop was protected in both red and black soil uniformly for sucking pests with systemic insecticides based on economic threshold limits (ETL) of one or more pests at a time. The ETL considered was 10 nymphs for aphids and thrips, two nymphs for jassids. The details of plant protection schedule are furnished in Appendix I.

The plant protection for bollworms was also based on ETL *i.e.*, one larvae per plant or 10 per cent damage to the fruiting bodies.

For DHH-11, the genotype received four rounds of sprays during 2008-09 and 2009-10. The applications were in the order of first spray with quinalphos 25 EC @ 2.5 ml per l at 65 DAS, second spray with chlorpyriphos 20 EC @ 2.5 ml per l at 90 DAS, third spray with cypermethrin 10 EC @ 0.5 ml per l at 105 DAS and fourth spray with profenophos 50 EC @ 2 ml per l at 120 DAS.

The Bt cotton genotype expressing only one gene (Cry1Ac) received profenophos 50 EC @ 2.0 ml per l at 110 DAS.

3.1.8.6 Harvesting

Harvesting of seed cotton from the net plot was taken up in four pickings. Dates of pickings are given in Appendix II.

3.2 Method of observations recorded

The following biometric observations were recorded at 60, 90, 120 DAS and at first picking on five tagged plants selected randomly in each plot.

Growth parameters

3.2.1 Plant height (cm)

Plant height was measured from base of the plant to the tip of fully opened leaf on main shoot and expressed in centimeters.

3.2.2 Number of monopodial branches per plant

The monopodial branches bearing at least one functional sympodial branch were counted separately in five tagged plants and the average value was recorded at the time of first picking.

3.2.3 Number of sympodial branches per plant

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

3.2.4 Leaf area index (LAI)

The leaf area was measured by disc method and then leaf area index per plant was calculated at 60, 90, 120 DAS and at first picking by using the formula given by Watson (1952).

$$\text{LAI} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area per plant (cm}^2\text{)}}$$

3.2.5 Total dry matter production

The plant samples were dried separately at 60 to 80^0C in hot air oven for 24 to 36 hours. Completely dried samples were weighed and dry weight of plant in grams per plant basis was recorded.

3.2.6 SPAD readings

Reading was taken from fully expanded leaf in between the leaf margin and the midrib. The average of five SPAD value was taken as the final value. The reading was recorded at 60, 90 and 120 DAS.

3.2.7 Number of bolls per plant

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

3.2.8 Number of bad opened bolls per plant

At harvest, the number of bad opened bolls (BOB) from five tagged plants were counted and recorded at each picking and finally added for total bad opened bolls per plant.

Yield parameters

3.2.9 Seed cotton yield per plant

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

3.2.10 Seed cotton yield per hectare

On the basis of seed cotton yield per net plot, the seed cotton yield per hectare was computed and expressed as seed cotton yield kg per hectare.

3.2.11 Harvest index

Harvest index was calculated by using the formula given by Donald (1962).

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.2.12 Economics of cotton cultivation

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

$$\text{B:C ratio} = \frac{\text{Gross returns (Rs./ha)}}{\text{Cost of cultivation (Rs./ha)}}$$

3.2.13 Microbial population

For analyzing the microbial activity, the rhizosphere soil samples were collected from the treatments (genotypes) in both black and red soils during cropping period (2009-10) at the time of flowering and at harvest. The composition of various medium used are being presented in Appendix III.

3.2.13.1 Methylotrophs

The population of methylotrophs was estimated by using serial dilution and standard plate count technique. Ammonium mineral salts (AMS) medium was the selective medium used for enumeration of methylotrophs (Whittenburg *et al.*, 1970).

3.2.13.2 Phosphate solubilizing microorganism (PSM)

The population of PSM was estimated by using serial dilution and standard plate count technique. The PSM were enumerated using Sperber's medium (1958).

3.2.13.3 *Azospirillum*

The population of *Azospirillum* was estimated by using most probable number technique (Doberiner *et al.*, 1976). The *Azospirillum* were enumerated using Okon's medium.

3.2.14 Collection of yield data in baby trials

Randomly selected 10 m $\times$ 10 m sampling unit from each farmers field grown with the experimental genotypes in both black and red soil, the yield data was calculated.

3.2.14.1 Yield per 100 m^2

The total seed cotton yield from all the pickings from 10 m $\times$ 10 m sampling unit was recorded or yield per 100 m^2 was calculated and was expressed in kg per 100 m^2.

3.2.14.2 Yield per hectare

Yield per hectare was calculated by converting the yield per 100 m^2 area to one hectare and expressed in kg per ha.

3.2.15 Collection and preparation of plant samples

Treatment-wise plant samples were collected at 60, 90, 120 DAS and 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 60 to 80^0C for 24 to 36 hours. Then the plant samples were powdered with the help of grinder and stored in butter paper bags. The samples were analyzed for nitrogen, phosphorus, potassium, calcium, magnesium and micronutrients content by following standard procedures.

3.2.15.1 Nitrogen

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

3.2.15.2 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 sulphur acid, nitric acid and prechloric acid (10:4:1). The clear digested material was made use for analyzing P, K, Ca and Mg and micronutrients.

3.2.15.3 Phosphorus

The phosphorus in the plant sample was determined by Vanadomolybdate yellow colour method in nitric acid medium. The intensity of colour was read at 420 mm wavelength using spectrophotometer.

3.2.15.4 Potassium

Potassium in the plant sample was estimated by automizing the diluted plant extract in the flame photometer.

3.2.15.5 Calcium and magnesium

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

3.2.15.6 Micronutrients

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

3.3 Fertility map of soils and yield map of Bt cotton growing areas of Bailhongal taluk

The methodologies adopted for the selection of study area, collection of soil samples, observational procedures for the collection of data required and also analytical tools and techniques adopted in this study.

3.3.1 Selection of the study area and crop

The first step in the investigation should be the selection of the crop to be estimated and the study area. The thumb rule is that the historical crop production should exceed 5 per cent of the geographical area or the crop should be in concentrated patches. Based on this thumb rule, Bailhongal taluk was selected for the present investigation as this taluk occupy majority of the area under cotton crop in Belgaum district of Karnataka.

3.3.2 Geographical location of the study area

The study area comprising Bailhongal taluk has the geographical area of 1,12,233 hectares. This taluk come under the northern transition zone (Zone-8) of Karnataka.

3.3.3 Climate

The Bailhongal taluk of zone-8 in Belgaum district of Karnataka have maximum temperature ranging from 35^0C to 39^0C during April and minimum temperature ranging from 12^0C to 15^0C during December. The total rainfall of the taluk ranges over 10 years (1999-2009), 336.3 mm to 951.00 mm per annum with an average of 660 mm. Most of the rainfall is received during southwest monsoon period from June to October and July is the peak rainfall month. The total rainfall received during the cropping season of 2008-09 in Bailhongal taluk is 589.4 mm and during 2009-10 is 736.4 mm.

The monthly rainfall recorded in Bailhongal taluk headquarters during the cropping seasons and the previous years are presented in Table 4.

3.3.4 Soil characteristics and water resources

Most of the soils of study are medium to deep black soils (Vertisols) with neutral to slightly alkane soil reaction and low soluble salts. The soils are low to medium in available nitrogen, medium in available phosphorus and high in available potassium.

Most of the soils of the study are red sandy to sandy clay soils (Alfisols) with slightly acidic to slightly alkaline and neutral soil reaction and low in available salts. The soils are low to medium in available nitrogen and low to medium in available phosphorus and high in potassium.

The Malaprabha left and right bank canal irrigates some part of the Bailhongal taluk.

3.3.5 Crops and cropping pattern

The main crops of the study area in *kharif* season are Bt cotton, soybean, sugarcane, greengram, maize, sorghum, bajra, wheat, chickpea, groundnut. There is considerable variation in sowing dates. However, main sowing of Bt cotton in this taluk extend from May II fortnight to July I fortnight and harvesting starts from I fortnight of January and extends upto II fortnight of March.

3.3.6 Soil analysis

3.3.6.1 Collection and preparation of soil samples

Composite soil samples (0 – 30 cm depth) were collected during May 2009-10 from the selected sites. The information about the crop was also noted using a questionnaire prepared for the crop. The sampling details are given in Table 5, 6 and Plate 3, 4, 5.

3.3.6.2 Soil reaction (pH)

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

3.3.6.3 Electrical conductivity (EC)

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

3.3.6.4 Organic carbon (%)

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

3.3.6.5 Available nitrogen

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

3.3.6.6 Available phosphorus

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

Table 5: List of soil sample sites of black soils in Bailhongal taluk

Sl. No.	Villages	Latitude	Longitude	Elevation (m)
1.	Govankoppa	$15^0$38'78.8"	$74^0$55'69.9"	698
2.	Mugabasava	$15^0$44'72.3"	$74^0$56'94.8"	633
3.	Belawadi	$15^0$43'07.1"	$74^0$55'81.8"	659
4.	Budihal	$15^0$44'59.8"	$74^0$56'73.8"	659
5.	Chikkabellikatti	$15^0$37'51.3"	$74^0$56'66.3"	662
6.	Doddawada	$15^0$40'43.2"	$74^0$58'11.2"	675
7.	Udikeri	$15^0$44'09.5"	$74^0$56'59.1"	647
8.	Sampagaon	$15^0$47'42.4"	$74^0$45'83.7"	665
9.	Bavihal	$15^0$49'71.9"	$74^0$44'87.4"	714
10.	Turamari	$15^0$41'80.4"	$74^0$47'44.0"	671
11.	Neginahal	$15^0$45'15.2"	$74^0$48'45.9"	648

Table 6: List of soil sample sites of red soils in Bailhongal taluk

Sl. No.	Villages	Latitude	Longitude	Elevation (m)
1.	Siddasamudra	15^{0}41'61.1"	74^{0}53'91.4"	671
2.	Hirebellikatti	15^{0}39'51.0"	74^{0}51'93.8"	689
3.	Kadasagatti	15^{0}38'99.2"	74^{0}52'26.5"	694
4.	Gudikatti	15^{0}38'49.1"	74^{0}57'05.0"	672
5.	Budarkatti	15^{0}39'62.3"	74^{0}54'50.7"	676
6.	Bidaragaddi	15^{0}39'77.6"	74^{0}52'94.0"	681
7.	Jallikoppa	15^{0}44'63.5"	74^{0}52'69.3"	642
8.	Aaravalli	15^{0}44'28.3"	74^{0}52'96.8"	660
9.	Patyal	15^{0}44'66.1"	74^{0}52'69.2"	673
10.	Khodhanpur	15^{0}40'30.5"	74^{0}51'33.2"	671
11.	Sangolli	15^{0}42'71.4"	74^{0}49'87.0"	664
12.	Garjur	15^{0}43'32.5"	74^{0}50'89.7"	638
13.	Savatagi	15^{0}42'17.1"	74^{0}50'55.2"	676

3.3.6.7 Available potassium

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

3.3.6.8 Exchangeable magnesium

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

3.3.6.9 Micronutrients (ppm)

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

3.3.6.10 Standard / nutrient limits used for the classification of nutrients into different groups

The available micronutrients content in the soil of Bailhongal taluk area is categorized into deficit, marginal and sufficient as outlined by Katyal and Randhawa (1983). The soil DTPA extractable micronutrient, categorized is as shown below.

	Deficient (ppm)	Marginal (ppm)	Sufficient (ppm)
Available Fe	<2.5	2.5 – 4.5	>4.5
Available Zn	<0.6	0.6 – 1.00	>1.0
Available Cu	<0.2	-	>0.2
Available Mn	<2.0	-	>2.0

Nutrient index to prepare the soil fertility map of Fe and Zn is given by Biswas and Mukerjee (1987).

Where, N1, Nm and Nh represents per cent samples falling under deficient, marginal and sufficient.

Ni <1.5 - Low

Nm 1.5 – 2.5 - Medium

Nh >2.5 - High

3.4 Documentation of existing cultivation practices in different soils of northern transition zone of Karnataka

For the purpose of documentation of existing cultivation practices followed by Bt cotton, 10 farmers (selected for soil sampling in each village for both red and black soils) were selected. Keeping in view the objectives of the study, a comprehensive structured questionnaire was prepared (Appendix V). The items included in the questionnaire schedule were structured questions and scale items which were relevant to the investigation. Later, the data collection was done by personal interview method using the schedule.

3.4.1 Preparation of report

The data thus collected from the sample respondents through interview schedule was coded, tabulated, analyzed and presented in the form of tables in order to make the findings meaningful and easily understandable. The findings emerged from the analysis of data were suitably interpreted and necessary conclusions and inferences were drawn.

3.5 Statistical analysis

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

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

For comparing the yield data in mother and baby trials paired 't' test was employed.

4. EXPERIMENTAL RESULTS

The results of the investigation carried out during 2008-09 and 2009-10 under rainfed condition are presented in this chapter. The interpretation is made with respect to only pooled data of two years.

4.1 Field experiments

4.1.1 Experiment I: Performance of Bt cotton genotypes in black soil

4.1.1.1 Plant height (cm)

The data on plant height recorded at 60, 90, 120 DAS and at harvest is presented in Table 7. The data indicated that the plant height increased progressively from 60 DAS to harvest. At all the growth stages, plant height differed significantly among the genotypes.

At 60 DAS, MRC-6918 Bt recorded significantly higher plant height (57.80 cm) than all the cotton genotypes. Similar trend was followed at 120 DAS. At 90 DAS, MRC-6918 Bt recorded significantly higher plant height (94.70 cm) than other cotton genotypes except RCH-708 Bt (90.10 cm) and Mallika Bt (87.95 cm) which were found on par to MRC-6918 Bt. At harvest, MRC-6918 Bt recorded significantly higher plant height (171.35 cm) compared to other cotton genotypes and found on par with RCH-708 Bt (160.35 cm).

4.1.1.2 Leaf area index

Genotypes exhibited significant difference in leaf area index at all the stages of crop growth (Table 8).

At 60 DAS, MRC-6918 Bt recorded significantly higher leaf area index (1.77) compared to other genotypes and found on par with RCH-708 Bt (1.73), Bunny BG-II Bt (1.66), Brahma Bt (1.65) and Mallika Bt (1.63). At 90 DAS, MRC-6918 Bt and Mallika Bt recorded significantly higher leaf area index (3.27) to other cotton genotypes and found on par with RCH-708 Bt (3.11) and JK-99 Bt (3.05). At 120 DAS, significantly higher leaf area index (3.84) was recorded with Mallika Bt compared to all other cotton genotypes. At harvest, MRC-6918 Bt recorded significantly higher leaf area index (3.01) compared to all other cotton genotypes.

4.1.1.3 Number of monopodial branches

Genotypes differed significantly with respect to number of monopodal branches at all the stages of crop growth (Table 9). RCH-708 Bt recorded significantly higher number of monopodial branches at 60 DAS (2.63), 90 DAS (3.73), 120 DAS (3.73) and at harvest (3.73) and found on par with DHH-11 non-Bt (2.60), MRC-6918 Bt (2.53), Bunny Bt BG-II (2.43) and Bunny Bt BG-I (2.37) at 60 DAS.

At 90 DAS, RCH-708 Bt recorded significantly higher number of monopodial branches than other cotton genotypes except for MRC-6918 Bt (3.47) and DHH-11 non-Bt (3.37).

RCH-708 Bt recorded significantly higher number of monopodial branches (3.73) at 120 DAS than other cotton genotypes except for DHH-11 (3.63), Bunny Bt BG-II (3.53) and MRC-6918 Bt (3.50). Similar trend was observed at harvest.

4.1.1.4 Number of sympodial branches

Bt cotton genotypes showed significant variation with respect to number of sympodial branches at all the stages of crop growth (Table 10). At 60 DAS, MRC-6918 Bt recorded significantly higher number of sympodial branches (9.03) than all other cotton genotypes.

At 90 DAS, MRC-6918 Bt recorded significantly higher number of sympodial branches (21.3) and found on par with RCH-708 Bt (21.25), RCH-2 Bt (19.95) and both JK-99 Bt and Mallika Bt (18.95).

Table 7: Plant height (cm) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	41.7	64.9	106.8	121.3	39.0	72.4	107.4	146.4	40.35	68.65	107.10	133.88
RCH-2 BG-II	42.6	65.1	108.6	129.6	41.7	73.6	113.5	144.6	42.15	69.35	111.05	137.10
Bunny BG-II	43.0	68.9	112.2	129.1	39.4	76.4	119.9	134.2	41.20	72.65	116.15	131.65
JK-99 Bt	47.3	75.3	115.8	121.3	41.8	75.4	128.9	129.8	44.55	75.35	122.35	125.55
Mallika Bt	43.5	88.3	130.0	135.6	44.9	87.6	135.0	145.6	44.20	87.95	132.50	140.60
MRC-6918 Bt	57.6	91.4	149.8	169.1	58.0	98.4	156.4	173.6	57.80	94.70	153.10	171.35
Brahma Bt	44.0	75.2	106.7	128.3	41.0	79.4	122.9	139.1	42.50	77.30	114.90	133.70
RCH-708 Bt	45.0	89.6	138.2	155.1	47.5	90.4	139.2	165.6	46.25	90.10	138.80	160.35
Bunny Bt	39.1	61.1	106.2	122.4	42.3	74.6	116.4	130.1	40.70	67.85	111.30	126.25
DHH-11	38.6	55.1	99.5	116.3	38.4	68.6	103.8	123.8	38.50	61.85	101.65	120.05
SEm±	2.90	5.17	6.80	6.61	3.41	5.52	5.65	6.09	2.55	4.26	4.73	5.65
CD at 5%	8.61	15.35	20.19	19.63	10.15	16.40	16.80	18.10	7.58	12.66	14.05	16.80
CV (%)	11.35	12.18	10.03	8.61	13.63	12.00	7.87	7.36	10.08	9.64	6.78	7.09

DAS – Days after sowing

Table 8: Leaf area index of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	1.29	1.97	2.67	2.01	1.68	2.85	3.52	2.15	1.49	2.41	3.10	2.08
RCH-2 BG-II	1.36	2.36	2.79	1.92	1.73	2.58	3.61	2.35	1.56	2.47	3.20	2.14
Bunny BG-II	1.52	2.39	2.86	1.83	1.79	2.87	3.48	2.65	1.66	2.63	3.17	2.24
JK-99 Bt	1.35	3.12	3.26	1.43	1.82	2.97	3.45	1.63	1.59	3.05	3.26	1.53
Mallika Bt	1.38	3.38	3.86	2.39	1.88	3.16	3.82	2.25	1.63	3.27	3.84	2.32
MRC-6918 Bt	1.59	3.17	3.41	3.16	1.95	3.37	3.37	2.85	1.77	3.27	3.49	3.01
Brahma Bt	1.46	2.21	3.13	1.82	1.84	3.13	3.32	1.59	1.65	2.67	3.23	1.71
RCH-708 Bt	1.53	3.03	2.96	2.88	1.93	3.19	3.71	1.73	1.73	3.11	3.34	2.31
Bunny Bt	1.32	2.16	2.56	1.71	1.60	2.51	3.59	1.90	1.46	2.34	3.08	1.81
DHH-11	1.25	2.24	2.97	2.14	1.51	3.03	2.75	1.43	1.38	2.64	2.86	1.79
SEm±	0.05	0.13	0.12	0.09	0.09	0.08	0.15	0.12	0.05	0.08	0.09	0.08
CD at 5%	0.14	0.39	0.36	0.27	0.27	0.23	0.44	0.36	0.14	0.22	0.28	0.22
CV (%)	5.98	8.78	6.98	7.52	8.73	4.56	7.33	10.13	5.31	4.70	5.03	6.26

DAS – Days after sowing

Table 9: Number of monopodial branches per plant of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	1.93	2.60	2.86	2.86	2.40	3.00	3.00	3.00	2.17	2.80	2.93	2.93
RCH-2 BG-II	1.73	2.87	3.06	3.06	2.46	3.06	3.26	3.26	2.09	2.97	3.16	3.16
Bunny BG-II	2.40	3.33	3.73	3.73	2.46	3.26	3.33	3.33	2.43	3.30	3.53	3.53
JK-99 Bt	1.93	2.86	3.00	3.00	2.40	3.06	3.20	3.20	2.17	2.96	3.10	3.10
Mallika Bt	1.93	2.86	3.00	3.50	2.46	3.20	3.26	3.26	2.20	3.03	3.13	3.13
MRC-6918 Bt	2.46	3.20	3.26	3.26	2.60	3.73	3.73	3.73	2.53	3.47	3.50	3.50
Brahma Bt	2.33	2.46	2.66	2.66	2.33	2.86	2.86	2.86	2.33	2.66	2.76	2.76
RCH-708 Bt	2.60	3.73	3.73	3.73	2.66	3.73	3.73	3.73	2.63	3.73	3.73	3.73
Bunny Bt	2.33	2.66	3.00	3.00	2.40	3.00	3.06	3.06	2.37	2.83	3.03	3.03
DHH-11	2.46	3.00	3.33	3.33	2.73	3.73	3.93	3.93	2.60	3.37	3.63	3.63
SEm±	0.12	0.16	0.19	0.19	0.12	0.14	0.16	0.16	0.10	0.13	0.14	0.14
CD at 5%	0.35	0.48	0.57	0.57	NS	0.42	0.47	0.47	0.29	0.38	0.40	0.40
CV (%)	9.22	9.37	10.52	10.52	8.46	7.56	8.27	8.27	7.15	7.21	7.25	7.25

DAS – Days after sowing

Table 10: Number of sympodial branches per plant of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	6.06	19.60	21.00	22.60	6.26	20.30	22.20	23.80	6.16	19.95	20.60	23.20
RCH-2 BG-II	6.53	17.30	19.60	22.30	6.40	19.30	22.00	23.30	6.47	18.30	20.80	22.80
Bunny BG-II	6.86	15.60	17.60	18.30	7.40	15.30	17.40	18.80	7.13	15.45	17.50	18.55
JK-99 Bt	7.13	18.60	20.60	21.60	6.26	19.30	21.20	22.40	6.70	18.95	20.90	22.00
Mallika Bt	7.60	18.30	20.30	21.30	6.73	19.60	21.60	22.80	7.17	18.95	20.95	22.05
MRC-6918 Bt	8.60	20.60	22.40	24.30	9.46	22.00	24.60	25.50	9.03	21.30	23.50	24.90
Brahma Bt	7.20	16.30	18.60	19.60	6.26	18.00	19.60	20.80	6.73	17.15	19.10	19.70
RCH-708 Bt	7.46	20.30	22.00	23.00	7.86	22.20	23.00	23.90	7.66	21.25	22.50	23.45
Bunny Bt	6.33	16.60	18.00	18.60	7.20	16.00	18.00	19.00	6.77	16.30	18.00	18.80
DHH-11	5.20	14.90	17.30	18.00	5.80	15.60	17.30	18.60	5.50	15.25	17.30	18.30
SEm±	0.46	1.26	1.10	0.92	0.29	1.03	0.96	1.14	0.31	0.90	0.75	0.69
CD at 5%	1.36	3.75	3.26	2.75	0.87	3.06	2.85	3.37	0.92	2.67	2.22	2.06
CV (%)	11.46	12.29	9.53	7.64	7.31	9.52	8.04	8.98	7.73	8.52	6.44	5.62

DAS – Days after sowing

At 120 DAS, MRC-6918 Bt recorded significantly higher number of sympodial branches (23.50) compared to all other cotton genotypes and found on par with RCH-708 Bt (22.50). Similar trend was observed at harvest.

4.1.1.5 SPAD observation

Data on SPAD observation at different growth stages is presented in Table 11. SPAD values differed significantly among different cotton genotypes.

At 60 DAS, Mallika Bt recorded significantly higher SPAD value (40.45) and was found on par with Bunny BG-II (40.15), MRC-6918 Bt (40.10), DHH-11 non-Bt (39.4), RCH-2 Bt (39.15), Brahma Bt (38.85), Bunny Bt (38.80) and RCH-708 Bt (38.45).

At 90 DAS, MRC-6918 Bt recorded significantly higher SPAD value (43.10) compared to RCH-2 Bt (39.3), Bunny Bt (37.75) and DHH-11 non-Bt (36.50) and found on par with other cotton genotypes.

At 120 DAS, MRC-6918 Bt recorded significantly higher SPAD value (44.35) compared to all other cotton genotypes. Similar trend was observed at harvest.

4.1.1.6 Number of bad opened bolls per plant

Genotypes differed significantly with respect to number of bad opened bolls per plant (Table 12), RCH-2 BG-II recorded significantly lower number of bad opened bolls per plant (1.40) compared to all other cotton genotypes except Bunny BG-II (1.85).

4.1.1.7 Total number of bolls per plant

The data on the number of bolls per plant is presented in Table 12. RCH-708 Bt recorded significantly higher total number of bolls per plant (37.95) compared to all other cotton genotypes except MRC-6918 Bt (37.20) was found on par.

4.1.1.8 Boll weight

There was significant difference in boll weight among the cotton genotypes (Table 12). Mallika Bt recorded significantly higher boll weight (5.62 g/boll) and was found on par with Brahma Bt (5.31 g/boll), Bunny Bt (5.20 g/boll) and MRC-6918 Bt (4.93 g/boll).

4.1.1.9 Total dry matter production (g/plant)

There were significant differences in total dry matter production at different growth stages among the cotton genotypes is presented in Table 13.

At 60 DAS, MRC-6918 Bt recorded significantly with respect to total dry matter production (81.15 g/plant) compared to Bunny Bt (67.20 g/plant), RCH-2 Bt (66.80 g/plant) and DHH-11 (59.40 g/plant).

At 90 DAS, MRC-6918 Bt recorded significantly higher total dry matter production (190.45 g/plant) compared to other cotton genotypes except RCH-708 Bt (184.35 g/plant), JK-99 Bt (182.35 g/plant) and Mallika Bt (181.95 g/plant).

At 120 DAS, MRC-6918 Bt recorded significantly higher total dry matter production (303.80 g/plant) and found on par with JK-99 Bt (292.30 g/plant), Mallika Bt (288.43 g/plant), RCH-708 Bt (286.10 g/plant) and Bunny BG-II (281.95 g/plant).

At harvest, MRC-6918 Bt recorded significantly higher total dry matter production (318.07 g/plant) compared to other cotton genotypes and found on par with RCH-708 Bt (311.25 g/plant) and JK-99 Bt (298.90 g/plant).

4.1.1.10 Yield parameters

Seed cotton yield per plant

Seed cotton yield per plant of cotton genotypes differed significantly (Table 14 and Fig. 5). MRC-6918 Bt recorded significantly higher seed cotton yield (130.80 g/plant) compared to other cotton genotypes and found on par with Bunny BG-II (130.00 g/plant), Bunny Bt (125.60 g/plant) and RCH-2 Bt BG-II (122.90 g/plant).

Table 11: SPAD value of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	38.70	38.10	37.80	36.90	39.60	40.50	38.50	37.90	39.15	39.30	38.15	37.40
RCH-2 BG-II	37.10	40.53	38.90	37.80	38.10	41.30	39.10	38.20	37.60	40.92	39.00	38.00
Bunny BG-II	39.20	40.90	40.10	39.80	41.10	40.90	40.90	37.10	40.15	40.90	40.50	38.45
JK-99 Bt	36.50	40.10	39.30	39.10	35.90	39.50	40.70	40.10	36.20	39.80	40.00	39.60
Mallika Bt	39.10	40.50	40.30	40.10	41.80	42.00	42.60	39.00	40.45	41.25	41.45	39.55
MRC-6918 Bt	39.90	42.90	44.80	43.50	40.30	43.30	43.90	41.90	40.10	43.10	44.35	42.70
Brahma Bt	37.20	39.70	38.30	37.10	40.50	41.90	41.90	38.10	38.85	40.70	40.10	37.60
RCH-708 Bt	37.90	38.40	39.50	38.20	39.00	42.10	41.90	39.20	38.45	40.25	40.70	38.70
Bunny Bt	38.10	35.60	37.10	36.90	39.50	39.90	37.50	36.50	38.80	37.75	37.30	36.70
DHH-11	33.90	35.90	39.50	37.50	44.90	37.10	38.10	35.90	39.40	36.50	38.80	36.70
SEm±	1.08	1.44	1.32	1.05	1.45	1.06	1.17	1.12	0.73	1.15	0.89	0.72
CD at 5%	3.20	4.28	3.91	3.13	4.32	3.15	3.49	3.33	2.16	3.43	2.65	2.14
CV (%)	4.94	6.36	5.76	4.71	6.29	4.50	5.02	5.00	3.24	4.99	3.86	3.23

DAS – Days after sowing

Table 12: Number of bad opened bolls per plant, total number of bolls per plant and boll weight (g/boll) of different cotton genotypes in black soil (Govankoppa)

Treatments (genotypes)	No. of bad opened bolls per plant			Total number of bolls per plant			Boll weight		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
RCH-2 Bt	6.20	5.40	5.80	29.70	30.90	30.30	4.65	4.64	4.65
RCH-2 BG-II	1.30	1.50	1.40	26.40	32.40	29.40	4.82	4.80	4.81
Bunny BG-II	1.60	2.10	1.85	25.20	25.80	25.50	5.13	5.15	4.63
JK-99 Bt	7.30	6.50	6.90	29.60	29.60	29.60	4.50	4.51	4.51
Mallika Bt	4.50	3.90	4.20	24.20	21.40	22.80	5.63	5.61	5.62
MRC-6918 Bt	8.90	10.30	9.60	35.80	38.60	37.20	5.50	4.36	4.93
Brahma Bt	6.70	7.20	6.95	25.90	29.80	27.85	5.52	5.10	5.31
RCH-708 Bt	7.10	11.50	9.30	34.60	41.30	37.95	4.36	4.25	4.16
Bunny Bt	1.33	4.70	3.02	23.20	28.10	25.65	5.19	5.20	5.20
DHH-11	13.60	11.80	12.70	32.00	35.30	33.65	4.40	4.43	4.42
SEm±	0.36	0.50	0.30	1.16	1.33	0.95	0.33	0.27	0.25
CD at 5%	1.08	1.48	0.90	3.45	3.94	2.83	0.98	0.79	0.75
CV (%)	10.79	13.30	8.55	7.01	7.34	5.50	11.72	9.58	9.07

Seed cotton yield per ha

Seed cotton yield differed significantly among the genotypes (Table 14). Bunny BG-II recorded significantly higher seed cotton yield (2385.00 kg/ha) than JK-99 Bt (1920.00 kg/ha), Brahma Bt (1770.00 kg/ha) and DHH-11 (1615 kg/ha). However, it was on par with RCH-2 BG-II (2307.00 kg/ha), MRC-6918 Bt (2290.00 kg/ha), RCH-708 Bt (2225.00 kg/ha), Bunny Bt (2190.00 kg/ha), RCH-2 Bt (2110 kg/ha) and Mallika Bt (2055 kg/ha).

Harvest index

Genotypes differed significantly with respect to harvest index (Table 14). Higher harvest index was recorded with RCH-2 BG-II (0.30) and differed significantly with JK-99 Bt (0.25) and Brahma Bt and DHH-11 non-Bt (0.24).

4.1.1.11 Economic analysis

The data on economics of cultivation of Bt cotton genotypes and non-Bt cotton hybrid cultivation in black soil are presented in Table 15. The mean data of two years revealed large variation in the gross and net returns per hectare among different cotton genotypes.

Cost of cultivation (Rs./ha)

The total cost of cultivation was higher in non-Bt cotton cultivation (Rs. 24241/ha) than Bt cotton genotypes.

Gross returns (Rs./ha)

Gross returns differed significantly among the cotton genotypes. MRC-6918 Bt recorded significantly higher gross returns (Rs. 90415/ha) than the other cotton genotypes. RCH-708 Bt (Rs. 87870/ha) was found on par with MRC-6918 Bt.

Net returns (Rs./ha)

Genotypes differed significantly with respect to net returns. MRC-6918 Bt recorded significantly higher net returns (Rs. 67924/ha) than the other cotton genotypes and found on par with RCH-708 Bt (Rs. 65379/ha).

Benefit:cost ratio

Benefit:cost ratio differed significantly among the different cotton genotypes. Higher B:C ratio (4.02) was recorded with MRC-6918 Bt and differed significantly to other cotton genotypes and was found on par with RCH-708 Bt (1:3.91).

4.1.2 Content and uptake of major, secondary and micronutrients

4.1.2.1a Nitrogen uptake (kg/ha)

The data recorded with respect to uptake and nitrogen content by different cotton genotypes at different stages of crop growth is presented in Table 16.

Nitrogen uptake differed significantly in different cotton genotypes at 60, 90 and 120 DAS.

At 60 DAS, MRC-6918 Bt recorded significantly higher nitrogen uptake (36.80 kg/ha) over other cotton genotypes and found on par with Bunny BG-II (35.45 kg/ha) and RCH-2 BG-II (34.10 kg/ha).

At 90 DAS, Bunny BG-II recorded significantly higher nitrogen content (90.75 kg/ha) and found on par with RCH-2 BG-II (89.60 kg/ha), MRC-6918 Bt (89.30 kg/ha) and RCH-708 Bt (84.45 kg/ha).

At 120 DAS, the uptake of nitrogen was found to be higher in Bunny BG-II (113.90 kg/ha) and differed significantly over RCH-708 Bt (105.10 kg/ha), Bunny Bt (101.30 kg/ha), RCH-2 Bt (101.15 kg/ha), Brahma Bt (99.45 kg/ha), Mallika Bt (94.10 kg/ha), JK-99 Bt (92.42 kg/ha) and DHH-11 non-Bt (87.80 kg/ha).

Table 13: Total dry matter production (g/plant) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	64.40	164.40	248.30	271.50	69.20	181.80	263.70	293.60	66.80	173.05	256.00	282.55
RCH-2 BG-II	68.20	168.30	262.50	268.50	78.90	176.70	273.20	289.70	73.55	172.50	267.85	279.10
Bunny BG-II	68.80	170.20	275.60	281.50	79.80	187.50	288.30	305.90	74.30	173.85	281.95	293.62
JK-99 Bt	69.40	172.20	286.50	287.60	77.60	192.50	298.10	310.20	73.50	182.35	292.30	298.90
Mallika Bt	67.30	167.30	281.50	277.20	74.70	196.60	295.50	292.40	71.00	181.95	288.43	284.80
MRC-6918 Bt	72.60	180.60	297.10	300.90	89.70	200.30	310.50	331.90	81.15	190.45	303.80	318.07
Brahma Bt	67.50	166.80	266.80	271.30	77.50	183.50	282.40	318.50	72.50	175.15	274.60	293.23
RCH-708 Bt	70.70	176.20	278.30	297.20	80.10	192.50	293.90	325.30	75.40	184.35	286.10	311.25
Bunny Bt	65.90	165.80	253.10	276.30	68.50	171.90	268.50	297.40	67.20	168.65	260.80	286.85
DHH-11	51.30	150.20	235.10	255.90	67.50	165.90	256.60	281.60	59.40	158.05	245.85	268.75
SEm±	3.63	4.94	10.33	8.47	4.29	6.99	10.96	10.79	3.44	3.39	9.27	7.10
CD at 5%	10.80	14.68	30.69	25.15	12.75	20.76	32.57	32.04	10.21	10.09	27.55	21.08
CV (%)	9.45	5.12	6.67	5.26	9.73	6.55	6.71	6.13	8.33	3.34	5.82	4.21

DAS – Days after sowing

Table 14: Seed cotton yield per plant (g/plant), seed cotton yield (kg/ha) and harvest index of different cotton genotypes in black soil (Govankoppa)

Treatments (genotypes)	Seed cotton yield (g/plant)			Seed cotton yield (kg/ha)			Harvest index		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
RCH-2 Bt	105.30	117.00	111.15	2050	2150	2110	0.28	0.28	0.28
RCH-2 BG-II	125.20	120.60	122.90	2225	2390	2307	0.30	0.30	0.30
Bunny BG-II	120.50	139.60	130.00	2320	2450	2385	0.31	0.30	0.30
JK-99 Bt	105.90	110.80	108.30	1860	1980	1920	0.25	0.25	0.25
Mallika Bt	110.80	118.30	114.50	1940	2170	2055	0.27	0.28	0.28
MRC-6918 Bt	129.90	131.70	130.80	2210	2370	2290	0.28	0.27	0.28
Brahma Bt	101.30	102.30	101.8	1710	1830	1770	0.25	0.23	0.24
RCH-708 Bt	105.60	120.50	113.0	2190	2260	2225	0.28	0.27	0.28
Bunny Bt	115.70	135.50	125.60	2110	2270	2190	0.29	0.29	0.29
DHH-11	92.40	85.40	88.90	1580	1650	1615	0.24	0.24	0.24
SEm±	5.20	5.08	4.49	87.56	101.65	72.71	0.01	0.01	0.01
CD at 5%	15.45	15.10	13.33	260.15	302.02	216.04	0.03	0.04	0.03
CV (%)	8.09	7.45	6.77	7.51	8.18	6.04	6.64	7.69	6.02

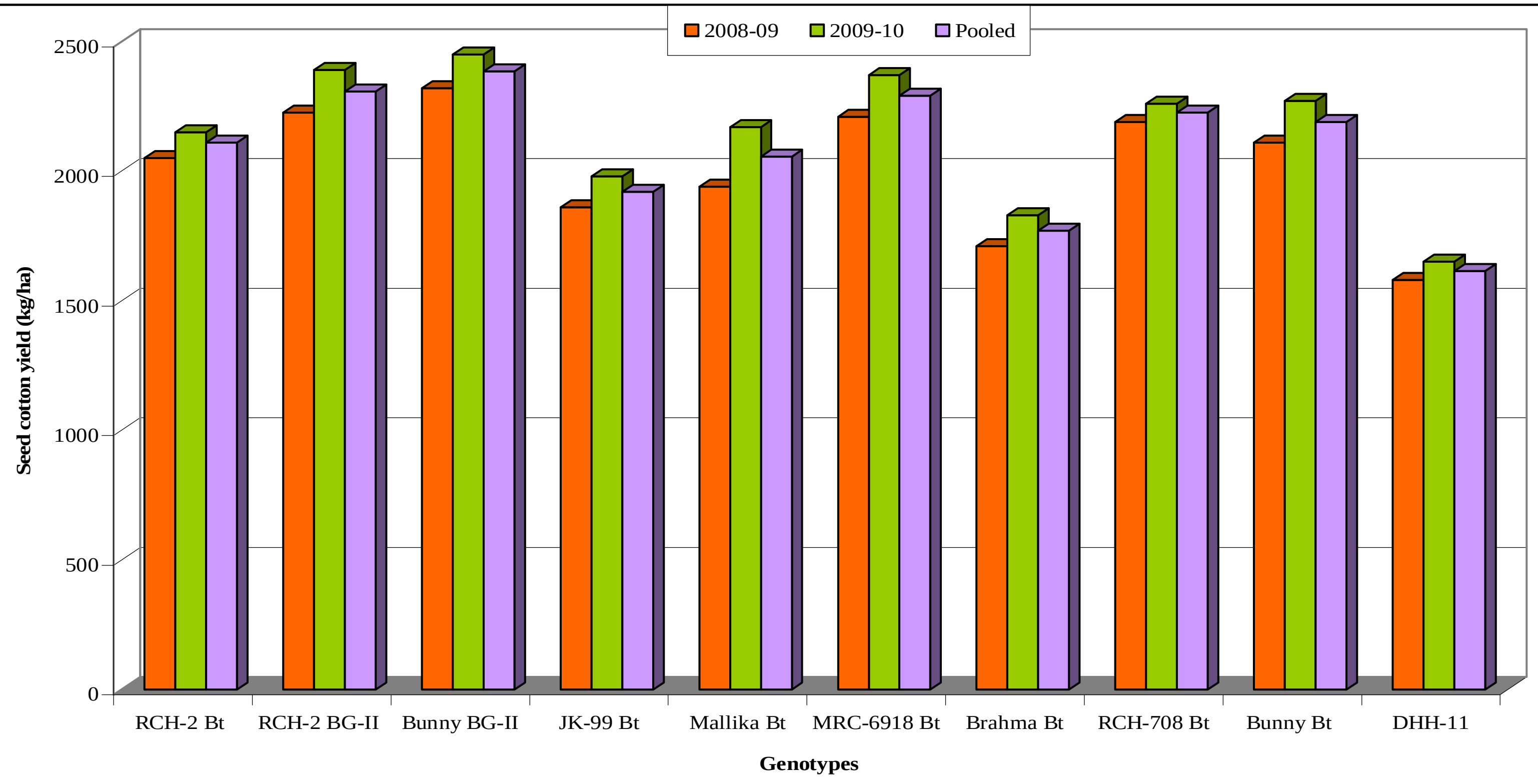

Fig. 5: Seed cotton yield (kg/ha) of different cotton genotypes in black soil (Govankoppa)

Fig. 5: Seed cotton yield (kg/ha) of different cotton genotypes in black soil (Govankoppa)

Table 15: Economics of different cotton genotypes in black soil (Rs./ha)

Sl. No.	Cotton hybrids	Cost of cultivation (except treatment cost)	Cost of treatment		Total cost of cultivation	Gross returns	Net returns	B:C ratio
			Seed cost	Plant protection measures				
2008-09								
1.	RCH-2 Bt	11640	1875	9101	22616	65600	42984	1:2.90
2.	RCH-2 BG-II Bt	11640	2375	7641	21656	71200	49544	1:3.28
3.	Bunny BG-II Bt	11640	2375	7641	21656	74240	52584	1:3.43
4.	JK-99 Bt	11640	1875	9101	22616	59520	36904	1:2.63
5.	Mallika Bt	11640	1875	9101	22616	62080	39464	1:2.74
6.	MRC-6918 Bt	11640	1875	9101	22616	88400	65784	1:3.90
7.	Brahma Bt	11640	1875	9101	22616	54720	32104	1:2.42
8.	RCH-708 Bt	11640	1875	9101	22616	87600	64984	1:3.87
9.	Bunny Bt	11640	1875	9101	22616	67520	44904	1:2.98
10.	DHH-11	11640	1200	11401	24241	50560	26319	1:2.08
	SEm±					1989.79	3559.55	0.13
	CD at 5%					5911.91	10575.85	0.40
	CV (%)					5.06	13.53	7.73
2009-10								
1.	RCH-2 Bt	11640	1625	9101	22366	66650	44284	1:2.98
2.	RCH-2 BG-II Bt	11640	1875	8266	21781	74090	52309	1:3.40
3.	Bunny BG-II Bt	11640	1875	8266	21781	75950	54169	1:3.49
4.	JK-99 Bt	11640	1625	9101	22366	61380	39014	1:2.75
5.	Mallika Bt	11640	1625	9101	22366	67270	44904	1:3.00
6.	MRC-6918 Bt	11640	1625	9101	22366	92430	70064	1:4.13
7.	Brahma Bt	11640	1625	9101	22366	56730	34364	1:2.54
8.	RCH-708 Bt	11640	1625	9101	22366	88140	65774	1:3.94
9.	Bunny Bt	11640	1625	9101	22366	70370	48004	1:3.15
10.	DHH-11	11640	1200	11401	24241	51150	26909	1:2.15
	SEm±					2544.42	2362.52	0.14
	CD at 5%					7559.79	7019.33	0.41
	CV (%)					6.26	8.53	7.63

Contd…….

Sl. No.	Cotton hybrids	Cost of cultivation (except treatment cost)	Cost of treatment		Total cost of cultivation	Gross returns	Net returns	B:C ratio
			Seed cost	Plant protection measures				
Mean of two years (pooled)								
1.	RCH-2 Bt	11640	1750	9101	22491	66125	43634	1:2.94
2.	RCH-2 BG-II Bt	11640	2125	7954	21719	72645	50926	1:3.34
3.	Bunny BG-II Bt	11640	2125	7954	21719	75095	53376	1:3.46
4.	JK-99 Bt	11640	1750	9101	22491	60450	37959	1:2.69
5.	Mallika Bt	11640	1750	9101	22491	64675	42184	1:2.87
6.	MRC-6918 Bt	11640	1750	9101	22491	90415	67924	1:4.02
7.	Brahma Bt	11640	1750	9101	22491	55725	33234	1:2.48
8.	RCH-708 Bt	11640	1750	9101	22491	87870	65379	1:3.91
9.	Bunny Bt	11640	1750	9101	22491	68945	46454	1:3.07
10.	DHH-11	11640	1200	11401	24241	50855	26614	1:2.10
	SEm±					1607.56	2082.33	0.07
	CD at 5%					4776.27	6186.87	0.20
	CV (%)					4.02	7.71	3.71

4.1.2.1b Nitrogen content

The nitrogen content differed significantly in different cotton genotypes at 60 and 90 DAS and found non-significant at 120 DAS. At 60 DAS, the higher content was recorded in Bunny BG-II (2.57%) and differed significantly over JK-99 Bt (1.98%), DHH-11 non-Bt (1.96%) and Mallika Bt (1.86%).

At 90 DAS, Bunny BG-II recorded significantly higher nitrogen content (2.82%) and differed significantly over Brahma Bt (2.33%), Mallika Bt (2.22%), DHH-11 non-Bt (2.20%) and JK-99 Bt (2.16%).

At 120 DAS, the data on nitrogen content was found to be non-significant.

4.1.2.2a Phosphorus uptake (kg/ha)

The data on uptake (kg/ha) and phosphorus content (%) by different cotton genotypes at different stages of crop growth is presented in Table 17.

The data on uptake (kg/ha) of phosphorus at different stages of crop growth differed significantly in different cotton genotypes. At 60 DAS, the uptake of phosphorus was found to be significantly higher in MRC-6918 Bt (7.15 kg/ha) over rest of the cotton genotypes. At 90 DAS, MRC-6918 Bt recorded significantly higher uptake of phosphorus (16.40 kg/ha) over other cotton genotypes and found on par with RCH-708 Bt (16.15 kg/ha), Bunny BG-II (15.60 kg/ha) and RCH-2 BG-II (14.95 kg/ha). At 120 DAS, MRC-6918 Bt recorded significantly higher uptake of phosphorus (27.80 kg/ha) and differed significantly over other cotton genotypes.

4.1.2.2b Phosphorus content (%)

The phosphorus content differed significantly at different stages of crop growth.

At 60 DAS, MRC-6918 Bt recorded significantly higher phosphorus content (0.47%) over DHH-11 non-Bt (0.41%), Brahma Bt (0.38%), JK-99 Bt and Mallika Bt (0.36%).

At 90 DAS, Bunny BG-II recorded significantly higher phosphorus content (0.49%) and found on par with RCH-708 Bt, MRC-6918 Bt and RCH-2 BG-II (0.47%).

At 120 DAS, the higher phosphorus content was recorded with RCH-2 BG-II (0.51%) and differed significantly over DHH-11 non-Bt (0.44%), Mallika Bt (0.43%) and JK-99 Bt (0.39%).

4.1.2.3a Potassium uptake (kg/ha)

The data on uptake of potassium (kg/ha) and potassium content (%) at different stages of crop growth by different cotton genotypes is presented in Table 18.

The higher uptake of potassium was recorded with MRC-6918 Bt (35.85 kg/ha) at 60 DAS and differed significantly over other cotton genotypes and found on par with Bunny BG-II (34.95 kg/ha) and RCH-2 BG-II (33.75 kg/ha).

At 90 DAS, the higher potassium uptake was recorded with MRC-6918 Bt (85.95 kg/ha) and differed significantly over other treatments except RCH-2 BG-II (81.90 kg/ha) which was found on par.

At 120 DAS, the lower uptake of potassium (108.05 kg/ha) was recorded with DHH-11 and differed significantly over all other cotton genotypes.

4.1.2.3b Potassium content (%)

The data on potassium content (%) at different crop stages showed significant variation with different cotton genotypes.

At 60 DAS, the higher potassium content was recorded with Bunny BG-II (2.54%) and differed significantly over rest of the treatments except RCH-2 BG-II (2.48%) and MRC-6918 Bt (2.39%).

At 90 DAS, the higher potassium content was recorded with RCH-2 BG-II (2.56) and differed significantly over RCH-2 Bt (2.39%), Mallika Bt (2.27%) and JK-99 Bt (2.20%).

Table 16: Uptake (kg/ha) and nitrogen content (%) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	26.5 (2.22)*	73.5 (2.41)	92.1 (2.00)	28.2 (2.20)	85.6 (2.54)	110.20 (2.26)	27.35 (2.21)	79.55 (2.48)	101.15 (2.13)
RCH-2 BG-II	29.6 (2.34)	86.8 (2.78)	105.1 (2.16)	38.6 (2.64)	92.4 (2.82)	115.60 (2.28)	34.10 (2.49)	89.60 (2.80)	110.35 (2.22)
Bunny BG-II	31.6 (2.48)	85.2 (2.87)	108.3 (2.12)	39.3 (2.66)	96.3 (2.77)	119.50 (2.24)	35.45 (2.57)	90.75 (2.82)	113.90 (2.18)
JK-99 Bt	24.9 (1.94)	65.6 (2.07)	83.2 (1.57)	28.9 (2.01)	79.8 (2.24)	101.30 (1.83)	26.90 (1.98)	72.70 (2.16)	92.42 (1.70)
Mallika Bt	22.1 (1.77)	72.7 (2.35)	85.1 (1.63)	26.9 (1.94)	75.9 (2.08)	103.10 (1.88)	24.50 (1.86)	74.30 (2.22)	94.10 (1.76)
MRC-6918 Bt	32.3 (2.40)	81.3 (2.43)	102.6 (1.86)	41.3 (2.49)	97.3 (2.62)	121.20 (2.11)	36.80 (2.45)	89.30 (2.52)	111.90 (1.99)
Brahma Bt	25.3 (2.02)	69.4 (2.25)	89.6 (1.81)	30.3 (2.11)	81.4 (2.40)	109.30 (2.09)	27.80 (2.07)	75.40 (2.33)	99.45 (1.95)
RCH-708 Bt	28.3 (2.16)	78.5 (2.41)	97.6 (1.89)	35.3 (2.38)	90.4 (2.54)	112.60 (2.07)	31.80 (2.27)	84.45 (2.48)	105.10 (1.98)
Bunny Bt	27.2 (2.23)	75.3 (2.45)	94.5 (2.02)	32.1 (2.53)	89.5 (2.82)	108.10 (2.17)	29.65 (2.38)	82.40 (2.64)	101.30 (2.10)
DHH-11	20.3 (2.14)	63.1 (2.27)	79.1 (1.82)	22.3 (1.78)	65.3 (2.13)	96.50 (2.03)	21.30 (1.96)	64.20 (2.20)	87.80 (1.93)
SEm±	1.31 (0.18)	3.51 (0.18)	4.09 (0.07)	1.47 (0.18)	3.59 (0.18)	4.60 (0.18)	1.08 (0.14)	2.50 (0.12)	2.38 (0.12)
CD at 5%	3.89 (NS)	10.42 (NS)	12.15 (0.21)	4.37 (0.54)	10.66 (NS)	13.66 (NS)	3.20 (0.40)	7.43 (0.37)	7.06 (NS)
CV (%)	8.47 (14.45)	8.08 (12.98)	7.56 (6.06)	7.88 (13.86)	7.28 (12.55)	7.26 (14.75)	6.31 (10.56)	5.40 (8.79)	4.05 (10.85)

DAS – Days after sowing; *Figures in parentheses indicate nitrogen content (%)

Table 17: Uptake (kg/ha) and phosphorus content (%)of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	5.00 (0.42)*	14.3 (0.44)	23.80 (0.52)	5.60 (0.44)	12.90 (0.38)	21.70 (0.44)	5.30 (0.43)	13.60 (0.41)	22.75 (0.49)
RCH-2 BG-II	5.50 (0.44)	15.20 (0.49)	26.50 (0.55)	6.60 (0.45)	14.70 (0.45)	23.20 (0.46)	6.05 (0.45)	14.95 (0.47)	24.85 (0.51)
Bunny BG-II	5.90 (0.46)	15.30 (0.52)	26.90 (0.53)	6.20 (0.42)	15.90 (0.46)	24.10 (0.45)	6.05 (0.44)	15.60 (0.49)	25.50 (0.49)
JK-99 Bt	4.80 (0.37)	14.00 (0.44)	21.30 (0.40)	5.10 (0.35)	13.60 (0.38)	20.30 (0.37)	4.95 (0.36)	13.80 (0.41)	20.80 (0.39)
Mallika Bt	4.60 (0.37)	13.90 (0.45)	24.30 (0.47)	4.90 (0.35)	13.10 (0.36)	21.30 (0.39)	4.75 (0.36)	13.50 (0.41)	22.80 (0.43)
MRC-6918 Bt	6.10 (0.45)	16.50 (0.50)	29.30 (0.53)	8.20 (0.49)	16.30 (0.44)	26.30 (0.45)	7.15 (0.47)	16.40 (0.47)	27.80 (0.49)
Brahma Bt	4.90 (0.39)	14.60 (0.48)	23.10 (0.47)	5.20 (0.36)	13.80 (0.41)	23.80 (0.46)	5.05 (0.38)	14.20 (0.45)	23.45 (0.47)
RCH-708 Bt	5.30 (0.40)	14.80 (0.45)	24.90 (0.48)	6.90 (0.47)	17.50 (0.49)	24.20 (0.44)	6.10 (0.44)	16.15 (0.47)	24.55 (0.46)
Bunny Bt	5.10 (0.42)	14.50 (0.47)	22.90 (0.49)	5.30 (0.43)	12.70 (0.40)	22.90 (0.46)	5.20 (0.42)	13.60 (0.43)	22.80 (0.48)
DHH-11	4.20 (0.44)	12.70 (0.46)	19.50 (0.45)	4.80 (0.38)	12.90 (0.42)	20.60 (0.43)	4.50 (0.41)	12.80 (0.40)	20.05 (0.44)
SEm±	0.32 (0.02)	0.58 (0.08)	0.84 (0.02)	0.27 (0.02)	0.90 (0.02)	0.96 (0.02)	0.24 (0.02)	0.57 (0.01)	0.66 (0.02)
CD at 5%	0.95 (0.05)	1.72 (NS)	2.49 (0.05)	0.82 (0.05)	2.67 (0.05)	2.84 (0.06)	0.71 (0.05)	1.70 (0.03)	1.96 (0.05)
CV (%)	10.73 (6.83)	6.88 (30.66)	5.99 (6.04)	8.08 (7.75)	10.87 (6.59)	7.25 (7.44)	7.51 (6.71)	6.84 (4.54)	4.85 (5.96)

DAS – Days after sowing; *Figures in parentheses indicate phosphorus content (%)

Table 18: Uptake (kg/ha) and potassium content (%) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	25.9 (2.17)*	72.9 (2.39)	117.6 (2.56)	29.3 (2.29)	80.1 (2.38)	123.5 (2.53)	27.6 (2.23)	76.50 (2.39)	120.55 (2.55)
RCH-2 BG-II	30.7 (2.43)	78.9 (2.53)	126.0 (2.59)	36.8 (2.52)	84.9 (2.59)	132.0 (2.61)	33.75 (2.48)	81.90 (2.56)	129.45 (2.60)
Bunny BG-II	32.6 (2.56)	73.8 (2.49)	129.0 (2.53)	37.3 (2.52)	85.5 (2.46)	134.0 (2.51)	34.95 (2.54)	79.65 (2.53)	131.77 (2.52)
JK-99 Bt	24.3 (1.89)	70.6 (2.22)	118.9 (2.24)	30.6 (2.13)	76.5 (2.15)	121.7 (2.20)	27.45 (2.01)	73.55 (2.20)	120.30 (2.22)
Mallika Bt	23.6 (1.89)	70.5 (2.28)	121.6 (2.33)	31.9 (2.31)	82.0 (2.25)	124.0 (2.27)	27.65 (2.10)	76.25 (2.27)	122.80 (2.30)
MRC-6918 Bt	31.9 (2.37)	81.6 (2.44)	135.6 (2.46)	39.8 (2.40)	90.3 (2.43)	142.3 (2.47)	35.85 (2.39)	85.95 (2.44)	138.80 (2.47)
Brahma Bt	23.8 (1.90)	72.5 (2.35)	120.3 (2.43)	32.4 (2.26)	82.9 (2.44)	128.0 (2.45)	28.10 (2.08)	77.70 (2.46)	124.15 (2.47)
RCH-708 Bt	28.6 (2.17)	76.5 (2.34)	123.2 (2.39)	34.5 (2.33)	84.3 (2.36)	130.2 (2.39)	31.55 (2.25)	80.40 (2.41)	126.60 (2.39)
Bunny Bt	26.7 (2.19)	72.8 (2.37)	115.8 (2.47)	29.6 (2.33)	78.3 (2.47)	122.9 (2.47)	28.15 (2.26)	75.55 (2.46)	119.35 (2.47)
DHH-11	22.8 (2.40)	68.5 (2.46)	99.8 (2.29)	28.2 (2.26)	72.4 (2.36)	116.3 (2.45)	25.50 (2.33)	70.45 (2.41)	108.05 (2.37)
SEm±	1.62 (0.11)	2.35 (0.06)	3.98 (0.08)	1.82 (0.07)	3.00 (0.07)	4.09 (0.08)	1.29 (0.07)	1.83 (0.05)	3.28 (0.07)
CD at 5%	4.81 (0.33)	6.99 (0.17)	11.83 (NS)	5.41 (0.22)	8.90 (0.21)	12.15 (0.24)	3.82 (0.20)	5.43 (0.15)	9.73 (0.22)
CV (%)	10.35 (8.77)	5.51 (4.18)	5.70 (5.84)	9.56 (5.47)	5.05 (5.17)	5.56 (5.82)	7.41 (5.14)	4.07 (3.53)	4.57 (5.29)

DAS – Days after sowing; *Figures in parentheses indicate potassium content (%)

At 120 DAS, significantly higher potassium content (2.60%) was recorded with RCH-2 BG-II and found on par with RCH-2 Bt (2.55%) and Bunny BG-II (2.52%).

4.1.2.4a Calcium uptake (kg/ha)

The data on uptake of calcium (kg/ha) and calcium content (%) at different stages of crop growth by different cotton genotypes are presented in Table 19.

Calcium uptake (kg/ha) differed significantly at different stages of crop growth. At 60 DAS, MRC-6918 Bt recorded the higher calcium uptake (21.00 kg/ha) and differed significantly over the other cotton genotypes except RCH-708 Bt (20.00 kg/ha). Similar trend was followed at 90 and 120 DAS.

4.1.2.4b Calcium content (%)

The calcium content (%) in different cotton genotypes differed significantly at different crop growth stages.

At 60 DAS, the higher content of calcium was recorded with DHH-11 non-Bt (1.49%) and differed significantly over Brahma Bt (1.31%), Bunny Bt (1.28%) and Mallika Bt and JK-99 Bt (1.19%).

At 90 DAS, the higher calcium content was recorded with DHH-11 non-Bt (1.52%) and differed significantly over RCH-2 Bt (1.37%), Bunny Bt (1.31%), JK-99 Bt (1.23%) and Mallika Bt (1.22%).

At 120 DAS, DHH-11 non-Bt recorded significantly higher calcium content (1.63%) and differed significantly over Brahma Bt (1.46%), JK-99 Bt (1.35%) and Mallika Bt (1.30%).

4.1.2.5a Magnesium uptake (g/ha)

The data on uptake of magnesium (g/ha) and magnesium content (%) at different crop growth stages by different cotton genotypes are presented in Table 20.

At 60 DAS, the higher magnesium content was recorded with MRC-6918 Bt (4.60 g/ha) and differed significantly over rest of the cotton genotypes.

At 90 DAS, the higher uptake of magnesium was recorded with MRC-6918 Bt (11.50 g/ha) and found on par with RCH-708 Bt (10.95 g/ha) and differed significantly over rest of the treatments.

At 120 DAS, MRC-6918 Bt recorded significantly higher uptake of magnesium (19.45 g/ha) and differed significantly over other cotton genotypes except RCH-708 Bt (17.30 g/ha) and Brahma Bt (17.25 g/ha) which was found on par.

4.1.2.5b Magnesium content (%)

The data on magnesium content (%) showed significant variation among different cotton genotypes at different stages of crop growth.

At 60 DAS, MRC-6918 Bt recorded significantly higher magnesium content (0.31%) and differed significantly over Bunny BG-II (0.26%), Bunny Bt (0.24%), RCH-2 BG-II (0.21%) and RCH-2 Bt (0.20%).

At 90 DAS, MRC-6918 Bt recorded significantly higher magnesium content (0.33%) over other cotton genotypes and found on par with RCH-708 Bt (0.32%), DHH-11 non-Bt and Brahma Bt (0.31%).

At 120 DAS, MRC-6918 Bt recorded significantly higher magnesium content (0.35%) and found on par with Brahma Bt (0.34%), DHH-11 non-Bt and RCH-708 Bt (0.33%) and Mallika Bt (0.32%).

4.1.2.6a Iron uptake (g/ha)

The data on iron uptake (g/ha) and iron content (ppm) of different cotton genotypes at different growth stages are presented in Table 21.

Table 19: Uptake (g/ha) and calcium content (%) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	15.9 (1.33)*	41.3 (1.36)	70.5 (1.53)	17.2 (1.34)	46.0 (1.37)	72.0 (1.47)	16.7 (1.34)	43.65 (1.37)	71.25 (1.50)
RCH-2 BG-II	16.5 (1.31)	44.2 (1.42)	78.0 (1.60)	20.0 (1.37)	48.0 (1.47)	75.0 (1.48)	18.3 (1.34)	46.10 (1.45)	76.50 (1.54)
Bunny BG-II	17.5 (1.37)	43.6 (1.47)	76.5 (1.50)	20.5 (1.39)	51.0 (1.47)	79.0 (1.48)	19.00 (1.38)	47.30 (1.47)	77.75 (1.49)
JK-99 Bt	14.9 (1.16)	38.2 (1.20)	74.5 (1.40)	17.5 (1.22)	45.0 (1.26)	72.0 (1.30)	16.20 (1.19)	41.60 (1.23)	73.25 (1.35)
Mallika Bt	14.4 (1.16)	37.2 (1.20)	69.5 (1.33)	16.9 (1.22)	45.0 (1.24)	69.0 (1.26)	15.65 (1.19)	41.10 (1.22)	69.25 (1.30)
MRC-6918 Bt	18.0 (1.34)	49.0 (1.47)	85.0 (1.54)	24.0 (1.44)	56.0 (1.51)	90.0 (1.57)	21.00 (1.39)	52.50 (1.49)	87.50 (1.57)
Brahma Bt	15.7 (1.26)	42.3 (1.37)	72.5 (1.47)	19.5 (1.36)	49.0 (1.44)	76.0 (1.45)	17.60 (1.31)	45.65 (1.41)	74.25 (1.46)
RCH-708 Bt	16.0 (1.22)	47.5 (1.46)	82.0 (1.59)	22.0 (1.48)	54.0 (1.51)	83.0 (1.52)	20.0 (1.35)	50.75 (1.49)	82.50 (1.56)
Bunny Bt	15.4 (1.26)	39.5 (1.29)	71.5 (1.53)	16.5 (1.30)	42.0 (1.32)	72.0 (1.45)	15.95 (1.28)	40.75 (1.31)	71.75 (1.49)
DHH-11	13.9 (1.46)	41.3 (1.48)	69.6 (1.60)	18.9 (1.51)	48.0 (1.56)	79.0 (1.66)	16.40 (1.49)	44.65 (1.52)	74.30 (1.63)
SEm±	0.92 (0.07)	1.28 (0.06)	1.86 (0.08)	0.76 (0.06)	1.98 (0.08)	2.74 (0.07)	0.54 (0.05)	1.39 (0.05)	1.91 (0.05)
CD at 5%	2.74 (NS)	3.80 (0.18)	5.52 (NS)	2.26 (0.17)	5.90 (NS)	8.13 (0.21)	1.61 (0.16)	4.14 (0.14)	5.68 (0.16)
CV (%)	9.96 (9.21)	5.22 (7.72)	4.29 (9.06)	6.81 (7.13)	7.10 (10.10)	6.18 (8.18)	5.33 (6.83)	5.31 (5.92)	4.37 (6.07)

DAS – Days after sowing; *Figures in parentheses indicate calcium content (%)

Table 20: Uptake (kg/ha) and magnesium content (%) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	2.3 (0.19)*	6.6 (0.22)	12.5 (0.27)	2.5 (0.20)	7.80 (0.23)	13.8 (0.28)	2.40 (0.20)	7.20 (0.23)	13.15 (0.27)
RCH-2 BG-II	2.5 (0.20)	6.5 (0.21)	11.9 (0.24)	3.0 (0.21)	8.10 (0.25)	13.2 (0.26)	2.75 (0.21)	7.30 (0.23)	12.55 (0.25)
Bunny BG-II	3.2 (0.25)	7.9 (0.27)	14.9 (0.29)	3.8 (0.26)	9.8 (0.28)	15.90 (0.30)	3.50 (0.26)	8.85 (0.28)	15.40 (0.30)
JK-99 Bt	3.5 (0.27)	9.0 (0.28)	15.9 (0.30)	4.10 (0.29)	10.50 (0.29)	16.50 (0.30)	3.80 (0.28)	9.75 (0.29)	16.20 (0.30)
Mallika Bt	3.3 (0.26)	8.9 (0.29)	15.9 (0.31)	4.0 (0.29)	10.9 (0.30)	17.50 (0.32)	3.65 (0.28)	9.90 (0.30)	16.70 (0.32)
MRC-6918 Bt	4.0 (0.30)	10.7 (0.32)	19.0 (0.35)	5.2 (0.31)	12.3 (0.33)	19.9 (0.35)	4.60 (0.31)	11.50 (0.33)	19.45 (0.35)
Brahma Bt	3.5 (0.28)	9.4 (0.30)	16.9 (0.34)	4.1 (0.29)	10.6 (0.31)	17.60 (0.34)	3.80 (0.29)	10.00 (0.31)	17.25 (0.34)
RCH-708 Bt	3.8 (0.29)	10.2 (0.31)	16.8 (0.33)	4.50 (0.30)	11.7 (0.33)	17.80 (0.33)	4.15 (0.30)	10.95 (0.32)	17.30 (0.33)
Bunny Bt	2.8 (0.23)	7.4 (0.24)	12.9 (0.28)	3.2 (0.25)	7.9 (0.25)	14.10 (0.28)	3.00 (0.24)	7.65 (0.25)	13.50 (0.28)
DHH-11	2.7 (0.28)	8.1 (0.29)	13.9 (0.32)	3.8 (0.30)	9.90 (0.32)	16.20 (0.34)	3.25 (0.29)	9.00 (0.31)	15.05 (0.33)
SEm$\pm$	0.11 (0.02)	0.25 (0.01)	1.20 (0.10)	0.16 (0.01)	0.88 (0.01)	0.94 (0.01)	0.11 (0.01)	0.47 (0.01)	0.78 (0.01)
CD at 5%	0.34 (0.06)	0.75 (0.03)	3.58 (0.03)	0.48 (0.03)	2.61 (0.04)	2.78 (0.04)	0.32 (0.04)	1.39 (0.02)	2.31 (0.03)
CV (%)	6.27 (12.69)	5.17 (6.86)	13.86 (5.90)	7.39 (6.67)	15.29 (8.21)	9.99 (7.38)	5.42 (9.10)	8.78 (5.13)	8.59 (5.22)

DAS – Days after sowing; *Figures in parentheses indicate magnesium content (%)

Table 21: Uptake (g/ha) and iron content (ppm) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	490 (41.09)*	1300 (42.70)	2490 (54.15)	639 (49.36)	1690 (50.22)	2780 (56.93)	564.50 (45.48)	1495 (46.46)	2635 (55.54)
RCH-2 BG-II	550 (43.55)	1540 (49.41)	2740 (56.36)	658 (45.03)	1790 (54.70)	3100 (61.27)	604.00 (44.29)	1665 (52.06)	2920 (58.82)
Bunny BG-II	580 (45.52)	1690 (56.96)	2850 (55.84)	647 (43.78)	1760 (50.69)	3000 (56.19)	613.50 (44.65)	1725 (53.83)	2925 (56.02)
JK-99 Bt	390 (30.35)	1200 (37.79)	2280 (42.97)	627 (43.63)	1580 (44.32)	2500 (45.29)	508.50 (36.99)	1390 (41.06)	2390 (44.13)
Mallika Bt	365 (29.29)	1250 (40.35)	2380 (45.68)	638 (46.12)	1565 (42.98)	2650 (48.43)	501.50 (37.71)	1407.5 (41.67)	2515 (47.06)
MRC-6918 Bt	730 (54.30)	1890 (56.51)	3050 (55.43)	725 (43.64)	1850 (49.87)	3300 (57.39)	727.50 (48.97)	1870.0 (53.19)	3175 (56.48)
Brahma Bt	450 (36.00)	1450 (46.94)	2540 (51.41)	651 (45.36)	1590 (46.79)	2980 (56.98)	550.50 (40.68)	1520.00 (46.87)	2760 (54.20)
RCH-708 Bt	690 (52.70)	1780 (54.55)	2960 (57.43)	698 (47.05)	1820 (51.05)	3200 (58.79)	694.00 (49.88)	1800.0 (52.80)	3080 (58.11)
Bunny Bt	470 (38.51)	1350 (43.97)	2680 (57.18)	642 (50.61)	1650 (51.95)	2890 (58.12)	556.00 (44.56)	1500 (47.96)	2785 (57.65)
DHH-11	359 (37.79)	1100 (39.55)	2180 (50.07)	615 (49.20)	1525 (49.64)	2400 (50.51)	487.00 (43.50)	1312.50 (44.60)	2290 (50.29)
SEm±	43.42 (3.27)	112.87 (2.72)	96.76 (2.27)	20.56 (2.43)	70.18 (2.43)	89.27 (1.63)	20.17 (1.67)	63.97 (1.98)	73.66 (1.52)
CD at 5%	128.99 (9.72)	335.37 (8.09)	287.49 (6.74)	61.09 (NS)	208.53 (7.23)	265.23 (4.85)	59.94 (4.96)	190.07 (5.88)	218.85 (4.53)
CV (%)	14.82 (13.84)	13.44 (10.09)	6.41 (7.47)	5.45 (9.06)	7.23 (8.56)	5.37 (5.14)	6.02 (6.62)	7.06 (7.14)	4.64 (4.91)

DAS – Days after sowing; *Figures in parentheses indicate iron content (ppm)

At 60 DAS, MRC-6918 Bt recorded significantly higher uptake of iron (727.50 g/ha) and found on par with RCH-708 Bt (694.00 g/ha) and differed significantly over rest of the treatments. At 90 DAS, MRC-6918 Bt recorded significantly higher uptake of iron (1870 g/ha) and differed significantly over other cotton genotypes except RCH-708 Bt (1800.00 g/ha) and Bunny BG-II (1725 g/ha).

At 120 DAS, MRC-6918 Bt recorded significantly higher iron content (3175.00 g/ha) over other cotton genotypes and found on par with RCH-708 Bt (3080 g/ha).

4.1.2.6b Iron content

The data on iron content (ppm) of different cotton genotypes at different crop growth stages showed significant variation.

At 60 DAS, RCH-708 Bt recorded significantly higher iron content (49.88 ppm) and differed significantly over other cotton genotypes and found on par with MRC-6918 Bt (48.97%) and RCH-2 Bt (45.48%).

At 90 DAS, Bunny BG-II recorded significantly higher iron content (53.83 ppm) and found on par with MRC-6918 Bt (53.19 ppm), RCH-2 Bt BG-II (52.06 ppm) and RCH-708 Bt (52.80 ppm).

At 120 DAS, RCH-2 BG-II recorded significantly higher iron content (58.82 ppm) and differed significantly over Brahma Bt (54.20 ppm), DHH-11 Bt (50.29 ppm), Mallika Bt (47.06 ppm) and JK-99 Bt (44.13 ppm).

4.1.2.7a Copper uptake (g/ha)

The data on uptake of copper (g/ha) and copper content (%) of different cotton genotypes at different stages of crop growth is presented in Table 22.

The uptake of copper was recorded significantly higher in MRC-6918 Bt (88.00 g/ha) at 60 DAS and found on par with RCH-708 Bt (82.00 g/ha) and differed significantly over other cotton genotypes.

At 90 DAS, MRC-6918 Bt recorded significantly higher copper content (209.00 g/ha) over rest of the treatments and found on par with RCH-708 Bt (203.00 g/ha).

At 120 DAS, MRC-6918 Bt recorded significantly higher uptake of copper (338.50 g/ha) and found on par with Bunny BG-II (325.00 g/ha) and differed significantly over other cotton genotypes.

4.1.2.7b Copper content

The data presented on copper content at 60 and 120 DAS showed significant variation among different cotton genotypes.

At 60 DAS, Bunny Bt recorded significantly higher copper content (5.94 ppm) over Mallika Bt (5.55 ppm) and JK-99 Bt (5.32 ppm) and found on par with cotton genotypes.

At 90 DAS, the copper content among different cotton genotypes showed non-significant variation. At 120 DAS, Bunny Bt recorded significantly higher copper content (6.40 ppm) over MRC-6918 Bt (6.02 ppm), RCH-708 Bt (6.00 ppm), Mallika Bt (5.74 ppm) and JK-99 Bt (5.64 ppm).

4.1.2.8a Manganese uptake (g/ha)

The data on uptake of manganese and manganese content is presented in Table 23. The uptake of manganese (g/ha) showed a significant variation among different cotton genotypes at different stages of crop growth.

At 60 DAS, MRC-6918 Bt recorded significantly higher uptake of manganese (670.00 g/ha) over other cotton genotypes except RCH-708 Bt (625.00 g/ha) which was found on par.

At 90 DAS, MRC-6918 Bt recorded significantly higher uptake of manganese (1685.00 g/ha) over rest of the treatment except Bunny BG-II (1615.00 g/ha) which was found on par.

Table 22: Uptake (g/ha) and copper content (ppm) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	69 (5.79)*	179 (5.88)	287 (6.24)	75 (5.85)	201 (5.97)	308 (6.31)	72.0 (5.82)	190 (5.93)	297.5 (6.28)
RCH-2 BG-II	72 (5.70)	182 (5.84)	305 (6.27)	87 (5.95)	202 (6.17)	318 (6.29)	79.5 (5.83)	192 (6.01)	311.5 (6.28)
Bunny BG-II	74 (5.81)	184 (6.20)	320 (6.27)	88 (5.95)	205 (5.90)	331 (6.20)	79.5 (5.88)	194.5 (6.05)	325.5 (6.24)
JK-99 Bt	67 (5.21)	174 (5.48)	293 (5.52)	78 (5.43)	195 (5.47)	318 (5.76)	72.5 (5.32)	184.5 (5.48)	305.5 (5.64)
Mallika Bt	67 (5.38)	175 (5.65)	298 (5.72)	79 (5.71)	209 (5.74)	315 (5.76)	73.0 (5.55)	192 (5.70)	306.5 (5.74)
MRC-6918 Bt	78 (5.80)	197 (5.89)	326 (5.93)	98 (5.90)	221 (5.96)	351 (6.10)	88.0 (5.85)	209 (5.93)	338.5 (6.02)
Brahma Bt	72 (5.76)	181 (5.86)	301 (6.09)	83 (5.78)	203 (5.97)	331 (6.33)	77.5 (5.77)	192 (5.92)	316.0 (6.21)
RCH-708 Bt	75 (5.73)	191 (5.85)	306 (5.94)	89 (6.00)	215 (6.03)	330 (6.06)	82.0 (5.87)	203 (5.94)	318.0 (6.00)
Bunny Bt	68 (5.57)	176 (5.73)	298 (6.36)	80 (6.31)	203 (6.39)	320 (6.44)	74.0 (5.94)	189.5 (6.06)	309.0 (6.40)
DHH-11	53 (5.58)	172 (6.18)	271 (6.22)	76 (6.08)	189 (6.15)	308 (6.48)	64.5 (5.83)	180.5 (6.17)	289.5 (6.35)
SEm±	3.25 (0.11)	4.95 (0.15)	2.95 (0.13)	3.13 (0.12)	5.41 (0.20)	7.96 (0.15)	2.36 (0.10)	3.85 (0.16)	4.63 (0.10)
CD at 5%	9.65 (0.35)	14.72 (NS)	8.77 (0.38)	9.29 (0.35)	16.07 (NS)	23.64 (0.44)	7.02 (0.28)	11.44 (NS)	13.75 (0.29)
CV (%)	8.10 (3.48)	4.74 (4.45)	1.70 (3.71)	6.52 (3.47)	4.59 (5.89)	4.27 (4.19)	5.37 (2.87)	3.46 (4.64)	2.57 (2.74)

DAS – Days after sowing; *Figures in parentheses indicate copper content (%)

Table 23: Uptake (g/ha) and manganese content (ppm) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	512 (42.93)*	1390 (45.66)	2150 (46.76)	551 (43.00)	1550 (46.06)	2350 (47.26)	531.50 (42.97)	1470.0 (45.86)	2250.0 (47.01)
RCH-2 BG-II	529 (41.88)	1460 (46.84)	2295 (47.21)	620 (42.43)	1580 (48.28)	2500 (49.41)	574.50 (42.16)	1520.0 (47.56)	2397.5 (48.31)
Bunny BG-II	568 (44.58)	1480 (49.89)	2569 (50.33)	660 (44.66)	1750 (50.40)	2700 (50.57)	614.0 (44.62)	1615.0 (50.15)	2634.5 (50.45)
JK-99 Bt	490 (38.13)	1325 (41.73)	2202 (41.50)	550 (38.27)	1496 (41.96)	2500 (45.29)	520.0 (38.20)	1410.5 (41.85)	2351.0 (43.40)
Mallika Bt	460 (36.91)	1285 (41.48)	2201 (42.24)	515 (37.23)	1550 (42.57)	2350 (42.94)	487.50 (37.07)	1417.5 (42.03)	2275.5 (42.59)
MRC-6918 Bt	585 (43.51)	1580 (47.24)	2650 (48.16)	755 (45.45)	1790 (48.26)	2800 (48.69)	670.0 (44.48)	1685.0 (47.75)	2725.0 (48.43)
Brahma Bt	508 (40.64)	1410 (45.65)	2290 (46.35)	590 (41.11)	1580 (46.49)	2505 (47.90)	549.0 (40.88)	1495.0 (46.07)	2397.5 (47.13)
RCH-708 Bt	560 (42.77)	1420 (43.52)	2290 (44.43)	690 (46.52)	1590 (44.60)	2550 (46.85)	625.0 (44.65)	1505.0 (44.06)	2420.0 (45.64)
Bunny Bt	521 (42.69)	1360 (44.29)	2158 (46.04)	550 (43.36)	1490 (46.91)	2350 (47.26)	535.50 (43.03)	1425.0 (45.60)	2254.0 (46.65)
DHH-11	390 (41.05)	1142 (41.06)	1892 (43.46)	531 (42.48)	1305 (42.48)	2150 (45.24)	460.5 (41.77)	1223.5 (41.77)	2021.0 (44.35)
SEm±	25.54 (0.97)	72.26 (1.23)	56.76 (1.40)	19.12 (1.01)	78.17 (1.16)	79.81 (1.28)	16.35 (0.68)	46.25 (0.86)	47.82 (0.84)
CD at 5%	75.88 (2.87)	214.71 (3.67)	168.65 (4.15)	56.81 (2.99)	232.26 (3.45)	237.14 (3.80)	48.58 (2.02)	137.41 (2.56)	142.09 (2.51)
CV (%)	8.63 (4.03)	9.04 (4.78)	4.33 (5.31)	5.51 (4.10)	8.63 (4.39)	5.58 (4.70)	5.09 (2.80)	5.42 (3.30)	3.49 (3.15)

DAS – Days after sowing; *Figures in parentheses indicate manganese content (ppm)

At 120 DAS, MRC-6918 Bt recorded significantly higher uptake of manganese (2725.00 g/ha) over rest of the cotton genotypes and found on par with Bunny BG-II (2634.50 g/ha).

4.1.2.8b Manganese content

The data on manganese content showed significant variation among different cotton genotypes at different stages of crop growth.

At 60 DAS, RCH-708 Bt recorded significantly higher manganese content (44.65 ppm) and found on par with Bunny BG-II (44.62 ppm), MRC-6918 Bt (44.48 ppm), Bunny Bt (43.03 ppm) and RCH-2 Bt (42.97 ppm).

At 90 DAS, Bunny BG-II recorded significantly higher manganese content (50.15 ppm) over rest of the cotton genotypes except MRC-6918 Bt (47.75 ppm), which was found on par.

At 120 DAS, Bunny BG-II recorded significantly higher manganese content (50.45 ppm) over other cotton genotypes except MRC-6918 Bt (48.43 ppm) and RCH-2 BG-II (48.30 ppm), which was found on par.

4.1.2.9a Zinc uptake (g/ha)

The data on uptake of zinc (g/ha) and zinc content (ppm) of different cotton genotypes at different growth stages are presented in Table 24.

The uptake of zinc (kg/ha) of different cotton genotypes at different growth stages showed significant variation.

At 60 DAS, MRC-6918 Bt recorded significantly higher uptake of zinc (179.00 g/ha) over rest of the treatments. Similar trend was observed at 90 and 120 DAS.

4.1.2.9b Zinc content

The data on zinc content of different cotton genotypes at 60 and 120 DAS showed non-significant variation. Whereas, at 90 DAS showed significant variation among different cotton genotypes.

RCH-2 BG-II recorded significantly higher zinc content (11.98 ppm) and differed significantly Bunny Bt (10.85 ppm), RCH-2 Bt (10.73 ppm), Mallika Bt (10.55 ppm) and JK-99 Bt (10.15 ppm).

4.1.3 Fibre quality

4.1.3.1 2.5% span length

Data on 2.5 per cent span length of different cotton genotypes in black soil are presented in Table 25.

All the Bt cotton genotypes recorded significantly higher 2.5 per cent span length than DHH-11 (29.00 mm), higher 2.5 per cent span length of 37.05 mm was recorded in RCH-708 Bt and differed significantly to all other cotton genotypes.

4.1.3.2 Fibre fineness

There were significant differences among the genotypes in black soil with respect to the fibre fineness (Table 25). JK-99 Bt recorded significantly higher fibre fineness (4.25 micronaire) than all other cotton genotypes except DHH-11 (4.00 micronaire).

4.1.3.3 Fibre maturity

There were significant differences among the cotton genotypes in black soil with respect to the fibre maturity (Table 25). JK-99 Bt recorded significantly higher fibre maturity (0.76 maturity ratio) than all other cotton genotypes except DHH-11 (0.72).

Table 24: Uptake (g/ha) and zinc content (ppm) of different cotton genotypes at different growth stages in black soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	122.0 (10.23)*	323 (10.61)	551 (11.98)	134 (10.46)	365 (10.85)	589 (12.06)	128 (10.35)	344.0 (10.73)	568.50 (12.02)
RCH-2 BG-II	129.0 (10.21)	373 (11.97)	585 (12.03)	159 (10.88)	392 (11.98)	609 (12.04)	144 (10.55)	382.50 (11.98)	597.0 (12.04)
Bunny BG-II	139.0 (10.91)	346 (11.66)	598 (11.72)	165 (11.17)	407 (11.72)	630 (11.80)	152 (11.04)	376.5 (11.69)	614.0 (11.93)
JK-99 Bt	125.0 (9.73)	316 (9.95)	530 (9.99)	142 (9.88)	369 (10.35)	586 (10.61)	133.5 (9.81)	342.5 (10.15)	558.0 (10.30)
Mallika Bt	128.0 (10.27)	320 (10.33)	569 (10.92)	148 (10.70)	392 (10.77)	599 (10.95)	138.0 (10.49)	356.0 (10.55)	584.0 (10.94)
MRC-6918 Bt	159.0 (11.83)	397 (11.87)	659 (11.98)	199 (11.98)	445 (12.00)	695 (12.09)	179.0 (11.91)	421.0 (11.94)	677.0 (12.04)
Brahma Bt	127.0 (10.16)	339 (10.97)	589 (11.92)	149 (10.38)	378 (11.12)	628 (12.01)	138.0 (10.27)	358.5 (11.02)	608.50 (11.97)
RCH-708 Bt	145.0 (11.07)	365 (11.19)	606 (11.76)	168 (11.33)	405 (11.36)	648 (11.91)	156.5 (11.20)	385.0 (11.28)	627.0 (11.84)
Bunny Bt	129.0 (10.57)	332 (10.81)	561 (11.97)	138 (10.88)	346 (10.89)	598 (12.03)	133.50 (10.73)	339.0 (10.85)	579.5 (12.00)
DHH-11	105.0 (11.05)	308 (11.07)	519 (11.92)	146 (11.68)	341 (11.10)	568 (11.95)	125.5 (11.37)	324.5 (11.09)	543.5 (11.94)
SEm±	8.88 (0.46)	14.39 (0.40)	20.87 (0.60)	6.99 (0.66)	11.25 (0.52)	15.94 (0.64)	6.30 (0.39)	8.46 (0.37)	12.03 (0.53)
CD at 5%	26.39 (NS)	42.74 (1.18)	62.01 (NS)	20.77 (NS)	33.43 (NS)	47.35 (NS)	18.73 (NS)	25.14 (1.11)	35.75 (NS)
CV (%)	11.76 (7.49)	7.29 (6.21)	6.27 (8.94)	7.82 (10.43)	5.07 (8.03)	4.49 (9.43)	7.64 (6.33)	4.04 (5.81)	3.50 (7.796)

DAS – Days after sowing; *Figures in parentheses indicate zinc content (ppm)

Table 25: Fibre quality parameters of Bt and non-Bt cotton genotypes in black soil

Treatments (genotypes)	2008-09				2009-10				Pooled			
	2.5% span length (mm)	Fibre fineness (micronaire)	Fibre maturity (maturity ratio)	Bundle strength (g/tex)	2.5% span length (mm)	Fibre fineness (micronaire)	Fibre maturity (maturity ratio)	Bundle strength (g/tex)	2.5% span length (mm)	Fibre fineness (micronaire)	Fibre maturity (maturity ratio)	Bundle strength (g/tex)
RCH-2 Bt	31.10	4.00	0.71	23.40	31.20	3.30	0.67	25.70	31.15	3.65	0.69	24.55
RCH-2 BG-II	30.20	3.50	0.67	23.80	29.90	3.80	0.71	22.40	30.05	3.65	0.69	23.10
Bunny BG-II	33.20	3.10	0.63	24.30	33.20	3.30	0.64	24.40	33.20	3.20	0.64	24.30
JK-99 Bt	29.20	4.10	0.75	24.50	28.30	4.40	0.77	23.80	28.75	4.25	0.76	24.15
Mallika Bt	32.00	3.40	0.66	25.10	32.50	3.50	0.68	24.50	32.25	3.45	0.67	24.80
MRC-6918 Bt	36.00	3.10	0.63	27.80	35.80	3.00	0.61	26.70	35.90	3.05	0.62	27.25
Brahma Bt	31.90	3.10	0.63	24.30	33.40	3.40	0.64	23.80	32.65	3.25	0.64	24.05
RCH-708 Bt	35.00	3.20	0.63	24.00	39.10	3.20	0.62	24.20	37.05	3.20	0.63	24.10
Bunny Bt	38.70	3.10	0.63	24.30	32.20	3.00	0.63	24.70	35.45	3.05	0.63	24.50
DHH-11	28.80	4.10	0.72	22.10	29.30	3.90	0.72	25.80	29.05	4.00	0.72	23.95
SEm±	0.57	0.15	0.01	1.90	0.59	0.08	0.02	0.84	0.48	0.10	0.01	0.94
CD at 5%	1.69	0.46	0.04	NS	1.74	0.23	0.06	NS	1.44	0.30	0.04	NS
CV (%)	3.02	7.73	3.32	13.52	3.13	3.29	5.04	5.89	2.57	5.01	3.16	6.65

4.1.3.4 Bundle strength (g/tex)

Genotypes did not differ significantly with respect to bundle strength (Table 25) in black soil.

4.1.4 Biological properties

4.1.4.1 Population of microorganisms in black soil

4.1.4.1a Population of methylotrophs

Data on the population of methylotrophs of different cotton genotypes at flowering and at harvest are presented in Table 26.

Genotypes exhibited significant differences at both flowering and at harvest stages. Significantly higher population of methylotrophs was recorded in MRC-6918 Bt (30×10^2/g soil) followed by Bunny Bt (12×10^2/g soil) as compared to all other cotton genotypes and DHH-11 non-Bt (2×10^2/g soil).

At harvest, Bunny BG-II recorded (12×10^2/g soil) significantly higher population of methylotrophs.

4.1.4.1b Population of P-solubilizers

The data on the population of P-solubilizers is presented in the Table 26. There were significant differences among different cotton genotypes at flowering and at harvest stages. At flowering stage, significantly higher population of P-solubilizers was recorded in RCH-2 Bt (31×10^3/g soil) as compared to all other cotton genotypes and DHH-11 non-Bt (17×10^3/g soil). At harvest, RCH-708 Bt (17×10^3/g soil) recorded significantly higher population of P solubilizers compared to all other genotypes.

4.1.4.1c Population of *Azospirillum*

The data on population of *Azospirillum* by different cotton genotypes at different stages is presented in Table 26.

Genotypes exhibited significant differences at flowering and at harvest.

At flowering stage, significantly higher population of *Azospirillum* was recorded in RCH-708 Bt (0.79×10^6/g soil) compared to all other cotton genotypes and DHH-11 non-Bt (0.45×10^6/g soil). Least population was recorded in Brahma Bt and Bunny Bt. Mallika Bt recorded significantly higher population of (0.49×10^6/g soil) population of Azospirillum compared to all other cotton genotypes at harvest.

4.1.5 Seed cotton yield in mother and baby trials

The data on seed cotton yield of different genotypes in mother and baby trials in black soil are presented in Table 27 and Fig. 7.

Higher yield (2103 kg/ha) was recorded in Baby trial with RCH-708 Bt and found on par with mother trial (2225 kg/ha). RCH-2 Bt (1665 kg/ha), JK-99 Bt (1654.00 kg/ha) and Brahma Bt (1554 kg/ha) were found on par with respective mother trial, whereas other cotton genotypes differed significantly with respect to yield of mother trial.

4.1.6 Experiment II: Performance of Bt cotton genotypes in red soil

4.1.6.1 Plant height (cm)

The data on plant height recorded at 60, 90, 120 DAS and at harvest presented in Table 28.

The data indicated that the plant height increased progressively from 60 DAS to harvest. At all the growth stages, plant height differed significantly among the genotypes.

At 60 DAS, MRC-6918 Bt recorded significantly higher plant height (44.40 cm) over rest of the treatments. Similar trend was observed at 120 DAS and at harvest.

Table 26: Population of microorganisms in the rhizosphere of Bt cotton grown in black soil at flowering and at harvest

Treatments	Flowering			At harvest		
	Methylotrophs (× 10^2/g soil)	P solubilizers (× 10^3/g soil)	*Azospirillum* (× 10^6/g soil)	Methylotrophs (× 10^2/g soil)	P solubilizers (× 10^3/g soil)	*Azospirillum* (× 10^6/g soil)
RCH-2 Bt	9.00	31.00	0.45	2.00	5.00	0.33
RCH-2 BG-II	8.00	17.00	0.54	1.00	5.00	0.40
Bunny BG-II	4.00	15.00	0.27	12.00	4.00	0.17
JK-99 Bt	2.00	9.00	0.27	1.00	7.00	0.21
Mallika Bt	9.00	8.00	0.56	5.00	3.00	0.49
MRC-6918 Bt	30.00	17.00	0.45	2.00	12.00	0.11
Brahma Bt	10.00	22.00	0.26	4.00	15.00	0.20
RCH-708 Bt	20.00	26.00	0.79	3.00	17.00	0.17
Bunny Bt	21.00	11.00	0.26	2.00	3.00	0.14
DHH-11	8.00	12.00	0.54	2.00	2.00	0.26
SEm±	0.50	0.53	0.02	0.20	0.26	0.01
CD at 5%	1.49	1.58	0.06	0.61	0.77	0.04
CV (%)	7.17	5.47	7.48	12.02	5.24	9.15

Table 27: Seed cotton yield of different genotypes in mother and baby trials in black soil

Treatments	2008				2009				Pooled			
	Yield (kg/ha)		Caclc. 't' value	Signi-ficance	Yield (kg/ha)		Caclc. 't' value	Signi-ficance	Yield (kg/ha)		Caclc. 't' value	Signi-ficance
	Mother trial	Baby trial			Mother trial	Baby trial			Mother trial	Baby trial		
RCH-2 Bt	2050	1644	3.57	NS	2150	1687	3.88	NS	2100	1665	3.53	NS
RCH-2 BG-II Bt	2225	1694	4.80	*	2390	1732	6.18	*	2307	1713	6.16	*
Bunny BG-II Bt	2320	1779	4.94	*	2450	1858	5.08	*	2385	1818	5.02	*
JK-99 Bt	1860	1599	4.76	*	1980	1622	3.12	NS	1920	1610	3.67	NS
Mallika Bt	1940	1722	1.90	NS	2170	1728	7.97	*	2055	1725	4.77	*
MRC-6918 Bt	2210	1633	5.43	*	2370	1760	5.17	*	2290	1697	5.46	*
Brahma Bt	1710	1533	2.26	NS	1830	1574	2.12	NS	1770	1553	2.18	NS
RCH-708 Bt	2190	1803	4.55	*	2260	1795	2.76	NS	2225	2103	0.29	NS
Bunny Bt	2110	1633	11.07	**	2270	1675	4.97	*	2190	1654	13.3	**
DHH-11	1580	1303	14.80	**	1650	1373	3.62	NS	1615	1338	9.57	*

Table 't' value – 4.03 NS – non-significant * - Significant at 5% level ** - Significant at 1% level

Table 28: Plant height (cm) of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	27.30	55.30	95.40	112.50	28.20	57.30	101.10	109.10	27.75	56.30	98.25	110.80
RCH-2 BG-II	29.10	58.50	97.40	115.00	30.10	59.20	104.30	115.20	29.60	58.85	100.85	115.10
Bunny BG-II	31.50	64.90	98.30	119.50	35.10	67.50	106.50	119.60	33.30	66.20	102.40	119.55
JK-99 Bt	35.50	67.50	105.10	110.10	36.20	68.20	111.20	120.50	35.85	67.85	108.15	115.30
Mallika Bt	35.40	79.30	125.10	131.50	39.90	81.50	125.30	129.50	37.65	80.40	125.20	130.50
MRC-6918 Bt	42.50	83.10	141.00	159.30	46.30	89.50	145.30	161.20	44.40	86.30	143.15	160.25
Brahma Bt	31.90	65.30	103.20	125.20	32.10	69.30	105.20	123.50	32.00	67.30	104.20	124.35
RCH-708 Bt	32.50	69.50	116.50	145.00	34.30	79.50	120.50	139.40	33.40	74.50	118.50	142.20
Bunny Bt	29.20	62.00	91.30	113.50	31.90	63.10	101.50	109.30	30.55	62.55	96.40	111.40
DHH-11	24.90	52.50	91.50	105.30	26.30	55.30	93.10	102.50	25.60	53.90	92.30	103.90
SEm±	2.83	3.76	5.35	5.15	2.81	3.38	5.51	5.24	2.17	3.13	4.58	5.16
CD at 5%	8.42	11.16	15.89	15.30	8.34	10.04	16.37	15.57	6.45	9.29	13.62	15.32
CV (%)	15.35	9.89	8.70	7.21	14.28	8.48	8.87	7.38	11.39	8.04	7.29	7.24

DAS – Days after sowing

At 90 DAS, MRC-6918 Bt recorded significantly higher plant height (86.30 cm) over other cotton genotypes except Mallika Bt (80.40 cm). At 120 DAS, MRC-6918 Bt recorded significantly higher plant height (143.15 cm) over other cotton genotypes.

4.1.6.2 Leaf area index

Genotypes exhibited significant differences among different cotton genotypes at all stages of crop growth (Table 29).

At 60 DAS, Mallika Bt recorded significantly higher leaf area index (1.67) compared to all other cotton genotypes.

At 90 DAS, MRC-6918 Bt recorded significantly higher leaf area index (3.12) and found on par with Bunny BG-II (3.10), Bunny Bt (2.90), RCH-2 Bt (2.84) and RCH-2 BG-II (2.80).

At 120 DAS, Bunny Bt recorded significantly higher leaf area index (3.48) as compared to other treatments except JK-99 (3.35).

At harvest, Bunny BG-II recorded significantly higher leaf area index (2.98) over other cotton genotypes except MRC-6918 Bt and Bunny Bt (2.83) and JK-99 Bt (2.87), which were found on par with Bunny BG-II.

4.1.6.3 Number of monopodial branches

The data on number of monopodial branches presented in Table 30. The number of monopodial branches differed significantly among the cotton genotypes.

At 60 DAS, MRC-6918 Bt recorded significantly higher number of monopodial branches (2.86) over rest of the treatments. Similar trend was observed at 90, 120 DAS and at harvest.

4.1.6.4 Number of sympodial branches

The data on number of sympodial branches at 60, 90, 120 DAS and at harvest is presented in Table 31. The results indicated significant difference among cotton genotypes.

At 60 DAS, MRC-6918 Bt recorded significantly higher number of sympodial branches (8.05) over other cotton genotypes and was on par with RCH-708 Bt (7.43) and Brahma Bt (7.18).

At 90 DAS, MRC-6918 Bt recorded significantly higher number of sympodial branches (18.60) and was on par with RCH-708 Bt (16.80). At 120 DAS, MRC-6918 Bt recorded significantly higher number of sympodial branches (19.55) and was on par with RCH-708 Bt (17.95). At harvest, MRC-6918 Bt recorded significantly higher number of sympodial branches (20.6) and was on par with RCH-708 Bt (19.10) and Mallika Bt (18.85).

4.1.6.5 SPAD observation

Data on SPAD observations at different growth stages is presented in Table 32. SPAD values differed significantly among different cotton genotypes.

At 60 DAS, MRC-6918 Bt recorded significantly higher SPAD value (36.50) over other cotton genotypes. Similar trend was followed at 90 DAS. At 120 DAS, MRC-6918 Bt recorded significantly higher SPAD value (40.30) and was found on par with JK-99 Bt (39.50), Mallika Bt (39.10), RCH-708 Bt (38.55), Bunny BG-II (38.10) and Brahma Bt (37.40). At harvest, MRC-6918 Bt recorded significantly higher SPAD values (39.82) and was on par with RCH-708 Bt (38.90) and Mallika Bt (38.70).

4.1.6.6 Number of bad opened bolls per plant

Genotypes differed significantly with respect to number of bad opened bolls per plant (Table 33).

RCH-2 BG-II recorded significantly lower number of bad opened bolls per plant (1.80). Higher number of bad opened bolls per plant were recorded in DHH-11 non-Bt (11.46) and differed significantly over other cotton genotypes.

Table 29: Leaf area index of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	1.46	2.78	2.87	2.85	1.34	2.89	2.91	2.17	1.40	2.84	2.89	2.51
RCH-2 BG-II	1.27	2.94	3.05	2.95	1.62	2.65	3.12	2.25	1.45	2.80	3.09	2.60
Bunny BG-II	1.48	3.08	3.35	3.32	1.57	3.11	2.89	2.64	1.53	3.10	3.12	2.98
JK-99 Bt	1.37	3.25	3.69	3.25	1.68	1.83	3.01	2.49	1.53	2.54	3.35	2.87
Mallika Bt	1.62	2.41	2.96	2.67	1.72	2.92	2.97	2.51	1.67	2.67	2.97	2.59
MRC-6918 Bt	1.32	3.15	3.53	2.98	1.60	3.09	2.78	2.67	1.46	3.12	3.16	2.83
Brahma Bt	1.26	2.51	2.69	2.59	1.58	3.01	3.38	2.25	1.52	2.76	3.04	2.42
RCH-708 Bt	1.35	2.87	3.12	2.86	1.59	2.55	3.27	2.39	1.47	2.71	3.20	2.63
Bunny Bt	1.35	3.02	3.61	3.09	1.60	2.78	3.35	2.56	1.48	2.90	3.48	2.83
DHH-11	1.42	2.23	2.65	2.50	1.51	2.58	2.73	2.78	1.47	2.41	2.69	2.64
SEm±	0.05	0.17	0.12	0.11	0.07	0.15	0.13	0.11	0.04	0.11	0.08	0.08
CD at 5%	0.16	0.49	0.34	0.32	0.21	0.45	0.39	0.32	0.11	0.32	0.24	0.25
CV (%)	6.66	10.20	6.34	6.37	7.58	9.64	7.57	7.52	4.14	6.79	4.46	5.44

DAS – Days after sowing

Table 30: Number of monopodial branches per plant of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	1.73	2.73	3.33	3.33	1.80	2.00	2.26	2.33	1.77	2.37	2.80	2.83
RCH-2 BG-II	1.93	2.73	3.40	3.46	1.86	2.20	2.33	2.40	1.90	2.47	2.87	2.93
Bunny BG-II	2.40	2.73	3.46	3.60	2.46	2.66	2.80	2.86	2.43	2.70	3.13	3.23
JK-99 Bt	2.13	2.73	3.60	3.46	2.40	2.66	2.66	2.66	2.27	2.70	3.13	3.16
Mallika Bt	2.46	3.06	3.40	3.40	2.46	2.80	2.93	3.06	2.46	2.93	3.17	3.23
MRC-6918 Bt	2.86	3.33	4.00	4.00	2.86	3.13	3.26	3.26	2.86	3.23	3.63	3.63
Brahma Bt	2.27	2.86	3.66	3.73	2.33	2.40	2.46	2.46	2.30	2.63	3.06	3.10
RCH-708 Bt	2.46	3.13	3.53	3.53	2.40	2.73	2.93	2.93	2.43	2.93	3.23	3.23
Bunny Bt	2.33	2.46	3.20	3.26	2.26	2.46	2.60	2.66	2.30	2.46	2.90	2.96
DHH-11	1.53	1.80	2.73	2.73	1.46	1.66	2.13	2.13	1.50	1.73	2.43	2.43
SEm±	0.14	0.15	0.16	0.14	0.14	0.12	0.14	0.14	0.11	0.08	0.10	0.10
CD at 5%	0.40	0.44	0.46	0.41	0.41	0.35	0.43	0.42	0.33	0.23	0.29	0.28
CV (%)	10.68	9.28	7.88	6.92	10.77	8.20	9.44	9.23	8.66	5.04	5.66	5.41

DAS – Days after sowing

Table 31: Number of sympodial branches per plant of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	5.80	14.40	15.50	15.60	6.06	15.10	16.00	17.30	5.93	14.75	15.75	16.45
RCH-2 BG-II	6.26	15.40	16.60	16.60	6.93	16.10	16.40	18.10	6.60	15.75	16.50	17.35
Bunny BG-II	6.06	15.80	16.80	16.90	6.46	16.60	17.10	18.30	6.26	16.20	16.95	17.55
JK-99 Bt	6.66	15.40	16.40	16.50	6.74	15.30	16.40	20.30	6.71	15.35	16.40	18.40
Mallika Bt	6.20	14.60	17.60	17.70	6.46	16.00	17.10	18.00	6.43	15.30	17.35	18.85
MRC-6918 Bt	7.90	17.70	18.90	19.10	8.20	18.50	20.20	22.10	8.05	18.60	19.55	20.60
Brahma Bt	7.30	15.30	17.20	17.30	7.06	15.60	17.20	19.60	7.18	15.45	17.20	18.45
RCH-708 Bt	7.40	17.20	17.30	17.40	7.46	16.40	18.60	20.80	7.43	16.80	17.95	19.10
Bunny Bt	5.80	15.00	15.80	15.90	6.33	15.70	16.60	17.60	6.07	15.35	16.20	16.75
DHH-11	4.50	12.70	14.50	14.70	5.93	14.90	15.40	16.00	5.22	13.80	14.95	15.35
SEm±	0.30	0.82	0.75	0.72	0.37	0.60	0.76	0.80	0.30	0.62	0.65	0.65
CD at 5%	0.89	2.43	2.24	2.13	1.10	1.80	2.27	2.39	0.89	1.84	1.94	1.94
CV (%)	8.14	9.24	7.83	7.41	9.50	6.53	7.72	7.39	7.90	6.82	6.70	6.32

DAS – Days after sowing

4.1.6.7 Total number of bolls per plant

The data on the number of bolls per plant is presented in Table 33. Genotypes differed significantly with respect to total number of bolls per plant. MRC-6918 Bt (34.55) followed by RCH-708 Bt recorded significantly higher number of total bolls per plant (34.55) as compared to other cotton genotypes.

4.1.6.8 Boll weight

There was significant difference in boll weight among the cotton genotypes (Table 33).

MRC-6918 Bt recorded significantly higher boll weight (5.50) and was on par with Mallika Bt (5.45), Bunny BG-II (5.12), Bunny Bt (5.07) and RCH-2 BG-II (4.77).

4.1.6.9 Total dry matter production (g/plant)

There were significant differences in total dry matter production at different growth stages among the cotton genotypes (Table 34).

At 60 DAS, MRC-6918 Bt recorded significantly higher total dry matter production (80.73 g/plant) and was on par with Brahma Bt (73.90 g/plant) and RCH-708 Bt (72.70 g/plant).

At 90 DAS, MRC-6918 Bt recorded significantly higher total dry matter production (168.65 g/plant) and was on par with RCH-708 Bt (158.35 g/plant). Similar trend was observed at 120 DAS.

At harvest, MRC-6918 Bt recorded significantly higher total dry matter production (295.65 g/plant) and was on par with RCH-708 Bt (279.15 g/plant) and Brahma Bt (274.30 g/plant), JK-99 Bt (275.60 g/plant) and Bunny BG-II (274.60 g/plant).

4.1.6.10 Seed cotton yield per plant (g/plant)

The data on seed cotton yield per plant is presented in Table 35. The yield differed significantly among the different cotton genotypes. Significantly higher seed cotton yield per plant (141.85 g/plant) was recorded with MRC-6918 Bt over other cotton genotypes.

4.1.6.10.1 Seed cotton yield per hectare (kg/ha)

Data on yield per ha is presented in Table 35 and Fig. 6. The results indicated significant difference among cotton genotypes. MRC-6918 Bt recorded significantly higher seed cotton yield (2257 kg/ha) and it was on par with Bunny BG-II (2196 kg/ha) and RCH-2 BG-II (2090 kg/ha).

4.1.6.11 Harvest index

The data on harvest index is presented in Table 35.

The results indicated significant differences among cotton genotypes. Bunny BG-II recorded significantly higher harvest index (0.31) and was on par with RCH-2 Bt, RCH-2 BG-II, Bunny Bt and MRC-6918 Bt (0.29).

4.1.6.12 Economic analysis

The data on economics of cultivation of Bt cotton genotypes and non-Bt cotton hybrid cultivation in red soil are presented in Table 36.

The mean data of two years revealed large variation in the gross and net returns per hectare among different cotton genotypes.

4.1.6.12.1 Cost of cultivation (Rs./ha)

The total cost of cultivation was higher in non-Bt cotton cultivation (Rs. 25991/ha) than Bt cotton genotypes. The cost of treatment (cost of seed + plant protection measures) in the non-Bt cotton was minimum (Rs. 1200 + Rs. 11401 = Rs. 12601/ha) when compared to Bt cotton.

Table 32: SPAD value of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest	60 DAS	90 DAS	120 DAS	At harvest
RCH-2 Bt	28.20	28.40	32.10	31.50	28.30	29.10	32.10	31.50	28.25	28.75	32.10	31.50
RCH-2 BG-II	29.40	31.80	33.50	31.70	32.80	32.00	33.50	31.80	31.10	31.90	33.50	31.75
Bunny BG-II	29.70	32.20	38.10	37.10	32.10	33.50	38.10	37.10	30.90	32.85	38.10	37.10
JK-99 Bt	31.50	34.70	39.50	38.20	29.50	33.90	39.50	38.20	30.50	34.30	39.50	38.20
Mallika Bt	28.00	33.50	39.10	38.70	28.40	32.90	39.10	38.70	28.20	33.20	39.10	38.70
MRC-6918 Bt	35.50	43.90	40.30	39.83	37.50	38.50	40.30	39.80	36.50	41.20	40.30	39.82
Brahma Bt	29.40	29.40	37.40	36.30	31.00	32.50	37.40	36.30	30.20	30.95	37.40	36.30
RCH-708 Bt	31.50	30.50	38.70	39.90	32.80	35.60	38.70	37.90	32.15	33.05	38.55	38.90
Bunny Bt	28.71	31.30	35.60	34.10	29.50	31.00	35.60	34.10	29.11	31.15	35.60	34.10
DHH-11	24.50	26.80	26.90	26.10	26.70	27.73	26.90	26.10	25.60	27.27	26.90	26.10
SEm±	1.01	1.16	1.20	1.10	1.21	1.21	1.17	1.17	0.78	0.89	1.00	0.81
CD at 5%	2.99	3.45	3.56	3.27	3.61	3.60	3.49	3.49	2.33	2.64	2.98	2.42
CV (%)	5.88	6.23	5.75	5.39	6.82	6.42	5.63	5.78	4.48	4.75	4.81	4.00

DAS – Days after sowing

Table 33: Number of bad opened bolls per plant, total number of bolls per plant and boll weight (g/boll) of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	No. of bad opened bolls per plant			Total number of bolls per plant			Boll weight		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
RCH-2 Bt	5.80	4.81	5.31	28.70	28.31	28.51	4.59	4.62	4.61
RCH-2 BG-II	2.30	1.30	1.80	26.60	27.20	26.90	4.75	4.78	4.77
Bunny BG-II	2.73	2.13	2.43	25.20	26.80	26.00	5.11	5.13	5.12
JK-99 Bt	6.31	5.19	5.75	32.10	29.50	30.80	4.20	4.21	4.21
Mallika Bt	3.23	3.21	3.22	21.40	23.90	22.65	5.50	5.40	5.45
MRC-6918 Bt	7.61	9.86	8.74	31.80	37.30	34.55	5.49	5.50	5.50
Brahma Bt	5.45	6.53	5.99	25.10	29.80	27.45	4.50	4.51	4.51
RCH-708 Bt	4.68	10.51	7.60	30.70	38.20	34.45	3.99	4.12	4.06
Bunny Bt	3.21	4.10	3.66	23.20	24.50	23.85	5.07	5.06	5.07
DHH-11	10.82	12.10	11.46	29.50	22.60	26.05	4.29	4.28	4.29
SEm±	0.35	0.31	0.12	1.31	1.28	1.00	0.33	0.29	0.27
CD at 5%	1.03	0.91	0.35	3.89	3.81	2.98	0.97	0.85	0.80
CV (%)	11.55	8.88	3.68	8.27	7.70	6.17	11.90	10.40	9.76

Table 34: Total dry matter production (g/plant) of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09				2009-10				Pooled			
	60 DAS	**90 DAS**	**120 DAS**	**At harvest**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**	**60 DAS**	**90 DAS**	**120 DAS**	**At harvest**
RCH-2 Bt	54.07	119.60	223.10	241.30	67.20	149.30	255.53	272.50	60.63	134.45	239.32	256.90
RCH-2 BG-II	53.70	126.50	228.50	255.60	71.50	161.60	267.30	285.10	62.60	144.05	247.90	270.35
Bunny BG-II	59.80	131.30	229.40	259.80	72.30	165.20	262.30	289.40	66.05	148.25	245.85	274.60
JK-99 Bt	63.57	135.40	242.50	265.40	65.30	171.90	274.10	285.80	64.43	153.65	258.30	275.60
Mallika Bt	64.90	128.60	236.40	263.80	70.50	154.50	275.40	278.40	67.70	141.55	255.90	271.10
MRC-6918 Bt	70.40	147.80	269.40	281.80	91.07	189.50	281.07	309.50	80.73	168.65	275.23	295.65
Brahma Bt	62.30	129.50	234.50	257.30	85.50	165.30	264.50	291.30	73.90	147.40	249.50	274.30
RCH-708 Bt	65.60	138.20	248.50	262.10	79.80	178.50	279.40	296.20	72.70	158.35	263.95	279.15
Bunny Bt	53.10	123.80	225.30	243.70	68.20	153.20	253.40	275.60	60.65	138.50	239.35	259.65
DHH-11	35.60	109.50	226.90	235.60	59.60	145.30	245.30	263.10	47.60	127.40	236.10	249.35
SEm±	4.44	6.06	6.83	8.19	4.93	7.32	7.57	8.28	3.96	4.71	5.26	7.79
CD at 5%	13.19	17.99	20.30	24.33	14.65	21.75	22.50	24.59	11.76	13.98	15.64	23.15
CV (%)	13.19	8.13	5.00	5.53	11.69	7.76	4.93	5.04	10.43	5.58	3.63	4.99

DAS – Days after sowing

Table 35: Seed cotton yield per plant, seed cotton yield and harvest index of different cotton genotypes in red soil (Budarkatti)

Treatments (genotypes)	Seed cotton yield (g/plant)			Seed cotton yield (kg/ha)			Harvest index		
	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled	2008-09	2009-10	Pooled
RCH-2 Bt	104.50	108.60	106.50	1875	2035	1988	0.29	0.28	0.29
RCH-2 BG-II	115.60	125.30	120.40	1916	2264	2090	0.28	0.30	0.29
Bunny BG-II	119.80	128.40	124.10	2056	2336	2196	0.32	0.30	0.31
JK-99 Bt	108.50	100.50	104.50	1653	1822	1737	0.25	0.25	0.25
Mallika Bt	100.10	110.50	105.30	1697	2036	1866	0.25	0.28	0.27
MRC-6918 Bt	131.90	151.80	141.85	2269	2245	2257	0.30	0.28	0.29
Brahma Bt	89.30	103.50	96.42	1584	1715	1649	0.24	0.24	0.24
RCH-708 Bt	101.50	119.90	110.70	1821	2236	2028	0.27	0.28	0.28
Bunny Bt	101.30	115.70	108.30	1847	2145	1996	0.29	0.29	0.29
DHH-11	79.80	87.30	83.55	1418	1574	1496	0.23	0.24	0.24
SEm±	6.91	5.81	3.56	8840	103.46	56.76	0.01	0.01	0.01
CD at 5%	20.54	17.25	10.58	262.65	307.39	168.65	0.03	0.04	0.02
CV (%)	11.38	8.74	5.60	8.44	8.75	5.09	7.29	7.94	4.76

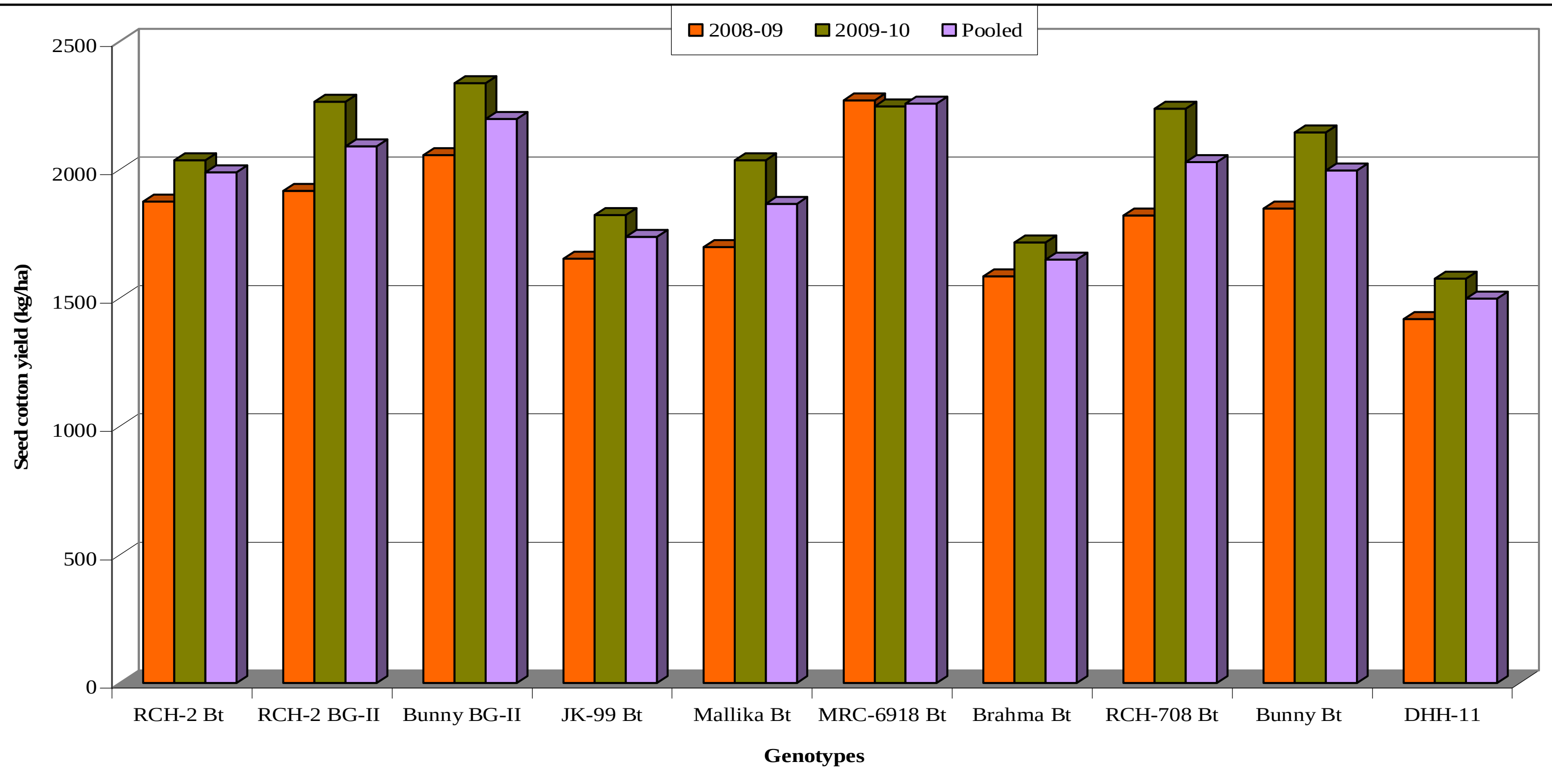

Fig. 6: Seed cotton yield (kg/ha) of different cotton genotypes in red soil (Budarkatti)

Fig. 6: Seed cotton yield (kg/ha) of different cotton genotypes in red soil (Budarkatti)

4.1.6.12.2 Gross returns (Rs./ha)

Gross returns differed significantly among the cotton genotypes. MRC-6918 Bt recorded significantly higher gross returns (Rs. 89131/ha) than all other cotton genotypes. DHH-11 recorded significantly lower gross returns (Rs. 47085/ha) than all other cotton genotypes except Brahma Bt.

4.1.6.12.3 Net returns (Rs./ha)

Genotypes differed significantly with respect to net returns. MRC-6918 Bt recorded significantly higher net returns (Rs. 64917/ha) than all other cotton genotypes. Lower net returns (Rs. 21094/ha) was recorded with DHH-11 and found significant to all other cotton genotypes but was found on par with Brahma Bt (Rs. 27686/ha).

4.1.6.12.4 Benefit:cost ratio

Benefit:cost ratio differed significantly among the different cotton genotypes. Higher B:C ratio (3.68) was recorded with MRC-6918 Bt and differed significantly to all other cotton genotypes. Lower B:C ratio of 1.81 was recorded with DHH-11.

4.1.6.13 Content and uptake of major, secondary and micronutrients

4.1.6.13.1a Nitrogen uptake (kg/ha)

The data recorded with respect to uptake of nitrogen and nitrogen content among different cotton genotypes is presented in Table 37.

Genotypes exhibited significant variation with respect to uptake of nitrogen at different stages of crop growth among different cotton genotypes.

At 60 DAS, MRC-6918 Bt recorded significantly higher uptake of nitrogen (31.40 kg/ha) and was found on par with RCH-708 Bt (28.80 kg/ha) and Bunny BG-II (28.50 kg/ha).

At 90 DAS, MRC-6918 Bt recorded significantly higher uptake of nitrogen (79.90 kg/ha) over other cotton genotypes.

At 120 DAS, MRC-6918 Bt recorded significantly higher uptake of nitrogen (129.00 kg/ha) and was on par with Mallika Bt (121.40 kg/ha).

4.1.6.13.1b Nitrogen content

The data on nitrogen content found to be non-significant among different cotton genotypes at different crop growth stages.

4.1.6.13.2a Phosphorus uptake (kg/ha)

The data on uptake of phosphorus and phosphorus content among different cotton genotypes at different growth stages is presented in Table 38.

Significant differences were obtained among different cotton genotypes at different growth stages.

At 60 DAS, MRC-6918 Bt showed significantly higher uptake of phosphorus (6.00 kg/ha) over other cotton genotypes and was on par with Bunny BG-II (5.40 kg/ha).

At 90 DAS, MRC-6918 exhibited significantly higher uptake of phosphorus over rest of the treatments.

At 120 DAS, MRC-6918 recorded significantly higher uptake of phosphorus (24.20 kg/ha) and was found on par with Mallika Bt (22.40 kg/ha) and JK-99 Bt (22.10 kg/ha).

4.1.6.13.2b Phosphorus content (%)

Significant differences were recorded among different cotton genotypes on phosphorus content at 60 and 90 DAS and found to be non-significant at 120 DAS.

At 60 DAS, significantly higher phosphorus content was recorded with MRC-6918 Bt (0.37%) and was on par with Bunny BG-II (0.39%) and RCH-2 BG-II (0.37%), Mallika Bt (0.37%), JK-99 Bt (0.37%) and DHH-11 (0.37%).

Table 36: Economics of different cotton genotypes in red soil (Rs./ha)

Sl. No.	Cotton hybrids	Cost of cultivation (except treatment cost)	Cost of treatment		Total cost of cultivation	Gross returns	Net returns	B:C ratio
			Seed cost	Plant protection measures				
				2008-09				
1.	RCH-2 Bt	13390	1875	9101	24366	60000	35634	1:2.46
2.	RCH-2 BG-II Bt	13390	2375	7641	23406	61312	37906	1:2.62
3.	Bunny BG-II Bt	13390	2375	7641	23406	65792	42386	1:2.81
4.	JK-99 Bt	13390	1875	9101	24366	52896	28530	1:2.17
5.	Mallika Bt	13390	1875	9101	24366	54304	29938	1:2.22
6.	MRC-6918 Bt	13390	1875	9101	24366	90760	66394	1:3.72
7.	Brahma Bt	13390	1875	9101	24366	50688	26322	1:2.08
8.	RCH-708 Bt	13390	1875	9101	24366	72840	48474	1:2.98
9.	Bunny Bt	13390	1875	9101	24366	59104	34738	1:2.43
10.	DHH-11	13390	1200	11401	25991	45376	19385	1:1.74
	SEm±					2582.71	2364.08	0.09
	CD at 5%					7673.54	7023.98	0.27
	CV (%)					7.30	11.08	6.24
				2009-10				
1.	RCH-2 Bt	13390	1625	9101	24116	63085	38969	1:2.62
2.	RCH-2 BG-II Bt	13390	1875	8266	23531	70184	46653	1:2.98
3.	Bunny BG-II Bt	13390	1875	8266	23531	72416	48885	1:3.07
4.	JK-99 Bt	13390	1625	9101	24116	56482	32366	1:2.34
5.	Mallika Bt	13390	1625	9101	24116	63116	39000	1:2.62
6.	MRC-6918 Bt	13390	1625	9101	24116	87555	63439	1:3.63
7.	Brahma Bt	13390	1625	9101	24116	53165	29049	1:2.20
8.	RCH-708 Bt	13390	1625	9101	24116	87204	63088	1:3.61
9.	Bunny Bt	13390	1625	9101	24116	66495	42379	1:2.76
10.	DHH-11	13390	1200	11401	25991	48794	22803	1:1.87
	SEm±					1577.62	2097.62	0.11
	CD at 5%					4687.31	6232.38	0.33
	CV (%)					4.09	8.52	6.84

Contd…….

Sl. No.	Cotton hybrids	Cost of cultivation (except treatment cost)	Cost of treatment		Total cost of cultivation	Gross returns	Net returns	B:C ratio
			Seed cost	Plant protection measures				
Mean of two years (pooled)								
1.	RCH-2 Bt	13390	1750	9101	24241	61543	37302	1:2.54
2.	RCH-2 BG-II Bt	13390	2125	7954	23469	65748	42280	1:2.80
3.	Bunny BG-II Bt	13390	2125	7954	23469	69104	45636	1:2.94
4.	JK-99 Bt	13390	1750	9101	24241	54689	30448	1:2.26
5.	Mallika Bt	13390	1750	9101	24241	58710	34469	1:2.42
6.	MRC-6918 Bt	13390	1750	9101	24241	89131	64917	1:3.68
7.	Brahma Bt	13390	1750	9101	24241	51917	27686	1:2.14
8.	RCH-708 Bt	13390	1750	9101	24241	80022	55781	1:3.30
9.	Bunny Bt	13390	1750	9101	24241	62799	38559	1:2.60
10.	DHH-11	13390	1200	11401	25991	47085	21094	1:1.81
	SEm±					1724.82	1926.18	0.06
	CD at 5%					5124.65	5722.93	0.18
	CV (%)					4.66	8.38	4.01

Table 37: Nitrogen uptake (kg/ha) and content (%) of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	22.3 (1.87)	62.5 (2.05)	98.5 (2.14)	24.8 (1.94)	72.2 (2.15)	109.8 (2.25)	23.6 (1.91)	67.34 (2.10)	104.2 (2.20)
RCH-2 BG-II Bt	25.5 (2.02)	65.0 (2.09)	104.8 (2.16)	30.1 (2.06)	68.5 (2.09)	115.9 (2.29)	27.8 (2.04)	66.78 (2.09)	110.4 (2.23)
Bunny Bt 2 (BG-II)	26.2 (2.06)	64.0 (2.16)	112.3 (2.20)	30.8 (2.08)	75.9 (2.19)	118.9 (2.23)	28.5 (2.07)	70.0 (2.18)	115.6 (2.22)
JK-99 Bt	25.4 (1.98)	67.2 (2.12)	115.0 (2.17)	29.0 (2.02)	76.2 (2.14)	120.8 (2.19)	27.2 (2.00)	71.7 (2.13)	117.9 (2.18)
Mallika Bt	22.6 (1.81)	67.2 (2.17)	118.0 (2.26)	26.4 (1.91)	80.6 (2.21)	124.8 (2.28)	24.5 (1.86)	73.9 (2.19)	121.4 (2.27)
MRC-6918 Bt	28.0 (2.08)	75.2 (2.25)	125.0 (2.27)	34.8 (2.09)	84.6 (2.28)	132.9 (2.31)	31.4 (2.09)	79.9 (2.27)	129.0 (2.29)
Brahma Bt	24.0 (1.92)	64.3 (2.08)	105.0 (2.13)	29.8 (2.08)	73.4 (2.16)	114.2 (2.18)	26.9 (2.00)	68.9 (2.12)	109.6 (2.16)
RCH-708 Bt	27.0 (2.06)	69.5 (2.13)	109.0 (2.11)	30.6 (2.06)	75.8 (2.13)	119.2 (2.19)	28.8 (2.06)	72.7 (2.13)	114.1 (2.15)
Bunny Bt	23.7 (1.94)	62.5 (2.04)	104.0 (2.22)	25.1 (1.98)	65.2 (2.05)	109.8 (2.21)	24.4 (1.96)	63.9 (2.05)	106.9 (2.22)
DHH-11	17.50 (1.84)	59.5 (2.14)	92.5 (2.12)	26.5 (2.12)	67.1 (2.18)	104.6 (2.20)	22.0 (1.98)	63.3 (2.16)	98.55 (2.16)
SEm±	1.45 (0.19)	2.10 (0.05)	4.54 (0.10)	1.85 (0.06)	2.94 (0.10)	4.84 (0.14)	1.05 (0.10)	1.99 (0.07)	3.58 (0.11)
CD at 5%	4.32 (NS)	6.23 (NS)	13.49 (NS)	5.51 (NS)	8.73 (NS)	14.37 (NS)	3.12 (NS)	5.92 (NS)	10.63 (NS)
CV (%)	10.40 (16.38)	5.53 (3.77)	7.25 (7.64)	11.15 (5.12)	6.88 (8.07)	7.16 (10.96)	6.87 (8.77)	4.94 (5.55)	5.50 (8.44)

DAS – Days after sowing; *Figures in parentheses indicate nitrogen content (%)

Table 38: Phosphorus uptake (kg/ha) and content (%) of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	3.8 (0.32)	11.6 (0.38)	19.9 (0.43)	4.6 (0.36)	13.1 (0.39)	19.2 (0.39)	4.2 (0.34)	12.4 (0.39)	19.6 (0.41)
RCH-2 BG-II Bt	4.7 (0.37)	12.3 (0.39)	19.8 (0.41)	5.4 (0.37)	12.9 (0.39)	21.0 (0.42)	5.1 (0.37)	12.6 (0.39)	20.4 (0.42)
Bunny Bt 2 (BG-II)	5.0 (0.39)	12.0 (0.40)	21.4 (0.42)	5.8 (0.39)	14.1 (0.41)	22.0 (0.42)	5.4 (0.39)	13.1 (0.41)	21.8 (0.42)
JK-99 Bt	4.5 (0.35)	12.0 (0.38)	21.5 (0.41)	5.5 (0.38)	14.1 (0.40)	22.6 (0.41)	5.0 (0.37)	13.1 (0.39)	22.1 (0.41)
Mallika Bt	4.5 (0.36)	12.1 (0.39)	21.5 (0.41)	5.1 (0.37)	15.6 (0.43)	23.3 (0.43)	4.8 (0.37)	13.9 (0.41)	22.4 (0.42)
MRC-6918 Bt	5.2 (0.39)	13.9 (0.42)	23.5 (0.43)	6.8 (0.41)	16.2 (0.44)	24.8 (0.44)	6.0 (0.40)	15.1 (0.43)	24.2 (0.43)
Brahma Bt	4.0 (0.32)	12.1 (0.39)	20.9 (0.42)	5.2 (0.36)	14.1 (0.41)	22.6 (0.43)	4.6 (0.34)	13.1 (0.40)	21.8 (0.43)
RCH-708 Bt	4.6 (0.35)	12.4 (0.38)	20.9 (0.41)	5.5 (0.37)	13.8 (0.39)	22.1 (0.41)	5.1 (0.36)	13.1 (0.39)	21.5 (0.41)
Bunny Bt	4.2 (0.34)	10.9 (0.35)	18.2 (0.39)	4.8 (0.38)	12.8 (0.40v	21.3 (0.43)	4.5 (0.36)	11.9 (0.38)	19.8 (0.41)
DHH-11	4.8 (0.38)	11.4 (0.41)	18.3 (0.42)	4.9 (0.39)	12.7 (0.41)	19.9 (0.42)	4.9 (0.37)	12.1 (0.41)	19.1 (0.42)
SEm±	0.25 (0.02)	0.50 (0.02)	0.97 (0.01)	0.40 (0.01)	0.67 (0.01)	1.01 (0.01)	0.28 (0.01)	0.34 (0.01)	0.79 (0.01)
CD at 5%	0.73 (0.05)	1.49 (NS)	2.88 (NS)	1.18 (NS)	1.99 (NS)	3.01 (NS)	0.84 (0.03)	1.01 (0.03)	2.34 (NS)
CV (%)	9.38 (7.43)	7.18 (7.70)	8.14 (5.16)	12.84 (5.20)	8.31 (5.18)	8.02 (4.10)	9.92 (4.54)	4.51 (4.19)	6.43 (3.34)

DAS – Days after sowing; *Figures in parentheses indicate phosphorus content (%)

At 90 DAS, significantly higher phosphorus content (0.43%) was recorded with MRC-6918 Bt and was on par with DHH-11 non-Bt, Bunny BG-II and Mallika Bt (0.41%), Brahma Bt (0.40%) and RCH-2 BG-II (0.39).

4.1.6.13.3a Potassium uptake (kg/ha)

The data on uptake and content of potassium at different growth stages and among different cotton genotypes is presented in Table 39.

Significant differences were exhibited among different cotton genotypes at different crop growth stages on uptake of potassium (kg/ha).

At 60 DAS, significantly higher uptake of potassium (33.50 kg/ha) was recorded with MRC-6918 Bt as compared to other cotton genotypes.

At 90 DAS, significantly higher uptake of potassium (78.90 kg/ha) was recorded with MRC-6918 Bt and was on par with Mallika Bt (73.30) and JK-99 Bt (73.40).

At 120 DAS, significantly higher uptake of potassium was recorded with MRC-6918 Bt (126.40 kg/ha) and was on par with Mallika Bt (120.10 kg/ha) and JK-99 Bt (118.10 kg/ha).

4.1.6.13.3b Potassium content

The data on potassium content among different cotton genotypes at 60 and 90 DAS showed significant variation, whereas at 120 DAS, variation on potassium content was found to be non-significant.

At 60 DAS, significantly higher potassium content was recorded with MRC-6918 Bt (2.23%) and was on par with Mallika Bt (2.19%), DHH-11 non-Bt (2.18%) and JK-99 Bt (2.16%).

At 90 DAS, MRC-6918 Bt recorded significantly higher potassium content (2.24%) and was on par with DHH-11 non-Bt (2.21%), Mallika Bt and JK-99 Bt (2.18%) and Bunny BG-II and RCH-708 Bt (2.06%).

Secondary nutrients

4.1.6.17a Calcium uptake (kg/ha)

The data on uptake of calcium and calcium content among different cotton genotypes at different growth stages is presented in Table 40.

Significant differences were observed among different cotton genotypes on uptake of calcium (kg/ha) at 60, 90 and 120 DAS.

At 60 DAS, significantly higher uptake of calcium (20.45 kg/ha) was recorded with MRC-6918 Bt over rest of the cotton genotypes. Similar trend was observed at 90 and 120 DAS.

4.1.6.17b Calcium content

The data on calcium content showed non-significant among different cotton genotypes at different growth stages.

4.1.6.18a Magnesium uptake (kg/ha)

The data pertaining to uptake of magnesium (kg/ha) and magnesium content at different growth stages among different cotton genotypes is presented in Table 41.

Significant differences were noticed among different cotton genotypes at different growth stages on uptake of magnesium.

At 60 DAS, significantly higher uptake of magnesium (4.75 kg/ha) was recorded with MRC-6918 Bt over other cotton genotypes.

At 90 DAS, significantly higher uptake of magnesium (11.70 g/ha) was recorded with MRC-6918 Bt and was found on par with RCH-708 Bt (10.95 g/ha). Similar trend was observed at 120 DAS.

Table 39: Potassium uptake (kg/ha) and content (%) of different cotton genotypes at different growth stages in red soil (Budarkatti)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	22.5 (1.89)	58.0 (1.91)	96.8 (2.11)	24.6 (1.92)	64.2 (1.91)	106.3 (2.18)	23.6 (1.91)	61.10 (1.90)	101.6 (2.15)
RCH-2 BG-II Bt	24.9 (1.97)	64.2 (2.06)	105.0 (2.16)	29.0 (1.98)	65.1 (1.99)	109.9 (2.17)	27.0 (1.98)	64.7 (2.03)	107.5 (2.17)
Bunny Bt 2 (BG-II)	25.9 (2.03)	61.3 (2.07)	109.4 (2.14)	29.7 (2.01)	71.2 (2.05)	115.2 (2.16)	27.8 (2.02)	66.3 (2.06)	112.3 (2.15)
JK-99 Bt	27.6 (2.15)	69.2 (2.18)	116.0 (2.19)	31.2 (2.17)	77.6 (2.18)	120.1 (2.18)	29.4 (2.16)	73.4 (2.18)	118.1 (2.19)
Mallika Bt	27.0 (2.17)	67.5 (2.18)	116.3 (2.23)	30.6 (2.21)	79.1 (2.17)	123.9 (2.26)	28.8 (2.19)	73.3 (2.18)	120.1 (2.25)
MRC-6918 Bt	29.9 (2.22)	74.1 (2.22)	121.6 (2.21)	37.0 (2.23)	83.6 (2.25)	131.2 (2.28)	33.5 (2.23)	78.9 (2.24)	126.4 (2.25)
Brahma Bt	24.1 (1.93)	60.6 (1.96)	101.8 (2.06)	29.0 (2.02)	67.4 (1.98)	109.1 (2.09)	26.6 (2.08)	64.0 (1.98)	105.5 (2.08)
RCH-708 Bt	26.8 (2.05)	68.0 (2.08)	109.2 (2.12)	30.6 (2.06)	72.9 (2.04)	117.2 (2.15)	28.7 (2.06)	70.5 (2.06)	113.2 (2.15)
Bunny Bt	22.3 (1.83)	60.5 (1.97)	94.5 (2.02)	23.6 (1.86)	59.4 (1.87)	103.4 (2.08)	23.0 (1.85)	60.0 (1.92)	99.0 (2.05)
DHH-11	20.8 (2.19)	61.6 (2.21)	97.4 (2.24)	27.0 (2.16)	67.9 (2.21)	106.5 (2.24)	23.9 (2.18)	64.8 (2.21)	102.0 (2.24)
SEm±	1.69 (0.69)	2.82 (0.08)	4.93 (0.10)	6.04 (0.10)	2.09 (0.08)	5.17 (0.10)	0.93 (0.04)	2.27 (0.06)	4.06 (0.08)
CD at 5%	5.01 (NS)	8.39 (NS)	14.65 (NS)	NS (NS)	8.61 (NS)	15.37 (NS)	2.75 (0.13)	6.75 (0.18)	12.05 (NS)
CV (%)	11.59 (58.66)	7.58 (6.46)	8.00 (8.46)	35.78 (8.14)	7.09 (7.08)	7.84 (7.44)	5.90 (3.70)	5.82 (5.12)	6.36 (6.31)

DAS – Days after sowing; *Figures in parentheses indicate potassium content (%)

4.1.6.18b Magnesium content

Magnesium content among different cotton genotypes at different growth stages showed significant differences.

At 60 DAS, significantly higher magnesium content (0.32%) was recorded with MRC-6918 Bt and was found on par with Mallika Bt and RCH-708 Bt (0.29%).

At 90 DAS, significantly higher magnesium content was recorded with MRC-6918 Bt (0.34%) and was on par with RCH-708 Bt (0.32%). Similar trend was observed at 120 DAS.

4.1.6.19a Iron uptake (g/ha)

The data on uptake of iron (g/ha) and iron content (ppm) among different cotton genotypes at different growth stages is presented in Table 42.

Significant differences was exhibited among different cotton genotypes at 60, 90 and 120 DAS.

At 60 DAS, significantly higher uptake of iron (654.00 g/ha) was recorded with MRC-6918 Bt over rest of the cotton genotypes. Similar trend was observed at 90 DAS.

At 120 DAS, Brahma Bt recorded significantly higher uptake of iron (2391.00 g/ha) over Bunny BG-II (2047 g/ha), RCH-2 BG-II (1959.50 g/ha), Bunny Bt (1909.00 g/ha) and RCH-2 Bt (1632.5 g/ha).

4.1.6.19b Iron content

Significant differences were noticed in iron content among different cotton genotypes at 90 DAS. At 60 DAS and 120 DAS, the iron content was found to be non-significant among different cotton genotypes.

At 90 DAS, significantly higher iron content was recorded with MRC-6918 Bt (45.04 ppm) and was found on par with DHH-11 non-Bt (42.43 ppm), RCH-708 Bt (41.72 ppm), JK-99 Bt (41.64 ppm) and Brahma Bt (41.22 ppm).

4.1.6.20a Copper uptake (g/ha)

The data pertaining to uptake of copper (g/ha) and copper content (ppm) at different growth stages among different cotton genotypes is presented in Table 43.

Significant differences were noticed at different growth stages among different cotton genotypes.

At 60 DAS, significantly higher uptake of copper (81.50 g/ha) was recorded with MRC-6918 Bt over rest of the cotton genotypes except Bunny BG-II (76.5).

At 90 DAS, significantly higher uptake of copper (192.00 g/ha) was noticed with MRC-6918 Bt than RCH-2 Bt (175.50 g/ha), Bunny Bt (172.00 g/ha). Brahma Bt (168.50 g/ha) and DHH-11 non-Bt (161.50 g/ha).

At 120 DAS, significantly higher uptake of copper (307.00 g/ha) was recorded with Bunny BG-II and was found on par with MRC-6918 Bt (305.50 g/ha), JK-99 Bt (300.50 g/ha), Mallika Bt (299.00 g/ha) and RCH-708 Bt (287.50 g/ha).

4.1.6.20b Copper content (ppm)

Significant difference was exhibited at 90 DAS among different cotton genotypes. Whereas at 60 and 120 DAS, the data was found to be non-significant among different cotton genotypes.

At 90 DAS, significantly higher copper content was recorded with RCH-2 BG-II (5.73 ppm) over RCH-2 Bt (5.48 ppm), DHH-11 non-Bt (5.34 ppm), JK-99 Bt (5.31 ppm) and Brahma Bt (5.20 ppm).

4.1.6.21a Manganese uptake (g/ha)

The data pertaining to uptake of manganese and manganese content among different cotton genotypes at different growth stages is presented in Table 44.

Table 40: Calcium uptake (kg/ha) and content (%) of different cotton genotypes at different growth stages in red soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	15.2 (1.27)	40.9 (1.34)	62.5 (1.36)	16.9 (1.32)	46.5 (1.38)	69.2 (1.42)	16.05 (1.33)	43.07 (1.38)	65.85 (1.39)
RCH-2 BG-II Bt	16.2 (1.28)	40.5 (1.30)	69.5 (1.43)	18.9 (1.29)	45.6 (1.39)	71.2 (1.41)	17.55 (1.34)	43.05 (1.36)	70.35 (1.42)
Bunny Bt 2 (BG-II)	16.8 (1.32)	39.8 (1.34)	70.5 (1.38)	19.9 (1.35)	48.2 (1.39)	75.6 (1.42)	18.35 (1.36)	44.00 (1.38)	73.05 (1.40)
JK-99 Bt	14.4 (1.12)	38.5 (1.21)	66.5 (1.25)	16.9 (1.18)	43.2 (1.21)	68.2 (1.24)	15.65 (1.17)	40.85 (1.23)	67.35 (1.25)
Mallika Bt	14.2 (1.14)	39.5 (1.27)	69.5 (1.33)	16.2 (1.17)	45.2 (1.24)	70.2 (1.28)	15.20 (1.19)	42.35 (1.28)	69.85 (1.31)
MRC-6918 Bt	17.4 (1.29)	45.6 (1.36)	76.5 (1.39)	23.5 (1.41)	53.2 (1.43)	86.8 (1.51)	20.45 (1.36)	49.40 (1.43)	81.65 (1.45)
Brahma Bt	15.4 (1.23)	38.5 (1.25)	63.5 (1.29)	17.9 (1.25)	43.2 (1.27)	72.2 (1.38)	16.65 (1.25)	40.85 (1.32)	67.85 (1.34)
RCH-708 Bt	15.9 (1.21)	40.5 (1.24)	67.5 (1.31)	19.1 (1.29)	48.2 (1.35)	76.2 (1.40)	17.50 (1.28)	44.35 (1.32)	71.85 (1.36)
Bunny Bt	14.6 (1.20)	38.5 (1.25)	61.5 (1.31)	16.1 (1.27)	41.2 (1.30)	67.2 (1.35)	15.35 (1.25)	39.85 (1.30)	64.35 (1.33)
DHH-11	12.1 (1.27)	36.5 (1.31)	61.5 (1.41)	16.1 (1.29)	41.2 (1.34)	65.2 (1.37)	14.10 (1.31)	38.85 (1.34)	63.35 (1.39)
SEm±	0.94 (0.10)	1.33 (0.06)	2.00 (0.04)	1.04 (0.05)	1.41 (0.08)	2.49 (0.10)	0.73 (0.07)	1.01 (0.06)	1.91 (0.05)
CD at 5%	2.78 (NS)	3.95 (NS)	5.95 (NS)	3.08 (0.14)	4.19 (NS)	7.40 (NS)	2.16 (NS)	3.01 (NS)	5.66 (NS)
CV (%)	10.66 (13.47)	5.77 (8.09)	5.19 (5.38)	9.91 (6.19)	5.36 (10.57)	5.98 (12.73)	7.55 (9.95)	4.11 (7.96)	4.75 (6.53)

DAS – Days after sowing; *Figures in parentheses indicate calcium content (%)

Table 41: Magnesium uptake (kg/ha) and content (%)of different cotton genotypes at different growth stages in red soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	2.10 (0.18)	6.20 (0.20)	12.10 (0.26)	2.40 (0.19)	7.50 (0.22)	13.10 (0.27)	2.25 (0.19)	6.85 (0.21)	12.60 (0.27)
RCH-2 BG-II Bt	2.40 (0.19)	6.90 (0.22)	13.20 (0.27)	2.90 (0.20)	8.10 (0.25)	14.60 (0.29)	2.65 (0.20)	7.50 (0.24)	13.90 (0.28)
Bunny Bt 2 (BG-II)	2.50 (0.20)	7.00 (0.24)	14.10 (0.28)	3.10 (0.21)	8.90 (0.26)	14.90 (0.28)	2.80 (0.21)	7.95 (0.25)	14.50 (0.28)
JK-99 Bt	2.80 (0.22)	6.50 (0.25)	13.60 (0.26)	3.30 (0.23)	8.10 (0.23)	13.20 (0.24)	3.05 (0.23)	7.30 (0.24)	13.40 (0.25)
Mallika Bt	3.50 (0.28)	8.90 (0.29)	14.90 (0.29)	4.00 (0.29)	10.60 (0.29)	15.80 (0.29)	3.75 (0.29)	9.75 (0.29)	15.35 (0.29)
MRC-6918 Bt	4.20 (0.31)	10.90 (0.33)	18.50 (0.34)	5.30 (0.32)	12.50 (0.34)	19.40 (0.34)	4.75 (0.32)	11.70 (0.34)	18.95 (0.34)
Brahma Bt	3.20 (0.26)	9.26 (0.30)	15.90 (0.32)	3.90 (0.27)	10.20 (0.30)	15.90 (0.30)	3.55 (0.27)	9.73 (0.30)	15.90 (0.31)
RCH-708 Bt	3.80 (0.29)	10.10 (0.31)	16.90 (0.33)	4.30 (0.29)	11.80 (0.33)	18.10 (0.33)	4.05 (0.29)	10.95 (0.32)	17.50 (0.33)
Bunny Bt	2.10 (0.17)	6.30 (0.21)	11.50 (0.25)	2.30 (0.18)	7.60 (0.24)	12.90 (0.26)	2.20 (0.18)	6.95 (0.22)	12.20 (0.26)
DHH-11	2.40 (0.25)	7.20 (0.26)	13.80 (0.32)	3.40 (0.27)	8.60 (0.28)	14.10 (0.30)	2.90 (0.26)	7.90 (0.27)	13.95 (0.31)
SEm±	0.13 (0.01)	0.29 (0.01)	0.94 (0.01)	0.16 (0.02)	0.48 (0.02)	0.88 (0.01)	0.09 (0.01)	0.26 (0.01)	0.62 (0.01)
CD at 5%	0.40 (0.03)	0.87 (0.03)	2.78 (0.03)	0.47 (0.06)	1.42 (0.05)	2.63 (0.04)	0.26 (0.04)	0.78 (0.03)	1.84 (0.02)
CV (%)	8.06 (8.04)	6.41 (6.28)	11.23 (6.96)	7.92 (14.76)	8.80 (11.48)	10.07 (8.84)	4.67 (9.14)	5.23 (7.41)	7.22 (4.84)

DAS – Days after sowing; *Figures in parentheses indicate magnesium content (%)

Table 42: Iron uptake (g/ha) and content (ppm) of different cotton genotypes at different growth stages in red soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	430.5 (36.1)	1136.0 (37.31)	1786.0 (38.84)	481.0 (37.53)	1286.0 (38.22)	1479.0 (40.22)	455.8 (36.82)	(1211.0 37.77)	1632.5 (39.52)
RCH-2 BG-II Bt	475.0 (37.61)	1193.0 (38.28)	1956.0 (40.24)	565.0 (38.67)	1312.0 (40.09)	1963.0 (39.65)	520.0 (38.14)	(1252.5 (39.19)	1959.5 (39.95)
Bunny Bt 2 (BG-II)	485.0 (38.07)	1189.0 (40.08)	2063.0 (40.42)	589.0 (39.86)	1423.0 (40.98)	2031.0 (41.88)	537.0 (38.97)	1306.0 (40.53)	2047.0 (41.15)
JK-99 Bt	518.0 (40.30)	1312.0 (41.32)	2236.0 (42.14)	603.0 (41.96)	1496.0 (41.96)	2236.0 (42.13)	560.5 (41.16)	1404.0 (41.64)	2236.0 (42.14)
Mallika Bt	489.0 (39.24)	1296.0 (41.83)	2286.0 (43.87)	536.0 (38.75)	1436.0 (39.44)	2096.0 (42.32)	512.5 (39.0)	1366.0 (40.64)	2191.0 (43.10)
MRC-6918 Bt	589.0 (43.81)	1486.0 (44.43)	2396.0 (43.55)	719.0 (43.28)	1693.0 (45.64)	2316.0 (46.92)	654.0 (45.63)	1589.5 (45.04)	2356.0 (45.24)
Brahma Bt	485.0 (38.80)	1263.0 (40.89)	2084 (42.18)	569.0 (39.65)	1412.0 (41.55)	2698.0 (43.39)	527.0 (39.23)	1337.5 (41.22)	2391.0 (42.79)
RCH-708 Bt	519.0 (39.64)	1369.0 (41.95)	2103.0 (40.80)	596.0 (40.18)	1479.0 (41.49)	2269.0 (42.48)	557.5 (39.91)	1424.0 (41.72)	2186.0 (41.64)
Bunny Bt	432.0 (35.40)	1136.0 (37.0)	1812.0 (38.66)	463.0 (36.5)	1185.0 (37.31)	2006.0 (40.85)	447.50 (35.95)	1160.5 (37.16)	1909.0 (39.76)
DHH-11	399.0 (42.0)	1169.0 (42.03)	1896.0 (43.55)	522.0 (41.76)	1316.0 (42.83)	2326.0 (44.11)	460.5 (41.88)	1242.5 (42.43)	2111.0 (43.83)
SEm±	31.51 (3.42)	53.19 (1.25)	98.88 (1.20)	45.47 (1.38)	64.12 (2.20)	117.22 (1.83)	29.18 (2.29)	47.60 (1.37)	98.74 (1.41)
CD at 5%	93.63 (NS)	158.04 (3.71)	293.79 (3.56)	135.11 (NS)	190.50 (NS)	348.28 (NS)	89.69 (NS)	141.42 (4.07)	293.37 (NS)
CV (%)	11.32 (15.15)	7.34 (5.33)	8.31 (5.01)	13.96 (6.01)	7.91 (9.30)	9.48 (7.46)	9.66 (9.99)	6.20 (5.82)	8.14 (5.84)

DAS – Days after sowing; *Figures in parentheses indicate iron content (ppm)

Table 43: Copper uptake (g/ha) and content (ppm) of different cotton genotypes at different growth stages in red soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	63.2 (5.30)	165.0 (5.42)	258.0 (5.61)	70.0 (5.46)	186.0 (5.53)	279.0 (5.71)	66.60 (5.38	175.5 (5.48)	268.5 (5.66)
RCH-2 BG-II Bt	69.0 (5.46)	176.0 (5.65)	269.0 (5.53)	83.0 (5.68)	190.0 (5.81)	296.0 (5.85)	76.0 (5.57)	183.0 (5.73)	282.5 (5.69)
Bunny Bt 2 (BG-II)	71.0 (5.57)	172.0 (5.80)	299.0 (5.86)	82.0 (5.55)	190.0 (5.47)	315.0 (5.90)	76.5 (5.56)	181.0 (5.64)	307.0 (5.88)
JK-99 Bt	68.0 (5.29)	169 (5.32)	315.0 (5.94)	74.0 (5.15)	189.0 (5.30)	286.0 (5.18)	71.0 (5.22)	179.0 (5.31)	300.5 (5.56)
Mallika Bt	65.0 (5.22)	170.0 (5.49)	299.0 (5.74)	74.0 (5.35)	201.0 (5.52)	299.0 (5.46)	69.2 (5.29)	185.5 (5.51)	299.0 (5.60)
MRC-6918 Bt	72.0 (5.36)	186.0 (5.56)	305.0 (5.54)	91.0 (5.48)	198.0 (5.34)	306.0 (5.32)	81.5 (5.42)	192.0 (5.45)	305.5 (5.43)
Brahma Bt	61.0 (4.88)	162.0 (5.24)	269.0 (5.44)	74.0 (5.16)	175.0 (5.15)	269.0 (5.14)	67.5 (5.02)	168.5 (5.20)	269.0 (5.29)
RCH-708 Bt	65.0 (4.96)	181.0 (5.55)	286.0 (5.55)	78.0 (5.26)	196.0 (5.50)	289.0 (5.31)	71.5 (5.11)	188.5 (5.53)	287.5 (5.43)
Bunny Bt	64.0 (5.24)	168.0 (5.47)	256.0 (5.46)	69.0 (5.44)	176.0 (5.54)	276.0 (5.55)	66.5 (5.34)	172.0 (5.51)	266.0 (5.51)
DHH-11	49.0 (5.16)	145.0 (5.21)	236.0 (5.42)	65.0 (5.20)	168.0 (5.47)	265.0 (5.58)	57.0 (5.18)	161.5 (5.34)	250.05 (5.50)
SEm±	2.24 (0.19)	6.03 (0.20)	10.01 (0.10)	3.64 (0.22)	5.68 (0.10)	9.67 (0.19)	2.02 (0.16)	5.26 (0.10)	7.77 (0.11)
CD at 5%	6.65 (NS)	17.93 (NS)	29.75 (0.31)	10.82 (NS)	16.87 (0.31)	28.72 (NS)	6.01 (NS)	15.63 (0.29)	23.08 (NS)
CV (%)	5.61 (6.24)	6.17 (6.33)	6.21 (3.21)	8.30 (7.05)	5.26 (3.28)	5.81 (6.05)	4.98 (5.20)	5.10 (3.09)	4.74 (3.31)

DAS – Days after sowing; *Figures in parentheses indicate copper content (ppm)

Table 44: Manganese uptake (g/ha) and content (ppm) of different cotton genotypes at different growth stages in red soil (Govankoppa)

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	439.0 (36.81)	1130.0 (37.12)	1751.0 (38.08)	476.0 (37.14)	1263.0 (37.53)	1859.0 (38.07)	457.5 (36.98)	1196.5 (37.33)	1805.0 (38.08)
RCH-2 BG-II Bt	469.0 (37.13)	1196.0 (38.37)	1861.0 (38.28)	536.0 (36.68)	1256.0 (38.38)	1956.0 (38.66)	502.5 (36.91)	1226.0 (38.38)	1908.5 (38.47)
Bunny Bt 2 (BG-II)	487.0 (38.22)	1125.0 (37.92)	1956.0 (38.32)	579.0 (39.18)	1321.0 (38.04)	2106.0 (39.45)	533.0 (38.70)	1223.0 (37.98)	2031.0 (38.89)
JK-99 Bt	455.0 (35.40)	1129.0 (35.55)	1895.0 (35.72)	531.0 (36.95)	1326.0 (37.20)	2225.0 (40.30)	493.0 (36.18)	1227.0 (36.38)	2060.0 (38.01)
Mallika Bt	451.0 (36.19)	1106.0 (35.70)	1956.0 (38.95)	498.0 (36.00)	1329.0 (36.50)	2120.0 (37.74)	474.50 (36.10)	1217.5 (36.10)	2038.0 (38.14)
MRC-6918 Bt	519.0 (38.60)	1321.0 (39.50)	2143.0 (36.75)	639.0 (38.47)	1436.0 (38.71)	2256.0 (39.23)	579.0 (38.54)	1378.5 (39.11)	2199.5 (39.09)
Brahma Bt	436.0 (34.88)	1096.0 (35.48)	1816.0 (39.89)	509.0 (35.46)	1216.0 (35.78)	1894.0 (36.22)	472.5 (35.17)	1156.0 (35.63)	1855.0 (36.49)
RCH-708 Bt	495.0 (37.81)	1236.0 (37.88)	2056.0 (39.89)	548.0 (36.94)	1336.0 (37.48)	2126.0 (39.06)	521.5 (37.38)	1286.0 (37.68)	2091.0 (39.48)
Bunny Bt	445.0 (36.46)	1120.0 (36.48)	1769.0 (37.74)	476.0 (37.52)	1164.0 (36.65)	1856.0 (37.33)	460.5 (36.99)	1142.0 (36.57)	1812.5 (37.54)
DHH-11	332.0 (34.95)	991.0 (35.63)	1565.0 (35.95)	443.0 (35.44)	1176.0 (38.28)	1895.0 (39.88)	387.5 (35.20)	1083.5 (36.96)	1730.0 (37.92)
SEm±	26.00 (1.71)	54.08 (2.27)	55.64 (1.64)	27.02 (1.55)	49.94 (1.72)	65.94 (1.39)	21.85 (1.41)	44.09 (1.41)	31.80 (1.03)
CD at 5%	77.24 (NS)	160.67 (NS)	165.32 (NS)	80.28 (NS)	148.39 (NS)	195.91 (NS)	64.93 (NS)	130.98 (NS)	94.48 (NS)
CV (%)	9.94 (8.09)	8.18 (10.66)	5.13 (7.52)	8.94 (7.26)	6.75 (7.97)	5.63 (6.22)	7.75 (6.65)	6.29 (6.55)	4.66 (4.66)

DAS – Days after sowing; *Figures in parentheses indicate manganese content (ppm)

Significant differences were observed at different growth stages among different cotton genotypes.

At 60 DAS, significantly higher uptake of manganese was recorded with MRC-6918 Bt (579.00 g/ha) and was found on par with RCH-708 Bt (521.5 g/ha) and Bunny BG-II (533.00 g/ha).

At 90 DAS, significantly higher uptake of manganese was recorded with MRC-6918 Bt (1378.50 g/ha) and was on par with RCH-708 Bt (1286.00 g/ha).

At 120 DAS, significantly higher uptake of manganese was noticed with MRC-6918 Bt (2199.50 g/ha) over rest of the other cotton genotypes.

4.1.6.21b Manganese content

The data on manganese content was found to be non-significant at different growth sages among different cotton genotypes.

4.1.6.22a Zinc uptake (g/ha)

The data pertaining to uptake of zinc (g/ha) and zinc content among different cotton genotypes at different growth stages is presented in Table 45.

Genotypes exhibited significant differences at different growth stages among different cotton genotypes.

At 60 DAS, significantly higher uptake of zinc (151.00 g/ha) with MRC-6918 Bt over Mallika Bt (134.00 g/ha), RCH-2 Bt and Bunny BG-II (123.50 g/ha) and DHH-11 non-Bt (108.00 g/ha).

At 90 DAS, significantly higher uptake of zinc was recorded with MRC-6918 Bt (365.5 g/ha) and was found on par with RCH-708 Bt (347.90 g/ha) and Mallika Bt (342.50 g/ha).

At 120 DAS, significantly higher uptake of zinc was recorded with MRC-6918 Bt (590.00 g/ha) over rest of the other cotton genotypes.

4.1.6.22b Zinc content (ppm)

The data pertaining to zinc content showed non-significant at different growth stages among different cotton genotypes.

4.1.7 Quality parameters

4.1.7.1 2.5% span length

Genotypes differed significantly with respect to 2.5% span length in red soil (Table 46). All the Bt cotton genotypes recorded significantly higher 2.5% span length than DHH-11 (29.00 mm).

4.1.7.2 Fibre fineness

There were significant differences among the cotton genotypes with respect to fibre fineness (Table 46) in red soil. DHH-11 non-Bt recorded significantly higher fibre fineness (4.60 micronaire) than all other cotton genotypes.

4.1.7.3 Fibre maturity

Genotypes differed significantly with respect to fibre maturity in red soil (Table 46). DHH-11 non-Bt recorded significantly higher fibre maturity (0.76) than other cotton genotypes except RCH-2 Bt BG-II.

4.1.7.4 Bundle strength

There were significant differences among the cotton genotypes with respect to bundle strength (Table 46) in red soil.

MRC-6918 Bt recorded significantly higher bundle strength (27.35 g/tex) than the other cotton genotypes.

Table 45: Zinc uptake (g/ha) and content (ppm) of different cotton genotypes at different growth stages in red soil

Treatments (genotypes)	2008-09			2009-10			Pooled		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
RCH-2 Bt	118.0 (9.89)	298.0 (9.79)	458.0 (9.96)	129.0 (10.07)	341.0 (10.13)	495.0 (10.14)	123.5 (9.98)	319.5 (9.96)	476.5 (10.05)
RCH-2 BG-II Bt	126.0 (9.98)	306.0 (9.82)	489.0 (10.06)	149.0 (10.20)	346.0 (10.57)	541.0 (10.69)	137.5 (10.09)	326.0 (10.20)	515.0 (10.38)
Bunny Bt 2 (BG-II)	127.0 (9.97)	296.0 (9.98)	512.0 (10.03)	152.0 (10.29)	361.0 (10.40)	561.0 (10.51)	139.5 (10.13)	328.5 (10.19)	536.5 (10.27)
JK-99 Bt	123.0 (9.57)	298.0 (9.38)	498.0 (9.39)	146.0 (10.16)	369.0 (10.35)	578.0 (10.47)	134.5 (9.87)	333.5 (9.87)	538.0 (9.93)
Mallika Bt	126.0 (10.11)	309.0 (9.97)	526.0 (10.09)	142.0 (10.26)	376.0 (10.33)	569.0 (10.40)	134.0 (10.19)	342.5 (10.15)	547.5 (10.25)
MRC-6918 Bt	127.2 (9.46)	336.0 (10.05)	565.0 (10.27)	175.0 (10.53)	395.0 (10.65)	615.0 (10.70)	151.0 (10.00)	365.5 (10.35)	590.0 (10.49)
Brahma Bt	132.0 (10.56)	336.0 (9.89)	501.0 (10.14)	146.0 (10.17)	316.0 (10.48)	551.0 (10.54)	139.0 (10.37)	326.0 (9.89)	526.0 (10.34)
RCH-708 Bt	134.0 (10.23)	326.0. (9.99)	524.0 (10.17)	152.0 (10.25)	369.0 (10.35)	568.0 (10.44)	143.0 (10.24)	347.5 (10.17)	546.0 (10.31)
Bunny Bt	119.0 (9.75)	297.0 (9.67)	469.0 (10.01)	128.0 (10.09)	326.0 (10.26)	512.0 (10.30)	123.5 (9.92)	311.5 (9.97)	490.5 (10.16)
DHH-11	87.0 (9.16)	268.0 (9.63)	421.0 (9.67)	129.0 (10.32)	305.0 (10.42)	501.0 (10.54)	108.0 (9.74)	286.5 (10.03)	461.0 (10.11)
SEm±	5.33 (0.29)	10.61 (0.21)	19.69 (0.07)	8.26 (0.39)	8.16 (0.67)	18.30 (0.39)	5.62 (0.25)	9.00 (0.36)	13.93 (0.19)
CD at 5%	15.85 (NS)	31.52 (NS)	58.51 (0.22)	24.55 (NS)	NS (NS)	54.38 (NS)	16.71 (NS)	26.73 (NS)	41.40 (NS)
CV (%)	7.58 (5.08)	5.99 (3.64)	6.87 (1.28)	9.88 (6.56)	4.06 (11.19)	5.77 (6.40)	7.30 (4.30)	4.74 (6.18)	4.62 (3.29)

DAS – Days after sowing; *Figures in parentheses indicate zinc content (ppm)

Table 46: Fibre quality parameters of Bt and non-Bt cotton genotypes in red soil

Treatments (genotypes)	2008-09				2009-10				Pooled			
	2.5% span length (mm)	Fibre fineness (micronaire)	Fibre maturity (maturity ratio)	Bundle strength (g/tex)	2.5% span length (mm)	Fibre fineness (micronaire)	Fibre maturity (maturity ratio)	Bundle strength (g/tex)	2.5% span length (mm)	Fibre fineness (micronaire)	Fibre maturity (maturity ratio)	Bundle strength (g/tex)
RCH-2 Bt	32.50	3.80	0.69	23.00	31.2	4.30	0.73	23.30	31.85	4.05	0.71	23.15
RCH-2 BG-II	33.10	4.30	0.77	23.10	31.2	4.20	0.72	22.70	32.15	4.25	0.75	22.90
Bunny BG-II	35.00	3.40	0.65	23.10	34.4	3.40	0.63	23.90	34.70	3.40	0.64	23.50
JK-99 Bt	28.60	4.90	0.78	23.00	33.2	3.60	0.66	23.50	30.90	4.25	0.72	23.25
Mallika Bt	31.40	4.30	0.72	23.40	32.7	3.80	0.69	23.30	32.05	4.05	0.71	23.35
MRC-6918 Bt	35.60	3.60	0.67	26.80	35.7	3.30	0.64	27.90	35.65	3.45	0.66	27.35
Brahma Bt	37.00	3.90	0.69	22.40	35.3	3.40	0.63	23.80	36.15	3.65	0.66	23.10
RCH-708 Bt	34.40	3.70	0.67	24.80	38.4	3.70	0.68	24.00	36.40	3.70	0.68	24.40
Bunny Bt	31.80	4.40	0.77	23.00	33.9	3.70	0.68	24.20	32.85	4.05	0.73	23.60
DHH-11	29.40	4.60	0.76	24.70	28.6	4.60	0.75	22.70	29.00	4.60	0.76	23.70
SEm±	0.57	0.07	0.01	5.19	0.57	0.06	0.01	0.55	0.42	0.05	0.01	0.45
CD at 5%	1.69	0.20	0.02	NS	1.69	0.18	0.02	1.63	1.24	0.14	0.02	1.34
CV (%)	2.99	2.79	1.26	4.21	2.94	2.76	1.63	3.96	2.18	2.10	1.97	3.29

4.1.8 Population of microorganisms in red soil

4.1.8.1 Population of methylotrophs

Data on population of methylotrophs by different cotton genotypes at different stages presented in Table 47. Genotypes exhibited significant differences at flowering and at harvest stages.

At both stages of flowering and harvest, significantly higher population of methylotrophs (13×10^2/g and 1×10^2/g soil, respectively) was recorded in RCH-2 Bt as compared to all other cotton genotypes and non-Bt DHH-11.

4.1.8.2 Population of P-solubilizers

The data on population of P-solubilizers by different cotton genotypes at different growth stages presented in Table 47.

There were significant differences among different cotton genotypes at flowering and at harvest stages.

Significantly higher population of P-solubilizers was recorded in JK-99 Bt as compared to all other cotton genotypes at flowering stage.

At harvest stage, significantly higher population of P-solubilizers was recorded (11×10^4/g soil) in DHH-11 as compared to all other cotton genotypes.

4.1.8.3 Population of *Azospirillum*

The data on population of *Azospirillum* by different cotton genotypes at different growth stages presented in Table 47.

Genotypes exhibited significant differences at different stages.

Significantly higher population of *Azospirillum* (1.2×10^6/g soil) was recorded in RCH-2 BG-II Bt and found on par with Brahma Bt (1.1×10^6/g soil) and RCH-708 Bt (1.1×10^6/g soil) at flowering stage. At harvest stage, significantly higher population of *Azospirillum* was recorded in RCH-708 Bt (0.68×10^6/g soil) compared to all other cotton genotypes and DHH-11 non-Bt (0.27×10^6/g soil). Least count was observed in Bunny Bt (0.01×10^6/g)

4.1.9 Seed cotton yield on mother and baby trials in red soil

The data on seed cotton yield of different genotypes in mother and baby trials in red soil presented in Table 48.Higher yield (1728 kg/ha) was recorded in baby trial with Bunny BG-II and differed significantly with mother trial (2196 kg/ha), RCH-2 Bt (1661 kg/ha), JK-99 (1590 kg/ha), DHH-11 (1262 kg/ha) and Brahma Bt (1580 kg/ha) were found on par with respective mother trial.

4.2 Soil properties and seed cotton yield in black and red soils of Bailhongal taluk

Table 49 to 59 represents soil nutrient status and seed cotton yield levels of individual farmers in different villages under black and red soils of Bailhongal taluk.

4.2.1 Soil reaction (pH)

The data on soil reaction in black and red soils is presented in Table 60 and 61.

The pH of the soil sample in the Govankoppa village ranged from 7.31 to 7.81 with a mean value of 7.51, Mugabasava village with a pH of 6.21 to 8.02 with a mean of 7.50, Belawadi village with a pH of 7.20 to 8.00 with a mean of 7.57, Budihala village with a pH of 7.05 to 7.62 with a mean of 7.27, Chikkabellikatti with a pH of 6.47 to 7.55 and a mean of 7.10, Doddawada village with a pH of 7.03 to 7.52 with a mean of 7.28, Udikeri village with a pH ranged from 7.14 to 7.45 with a mean of 7.53, Sampagaon village with a pH ranged from 7.03 to 8.02 with mean value of 7.53, Bavihal village with a pH ranged from 7.34 to 8.01 with a mean of 7.56, Turamari village with a pH of 7.43 to 7.93 with a mean of 7.66 and in Neginahal with a pH ranged from 6.53 to 8.64 with a mean of 7.72.

Table 47: Population of microorganisms in the rhizosphere of Bt cotton grown red soil at different stages

Treatments	Flowering			At harvest		
	Methylotrophs (× 10^2/g soil)	P solubilizers (× 10^3/g soil)	*Azospirillum* (× 10^6/g soil)	Methylotrophs (× 10^2/g soil)	P solubilizers (× 10^3/g soil)	*Azospirillum* (× 10^6/g soil)
RCH-2 Bt	13.00	13.00	0.57	1.00	8.00	0.49
RCH-2 BG-II	2.00	35.00	1.20	1.00	9.00	0.17
Bunny BG-II	1.00	8.00	0.33	0.20	7.00	0.33
JK-99 Bt	2.00	38.00	0.47	0.10	6.00	0.22
Mallika Bt	4.00	28.00	0.47	0.10	3.00	0.20
MRC-6918 Bt	6.00	36.00	0.27	0.10	8.00	0.27
Brahma Bt	1.00	15.00	1.10	0.10	8.00	0.11
RCH-708 Bt	1.00	25.00	1.10	0.20	6.00	0.68
Bunny Bt	1.00	9.00	0.39	0.40	7.00	0.01
DHH-11	2.00	13.00	0.17	0.10	11.00	0.03
SEm±	0.20	0.61	0.04	0.02	0.60	0.02
CD at 5%	0.59	1.80	0.12	0.06	1.78	0.05
CV (%)	10.47	4.77	11.26	10.95	14.22	12.58

Table 48: Seed cotton yield of different genotypes in mother and baby trials in red soil

Treatments	2008				2009				Pooled			
	Yield (kg/ha)		Caclc. 't' value	Signi-ficance	Yield (kg/ha)		Caclc. 't' value	Signi-ficance	Yield (kg/ha)		Caclc. 't' value	Signi-ficance
	Mother trial	Baby trial			Mother trial	Baby trial			Mother trial	Baby trial		
RCH-2 Bt	1875	1535	2.89	NS	2101	1787	2.93	NS	1988	1661	3.01	NS
RCH-2 BG-II Bt	1916	1698	4.32	*	2264	1700	5.63	*	2090	1699	5.10	*
Bunny BG-II Bt	2056	1717	5.42	*	2336	1739	11.74	**	2196	1728	8.90	*
JK-99 Bt	1653	1600	0.92	NS	1822	1600	3.93	NS	1737	1590	2.39	NS
Mallika Bt	1697	1650	0.40	NS	2036	1650	5.95	*	1866	1654	7.15	*
MRC-6918 Bt	2269	1582	5.47	*	2245	1613	5.54	*	2257	1597	4.95	*
Brahma Bt	1584	1535	0.81	NS	1715	1558	3.67	NS	1649	1580	2.98	NS
RCH-708 Bt	1821	1701	3.37	NS	2236	1713	4.42	*	2028	1707	4.40	*
Bunny Bt	1847	1608	4.00	NS	2145	1621	4.69	*	1996	1615	14.5	**
DHH-11	1418	1272	1.05	NS	1574	1250	5.38	*	1496	1262	2.35	NS

Table 't' value – 4.03 NS – non-significant * - Significant at 5% level ** - Significant at 1% level

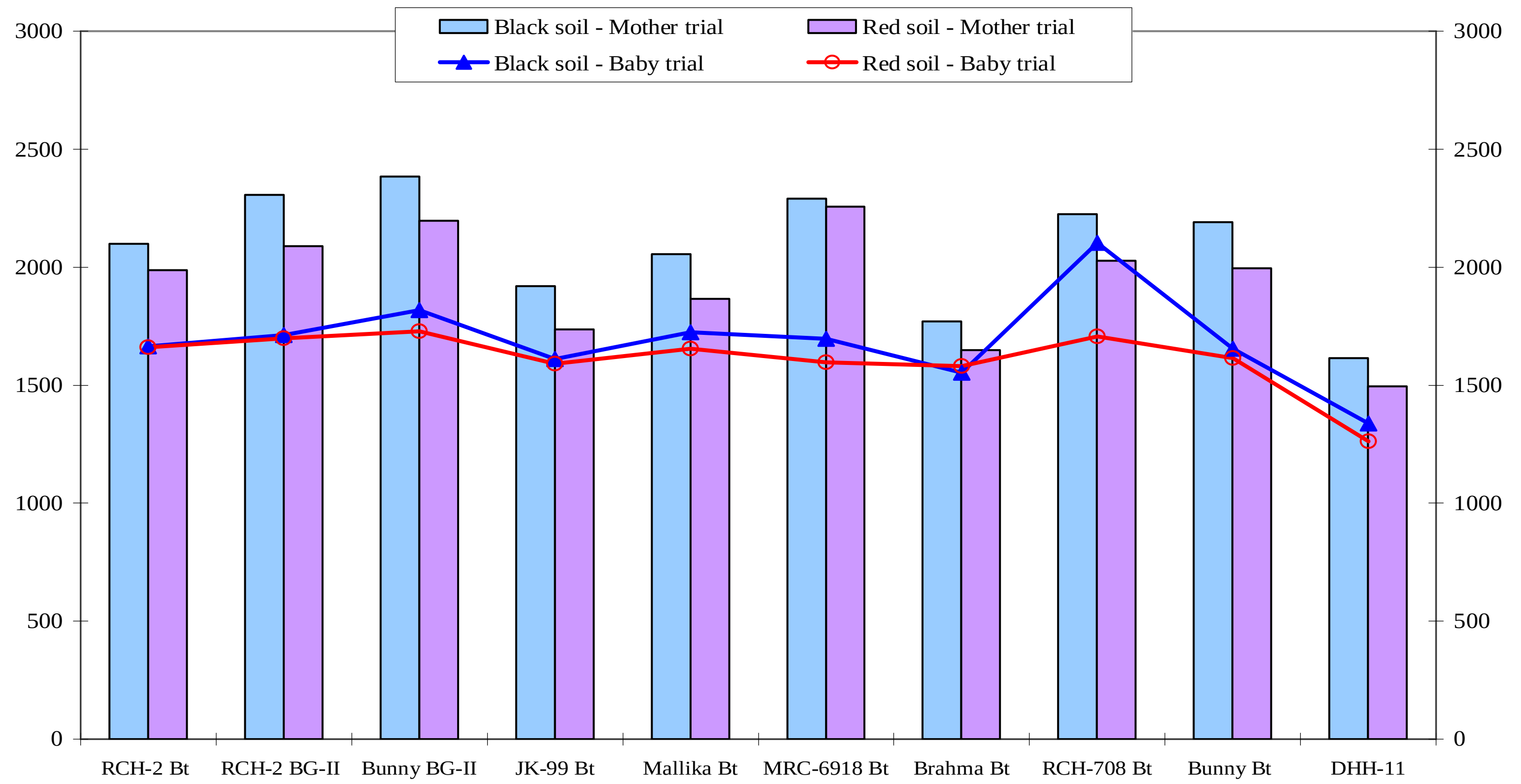

Fig. 7: Seed cotton yield of different genotypes in black and red soils under both mother and baby trials

Fig. 7: Seed cotton yield of different genotypes in black and red soils under both mother and baby trials

The pH of the soil samples in the red soils ranged from 6.1 to 7.70 with a mean value of 6.52, 5.47 to 6.69 with a mean value of 5.98, 5.31 to 7.19 with a mean value of 6.50, 7.77 to 8.44 with a mean value of 8.11, 6.17 to 7.64 with a mean values of 6.99, 7.00 to 8.20 with a mean value of 7.60, 7.30 to 8.26 with a mean value of 7.76, 7.53 to 8.36 with a mean value of 7.93, 6.52 to 7.99 with a mean value of 7.33, 6.45 to 7.26 with a mean value of 6.98, 6.97 to 7.24 with a mean value of 7.05, 7.40 to 8.45 with a mean value of 7.97 and 6.86 to 8.28 with a mean value of 7.59 in the villages Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidargaddi, Jallikoppa, Aaravalli, Patyala, Khodhanpur, Sangolli, Garjur and Savatagi, respectively.

4.2.2 Electrical conductivity (EC)

The data on electrical conductivity in black and red soils of Bailhongal taluk is presented in Table 60 and 61, respectively.

The electrical conductivity of the black soils ranged from 0.13 to 0.27 with a mean of 0.20, 0.14 to 0.32 with a mean value of 0.23, 0.14 to 0.31 with a mean value of 0.22, 0.14 to 0.35 with a mean value of 0.24, 0.13 to 0.32 with a mean value of 0.22, 0.15 to 0.33 with a mean value of 0.21, 0.17 to 0.33 with a mean value of 0.26, 0.15 to 0.28 with a mean value of 0.21, 0.18 to 0.28 with a mean value of 0.23 and 0.16 to 0.28 with a mean value of 0.21 in the villages Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawada, Udikeri, Sampagaon, Bavihal, Turamari and Neginahal, respectively.

The electrical conductivity of the red soils ranged from 0.11 to 0.41 with a mean value of 0.25, 0.15 to 0.31 with a mean value of 0.19, 0.11 to 0.38 with a mean value of 0.23, 0.14 to 0.64 with a mean value of 0.33, 0.12 to 0.31 with a mean value of 0.21, 0.12 to 0.41 with a mean value of 0.28, 0.14 to 0.41 with a mean value of 0.26, 0.27 to 0.36 with a mean value of 0.31, 0.31 to 0.37 with a mean value of 0.34, 0.15 to 0.36 with a mean value of 0.27, 0.18 to 0.35 with a mean value of 0.21 and 0.20 to 0.35 with a mean value of 0.25 in the villages of Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidargaddi, Jallikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi, respectively.

4.2.3 Organic carbon

The results of the organic carbon status in black and red soils of Bailhongal taluk is presented in Table 60 and 61, respectively.

The organic carbon status in black soils ranged from 0.48 to 0.81 with a mean value of 0.65, 0.43 to 0.83 with a mean value of 0.67, 0.48 to 0.87 with a mean value of 0.67, 0.47 to 0.86 with a mean value of 0.63, 0.44 to 0.66 with a mean value of 0.56, 0.41 to 0.72 with a mean value of 0.55, 0.45 to 0.82 with a mean value of 0.62, 0.45 to 0.87 with a mean value of 0.69, 0.51 to 0.83 with a mean value of 0.69, 0.48 to 0.87 with a mean value of 0.64 in the villages of Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawada, Udikeri, Sampagaon, Bavihal, Turamari and Neginahal, respectively.

The organic carbon status in red soils of Siddasamudra ranged form 0.22 to 0.35 with a mean value of 0.26. Hirebellikatti with a organic carbon status ranged from 0.20 to 0.29 with a mean value of 0.23, Kadasagatti with a organic carbon status ranged from 0.21 to 0.34 with a mean value of 0.28, Gudikatti with organic carbon status ranged from 0.43 to 0.49 with a mean value of 0.46, Budarkatti with organic carbon status ranged from 0.23 to 0.43 with a mean value of 0.34, Bidargaddi with organic carbon status ranged from 0.34 to 0.48 with a mean value of 0.43, Jallikoppa with organic carbon status ranged from 0.36 to 0.47 with a mean value of 0.43, Aaravalli with organic carbon status ranged from 0.42 to 0.48 with a mean value of 0.45, Patyal with organic carbon status ranged from 0.30 to 0.45 with a pH of 0.38. Khodhanpur with organic carbon status ranged from 0.26 to 0.35 with a mean value of 0.32, Sangolli with organic carbon status ranged from 0.31 to 0.32 with a mean value of 0.32, Garjur with organic carbon status ranged from 0.39 to 0.49 with a mean value of 0.44 and Savatagi with organic carbon status ranged from 0.32 to 0.47 with a mean value of 0.40.

4.2.4 Available nitrogen (kg/ha)

The data on available nitrogen in black and red soils of Bailhongal taluk is presented in Table 62, 63 and Fig. 8, 9, respectively.

Table 49: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in black soil of Govankoppa and Mugabasav villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Govankoppa											
1	7.41	0.25	0.78	185	18	523	29.20	1.94	0.30	7.49	0.39	17.0
2	7.52	0.27	0.51	154	39	395	12.30	1.41	0.42	3.37	0.36	16.0
3	7.63	0.22	0.63	189	19	614	2.70	1.90	0.35	2.35	0.45	18.0
4	7.31	0.16	0.48	103	35	529	16.20	1.40	0.47	6.04	0.29	19.0
5	7.72	0.23	0.80	200	28	363	13.20	1.66	5.89	1.16	0.48	20.0
6	7.81	0.21	0.63	165	22	388	12.90	1.95	0.35	6.35	0.21	16.0
7	7.45	0.18	0.48	182	23	335	3.20	1.74	0.94	2.86	0.87	17.0
8	7.32	0.16	0.81	187	26	393	9.50	1.53	0.86	2.28	0.94	16.0
9	7.43	0.13	0.75	202	16	392	9.80	1.70	0.98	3.82	0.73	15.0
10	7.51	0.14	0.65	127	28	563	14.20	1.43	2.19	9.81	0.94	16.0
Mean	**7.51**	**0.20**	**0.65**	**169.40**	**25.40**	**449.50**	**12.32**	**1.67**	**1.27**	**4.55**	**0.57**	**17.0**
Min.	7.31	0.13	0.48	103.00	16.00	335.00	2.70	1.40	0.30	1.16	0.21	15.0
Max.	7.81	0.27	0.81	202.00	39.00	614.00	29.20	1.95	5.89	9.81	0.94	20.0
	Mugabasava											
1	6.21	0.17	0.43	126	23	519	13.80	1.16	0.31	3.50	0.30	18.0
2	7.70	0.32	0.83	205	31	365	14.60	0.99	0.22	1.21	0.33	16.0
3	7.07	0.31	0.66	215	15	592	8.10	0.96	0.31	4.06	0.31	17.0
4	7.58	0.20	0.63	139	23	384	9.80	0.95	0.31	3.72	0.30	18.0
5	7.59	0.14	0.65	126	28	553	8.50	0.75	3.74	3.30	0.29	19.0
6	7.74	0.23	0.54	216	25	325	8.10	1.16	0.31	3.14	0.31	15.0
7	7.62	0.22	0.67	183	19	604	9.50	1.12	0.22	3.09	0.35	16.0
8	7.81	0.25	0.80	248	20	381	13.50	1.10	0.32	3.01	0.37	17.0
9	7.66	0.23	0.67	181	15	580	12.90	0.98	0.38	3.22	0.32	18.0
10	8.02	0.25	0.83	231	19	415	14.10	0.90	0.57	3.52	0.30	20.0
Mean	**7.50**	**0.23**	**0.67**	**187.00**	**21.80**	**471.80**	**11.29**	**1.01**	**0.67**	**3.18**	**0.32**	**17.4**
Min.	6.21	0.14	0.43	126.00	15.00	325.00	8.10	0.75	0.22	1.21	0.29	15.0
Max.	8.02	0.32	0.83	248.00	31.00	604.00	14.60	1.16	3.74	4.06	0.37	20.0

Table 50: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in black soil of Belawadi and Budihal villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Belawadi											
1	7.20	0.31	0.48	163	18	406	7.70	1.80	0.41	3.41	0.58	16.0
2	7.30	0.18	0.81	189	26	389	7.80	1.79	0.33	3.37	0.50	17.0
3	7.50	0.14	0.65	121	25	513	8.20	1.73	0.39	3.96	0.52	18.0
4	7.60	0.24	0.58	169	18	605	7.70	1.80	0.29	3.59	0.41	18.0
5	7.70	0.25	0.61	218	27	325	2.60	1.48	0.18	1.97	0.40	19.0
6	7.80	0.23	0.59	209	28	318	2.80	1.80	0.42	3.32	0.59	18.0
7	7.90	0.20	0.87	206	23	453	3.60	1.83	0.32	3.52	0.41	16.0
8	8.00	0.23	0.83	232	18	415	8.20	1.77	0.39	3.98	0.54	15.0
9	7.40	0.28	0.51	138	16	381	7.10	1.73	0.28	3.11	0.52	14.0
10	7.30	0.18	0.81	179	32	378	7.90	1.81	0.25	3.73	0.61	20.0
Mean	**7.57**	**0.22**	**0.67**	**182.40**	**23.10**	**418.30**	**6.36**	**1.75**	**0.33**	**3.40**	**0.51**	**17.1**
Min.	7.20	0.14	0.48	121.00	16.00	318.00	2.60	1.48	0.18	1.97	0.40	15.0
Max.	8.00	0.31	0.87	232.00	32.00	605.00	8.20	1.83	0.42	3.98	0.61	20.0
	Budihal											
1	7.20	0.32	0.47	148	28	410	11.00	0.63	0.19	0.56	0.25	17.0
2	7.10	0.28	0.65	241	19	481	10.00	0.77	0.21	0.89	0.30	16.0
3	7.20	0.35	0.56	163	24	378	7.40	0.82	0.21	0.97	0.36	15.0
4	7.30	0.19	0.86	101	26	424	13.40	0.90	0.21	0.96	0.31	18.0
5	7.13	0.14	0.56	131	25	432	12.20	0.89	3.61	1.09	0.35	17.0
6	7.22	0.34	0.48	143	28	408	10.80	0.81	0.22	1.08	0.27	20.0
7	7.34	0.18	0.82	184	22	389	11.50	0.92	0.21	1.02	0.31	20.0
8	7.51	0.14	0.63	127	26	533	12.80	0.88	0.20	1.08	0.32	18.0
9	7.62	0.17	0.53	212	28	521	13.20	0.91	0.22	1.56	0.39	17.0
10	7.05	0.21	0.75	152	26	333	12.90	0.74	0.19	0.99	0.40	16.0
Mean	**7.27**	**0.23**	**0.63**	**160.20**	**25.20**	**430.90**	**11.52**	**0.83**	**0.55**	**1.02**	**0.32**	**17.4**
Min.	7.05	0.14	0.47	101.00	19.00	333.00	7.40	0.63	0.19	0.56	0.25	15.0
Max.	7.62	0.35	0.86	241.00	28.00	533.00	13.40	0.92	3.61	1.56	0.40	20.0

Table 51: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in black soil of Chikkabellikatti and Doddawada villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Chikkabellikatti											
1	7.55	0.22	0.61	129	21	363	11.20	1.57	0.49	2.44	0.35	16.0
2	7.36	0.33	0.66	192	26	451	12.60	1.67	0.52	2.66	0.34	14.0
3	6.63	0.14	0.49	132	20	353	12.40	1.30	2.27	1.38	0.54	15.0
4	7.28	0.33	0.45	145	16	410	13.20	1.61	0.60	2.79	0.35	16.0
5	7.14	0.15	0.62	112	17	398	9.80	1.63	0.67	4.50	0.42	17.0
6	7.31	0.33	0.64	199	24	408	9.50	1.74	0.50	4.51	0.52	19.0
7	7.30	0.35	0.59	198	25	415	10.90	1.89	0.71	5.32	0.42	18.0
8	6.93	0.18	0.44	123	24	516	11.50	1.70	0.84	6.12	0.36	20.0
9	6.47	0.19	0.53	108	26	472	12.30	1.64	1.97	2.53	0.30	21.0
10	7.04	0.15	0.54	202	28	453	12.60	1.54	2.31	3.92	0.35	16.0
Mean	**7.10**	**0.24**	**0.56**	**154.00**	**22.70**	**423.90**	**11.60**	**1.63**	**1.09**	**3.62**	**0.39**	**17.2**
Min.	6.47	0.14	0.44	108.00	16.00	353.00	9.50	1.30	0.49	1.38	0.30	15.0
Max.	7.55	0.35	0.66	202.00	28.00	516.00	13.20	1.89	2.31	6.12	0.54	21.0
	Doddawada											
1	7.21	0.32	0.53	169	19	405	12.40	1.69	0.47	2.91	0.56	17.0
2	7.42	0.18	0.48	185	21	325	13.60	1.67	0.39	2.31	0.62	16.0
3	7.35	0.16	0.41	196	32	505	13.00	2.08	0.60	6.82	0.77	18.0
4	7.26	0.17	0.45	141	28	478	14.20	1.59	0.44	3.22	0.51	14.0
5	7.12	0.21	0.66	158	23	364	13.20	1.80	0.50	4.36	0.69	21.0
6	7.03	0.32	0.64	215	15	509	12.50	1.73	0.45	2.94	0.73	20.0
7	7.25	0.21	0.42	232	25	503	13.80	1.84	0.40	3.29	0.60	19.0
8	7.41	0.26	0.71	183	18	505	13.20	2.14	0.49	4.31	0.64	18.0
9	7.52	0.23	0.51	154	38	381	14.60	1.63	0.33	4.92	0.72	19.0
10	7.23	0.13	0.72	158	21	364	13.10	1.75	0.40	3.79	0.84	17.0
Mean	**7.28**	**0.22**	**0.55**	**179.10**	**24.00**	**433.90**	**13.36**	**1.79**	**0.45**	**3.89**	**0.67**	**17.9**
Min.	7.03	0.13	0.41	141.00	15.00	325.00	12.40	1.59	0.33	2.31	0.51	14.0
Max.	7.52	0.32	0.72	232.00	38.00	509.00	14.60	2.14	0.60	6.82	0.84	21.0

Table 52: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in black soil of Udikeri and Sampagaon villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
						Udikeri						
1	7.34	0.16	0.48	102	34	581	2.40	1.11	0.47	1.55	0.34	16.0
2	7.45	0.26	0.78	183	24	452	11.20	1.40	0.53	2.00	0.36	17.0
3	7.26	0.23	0.53	236	29	409	10.80	1.16	0.41	1.30	0.28	20.0
4	7.38	0.21	0.81	182	22	380	11.00	1.10	0.33	1.22	0.26	19.0
5	7.21	0.33	0.45	143	18	410	12.00	1.14	0.43	1.15	0.25	18.0
6	7.14	0.15	0.75	199	28	346	2.90	1.15	0.43	1.51	0.36	18.0
7	7.35	0.18	0.82	186	23	358	3.60	1.33	0.51	2.01	0.31	16.0
8	7.28	0.23	0.68	250	12	431	4.90	1.23	0.41	1.21	0.30	17.0
9	7.31	0.16	0.48	196	32	489	5.60	1.17	0.31	1.22	0.27	18.0
10	7.22	0.18	0.45	141	26	463	11.90	1.14	0.41	1.15	0.25	19.0
Mean	**7.29**	**0.21**	**0.62**	**181.80**	**24.80**	**431.90**	**7.63**	**1.19**	**0.43**	**1.43**	**0.30**	**17.8**
Min.	7.14	0.15	0.45	102.00	12.00	346.00	2.40	1.10	0.31	1.15	0.25	16.0
Max.	7.45	0.33	0.82	250.00	34.00	581.00	12.00	1.40	0.53	2.01	0.36	20.0
						Sampagaon						
1	7.03	0.32	0.65	206	15	581	4.20	4.77	0.33	5.65	1.49	17.0
2	7.24	0.22	0.61	125	22	415	7.40	1.19	1.10	0.88	0.36	18.0
3	7.76	0.31	0.81	200	28	360	6.30	1.23	1.22	0.53	0.45	19.0
4	7.87	0.25	0.82	246	25	380	5.90	1.65	1.62	0.70	0.65	18.0
5	7.91	0.21	0.87	202	23	469	4.80	1.83	1.73	0.93	0.90	17.0
6	7.22	0.33	0.45	143	16	410	3.70	1.75	0.57	0.90	1.32	17.0
7	7.36	0.17	0.79	182	21	390	8.10	1.63	0.83	4.39	1.59	16.0
8	7.65	0.22	0.67	181	15	518	7.40	2.45	0.73	3.45	1.29	17.0
9	8.02	0.23	0.81	215	18	421	6.90	3.83	0.85	3.98	1.16	18.0
10	7.23	0.33	0.45	143	16	410	5.80	4.19	0.63	3.65	0.98	19.0
Mean	**7.53**	**0.26**	**0.69**	**184.30**	**19.90**	**435.40**	**6.05**	**2.45**	**0.96**	**2.51**	**1.02**	**17.6**
Min.	7.03	0.17	0.45	125.00	15.00	360.00	3.70	1.19	0.33	0.53	0.36	16.0
Max.	8.02	0.33	0.87	246.00	28.00	581.00	8.10	4.77	1.73	5.65	1.59	19.0

Table 53: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in black soil of Bavihal, Turamari and Neginahal villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Bavihal											
1	7.34	0.18	0.82	189	22	506	10.20	3.99	0.19	11.07	0.58	15.0
2	7.45	0.28	0.51	138	25	406	9.60	1.65	0.20	0.70	0.36	16.0
3	7.51	0.15	0.63	121	19	393	8.60	1.65	0.27	0.73	0.32	18.0
4	7.62	0.23	0.54	216	25	303	9.30	1.75	0.26	0.97	0.64	19.0
5	7.76	0.21	0.51	205	29	350	5.90	1.32	0.33	0.84	0.83	18.0
6	7.41	0.26	0.78	183	19	345	8.10	1.43	0.42	12.35	0.76	21.0
7	7.52	0.21	0.62	141	22	383	6.50	1.53	0.53	14.65	0.65	20.0
8	7.64	0.17	0.56	215	23	520	4.30	1.63	0.63	13.39	0.73	19.0
9	8.01	0.23	0.83	205	18	416	2.10	2.98	0.73	14.61	0.98	18.0
10	7.34	0.18	0.78	186	19	383	1.90	3.23	0.82	12.82	0.43	17.0
Mean	**7.56**	**0.21**	**0.66**	**179.90**	**22.10**	**390.50**	**6.65**	**2.12**	**0.44**	**8.21**	**0.63**	**18.1**
Min.	7.34	0.15	0.51	121.00	18.00	303.00	1.90	1.32	0.19	0.70	0.32	15.0
Max.	8.01	0.28	0.83	216.00	29.00	520.00	10.20	3.99	0.82	14.65	0.98	21.0

Contd……

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Turamari											
1	7.43	0.18	0.51	192	25	328	6.0	1.51	9.78	6.13	0.45	16.0
2	7.62	0.24	0.68	191	17	593	4.8	4.61	6.90	14.40	0.83	16.0
3	7.51	0.28	0.61	128	23	392	4.2	1.98	6.53	6.98	0.74	18.0
4	7.82	0.25	0.83	250	25	381	3.9	2.38	7.43	9.87	0.65	19.0
5	7.93	0.21	0.86	203	27	425	5.3	3.52	8.53	9.65	0.53	19.0
Mean	**7.66**	**0.23**	**0.69**	**192.8**	**23.4**	**423**	**4.84**	**2.80**	**7.84**	**9.40**	**0.64**	**17.6**
Min.	7.43	0.18	0.51	128	17	328	3.9	1.51	6.53	6.13	0.45	16.0
Max.	7.93	0.28	0.86	250	27	593	6.0	4.61	9.78	14.40	0.83	19.0
	Neginahal											
1	8.64	0.26	0.70	249	30	460	15.6	1.51	0.48	3.72	0.52	18.0
2	6.53	0.18	0.54	108	24	470	12.6	2.65	1.82	13.01	0.66	19.0
3	8.22	0.28	0.61	203	26	400	12.3	1.99	1.74	5.78	0.49	17.0
4	7.97	0.20	0.87	205	23	450	13.8	2.53	1.63	6.54	0.59	17.0
5	7.20	0.16	0.48	153	22	490	14.8	1.90	0.48	9.63	0.61	20.0
Mean	**7.72**	**0.21**	**0.64**	**183.6**	**25.0**	**454**	**13.82**	**2.12**	**1.23**	**7.73**	**0.57**	**18.2**
Min.	6.53	0.16	0.48	108	22	400	12.3	1.51	0.48	3.71	0.49	17
Max.	8.64	0.28	0.87	249	30	490	15.6	2.64	1.82	13.01	0.66	20

Table 54: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in red soils of Siddasamudra and Hirebellikatti villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Siddasamudra											
1	7.70	0.23	0.35	196	12	288	3.00	3.75	3.08	22.73	0.60	13.0
2	7.00	0.20	0.30	168	12	384	3.90	3.12	2.91	21.07	0.59	12.0
3	6.63	0.11	0.28	167	13	408	4.80	3.66	3.00	22.20	0.58	11.0
4	6.53	0.26	0.26	154	19	480	3.10	3.51	2.90	19.01	0.56	12.0
5	6.35	0.21	0.25	176	16	336	3.20	3.70	3.14	22.13	0.57	13.0
6	6.24	0.21	0.24	152	15	456	3.30	3.52	2.90	20.01	0.55	14.0
7	6.26	0.22	0.25	260	21	552	3.80	3.12	2.92	21.07	0.59	15.0
8	6.18	0.23	0.23	154	19	528	4.20	3.12	2.96	21.09	0.61	12.0
9	6.10	0.15	0.22	145	17	456	4.30	3.43	3.00	22.10	0.57	13.0
10	6.19	0.13	0.23	134	21	480	4.50	3.49	3.01	22.12	0.59	12.0
Mean	**6.52**	**0.19**	**0.26**	**170.60**	**16.63**	**436.80**	**3.81**	**3.44**	**2.98**	**21.35**	**0.58**	**12.7**
Min.	6.10	0.11	0.22	134.00	11.90	288.00	3.00	3.12	2.90	19.01	0.55	11.0
Max.	7.70	0.26	0.35	260.00	21.30	552.00	4.80	3.75	3.14	22.73	0.61	15.0
	Hirebellikatti											
1	6.04	0.15	0.22	161	17	384	2.80	0.95	14.20	14.65	0.32	10.0
2	6.69	0.17	0.29	181	17	216	2.20	1.65	11.33	21.96	0.32	12.0
3	6.40	0.19	0.26	195	18	240	3.60	3.21	15.61	5.10	0.57	13.0
4	5.93	0.16	0.22	170	12	148	8.00	2.36	3.45	19.40	0.49	12.0
5	5.54	0.17	0.20	184	15	168	2.80	2.14	14.44	23.10	0.59	11.0
6	5.85	0.19	0.21	170	20	240	2.60	0.91	12.10	23.50	0.31	13.0
7	6.10	0.26	0.22	165	15	172	2.50	1.69	10.10	16.90	0.59	12.0
8	5.47	0.16	0.20	154	13	264	3.20	3.20	12.51	21.70	0.57	13.0
9	6.21	0.21	0.23	165	17	240	3.60	3.21	13.10	16.10	0.54	12.0
10	5.60	0.16	0.22	128	17	216	3.30	2.91	15.61	17.30	0.49	10.0
Mean	**5.98**	**0.18**	**0.23**	**167.30**	**16.12**	**228.80**	**3.46**	**2.22**	**12.25**	**17.97**	**0.48**	**11.8**
Min.	5.47	0.15	0.20	128.00	12.30	148.00	2.20	0.91	3.45	5.10	0.31	10.0
Max.	6.69	0.26	0.29	195.00	19.60	384.00	8.00	3.21	15.61	23.50	0.59	13.0

Table 55: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in red soils of Kadasgatti and Gudikatti villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Kadasagatti											
1	5.85	0.18	0.21	128	23	172	2.00	2.52	2.71	18.44	0.77	11.0
2	5.31	0.19	0.22	139	17	168	2.40	2.94	4.96	24.10	1.00	10.0
3	6.64	0.16	0.31	159	15	124	4.80	2.08	5.19	4.50	0.49	12.0
4	7.00	0.23	0.33	190	15	124	2.20	2.56	2.86	3.40	0.50	10.0
5	7.07	0.15	0.34	170	18	172	3.00	2.45	2.77	7.20	0.47	11.0
6	6.67	0.11	0.29	104	13	456	3.20	2.59	2.93	12.34	0.57	12.0
7	6.12	0.19	0.22	101	13	172	4.40	2.08	2.94	20.10	0.48	13.0
8	6.22	0.20	0.24	187	22	192	2.40	2.83	6.10	34.56	1.00	12.0
9	7.19	0.21	0.33	167	24	148	2.00	2.49	2.80	28.10	0.78	13.0
10	6.96	0.18	0.32	173	14	168	2.80	2.23	3.10	10.83	0.41	12.0
Mean	**6.50**	**0.18**	**0.28**	**151.68**	**17.24**	**189.60**	**2.92**	**2.48**	**3.64**	**16.36**	**0.65**	**11.6**
Min.	5.31	0.11	0.21	100.80	12.80	124.00	2.00	2.08	2.71	3.40	0.41	10.0
Max.	7.19	0.23	0.34	189.60	23.60	456.00	4.80	2.94	6.10	34.56	1.00	13.0
	Gudikatti											
1	7.77	0.14	0.43	145	18	672	7.80	2.59	0.94	5.40	0.55	16.0
2	8.31	0.12	0.48	162	16	456	8.40	2.41	1.00	6.26	0.50	15.0
3	8.44	0.23	0.49	170	13	624	10.20	2.71	0.99	7.24	0.69	14.0
4	7.99	0.14	0.45	162	16	552	6.40	2.00	0.76	4.14	0.48	16.0
5	7.84	0.18	0.44	120	13	576	7.20	2.10	0.94	4.88	0.45	17.0
6	8.38	0.15	0.49	122	15	546	7.80	2.14	0.76	4.83	0.53	15.0
7	8.12	0.25	0.48	136	21	432	6.90	2.74	0.83	4.96	0.51	15.0
8	8.20	0.25	0.46	162	14	360	8.20	2.32	0.93	4.31	0.49	12.0
9	8.08	0.21	0.45	150	19	504	6.50	2.16	0.53	4.79	0.48	12.0
10	7.99	0.20	0.45	142	19	528	7.50	2.53	0.73	4.14	0.51	16.0
Mean	**8.11**	**0.18**	**0.46**	**147.04**	**16.40**	**525.00**	**7.69**	**2.37**	**0.84**	**5.10**	**0.52**	**14.8**
Min.	7.77	0.14	0.43	119.60	12.90	360.00	6.40	2.00	0.53	4.14	0.45	12.0
Max.	8.44	0.25	0.49	170.00	21.30	672.00	10.20	2.74	1.00	7.24	0.69	16.0

Table 56: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in red soils of Budarkatti and Bidargaddi villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Budarkatti											
1	6.40	0.26	0.29	156	22	216	2.2	2.85	3.91	13.70	0.40	15.0
2	7.64	0.23	0.43	164	22	512	4.3	2.98	1.19	2.93	1.23	14.0
3	6.84	0.25	0.32	120	14	552	4.1	2.68	2.13	1.97	0.73	16.0
4	7.52	0.21	0.41	190	16	552	4.8	3.58	1.83	6.80	0.97	15.0
5	6.60	0.12	0.30	115	15	504	4.8	2.51	0.33	2.58	0.88	13.0
6	6.17	0.25	0.23	116	23	552	2.8	2.78	1.83	2.98	0.23	12.0
7	7.30	0.20	0.37	176	16	240	3.5	2.98	2.51	3.02	0.13	15.0
8	7.02	0.14	0.32	140	15	216	4.4	2.75	3.11	5.31	1.28	16.0
9	7.13	0.18	0.33	153	17	292	4.2	3.42	2.16	4.21	0.98	17.0
10	7.26	0.19	0.35	153	16	456	4.6	2.64	0.98	6.20	1.23	15.0
Mean	**6.98**	**0.20**	**0.33**	**148.22**	**17.71**	**409.20**	**3.97**	**2.91**	**1.99**	**4.97**	**0.80**	**14.8**
Min.	6.17	0.12	0.23	114.80	14.30	216.00	2.20	2.51	0.33	1.97	0.13	12.0
Max.	7.64	0.26	0.43	189.60	23.10	552.00	4.80	3.58	3.91	13.70	1.28	17.0
	Bidargaddi											
1	7.23	0.20	0.34	122	15	534	3.80	5.94	4.57	28.90	0.34	16.0
2	7.36	0.12	0.37	175	17	602	4.40	4.52	9.50	22.40	0.81	17.0
3	7.46	0.19	0.39	144	18	281	5.40	3.87	5.86	19.40	0.30	18.0
4	7.99	0.18	0.45	152	19	492	9.00	6.33	4.11	24.30	0.62	16.0
5	7.84	0.19	0.43	108	21	393	2.40	5.85	14.60	18.60	0.54	15.0
6	8.12	0.15	0.46	118	22	503	2.80	5.91	4.53	18.60	0.31	13.0
7	8.20	0.16	0.47	116	14	286	2.90	4.81	8.32	17.20	0.72	12.0
8	7.39	0.19	0.48	149	13	303	3.60	3.19	5.18	24.30	0.35	14.0
9	7.09	0.14	0.45	159	14	360	4.80	6.13	4.21	26.80	0.61	15.0
10	7.30	0.21	0.46	169	12	528	5.50	6.00	9.31	20.30	0.49	17.0
Mean	**7.60**	**0.17**	**0.43**	**141.17**	**16.40**	**428.20**	**4.46**	**5.26**	**7.02**	**22.08**	**0.51**	**15.3**
Min.	7.09	0.12	0.34	107.60	12.30	281.00	2.40	3.19	4.11	17.20	0.30	12.0
Max.	8.20	0.21	0.48	175.30	21.50	602.00	9.00	6.33	14.60	28.90	0.81	18.0

Table 57: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in red soils of Jallikoppa and Aaravalli villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Jallikoppa											
1	7.30	0.20	0.37	193	20	286	5.20	1.88	0.59	3.63	0.40	13.0
2	7.66	0.25	0.36	48	18	382	4.40	1.20	0.55	1.98	0.37	16.0
3	7.50	0.26	0.41	150	15	407	4.40	1.52	0.86	2.68	0.54	18.0
4	7.60	0.14	0.43	153	13	335	2.60	1.70	0.58	4.66	0.30	15.0
5	7.70	0.18	0.45	164	15	305	4.80	1.95	0.58	5.89	0.39	16.0
6	7.80	0.19	0.43	121	14	502	2.80	1.35	0.51	4.81	0.39	18.0
7	7.92	0.26	0.45	123	21	521	3.60	1.65	0.81	2.41	0.36	16.0
8	8.18	0.16	0.46	141	20	384	4.20	1.89	0.57	3.86	0.49	13.0
9	8.26	0.14	0.47	154	19	205	3.80	1.49	0.61	4.81	0.52	12.0
10	7.63	0.19	0.43	172	19	214	2.90	1.81	0.52	5.16	0.35	15.0
Mean	**7.76**	**0.19**	**0.43**	**141.82**	**17.31**	**354.10**	**3.87**	**1.64**	**0.62**	**3.99**	**0.41**	**15.2**
Min.	7.30	0.14	0.36	48.30	12.60	205.00	2.60	1.20	0.51	1.98	0.30	12.0
Max.	8.26	0.26	0.47	193.10	21.20	521.00	5.20	1.95	0.86	5.89	0.54	18.0
	Aaravalli											
1	7.53	0.24	0.42	187	18	172	5.40	1.74	0.92	2.13	0.56	16.0
2	7.62	0.21	0.43	194	15	143	5.00	1.33	0.52	1.22	0.33	17.0
3	7.74	0.22	0.44	144	12	169	2.80	1.00	0.61	2.39	0.23	18.0
4	7.80	0.18	0.43	195	14	196	6.20	1.73	0.83	2.72	0.57	16.0
5	7.92	0.19	0.45	104	14	470	4.80	1.44	0.61	1.75	0.45	15.0
6	8.03	0.21	0.46	120	19	505	2.90	1.35	0.89	4.15	0.31	13.0
7	8.30	0.15	0.47	145	27	515	3.60	1.45	0.63	3.21	0.29	12.0
8	8.24	0.19	0.47	194	19	552	4.20	1.35	0.75	2.96	0.49	15.0
9	8.36	0.17	0.48	170	18	528	4.90	1.64	0.65	2.83	0.58	14.0
10	7.71	0.24	0.45	135	16	506	5.20	1.83	0.59	1.86	0.56	13.0
Mean	**7.93**	**0.20**	**0.45**	**158.57**	**17.10**	**375.60**	**4.50**	**1.49**	**0.70**	**2.52**	**0.44**	**14.9**
Min.	7.53	0.17	0.42	103.70	12.30	143.00	2.80	1.00	0.52	1.22	0.23	12.0
Max.	8.36	0.24	0.48	195.00	26.50	552.00	6.20	1.83	0.92	4.15	0.58	18.0

Table 58: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in red soils of Patyal, Khodhanpur, Sangolli and Garjur villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Patyal											
1	6.52	0.15	0.30	111	15	120	2.30	5.90	9.86	18.76	1.25	12.0
2	7.46	0.17	0.39	128	13	168	5.20	3.01	0.70	32.30	1.47	14.0
3	7.99	0.18	0.45	114	14	120	3.80	3.01	0.61	33.56	1.23	13.0
4	7.20	0.19	0.35	131	12	168	4.80	2.91	0.53	25.15	1.39	15.0
5	7.49	0.20	0.39	126	18	144	5.10	4.21	0.84	12.00	1.42	12.0
Mean	**7.33**	**0.17**	**0.38**	**122**	**14.4**	**144**	**4.24**	**3.80**	**2.5**	**24.35**	**1.35**	**13.2**
Min.	6.52	0.15	0.30	111	12	120	2.3	2.91	0.53	12.00	1.23	12
Max.	7.99	0.20	0.45	131	18	168	5.2	5.90	9.86	33.56	1.47	15
	Khodanpur											
1	7.17	0.15	0.33	111	12	472	7.20	1.52	5.58	31.38	2.61	17.0
2	6.45	0.17	0.26	111	16	192	2.80	3.60	9.45	15.32	0.56	12.0
3	6.86	0.19	0.31	178	18	120	6.30	1.83	9.83	25.00	0.83	13.0
4	7.26	0.12	0.35	122	21	288	5.20	2.63	7.92	26.50	1.29	15.0
5	7.16	0.14	0.33	111	22	120	4.90	3.25	5.82	29.82	2.51	14.0
Mean	**6.98**	**0.15**	**0.32**	**126.6**	**17.8**	**238.4**	**5.28**	**2.57**	**7.72**	**25.60**	**1.56**	**14.2**
Min.	6.45	0.15	0.26	111	12	120	2.8	1.52	5.58	15.32	0.56	12
Max.	7.26	0.19	0.35	178	22	472	7.2	3.60	9.83	31.38	2.61	17

Contd…….

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Sangolli											
1	7.03	0.15	0.32	125	21	120	3.40	3.51	1.83	15.90	2.71	15.0
2	7.24	0.12	0.35	122	17	312	7.80	3.06	0.85	24.45	0.78	14.0
3	7.01	0.18	0.32	148	15	408	6.30	3.41	0.98	29.85	0.98	15.0
4	6.99	0.21	0.31	111	13	480	4.80	3.21	1.56	23.95	1.65	12.0
5	6.97	0.18	0.31	156	14	192	5.20	3.21	1.98	28.63	2.18	13.0
Mean	**7.05**	**0.16**	**0.32**	**132.4**	**16.0**	**302.4**	**5.5**	**3.28**	**1.44**	**24.56**	**1.66**	**13.8**
Min.	6.97	0.18	0.31	111	13	120	3.4	3.06	0.85	9.85	0.78	12
Max.	7.24	0.21	0.35	156	21	480	7.8	3.51	1.98	15.92	2.71	15
	Garjur											
1	8.28	0.19	0.47	117	21	455	5.00	2.03	0.32	16.72	0.44	15.0
2	8.15	0.21	0.46	170	21	405	11.20	1.58	2.70	11.43	0.67	14.0
3	7.55	0.25	0.41	179	19	308	6.90	1.89	2.69	11.78	0.53	15.0
4	7.40	0.26	0.39	185	13	125	7.20	1.63	0.98	12.38	0.69	16.0
5	8.45	0.12	0.49	194	15	163	8.50	2.01	1.78	15.93	0.83	13.0
Mean	**7.97**	**0.21**	**0.44**	**169**	**17.8**	**291.2**	**7.76**	**1.83**	**1.69**	**13.64**	**0.63**	**14.6**
Min.	7.40	0.12	0.39	117	13	125	5.0	1.58	0.32	11.43	0.44	13
Max.	8.45	0.26	0.49	194	21	455	11.2	2.03	2.70	16.72	0.83	16

Table 59: pH, EC, organic carbon, major, secondary and micronutrients status of different samples in red soils of Savatagi villages

Sl. No.	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Exchangeable Mg (meq/100 g)	DTPA extractable (ppm)				Yield (q/ha)
								Cu	Fe	Mn	Zn	
	Savatagi											
1	7.48	0.20	0.40	107	16	139	4.80	1.78	0.49	11.48	0.85	14.0
2	7.83	0.23	0.43	115	18	161	8.80	2.25	1.96	8.20	1.04	15.0
3	7.48	0.25	0.39	121	19	178	5.30	1.98	1.83	9.36	0.98	13.0
4	6.86	0.21	0.32	121	16	163	4.50	1.86	1.79	8.06	0.65	12.0
5	8.28	0.15	0.47	117	15	175	3.90	1.68	0.98	7.93	1.05	14.0
Mean	**7.59**	**0.20**	**0.40**	**115.94**	**16.86**	**163.20**	**5.46**	**1.91**	**1.41**	**9.01**	**0.91**	**11.6**
Min.	6.86	0.15	0.32	106.50	14.50	139.00	3.90	1.68	0.49	7.93	0.65	12.0
Max.	8.28	0.25	0.47	121.30	19.20	178.00	8.80	2.25	1.96	11.48	1.05	15.0

Table 60: Range and mean values of pH, EC, organic carbon status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	pH		Electrical conductivity (dS/m)		Organic carbon (%)	
		Range	Mean	Range	Mean	Range	Mean
1.	Govankoppa	7.31 – 7.81	7.51	0.13 – 0.27	0.20	0.48 – 0.81	0.65
2.	Mugabasava	6.21 – 8.02	7.50	0.14 – 0.32	0.23	0.43 – 0.83	0.67
3.	Belawadi	7.20 – 8.00	7.57	0.14 – 0.31	0.22	0.48 – 0.87	0.67
4.	Budihal	7.05 – 7.62	7.27	0.14 – 0.35	0.23	0.47 – 0.86	0.63
5.	Chikkabellikatti	6.47 – 7.55	7.10	0.14 – 0.35	0.24	0.44 – 0.66	0.56
6.	Doddawada	7.03 – 7.52	7.28	0.13 – 0.32	0.22	0.41 – 0.72	0.55
7.	Udikeri	7.14 – 7.45	7.29	0.15 – 0.33	0.21	0.45 – 0.82	0.62
8.	Sampagaon	7.03 – 8.02	7.53	0.17 – 0.33	0.26	0.45 – 0.87	0.69
9.	Bavihal	7.34 – 8.01	7.56	0.15 – 0.28	0.21	0.51 – 0.83	0.66
10.	Turamari	7.43 – 7.93	7.66	0.18 – 0.28	0.23	0.51 – 0.86	0.69
11.	Neginahal	6.53 – 8.64	7.72	0.16 – 0.28	0.21	0.48 – 0.87	0.64

Table 61: Range and mean values of pH, EC, organic carbon status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	pH		Electrical conductivity (dS/m)		Organic carbon (%)	
		Range	Mean	Range	Mean	Range	Mean
1.	Siddasamudra	6.10 – 7.70	6.52	0.11 – 0.26	0.19	0.22 – 0.35	0.26
2.	Hirebellikatti	5.47 – 6.69	5.98	0.15 – 0.26	0.18	0.20 – 0.29	0.23
3.	Kadasagatti	5.31 – 7.19	6.50	0.11 – 0.23	0.18	0.21 – 0.34	0.28
4.	Gudikatti	7.77 – 8.44	8.11	0.18 – 0.25	0.18	0.43 – 0.49	0.46
5.	Budarkatti	6.17 – 7.64	6.99	0.12 – 0.26	0.20	0.23 – 0.43	0.34
6.	Bidaragaddi	7.09 – 8.20	7.60	0.12 – 0.21	0.17	0.34 – 0.48	0.43
7.	Jallikoppa	7.30 – 8.26	7.76	0.14 – 0.26	0.19	0.36 – 0.47	0.43
8.	Aaravalli	7.53 – 8.36	7.93	0.17 – 0.24	0.20	0.42 – 0.48	0.45
9.	Patyal	6.52 – 7.99	7.33	0.15 – 0.20	0.17	0.30 – 0.45	0.38
10.	Khodhanpur	6.45 – 7.26	6.98	0.15 – 0.19	0.15	0.26 – 0.35	0.32
11.	Sangolli	6.97 – 7.24	7.05	0.18 – 0.21	0.16	0.31 – 0.35	0.32
12.	Garjur	7.40 – 8.45	7.97	0.12 – 0.26	0.21	0.39 – 0.49	0.44
13.	Savatagi	6.86 – 8.28	7.59	0.15 - 025	0.20	0.32 – 0.47	0.40

The available nitrogen status in black soils of Govankoppa village ranged from 103 to 202 kg per ha with a mean of 169.4 kg per ha, Mugabasava village with available nitrogen status ranged from 126 to 248 kg per ha with a mean value of 187 kg per ha, Belawadi with available nitrogen status ranged from 121 to 232 kg per ha with a mean value of 182.40 kg per ha, Budihal with available nitrogen status ranged from 101 to 241 kg per ha with mean value of 160.20 kg per ha, Chikkabellikatti with available nitrogen status ranged from 108 to 202 kg per ha with a mean value of 154 kg per ha, Doddawada village with available nitrogen status ranged from 141 to 232 kg per ha with a mean value of 179.1 kg per ha, Udikeri village with available nitrogen status ranged from 102 to 250 kg per ha with a mean value of 181.8 kg per ha, Sampagaon with available nitrogen status ranged from 125 to 246 with a mean value of 184.3 kg per ha, Bavihal with available nitrogen status ranged from 121 to 216 kg per ha with a mean value of 179.9 kg per ha, Turamari with available nitrogen status from 128 to 250 kg per ha with a mean value of 192.8 kg per ha and Neginahal village with available nitrogen status ranged from 108 to 240 kg per ha with a mean value of 183.6 kg per ha.

The available nitrogen status in red soils ranged from 134 to 260 kg per ha with a mean value of 170.6 kg per ha, 128 to 195 kg per ha with a mean value of 167.3 kg per ha, 100.8 to 189.6 kg per ha with a mean value of 151.6 kg per ha, 119.6 to 170.0 kg per ha with a mean value of 147.04 kg per ha, 114.8 to 189.6 kg per ha with a mean value of 141.2 kg per ha, 121 to 193 kg per ha with a mean value of 151.9 kg per ha, 104 to 195 kg per ha with a mean value of 158.6 kg per ha, 111 to 131 kg per ha with a mean value of 122 kg per ha, 111 to 178 kg per ha with a mean value of 126.6 kg per ha, 111 to 156 kg per ha with a mean value of 132.4 kg per ha, 117 to 194 kg per ha with a mean value of 169 kg per ha and 107 to 121 kg per ha with a mean value of 116.2 kg per ha in the villages of Siddasamudra, Hirebellikatti, Kadasgatti, Gudikatti, Budarkatti, Bidargaddi, Jallikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi, respectively.

4.2.5 Available phosphorus (kg/ha)

The results on available phosphorus status in black and red soils of Bailhongal taluk is presented in Table 64, 65 and Fig. 10, 11.

The available phosphorus status in black soils of the villages Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawada, Udikeri, Sampagaon, Bevihal, Turamari and Neginahal ranged from 16 to 39 kg per ha with a mean value of 25.4 kg per ha, 15 to 31 kg per ha with a mean value of 21.8 kg per ha, 16 to 32 kg per ha with a mean value of 23.1 kg per ha, 19 to 28 kg per ha with a mean value of 25.2 kg per ha, 16 to 28 kg per ha with a mean value of 22.7 kg per ha, 15 to 38 kg per ha with a mean value of 24.0 kg per ha, 12 to 34 kg per ha with a mean value of 24.8 kg per ha, 15 to 28 kg per ha with a mean value of 19.9 kg per ha, 18 to 29 kg per ha with a mean value of 22.1 kg per ha, 17 to 27 kg per ha with a mean value of 23.4 kg per ha and 22 to 30 kg per ha with a mean value of 25 kg per ha, respectively.

The available phosphorus status in red soils ranged from 12 to 21 kg per ha with a mean value of 16.5 kg per ha, 12 to 20 kg per ha with a mean value of 16.1 kg per ha, 13 to 24 kg per ha with a mean value of 17.4 kg per ha, 13 to 21 kg per ha with a mean value of 16.4 kg per ha, 14 to 23 kg per ha with a mean value of 17.6 kg per ha, 12 to 22 kg per ha with a mean value of 16.5 kg per ha, 13 to 21 kg per ha with a mean value of 17.4 kg per ha, 12 to 27 kg per ha with a mean value of 17.2 kg per ha, 12 to 18 kg per ha with a mean value of 14.4 kg per ha, 12 to 22 kg per ha with a mean value of 17.8 kg per ha, 13 to 21 kg per ha with a mean value of 17.8 kg per ha, 13 to 21 kg with a mean value of 17.8 kg per ha and 15 to 9 kg per ha with a mean value of 16.8 kg per ha in the villages of Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidargaddi, Jalikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi, respectively.

4.2.6 Available potassium (kg/ha)

The data on available potassium in black and red soils of Bt cotton growing areas of Bailhongal taluk is presented in Table 66, 67 and Fig. 12, 13.

Table 62: Range, mean values and per cent samples of available nitrogen status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Govankoppa	103 – 202	169.4	100	-	-
2.	Mugabasava	126 – 248	187.0	100	-	-
3.	Belawadi	121 – 232	182.4	100	-	-
4.	Budihal	101 – 241	160.2	100	-	-
5.	Chikkabellikatti	108 – 202	154.0	100	-	-
6.	Doddawada	141 – 232	179.1	100	-	-
7.	Udikeri	102 – 250	181.8	100	-	-
8.	Sampagaon	125 – 246	184.3	100	-	-
9.	Bavihal	121 – 216	179.9	100	-	-
10.	Turamari	128 – 250	192.8	100	-	-
11.	Neginahal	108 – 249	183.6	100	-	-

Table 63: Range, mean values and per cent samples of available nitrogen status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Siddasamudra	134.0 – 260.0	170.6	100	-	-
2.	Hirebellikatti	128.0 – 195.0	167.3	100	-	-
3.	Kadasagatti	100.8 – 189.6	151.6	100	-	-
4.	Gudikatti	119.6 – 170.0	147.04	100	-	-
5.	Budarkatti	114.8 – 189.6	148.2	100	-	-
6.	Bidaragaddi	107.6 – 175.3	141.2	100	-	-
7.	Jallikoppa	121.0 – 193.0	151.9	100	-	-
8.	Aaravalli	104.0 – 195.0	158.6	100	-	-
9.	Patyal	111.0 – 131.0	122.0	100	-	-
10.	Khodhanpur	111.0 – 178.0	126.6	100	-	-
11.	Sangolli	111.0 – 156.0	132.4	100	-	-
12.	Garjur	117.0 – 194.0	169.0	100		
13.	Savatagi	107.0 – 121.0	116.0	100		

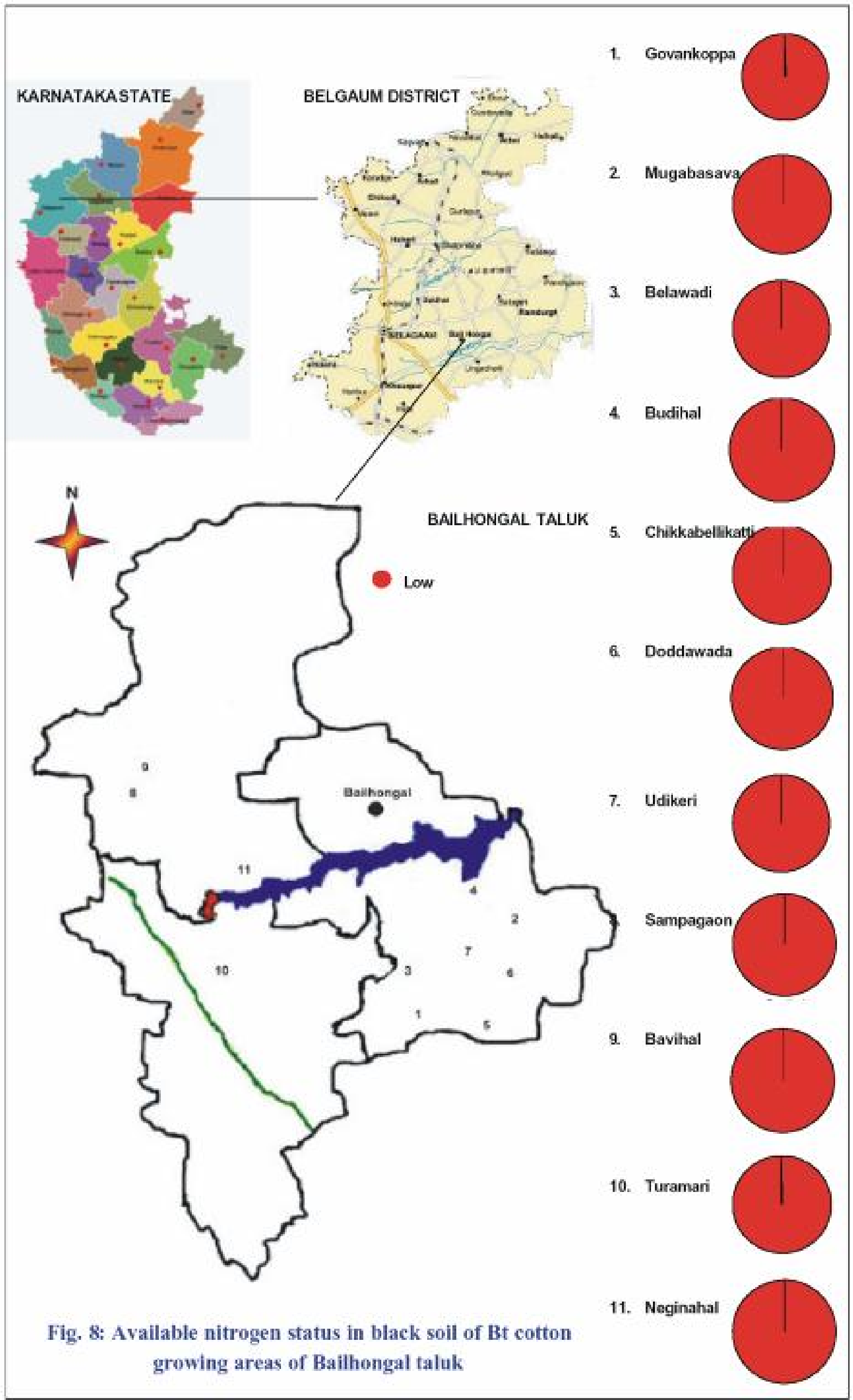

Fig. 8: Available nitrogen status in black soil of Bt cotton growing areas of Bailhongal taluk

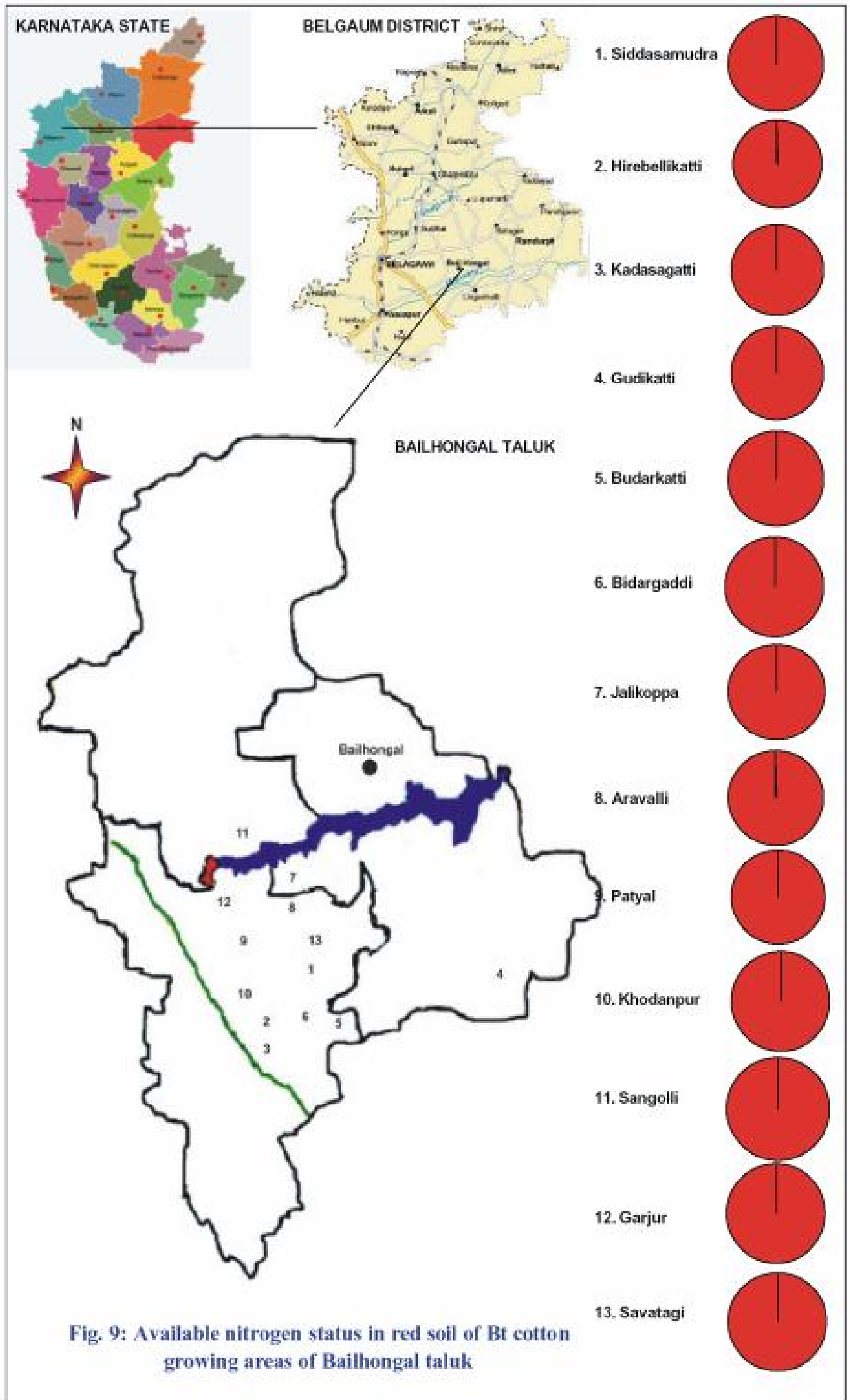

Fig. 9: Available nitrogen status in red soil of Bt cotton growing areas of Bailhongal taluk

Table 64: Range, mean values and per cent samples of available P_2O_5 status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Govankoppa	16 – 39	25.4	30	70	-
2.	Mugabasava	15 – 31	21.8	50	50	-
3.	Belawadi	16 – 32	23.1	40	60	-
4.	Budihal	19 – 28	25.2	10	90	-
5.	Chikkabellikatti	16 – 28	22.7	20	80	-
6.	Doddawada	15 – 38	24.0	30	70	-
7.	Udikeri	12 – 34	24.8	20	80	-
8.	Sampagaon	15 – 28	19.9	50	50	-
9.	Bavihal	18 – 29	22.1	40	60	-
10.	Turamari	17 – 27	23.4	20	80	-
11.	Neginahal	22 – 30	25.0	-	100	-

Table 65: Range, mean values and per cent samples of available P_2O_5 status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Siddasamudra	12 – 21	16.5	80	20	-
2.	Hirebellikatti	12 – 20	16.1	100	-	-
3.	Kadasagatti	13 – 24	17.4	70	30	-
4.	Gudikatti	13 – 21	16.4	90	10	-
5.	Budarkatti	14 – 23	17.6	70	30	-
6.	Bidaragaddi	12 – 22	16.5	80	20	-
7.	Jallikoppa	13 – 21	17.4	70	30	-
8.	Aaravalli	12 – 27	17.2	90	10	-
9.	Patyal	12 – 18	14.4	100	-	-
10.	Khodhanpur	12 – 22	17.8	80	20	-
11.	Sangolli	13 – 21	16.0	80	20	-
12.	Garjur	13 – 21	17.8	60	40	
13.	Savatagi	15 – 19	16.8	100	-	

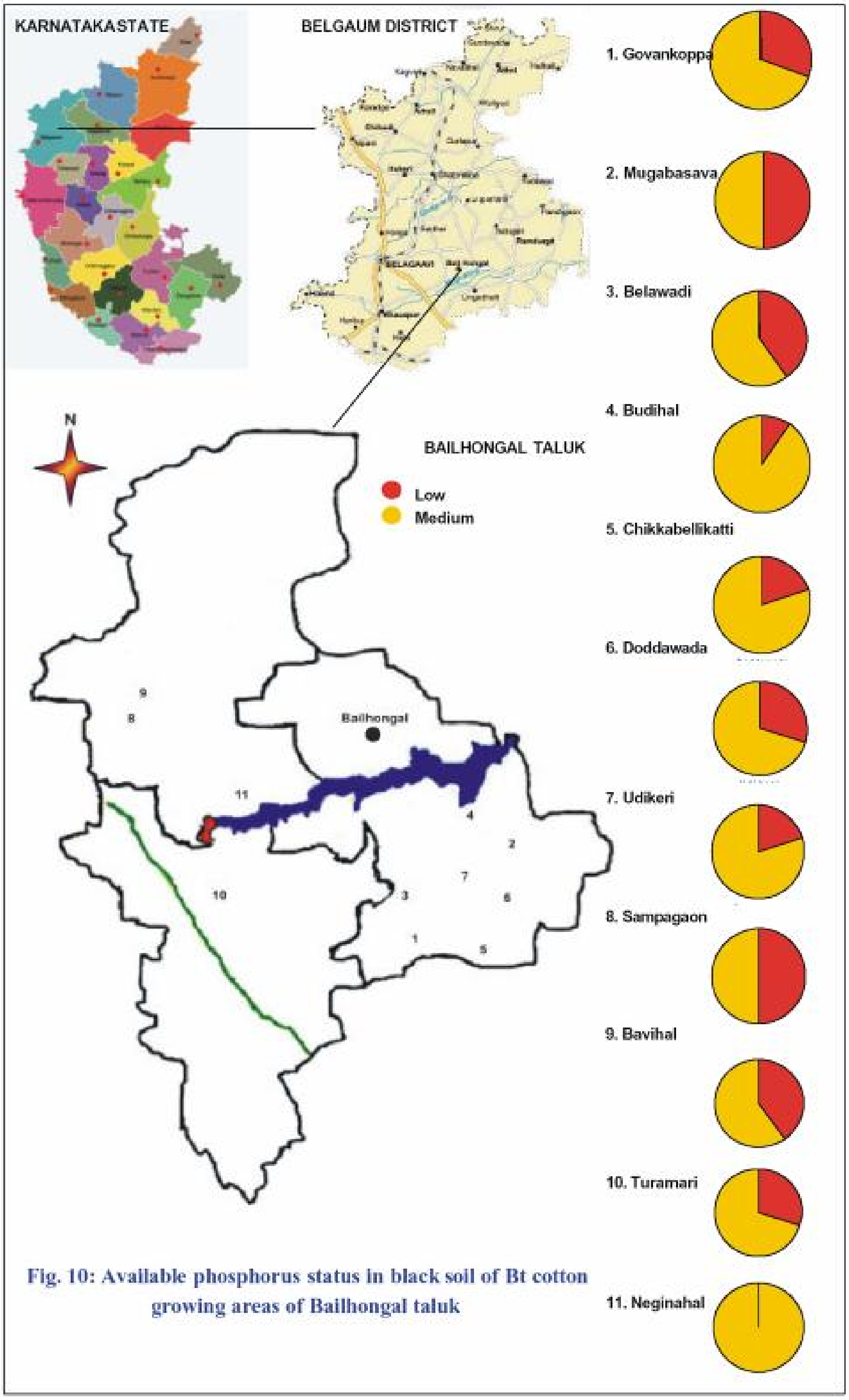

Fig. 10: Available phosphorus status in black soil of Bt cotton growing areas of Bailhongal taluk

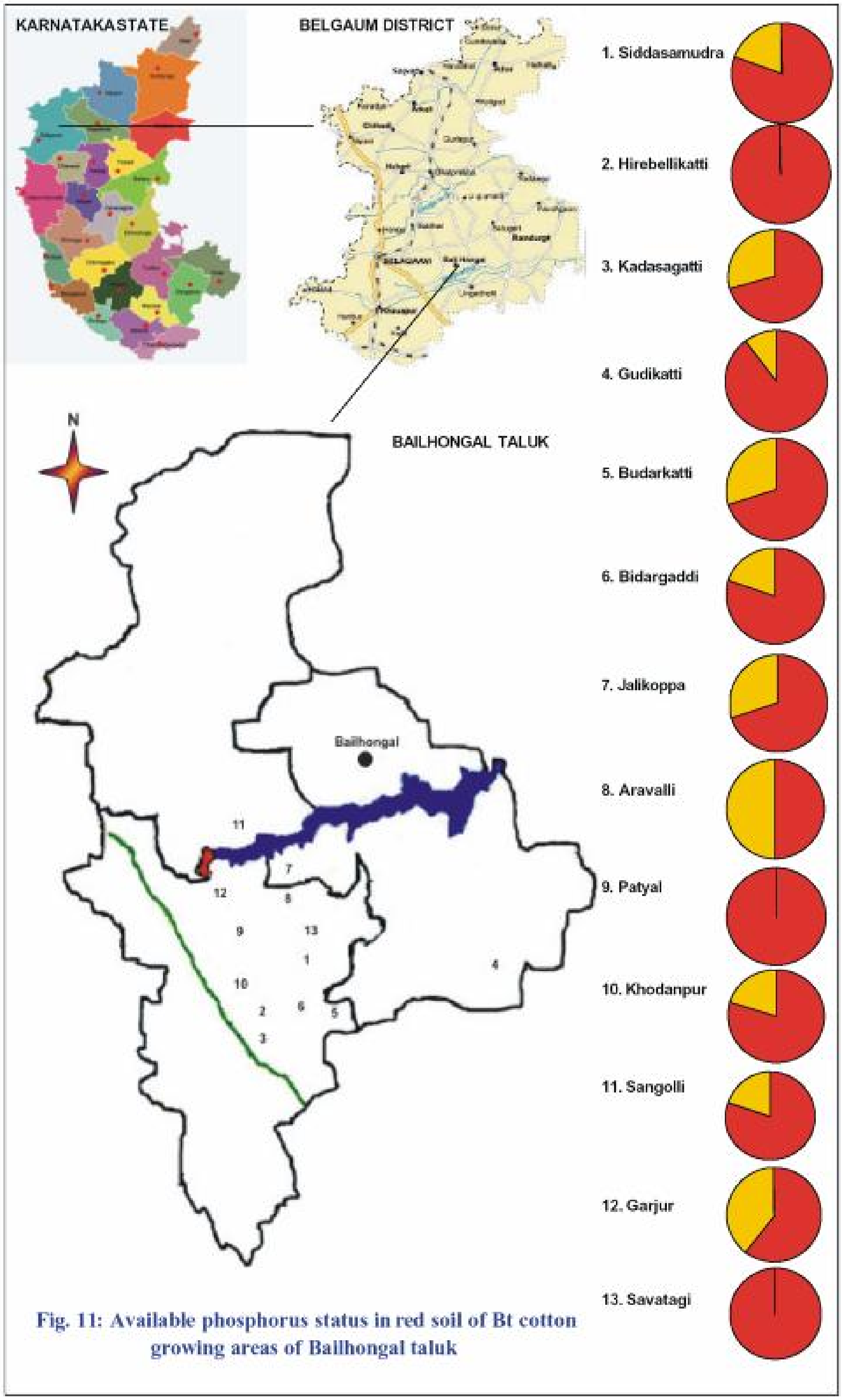

Fig. 11: Available phosphorus status in red soil of Bt cotton growing areas of Bailhongal taluk

Table 66: Range, mean values and per cent samples of available potassium status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Govankoppa	335 – 614	449.5	-	-	100
2.	Mugabasava	325 – 604	471.8	-	-	100
3.	Belawadi	318 – 605	418.3	-	-	100
4.	Budihal	333 – 533	430.9	-	-	100
5.	Chikkabellikatti	353 – 516	423.9	-	-	100
6.	Doddawada	325 – 509	433.9	-	-	100
7.	Udikeri	346 – 581	431.9	-	-	100
8.	Sampagaon	360 – 581	435.4	-	-	100
9.	Bavihal	303 – 520	40.5	-	-	100
10.	Turamari	328 – 593	423.0	-	-	100
11.	Neginahal	400 – 490	454.0	-	-	100

Table 67: Range, mean values and per cent samples of available potassium status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Siddasamudra	288 – 552	436.8	-	-	100
2.	Hirebellikatti	148 – 384	228.8	30	60	10
3.	Kadasagatti	124 – 456	189.6	80	10	10
4.	Gudikatti	360 – 672	525.0	-	-	100
5.	Budarkatti	216 – 552	409.2	-	30	70
6.	Bidaragaddi	281 – 602	428.2	-	-	100
7.	Jallikoppa	205 – 521	354.1	-	20	80
8.	Aaravalli	143 – 552	375.6	30	10	60
9.	Patyal	120 – 168	144.0	100	-	-
10.	Khodhanpur	120 – 472	238.4	40	20	40
11.	Sangolli	120 – 480	302.4	20	20	60
12.	Garjur	125 – 455	291.2	40	-	60
13.	Savatagi	139 – 178	163.2	100	-	-

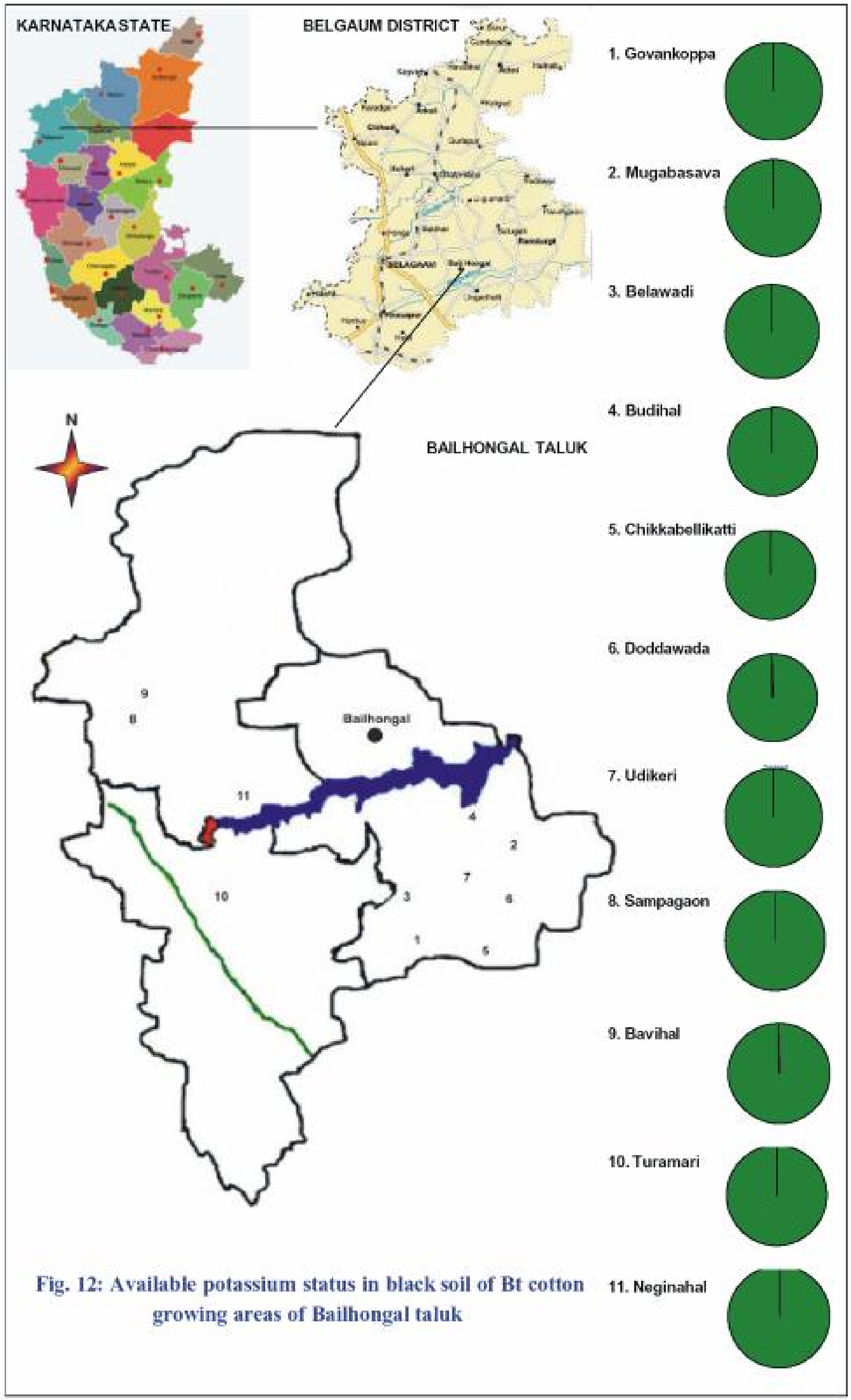

Fig. 12: Available potassium status in black soil of Bt cotton growing areas of Bailhongal taluk

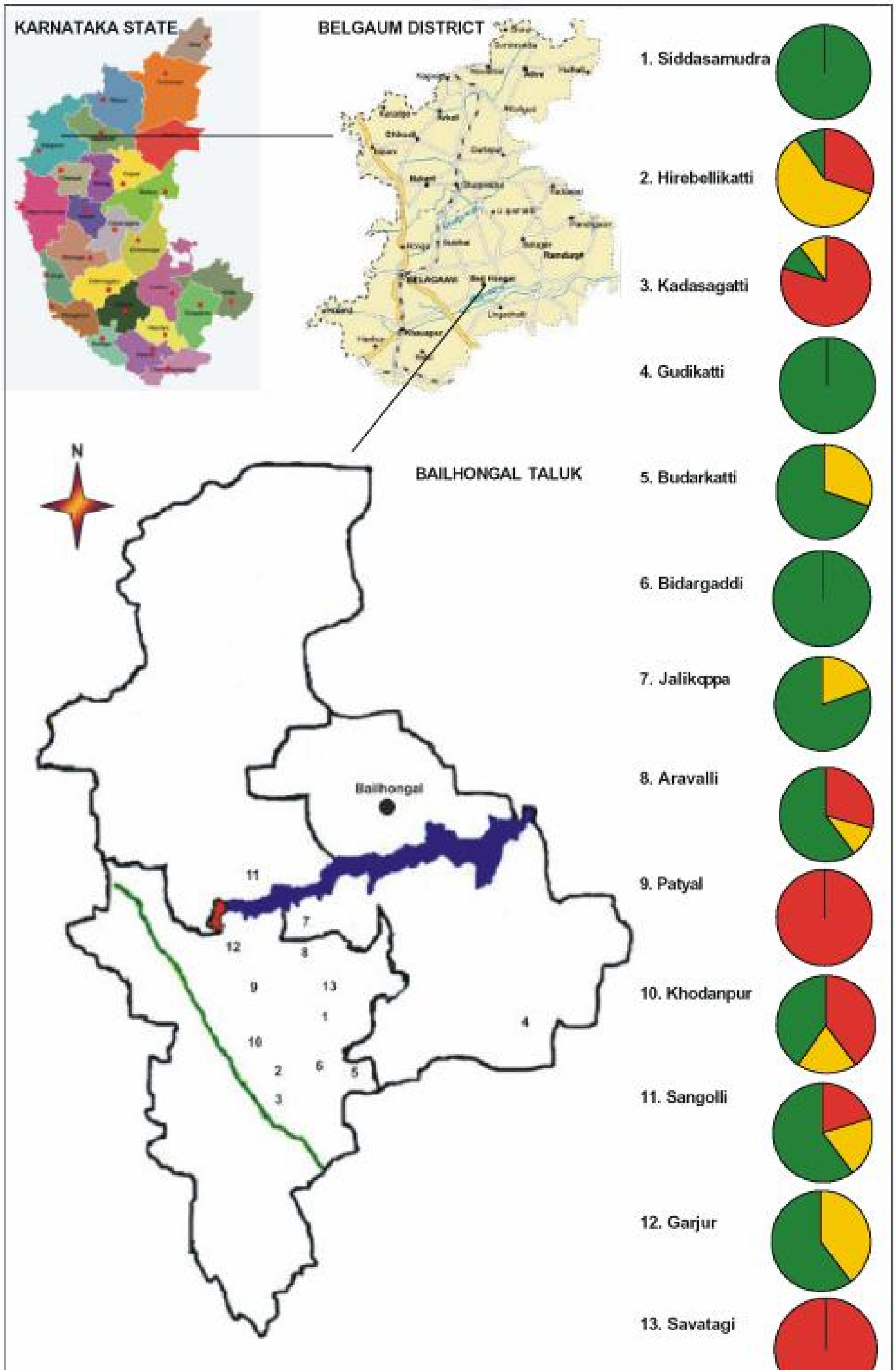

Fig. 13: Available potassium status in red soil of Bt cotton growing areas of Bailhongal taluk

Fig. 13: Available potassium status in red soil of Bt cotton growing areas of Bailhongal taluk

The available potassium status in black soils ranged from 335 to 614 kg per ha with a mean value of 449.5 kg per ha, 325 to 604 kg per ha with a mean value of 418.3 kg per ha, 333 to 533 kg per ha with a mean value of 430.90 kg per ha, 353 to 516 kg per ha with a mean value of 423.9 kg per ha, 325 to 509 kg per ha with mean value of 433.90 kg per ha, 346 to 581 kg per ha with a mean value of 431.90 kg per ha, 360 to 581 kg per ha with a mean value of 435.40 kg per ha, 303 to 520 kg per ha with a mean value of 400.5 kg per ha, 328 to 593 kg per ha with a mean value of 423 kg per ha and 400 to 490 kg per ha with a mean value of 454 kg per ha in the villages of Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawada, Udikeri, Sampagoan, Bevihal, Turamari and Neginahal, respectively.

The available potassium status in red soils of cotton growing areas of Bailhongal taluk ranged from 288 to 552 kg per ha with a mean value of 436.8 kg per ha, 148 to 384 kg per ha with a mean value of 228.3 kg per ha, 124 to 456 kg per ha with a mean value of 189.6 kg per ha, 360 to 672 kg per ha with a mean value of 525 kg per ha, 216 to 552 kg per ha with a mean value of 409.2 kg per ha, 281 to 602 kg per ha with a mean value of 428.2 kg per ha, 205 to 521 kg per ha with a mean value of 354.1 kg per ha, 143 to 552 kg per ha with a mean value of 375.6 kg per ha, 120 to 168 kg per ha with a mean value of 144 kg per ha, 120 to 472 kg per ha with a mean value of 238.4 kg per ha, 120 to 480 kg per ha with a mean value of 302.4 kg per ha, 125 to 455 kg per ha with a mean value of 291.2 kg per ha and 139 to 178 kg per ha with a mean value of 163.2 kg per ha in the villages of Siddasamudra, Hirebellikatti, Kadasgatti, Gudikatti, Budarkatti, Bidargaddi, Jalikoppa, Garjur and Savatagi.

4.2.7 Exchangeable magnesium (meq/100 g soil)

The data presented in Table 68 and 69 on exchangeable magnesium pertained to the black and red soils of Bailhongal taluk.

The exchangeable magnesium in black soils of Bt cotton growing areas in the villages Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawada, Udikeri, Sampagaon, Bavihal, Turamari and Neginahal ranged from 2.70 to 29.20 meq per 100 g soil with a mean value of 12.32 meq per 100 g, 8.10 to 14.60 meq per 100 g soil with a mean value of 11.29 meq per 100 g, 2.60 to 8.20 meq per 100 g soil with a mean value of 6.36 meq per 100 g, 7.40 to 13.40 meq per 100 g soil with a mean value of 11.52 meq per 100 g, 9.50 to 1.3.20 meq per 100 g soil with a mean value of 11.60 meq per 100 g, 12.40 to 13.60 meq per 100 g soil with a mean value of 13.36 meq per 100 g, 2.40 to 12.00 meq per 100 g soil with a mean value of 7.63 meq per 100 g, 3.70 to 8.10 meq per 100 g soil with a mean value of 6.05 meq per 100 g, 1.92 to 10.20 meq per 100 g soil with a mean value of 6.65 meq per 100 g, 3.90 to 6.00 meq per 100 g soil with a mean value of 4.89 meq per 100 g, 12.30 to 15.60 meq per 100 g soil with a mean value of 13.82 meq per 100 g, respectively.

The exchangeable magnesium (meq/100 g soil) in red soils ranged from 3.0 to 4.8 meq per 100 g with a mean value of 3.81 meq per 100 g, 2.20 to 8.00 meq per 100 g with a mean value of 3.46 meq per 100 g, 2.00 to 4.80 meq per 100 g with a mean value of 2.92 meq per 100 g, 6.40 to 10.20 meq per 100 g with a mean value of 7.69 meq per 100 g, 2.20 to 4.80 meq per 100 g with a mean value of 3.97 meq per 100 g, 2.40 to 9.00 meq per 100 g with a mean value of 4.46 meq per 100 g, 2.60 to 5.20 meq per 100 g with a mean value of 3.87 meq per 100 g, 2.80 to 6.20 meq per 100 g with a mean value of 4.50 meq per 100 g, 2.30 to 5.20 meq per 100 g with a mean value of 4.24 meq per 100 g, 2.80 to 7.20 meq per 100 g with a mean value of 5.28 meq per 100 g, 3.40 to 7.80 meq per 100 g with a mean value of 5.50 meq per 100 g, 5.00 to 11.20 meq per 100 g with a mean value of 7.76 meq per 100 g and 3.90 to 8.80 meq per 100 g with a mean value of 5.46 meq per 100 g, in the villages of Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidaragaddi, Jalikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi, respectively.

4.2.8 DTPA extractable iron (ppm)

The results of DTPA extractable iron in black and red soils of Bailhongal taluk is presented in Table 70 and 71.

Table 68: Range, mean values and per cent samples of magnesium status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Govankoppa	2.7 – 29.2	12.32	-	-	100
2.	Mugabasava	8.1 – 14.6	11.29	-	-	100
3.	Belawadi	2.6 – 8.2	6.36	-	-	100
4.	Budihal	7.4 – 13.4	11.52	-	-	100
5.	Chikkabellikatti	9.5 – 13.2	11.60	-	-	100
6.	Doddawada	12.4 – 14.6	13.36	-	-	100
7.	Udikeri	2.4 – 12.0	7.63	-	-	100
8.	Sampagaon	3.7 – 8.1	6.05	-	-	100
9.	Bavihal	1.9 – 10.2	6.65	-	-	100
10.	Turamari	3.9 – 6.0	4.84	-	-	100
11.	Neginahal	12.3 – 15.6	13.82	-	-	100

Table 69: Range, mean values and per cent samples of magnesium status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples		
				Low	Medium	High
1.	Siddasamudra	3.0 – 4.8	3.81	-	-	100
2.	Hirebellikatti	2.2 – 8.0	3.46	-	-	100
3.	Kadasagatti	2.0 – 4.8	2.92	-	-	100
4.	Gudikatti	6.4 – 10.2	7.69	-	-	100
5.	Budarkatti	2.2 – 4.8	3.97	-	-	100
6.	Bidaragaddi	2.4 – 9.0	4.46	-	-	100
7.	Jallikoppa	2.6 – 5.2	3.87	-	-	100
8.	Aaravalli	2.8 – 6.2	4.50	-	-	100
9.	Patyal	2.3 – 5.2	4.24	-	-	100
10.	Khodhanpur	2.8 – 7.2	5.28	-	-	100
11.	Sangolli	3.4 – 7.8	5.50	-	-	100
12.	Garjur	5.0 – 11.2	7.76	-	-	100
13.	Savatagi	3.9 – 8.8	5.46	-	-	100

The DTPA extractable iron in black soils ranged from 1.16 to 9.81 ppm with a mean value of 4.55 ppm, 0.22 to 3.74 ppm with a mean value of 0.67 ppm, 0.18 to 0.42 ppm with a mean value of 0.33 ppm, 0.19 to 3.61 ppm with a mean value of 0.55 ppm, 0.49 to 2.31 ppm with a mean value of 1.09 ppm, 0.33 to 0.60 ppm with a mean value of 0.45 ppm, 0.31 to 0.53 ppm with a mean value of 0.43 ppm, 0.33 to 1.73 ppm with a mean value of 0.96 ppm, 0.19 to 0.82 ppm with a mean value of 0.44 ppm, 6.53 to 9.78 ppm with a mean value of 7.84 ppm and 0.48 to 1.82 ppm with a mean value of 1.23 ppm, in the villages of Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawad, Udikeri, Sampagaon, Bavihal, Turamari and Neginahal, respectively.

The DTPA extractable iron status in red soils of the villages Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidaragaddi, Jallikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi ranged from 2.90 to 3.14 ppm with a mean value of 2.98 ppm, 3.45 to 15.61 ppm with a mean value of 12.25 ppm, 2.71 to 6.10 ppm with a mean value of 3.64 ppm, 0.53 to 1.30 ppm with a mean value of 0.84 ppm, 0.33 to 3.91 ppm with a mean value of 1.99 ppm, 4.11 to 14.60 ppm with a mean value of 7.02 ppm, 0.51 to 0.86 ppm with a mean value of 0.62 ppm, 0.52 to 0.92 ppm with a mean value of 0.70 ppm, 0.53 to 9.86 ppm with a mean value of 2.50 ppm, 5.58 to 9.83 ppm with a mean value of 7.72 ppm, 0.85 to 1.98 ppm with a mean value of 1.44 ppm, 0.32 to 2.70 ppm with a mean value of 1.69 ppm, 0.49 to 1.96 ppm with a mean value of 1.41 ppm, respectively.

4.2.9 DTPA extractable zinc status (ppm)

The data is pertained to the DTPA extractable zinc status in black and red soils of Bt cotton growing areas of Bailhongal taluk is presented in Table 72 and 73.

The DTPA extractable zinc status in black soils ranged from 0.21 to 0.94 ppm with a mean value of 0.57 ppm, 0.29 to 0.37 ppm with a mean value of 3.18 ppm, 0.40 to 0.61 with a mean value of 0.51 ppm, 0.25 to 0.40 ppm with a mean value of 0.32 ppm, 0.30 to 0.54 ppm with a mean value of 0.39 ppm, 0.51 to 0.84 ppm with a mean value of 0.67 ppm, 0.25 to 0.36 ppm with a mean value of 0.30 ppm, 0.36 to 1.59 ppm with a mean value of 1.02 ppm, 0.32 to 0.98 ppm with a mean value of 0.63 ppm, 0.45 to 0.83 ppm with a mean value of 0.64 ppm and 0.49 to 0.66 ppm with a mean value of 0.57 ppm, in the villages of Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawad, Udikeri, Sampagaon, Bavihal, Turamari and Neginal, respectively.

The DTPA extractable zinc status in red soils of the villages Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidargaddi, Jallikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi ranged from 0.55 to 0.61 ppm with a mean value of 0.58 ppm, 0.31 to 0.59 ppm with a mean value of 0.48 ppm, 0.41 to 1.00 ppm with a mean value of 0.65 ppm, 0.45 to 0.69 ppm with a mean value of 0.52 ppm, 0.13 to 1.28 ppm with a mean value of 0.80 ppm, 0.30 to 0.81 ppm with a mean value of 0.51 ppm, 0.30 to 0.54 ppm with a mean value of 0.41 ppm, 0.23 to 0.58 ppm with a mean value of 0.44 ppm, 1.23 to 1.47 ppm with a mean value of 1.35 ppm, 0.56 to 2.61 ppm with a mean value of 1.56 ppm, 0.78 to 2.71 ppm with a mean value of 1.66 ppm, 0.44 to 0.83 ppm with a mean value of 0.63 ppm, 0.65 to 1.05 ppm with a mean value of 0.91 ppm, respectively.

4.2.10 DTPA extractable copper (ppm)

The data on DTPA extractable copper (ppm) in black and red soils of Bt cotton growing areas of Bailhongal taluk is presented in Table 74 and 75.

The DTPA extractable copper in black soils ranged from 1.40 to 1.95 ppm with a mean value of 1.67 ppm in Govankoppa villages, 0.75 to 1.16 ppm with a mean value of 1.01 ppm in Mugabasava village, 1.48 to 1.83 ppm with a mean value of 1.75 ppm in Belavadi village, 7.40 to 13.40 ppm with a mean value of 11.52 ppm in Budihal village, 1.30 to 1.89 ppm with a mean value of 1.63 ppm in Chikkabellikatti village, 1.59 to 2.14 ppm with a mean value of 1.79 ppm in Dodawad village, 1.10 to 1.40 ppm with a mean value of 1.19 ppm in Udikeri village, 1.19 to 4.77 ppm with a mean value of 2.45 ppm in Sasmpagaon village, 1.32 to 3.99 ppm with a mean value of 2.12 ppm in Bavihal village, 1.51 to 4.61 ppm with a mean value of 2.80 ppm in Turumari village and 1.51 to 2.65 ppm with a mean value of 2.12 ppm in Neginahal village,

Table 70: Range, mean values and per cent samples on iron status (ppm) in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Deficit	Marginal	Sufficient	NI	Category
1.	Govankoppa	1.16 – 9.81	4.55	90	-	10	1.2	Low
2.	Mugabasava	0.22 – 3.74	0.67	90	10	-	1.1	Low
3.	Belawadi	0.18 – 0.42	0.33	100	-	-	1.0	Low
4.	Budihal	0.19 – 3.61	0.55	90	10	-	1.1	Low
5.	Chikkabellikatti	0.49 – 2.31	1.09	100	-	-	1.0	Low
6.	Doddawada	0.33 – 0.60	0.45	100	-	-	1.0	Low
7.	Udikeri	0.31 – 0.53	0.43	100	-	-	1.0	Low
8.	Sampagaon	0.33 – 1.73	0.96	100	-	-	1.0	Low
9.	Bavihal	0.19 – 0.82	0.44	100	-	-	1.0	Low
10.	Turamari	6.53 – 9.78	7.84	-	-	100	3.0	High
11.	Neginahal	0.48 – 1.82	1.23	100	-	-	1.0	Low

Table 71: Range, mean values and per cent samples on iron status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Deficit	Marginal	Sufficient	NI	Category
1.	Siddasamudra	2.90 – 3.14	2.98	-	-	100	3.0	High
2.	Hirebellikatti	3.45 – 15.61	12.25	-	-	100	3.0	High
3.	Kadasagatti	2.71 – 6.10	3.64	-	-	100	3.0	High
4.	Gudikatti	0.53 – 1.00	0.84	100	-	-	1.0	Low
5.	Budarkatti	0.33 – 3.91	1.99	80	20	-	1.2	Low
6.	Bidaragaddi	4.11 – 14.60	7.02	-	-	100	3.0	High
7.	Jallikoppa	0.51 – 0.86	0.62	100	-	-	1.0	Low
8.	Aaravalli	0.52 – 0.92	0.70	100	-	-	1.0	Low
9.	Patyal	0.53 – 9.86	2.50	80	-	20	1.4	Low
10.	Khodhanpur	5.58 – 9.83	7.72	-	-	100	3.0	High
11.	Sangolli	0.85 – 1.98	1.44	100	-	-	1.0	Low
12.	Garjur	0.32 – 2.70	1.69	60	40	-	1.4	Low
13.	Savatagi	0.49 – 1.96	1.41	100	-	-	1.0	Low

Table 72: Range, mean values and per cent samples on zinc status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Deficit	Marginal	Sufficient	NI	Category
1.	Govankoppa	0.21 – 0.94	0.57	60	40	-	1.4	Low
2.	Mugabasava	0.29 – 0.37	3.18	100	-	-	1.0	Low
3.	Belawadi	0.40 – 0.61	0.51	90	10	-	1.1	Low
4.	Budihal	0.25 – 0.40	0.32	100	-	-	1.0	Low
5.	Chikkabellikatti	0.30 – 0.54	0.39	100	-	-	1.0	Low
6.	Doddawada	0.51 – 0.84	0.67	30	70	-	1.7	Medium
7.	Udikeri	0.25 – 0.36	0.30	100	-	-	1.0	Low
8.	Sampagaon	0.36 – 1.59	1.02	20	30	50	2.3	Medium
9.	Bavihal	0.32 – 0.98	0.63	40	60	-	1.6	Medium
10.	Turamari	0.45 – 0.83	0.64	40	60	-	1.6	Medium
11.	Neginahal	0.49 – 0.66	0.57	60	40	-	1.4	Low

Table 73: Range, mean values and per cent samples on zinc status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Deficit	Marginal	Sufficient	NI	Category
1.	Siddasamudra	0.55 – 0.61	0.58	90	10	-	1.2	Low
2.	Hirebellikatti	0.31 – 0.59	0.48	100	-	-	1.0	Low
3.	Kadasagatti	0.41 – 1.00	0.65	60	40	-	1.4	Low
4.	Gudikatti	0.45 – 0.69	0.52	90	10	-	1.2	Low
5.	Budarkatti	0.13 – 1.28	0.80	30	40	30	2.0	Medium
6.	Bidaragaddi	0.30 – 0.81	0.51	60	40	-	1.4	Low
7.	Jallikoppa	0.30 – 0.54	0.41	100	-	-	1.0	Low
8.	Aaravalli	0.23 – 0.58	0.44	100	-	-	1.0	Low
9.	Patyal	1.23 – 1.47	1.35	-	-	100	3.0	High
10.	Khodhanpur	0.56 – 2.61	1.56	20	20	60	2.4	Medium
11.	Sangolli	0.78 – 2.71	1.66	-	40	60	2.6	High
12.	Garjur	0.44 – 0.83	0.63	40	60	-	1.6	Medium
13.	Savatagi	0.65 – 1.05	0.91	-	60	40	2.4	Medium

Table 74: Range, mean values and per cent samples on copper status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples	
				Deficit	Sufficient
1.	Govankoppa	1.40 – 1.95	1.67	-	100
2.	Mugabasava	0.75 – 1.16	1.01	-	100
3.	Belawadi	1.48 – 1.83	1.75	-	100
4.	Budihal	7.40 – 13.4	11.52	-	100
5.	Chikkabellikatti	1.30 – 1.89	1.63	-	100
6.	Doddawada	1.59 – 2.14	1.79	-	100
7.	Udikeri	1.10 – 1.40	1.19	-	100
8.	Sampagaon	1.19 – 4.77	2.45	-	100
9.	Bavihal	1.32 – 3.99	2.12	-	100
10.	Turamari	1.51 – 4.61	2.80	-	100
11.	Neginahal	1.51 – 2.65	2.12	-	100

Table 75: Range, mean values and per cent samples on copper status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples	
				Deficit	Sufficient
1.	Siddasamudra	3.12 – 3.75	3.44	-	100
2.	Hirebellikatti	0.91 – 3.21	2.22	-	100
3.	Kadasagatti	2.08 – 2.94	2.48	-	100
4.	Gudikatti	2.00 – 2.74	2.37	-	100
5.	Budarkatti	2.51 – 3.58	2.92	-	100
6.	Bidaragaddi	3.19 – 6.33	5.26	-	100
7.	Jallikoppa	1.20 – 1.95	1.64	-	100
8.	Aaravalli	1.00 – 1.83	1.49	-	100
9.	Patyal	2.91 – 5.90	3.80	-	100
10.	Khodhanpur	1.52 – 3.60	2.57	-	100
11.	Sangolli	3.06 – 3.51	3.28	-	100
12.	Garjur	1.58 – 2.03	1.83	-	100
13.	Savatagi	1.68 – 2.25	1.91	-	100

The DTPA extractable copper in red soils ranged from 3.12 to 3.75 ppm with a mean value of 3.44 ppm, 0.91 to 3.21 ppm with a mean value of 2.22 ppm, 2.08 to 2.94 ppm with a mean value of 2.48 ppm, 2.00 to 2.74 ppm with a mean value of 2.37 ppm, 2.51 to 3.58 ppm with a mean value of 2.92 ppm, 3.19 to 6.33 ppm with a mean value of 5.26 ppm, 1.20 to 1.95 ppm with a mean value of 1.64 ppm, 1.00 to 1.83 ppm with a mean value of 1.49 ppm, 2.91 to 5.90 ppm with a mean value of 3.80 ppm, 1.52 to 3.60 ppm with a mean value of 2.578 ppm, 3.06 to 3.51 ppm with a mean value of 3.28 ppm, 1.58 to 2.03 ppm with a mean value of 1.83 ppm and 1.68 to 2.25 ppm with a mean value of 1.91 ppm, in the villages of Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidaragaddi, Jallikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi, respectively.

4.2.11 DTPA extractable manganese (ppm)

The results on DTPA extractable manganese of black and red soils of Bt cotton growing areas of Bailhongal taluk is presented in Table 76 and 77.

The DTPA extractable manganese in black soils ranged from 1.16 to 9.81 ppm with a mean value of 4.55 ppm in Govankoppa village, 1.21 to 4.06 ppm with a mean value of 3.18 ppm in Mugabasava village, 1.97 to 3.98 ppm with a mean value of 3.40 ppm in Belavadi village, 0.56 to 1.56 ppm with a mean value of 1.02 ppm in Budihal village, 1.38 to 6.12 ppm with a mean value of 3.62 ppm in Chikkabellikatti village, 2.31 to 6.82 ppm with a mean value of 3.89 ppm in Dodawad village, 1.15 to 2.01 ppm with a mean value of 1.43 ppm in Udikeri village, 0.53 to 0.65 ppm with a mean value of 2.51 ppm in Sampagaon village, 0.70 to 14.65 ppm with a mean value of 8.21 ppm in Bavihal village, 6.13 to 14.40 ppm with a mean value of 9.40 ppm in Turumati village, 3.72 to 13.01 ppm with a mean value of 7.73 ppm in Neginahal village. The DTPA extractable manganese in red soils of Bailhongal taluk ranged from 19.01 to 22.73 ppm with a mean value of 21.35 ppm, 5.10 to 23.50 ppm with a mean value of 17.97 ppm, 3.40 to 34.56 ppm with a mean value of 16.36 ppm, 4.14 to 7.24 ppm with a mean value of 5.10 ppm, 1.97 to 13.70 ppm with a mean value of 4.97 ppm, 17.20 to 28.90 ppm with a mean value of 22.08 ppm, 1.98 to 5.89 ppm with a mean value of 3.99 ppm, 1.22 to 4.15 ppm with a mean value of 2.52 ppm, 12.00 to 33.56 ppm with a mean value of 24.35 ppm, 15.32 to 31.38 ppm with a mean value of 25.60 ppm, 15.90 to 29.85 ppm with a mean value of 24.56 ppm, 11.43 to 16.72 ppm with a mean value of 13.64 ppm and 7.93 to 11.48 ppm with a mean value of 9.01 ppm in the villages of Siddasamudra, Hirebellikatti, Kadasagatti, Gudikatti, Budarkatti, Bidaragaddi, Jallikoppa, Aaravalli, Patyal, Khodhanpur, Sangolli, Garjur and Savatagi, respectively.

4.2.12 Seed cotton yield (q/ha)

The data on seed cotton yield in black and red soils of Bailhongal taluk is presented in Table 78, 79 and Fig. 14, 15.

The seed cotton yield in black soils of Bailhongal taluk ranged from 15-20 q per ha with a mean value of 17.0 q per ha, 15-20 q per ha with a mean value of 17.4 q per ha, 15-20 q per ha with a mean value of 17.1 q per ha, 15-20 q per ha with a mean value of 17.4 q per ha, 15-21 q per ha with a mean value of 17.2 q per ha, 14-21 q per ha with a mean value of 17.9 q per ha, 16-20 q per ha with a mean value of 17.8 q per ha, 16-19 q per ha with a mean value of 17.6 q per ha, 15-21 q per ha with a mean value of 18-21 q per ha, 16-19 q per ha with a mean value of 17.6 q per ha, 17-20 q per ha with a mean value of 18-20 q per ha Govankoppa, Mugabasava, Belawadi, Budihal, Chikkabellikatti, Doddawad, Udikeri, Sampagaon, Bavihal, Turamari and Neginal, respectively.

The seed cotton yield in red soils ranged from 11-15 q per ha with a mean value of 12.7 q per ha in Siddasamudra, 10-13 q per ha with a mean value of 11.8 q per ha in Hirebellikatti, 10-13 q per ha with a mean value of 11.6 q per ha in Kadasgatti, 12-16 q per ha with a mean value of 14.8 q per ha in Gudikatti, 12-17 q per ha with a mean value of 14.8 q per ha in Budarkatti, 12-18 q per ha with a mean value of 15.3 q per ha in Bidargaddi, 12-18 q per ha with a mean value of 15.2 q per ha in Jalikoppa, 12-18 q per ha with a mean value of 14.9 q per ha in Aravalli, 12-15 q per ha with a mean value of 13.2 in Patyal, 12-17 q per ha with a mean value of 14.2 q per ha in Khodanpur, 12-15 q per ha with a mean value of 13.8 q per ha in Sangolli, 13-16 q per ha with a mean value of 14.6 q per ha in Garjur and 12.15 q per ha with a mean value of 11.6 q per ha in Savatagi, respectively.

Table 76: Range, mean values and per cent samples on manganese status in black soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples	
				Deficit	Sufficient
1.	Govankoppa	1.16 – 9.81	4.55	10	90
2.	Mugabasava	1.21 – 4.06	3.18	10	90
3.	Belawadi	1.97 – 3.98	3.40	10	90
4.	Budihal	0.56 – 1.56	1.02	100	-
5.	Chikkabellikatti	1.38 – 6.12	3.62	10	90
6.	Doddawada	2.31 – 6.82	3.89	-	100
7.	Udikeri	1.15 – 2.01	1.43	90	10
8.	Sampagaon	0.53 – 5.65	2.51	50	50
9.	Bavihal	0.70 – 14.65	8.21	40	60
10.	Turamari	6.13 – 14.40	9.40	-	100
11.	Neginahal	3.71 – 13.01	7.73	-	100

Table 77: Range, mean values and per cent samples on manganese status in red soils of Bt cotton growing areas of Bailhongal taluk

Sl. No.	Villages	Range	Mean	Per cent samples	
				Deficit	Sufficient
1.	Siddasamudra	19.01 – 22.73	21.36	-	100
2.	Hirebellikatti	5.10 – 23.50	17.97	-	100
3.	Kadasagatti	3.43 – 4.56	16.36	-	100
4.	Gudikatti	4.14 – 7.24	5.10	-	100
5.	Budarkatti	1.97 – 13.70	4.97	-	90
6.	Bidaragaddi	17.20 – 28.90	22.08	-	100
7.	Jallikoppa	1.98 – 5.89	3.99	10	90
8.	Aaravalli	1.22 – 4.150	2.52	30	70
9.	Patyal	12.00 – 33.56	24.35	-	100
10.	Khodhanpur	15.32 – 31.38	25.60	-	100
11.	Sangolli	9.85 – 15.92	24.56	-	100
12.	Garjur	11.43 – 16.72	13.64	-	100
13.	Savatagi	7.93 – 11.48	9.01	-	100

Table 78: Range and mean values of seed cotton yield (q/ha) in black soils of Bt cotton growing area of Bailhongal

Sl. No.	Villages	Range	Mean	Low	High
1.	Govankoppa	15 – 20	17.0		100
2.	Mugabasava	15 – 20	17.4		100
3.	Belawadi	15 – 20	17.1		100
4.	Budihal	15 – 20	17.4		100
5.	Chikkabellikatti	15 – 21	17.2		100
6.	Doddawada	14 – 21	17.9		100
7.	Udikeri	16 – 20	17.8		100
8.	Sampagaon	16 – 19	17.6		100
9.	Bavihal	15 – 21	18.1		100
10.	Turamari	16 – 19	17.6		100
11.	Neginahal	17 - 20	18.2		100

Table 79: Range and mean values of seed cotton yield (q/ha) in red soils of Bt cotton growing area of Bailhongal

Sl. No.	Villages	Range	Mean	Low	High
1.	Siddasamudra	11 – 15	12.7	100	
2.	Hirebellikatti	10 – 13	11.8	100	
3.	Kadasagatti	10 – 13	11.6	100	
4.	Gudikatti	12 – 16	14.8	100	
5.	Budarkatti	12 – 17	14.8	100	
6.	Bidaragaddi	12 – 18	15.3		100
7.	Jallikoppa	12 – 18	15.2		100
8.	Aaravalli	12 – 18	14.9	100	
9.	Patyal	12 – 15	13.2	100	
10.	Khodhanpur	12 – 17	14.2	100	
11.	Sangolli	12 – 15	13.8	100	
12.	Garjur	13 – 16	14.6	100	
13.	Savatagi	12 - 15	11.6	100	

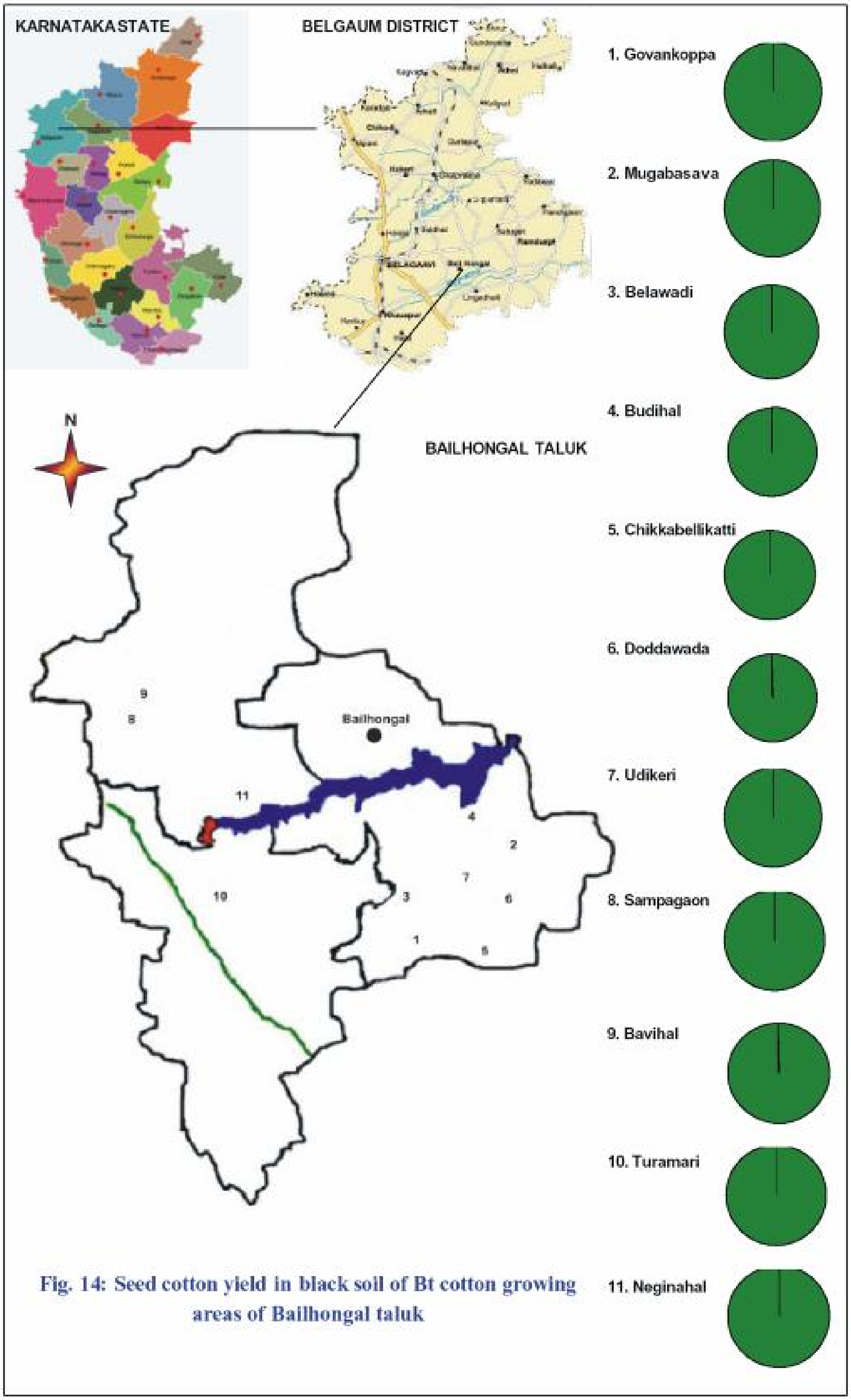

Fig. 14: Seed cotton yield in black soil of Bt cotton growing areas of Bailhongal taluk

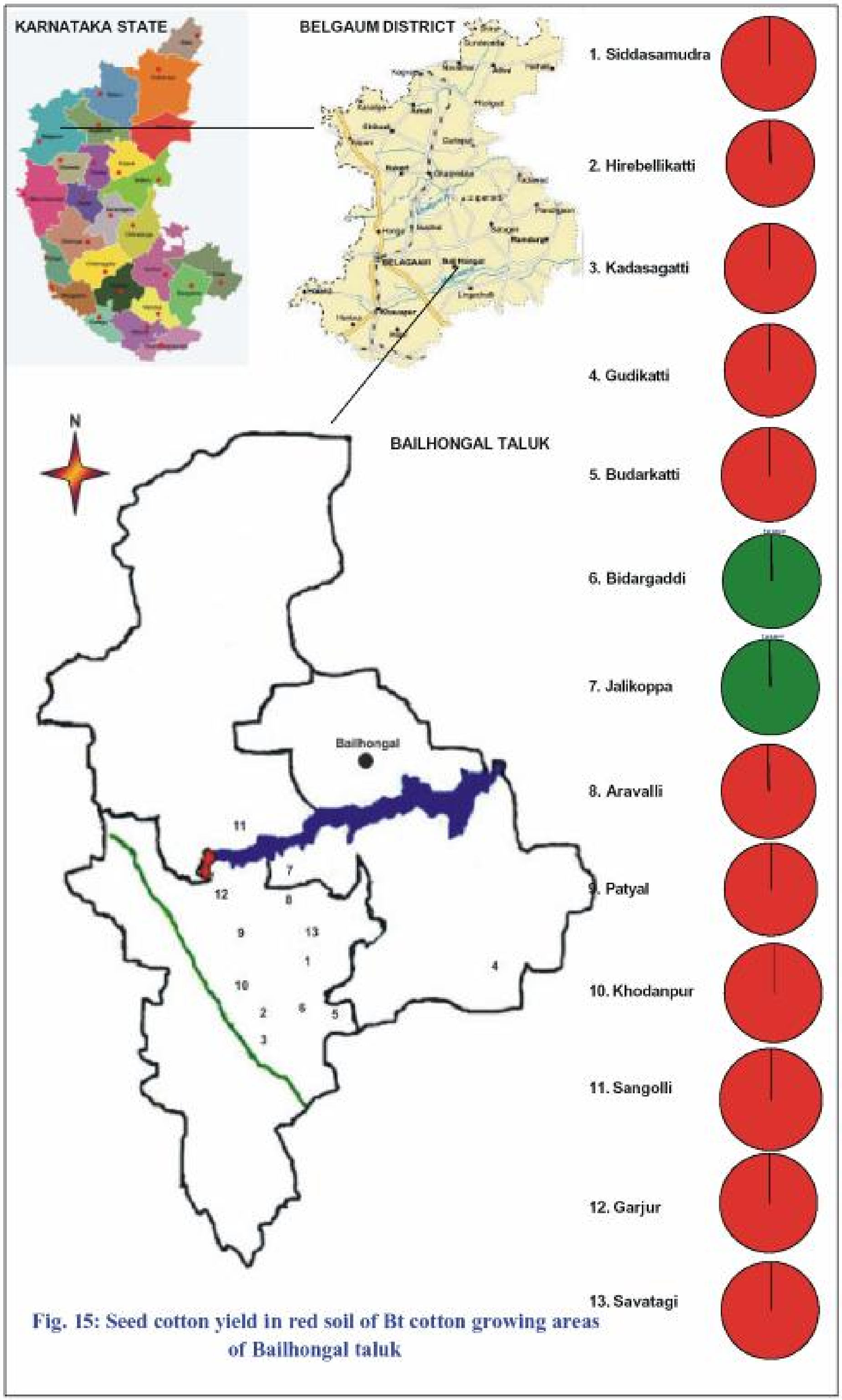

Fig. 15: Seed cotton yield in red soil of Bt cotton growing areas of Bailhongal taluk

4.3 Cultivation practices adopted by farmers in black and red soils of Bt cotton growing areas of Bailhongal taluk

4.3.1 Method of sowing

The data presented in Table 80 indicates that majority of the farmers (100%) follow dibbling method in both black and red soils of Bailhongal taluk.

4.3.2 Hybrids used

The hybrids used by the farmers are presented in Table 80 indicates that Bunny Bt was the prominent hybrid used in both black and red soils to the extent of 68.00 and 30.50 per cent, respectively. Next widely used hybrid was Kanaka to the extent of 12.00 and 22.80 per cent in black and red soils, respectively. Other hybrids used in black soils are Neeraj (2.00%), Tulsi (5.00%), MRC-6918 (8.00%), JK-99 (3.00%), Akka (2.00%), whereas in red soils, the other hybrids used are Neeraj (19.20%), Tulsi (1.90%), Kanaka (22.80%), MRC-6918 (21.00%) and Brahma (3.80%).

4.3.3 Seed rate used

The seed rate used by the farmers in black and red soils is presented in Table 80.

The data indicated that 68.00 per cent in black soil and 68.40 per cent in red soil the farmers use recommended seed rate (450 g/acre), while the above recommended seed rate to the extent of 20.00 and 22.30 per cent were used by the farmers in black and red soil, respectively, 12.00 and 14.30 per cent farmers used the below recommended seed rate in black and red soils, respectively.

4.3.4 Seed treatment

None of the farmers in black and red soils were practicing seed treatment before sowing (Table 80).

4.3.5 Time of sowing

The data on time of sowing in black and red soils of Bt cotton is presented in Table 80.

Majority of the farmers (42.00%) have sown the crop during June I fortnight in black soil and 45.60 per cent in red soils. And 38.00 and 40.00 per cent of farmers have sown the crop during May II fortnight. About 16.00 and 4.00 per cent have sown during June II fortnight and July I fortnight in black soil and 12.40 and 2.00 per cent in red soil have sown the crop during June II fortnight and July I fortnight.

4.3.6 Gap filling

The data on gap filling is presented in Table 80 in both black and red soils of Bt cotton growing areas of Bailhongal taluk. About 88.00 and 74.10 per cent of farmers in black and red soils, respectively followed gap filling after 15 to 20 days after sowing. Majority of the farmers used non-Bt seeds to fill the gaps.

4.3.7 Practice of refugia

The data on practice of refugia is presented in Table 80.

Majority of the farmers in black and red soils (68.00% and 62.20%) have not followed refugia crop. Practice of refugia was done to the extent of 32 per cent and 42.8 per cent in black and red soils, respectively.

4.3.8 Spacing

The information on practice of spacing is presented in Table 80.

About 72.00 and 90.30 per cent of farmers in black and red soils followed 90 × 60 cm spacing. About 28.00 and 14.70 per cent farmers have followed wide spacing of 120 × 60 cm in black and red soils, respectively.

4.3.9 Nipping

The information on practice of nipping is presented in Table 80 for both black and red soils.

About 72.00 per cent in black soil and 64.60 per cent in red soil have not followed nipping. Remaining 28 and 40.40 per cent in black and red soils have followed nipping.

4.3.10 Fertilizer management

The results on fertilizer management are presented in Table 80 for both black and red soils.

4.3.10.1 Nitrogen application

Majority of the farmers (86.00%) in black soil and 86.50 per cent in red soil have followed below recommended dose. Whereas 8.00 per cent in black soil and 5.70 per cent in red soils farmers have followed equal to recommended dose. Less per cent of the farmers have followed 6.00 and 12.80 per cent have followed above recommended dose in black and red soil, respectively.

4.3.10.2 Phosphorus application

About 72.00 per cent in black and 83.60 per cent in red soil have followed below recommended dose of phosphorus application, 18 farmers in black soil, 13.30 per cent in red soil have followed equal to recommended dose, 10.00 per cent in black soil and 8.10 per cent in red soil have followed above recommended dose of fertilizer.

4.3.10.3 Potassium application

The results on potassium application indicated that 78.00 per cent in black soil and 77.90 per cent in red soil have followed below recommended dose, 12.00 per cent in black and 19.90 per cent in red soil have followed equal to recommended dose, 10.00 per cent in black soil and 7.20 per cent in red soil have followed above recommended dose of phosphorus application.

4.3.11 Method of fertilizer application

The information on method of fertilizer application is presented in Table 80.

4.3.11.1 Nitrogenous fertilizer

In black soils, 82.00 and 79.40 per cent in red soil have followed both basal application and top dressing for nitrogenous fertilizer, 16.00 and 22.80 per cent in black and red soils have followed basal application of nitrogenous fertilizers, 2.00 and 2.85 per cent have followed top dressing of nitrogenous fertilizer in black and red soils, respectively.

4.3.11.2 Phosphorus fertilizer

In black soil, 78.00 and 77.40 per cent in red soil have followed both basal application and top dressing of fertilizer, 19.00 and 23.80 per cent have followed basal application of phosphorus fertilizer, 3.00 and 3.80 per cent of farmers in black and red soils.

4.3.11.3 Potassium fertilizer

Majority of the farmers (100%) in black and red soil have followed only basal application of potassium fertilizer.

4.3.12 Organic manures

The results on organic manures in black and red soil is indicated in Table 80.

About 82.00 per cent in black and 78.90 per cent in red soil have applied organic manure before one month sowing of cotton, 84.00 and 84.60 per cent in black and red soils have applied <2 t per ha of manures and 16.00 per cent and 20.4 t per ha have applied 2.00 to 5.00 t per ha of organic manures.

4.3.13 Weed control measures

The data on weed control measures is presented in Table 80 for both black and red soils. Majority of the farmers (100%) in both black and red soils have adopted weed control measures.

4.3.13.1 Intercultivation

About 78.00 and 68.40 per cent in black and red soils have followed two intercultivations, 22.00 and 27.60 per cent have followed three intercultivations in black and red soils, respectively, 9.00 per cent of farmers have followed four intercultivations in red soils.

4.3.13.2 Hand weeding

About 88.00 per cent of farmers have two hand weedings and 77.90 per cent farmers have followed three hand weedings in black and red soils, respectively. About 12.00 per cent in black soil and 27.10 per cent in red soils have followed three hand weedings, respectively.

4.3.14 Pest management

The data on pest management in both black and red soil is presented in Table 80.

Low pest load of 15.00 and 13.30 per cent in black and red soils, respectively was observed and high pest load of 85.00 and 91.70 per cent in black and red soils was observed.

Majority of the farmers had the problem of sucking pest and bollworm in both black and red soils to the extent of 95.00 and 98.35 per cent, respectively. 4.00 and 4.75 per cent farmers had only the sucking pest problem in black and red soils, respectively, 1.00 per cent in black soil and 1.90 per cent in red soil was observed.

For the management of pests, 45.00 per cent farmers in black soil and 37.14 per cent in red soil sprayed pride, confider and acephate for the control of pests, 20.00 and 17.14 per cent in black and red soils used confider and pride, only confider 10 per cent in black and 15.23 per cent in red have sprayed for the control of pests, 6.00 per cent in black and 8.57 per cent in red soils have sprayed only pride, 9.00 and 13.33 per cent in black and red soils, respectively have sprayed only acephate and 4.00 per cent in black and 8.57 per cent in red soils, respectively have sprayed both monocrotophos and neem based products for the control of pests.

4.3.15 Leaf reddening management

The information on leaf reddening management is presented in Table 80 for both black and red soils. None of the farmers have sprayed DAP or urea for the management of leaf reddening, whereas 28.00 per cent of farmers in black soil, 30.40 per cent in red soil have sprayed twice with $MgSO_4$ and 48.00 per cent in black and 37.10 per cent in red soil have sprayed once with $MgSO_4$. Nearly 26.00 per cent and 37.50 per cent have not sprayed with $MgSO_4$ in black and red soils, respectively.

4.3.16 Flower or fruit dropping management

The data on management of flower and fruit drop for both black and red soils is presented in Table 80.

17.00 per cent in black soil and 13.30 per cent in red soil have sprayed planofix for flower or fruit dropping, 83.00 per cent in black soil and 91.70 per cent in red soil have not sprayed planofix for the flower or fruit dropping.

4.3.17 Yield levels per ha

The data on yield obtained by the farmers in growing Bt cotton in black and red soils is presented in Table 80.

About 89 per cent in black soil and 73 per cent in red soil have obtained yield in the range of 15-20 q per ha while 10-15 q per ha yield obtained in black and red soils was to the extent of 8 and 32 per cent, respectively, 3 per cent of farmers obtained yield in the range of 20-25 q per ha in black soils.

Table 80: Cultivation practices adopted by farmers in black and red soils of Bailhongal taluk

Sl. No.	Bt cotton cultivation practices	Black soil (100)		Red soil (105)	
		Frequency	Percentage	Frequency	Percentage
1.	**Method of sowing**				
a)	Drill sowing				
b)	Diblling	100	100	105	100
2.	**Hybrids used**				
a)	Bunny Bt	68	68	32	30.5
b)	Neeraj	2	2	20	19.2
c)	Tulsi	5	5	2	1.9
d)	Kanak	12	12	24	22.8
e)	MRC-6918	8	8	23	21.8
f)	JK-99	3	3	0	0
g)	Akka	2	2	0	0
h)	Brahma	0	0	4	3.8
3.	**Seed rate used**				
a)	Below recommended seed rate	12	12	15	14.3
b)	Recommended seed rate (450 g/acre)	68	68	72	68.4
c)	Above recommended seed rate	20	20	18	22.3
4.	**Seed treatment**	0	0	0	0
5.	**Time of sowing**				
a)	May II fortnight	38	38	42	40.0
b)	June I fortnight	42	42	48	45.6
c)	June II fortnight	16	16	13	12.4
d)	July I fortnight	4	4	2	2.0
6.	**Gap filling**				
a)	Followed	88	88	78	74.1
b)	Not followed	12	12	22	30.9
7.	**Refugia**				
a)	Followed	32	32	45	42.8
b)	Not followed	68	68	55	62.2

Contd……..

Sl. No.	Bt cotton cultivation practices	Black soil (100)		Red soil (105)	
		Frequency	Percentage	Frequency	Percentage
8.	**Spacing**				
a)	120 cm × 60 cm	72	72	95	90.3
b)	90 cm × 60 cm	28	28	10	14.7
9.	**Nipping**				
a)	Not followed	72	72	68	64.6
b)	Followed	28	28	32	40.4
10.	**Fertilizer management NPK used**				
a)	N application				
	Below recommended dose	86	86	91	86.5
	Equal to recommended dose	8	8	6	5.7
	Above recommended dose	6	6	8	12.8
b)	P_2O_5 application				
	Below recommended dose	72	72	88	83.6
	Equal to recommended dose	18	18	14	13.3
	Above recommended dose	10	10	3	8.10
c)	K_2O application				
	Below recommended dose	78	78	82	77.9
	Equal to recommended dose	12	12	21	19.9
	Above recommended dose	10	10	2	7.2
	Method of fertilizer application				
a)	Nitrogenous fertilizer				
	Basal application	16	16	24	22.8
	Top dressing	2	2	3	2.85
	Basal application + top dressing	82	82	78	79.4
b)	Phosphorus fertilizers				
	Basal application	19	19	25	23.8
	Top dressing	3	3	4	3.8
	Basal application + top dressing	78	78	76	77.4
c)	Potassium fertilizers				
	Basal application	100	100	105	100
	Top dressing	0	0	0	0
	Basal application + top dressing	0	0	0	0

Contd……

Sl. No.	Bt cotton cultivation practices	Black soil (100)		Red soil (105)	
		Frequency	Percentage	Frequency	Percentage
11.	**Organic manures**				
a)	Used	82	82	83	78.9
b)	Not used	18	18	22	26.1
11a.	**Quantity of manures used**				
a)	<2 t/ha	84	84	89	84.6
b)	2 – 5 t/ha	16	16	16	20.4
12.	**Weed control measures**				
a)	Adopted	100	100	105	100
b)	Not adopted	0	0	0	0
12a.	**Type of weed control measures**				
	Intercultivation				
	2	78	78	72	68.4
	3	22	22	29	27.6
	4	0	0	4	9.0
	Hand weeding 2	88	88	82	77.9
	Hand weeding 3	12	12	23	27.1
13.	**Pest management : Pest load**				
	No pests	0	0	0	0
	Low pest load	15	15	14	13.3
	High pest load	85	85	91	91.7
13a.	**Major type of pest**				
	Sucking pests	4	4	5	4.75
	Bollworm	1	1	2	1.90
	Sucking pests + bollworm	95	95	98	98.35
13b.	**Pest management**				
	Pride + Confidar + Acephate	45	45	30	37.14
	Confidar + Pride	22	20	18	17.14
	Confidar	12	10	16	15.23
	Pride	7	6	9	8.57
	Acephate	9	9	14	13.33
	Monocrotophos	5	4	9	8.57

Contd……

Sl. No.	Bt cotton cultivation practices	Black soil (100)		Red soil (105)	
		Frequency	Percentage	Frequency	Percentage
14.	**Leaf reddening management**				
	DAP spray	0	0	0	0
	Urea spray	0	0	0	0
	$MgSO_4$ - Once	48	48	39	37.1
	$MgSO_4$ - Twice	28	28	32	30.4
	No spray	26	26	34	37.5
15.	**Flower/fruit dropping management**				
	Planofix spray followed	17	17	14	13.3
	Planofix spray not followed	83	83	91	91.7
16.	**Yield levels (q/ha)**				
	10 – 15	8	8	32	30.5
	15 – 20	89	89	73	69.5
	20 - 25	3	3	0	0

5. DISCUSSION

The development of Bt cotton containing a genetically introgressed endotoxin gene from the gram negative soil bacteria (*Bacillus thuringiensis* Hubner) represents a significant technological landmark in the global cotton research. India adopted this technology in 2002-03 amongst those countries that adopted Bt cotton. India derived the greatest benefit from the insect resistance trait.

Cotton is the major cash crop of India and accounts for 75 per cent of the fiber used in the textile industry, which has 1063 spinning mills and accounts for 4 per cent GDP. India is the only country to grow all four species of cultivated cotton. *Gossypium hirsutum* represents more than 90 per cent of the hybrid cotton production in India and all the current Bt cotton hybrids are *G. hirsutum* grown in an area of 87 per cent or 8.4 million hectares a remarkably high proportion in a fairly short period of eight years equivalent to an unprecedented 168 fold increase from 2002 to 2009. In 2009, the multiple gene Bt cotton hybrids were planted for the first time on more area (57%) than single gene Bt cotton hybrids occupying 4.82 million hectares as compared to 3.58 million (43%) occupied by single gene Bt cotton hybrids. Farmers prefer multiple genes over a single gene Bt cotton hybrids because multiple gene Bt cotton hybrids provide additional protection increases efficacy of protection and higher profit through savings associated with fewer sprays and increasing yield by 8 to 10 per cent over single gene Bt hybrids.

Therefore, to realize the utility of BG-II for enhanced yield in comparison with BG-I and non-Bt in different soils with agronomic performance, the present study was undertaken. The results obtained in experiments carried out on both black and red soils on farmers field in participatory mode of research with mother and baby trial design have been discussed in this chapter under different headings.

5.1 Agronomic performance of Bt cotton hybrids in black and red soils

Variability of crop yield is a consequence of variation in the genetic properties of the plants and of environmental factors. Different genotypes exhibit different yield levels depending on many factors and are the resultant of complex, morphological and physiological processes occurring in various parts of plants. Yielding ability of genotypes again depends on the production of higher yield attributes.

In evaluation of different genotypes in black soil, Bunny BG-II Bt recorded significantly higher seed cotton yield (2385 kg/ha) than JK-99 Bt (1922 kg/ha), Brahma Bt (1770 kg/ha) and DHH-11 (1615 kg/ha). The yield was significantly lower with DHH-11 (1615 kg/ha) compared to all other Bt cotton genotypes. The results indicated the superiority of Bt cotton hybrids with respect to seed cotton yield over that of non-Bt hybrid. The results obtained are similar to the findings of Sunitha *et al.* (2010), where both the Bt hybrids Bunny Bt and Mallika Bt showed higher yield parameters and seed cotton yield over that of non-Bt hybrid. Bunny BG-II Bt recorded 33 per cent higher yield over non-Bt DHH-11. Higher yield per ha in Bunny BG II Bt is supported by higher per plant yield (130 g/plant) and found significant over non-Bt hybrid DHH-11 (89 g/plant) (Plate 6). Similar findings were reported by Hosmath *et al.* (2004) indicated that seed cotton yield was significantly higher in MECH-162 Bt (1172.39 kg/ha) than DHH-11 (875.96 kg/ha) and non-Bt MECH-162 (719.31 kg/ha) in medium black soil. The study conducted in USA by Carlson *et al.* (1998) indicated 11.40 per cent yield advantage due to Bt cotton genotypes over the conventional cotton genotypes. 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, respectively in medium deep black soil (Hallikeri *et al.*, 2004).

Plate 3: Different genotypes performance in black soil (Mother trial)

Comparison within Bt genotypes in the present study has shown greater variations (4% – 14%) in yield advantage among different tested Bt genotypes. Comparison among Bt genotypes in the present study revealed that Bunny BG-II Bt recorded significantly higher seed cotton yield (2385 kg/ha) and was found on par with RCH-2 BG-II (2307 kg/ha), MRC-6918 Bt (2290 kg/ha), RCH-708 Bt (2225 kg/ha), Bunny Bt (2190 kg/ha), RCH-2 Bt (2110 kg/ha) and Mallika Bt (2055 kg/ha). In the present investigation, the Bollgard genotypes JK-99 Bt and Brahma Bt recorded 19.40 and 25.70 per cent lower yield than the highest yielding Bunny BG-II (2385 kg/ha). This is due to the genetic make up the genotypes that caused variations in yield among the genotypes.

The yield contributing factor in cotton is sympodial branches which were found significantly higher in MRC-6918 Bt as compared to non-Bt hybrid DHH-11. MRC-6918 Bt produced 26.5 per cent more number of sympodial branches than DHH-11. Joshi (2007) also noticed 43.2 and 42.6 per cent more number of sympodial branches in DCH-32 and DHH-11 non-Bt, respectively. LAI also varied significantly and the highest LAI was noticed in MRC-6918 Bt (3.01), which was 40 per cent higher than the DHH-11. Among Bt cotton genotypes, LAI variations were in the range of 41.1 to 77.0 per cent. Higher SPAD value of 42.7 was recorded with MRC-6918 compared to all other cotton genotypes.

Bt cotton genotypes recorded higher total number of bolls per plant compared to non-Bt hybrid. Total number of bolls per plant were significantly higher in RCH-708 Bt compared to all other cotton genotypes but on par with MRC-6918 Bt. Higher number of total bolls in these Bt genotypes reflected their performance in recording lower bad opened bolls per plant compared to non-Bt hybrid.

Mallika Bt recorded 21.2 per cent higher boll weight than non-Bt hybrid DHH-11. Total dry matter production was found to be significantly higher in MRC-6918 Bt (318 g/plant), which was 15.5 per cent higher than the DHH-11 non-Bt hybrid.

In evaluation of different genotypes in red soil, MRC-6918 Bt recorded significantly higher seed cotton yield (2257 kg/ha) than all other cotton genotypes and was found on par with Bunny BG-II Bt (2196 kg/ha) and RCH-2 BG-II (2090 kg/ha) (Plate 7). The lowest yield was recorded with DHH-11 (1496 kg/ha). The results indicated the better translocation of assimilates from source to sink. The results obtained are similar to the findings of Radhika *et al.* (2004) who recorded the highest yield of 14.89 q per ha in MECH-184 Bt which was on par with other Bt hybrids, but significantly higher than in non-Bt versions and checks. Higher yield per ha is supported by higher yield per plant (141.8 g/plant) in MRC-6918 and found significantly superior over other Bt cotton genotypes and non-Bt cotton DHH-11 (83.5 g/plant). Similar findings were reported by Kristen *et al.* (2002) showed the yield advantage of Bt cotton, which ranged from 14.19 per cent over non-Bt cotton and check. Naik (2001) noticed the yield advantage of Bt cotton hybrids compared to non-Bt, which ranged from 24.56 per cent more over non-Bt cotton. Khadi *et al.* (2002) noticed that among Bt cotton hybrids MECH-184 Bt recorded significantly higher seed cotton yield than the commercial hybrids and zonal check hybrids.

Comparison among Bt cotton genotypes in the present study has shown greater variation (3 – 27%) yield advantage among different tested Bt genotypes which were higher than reported by Carlson *et al.* (1998), who reported Bt cotton grown produced 11.40 per cent higher yield than conventional cotton. Comparison among Bt genotypes in the present investigation revealed that MRC-6918 recorded significantly higher yield (2257 kg/ha) over RCH-708 Bt (2028 kg/ha), RCH-2 Bt (1988 kg/ha), Bunny Bt (1996 kg/ha), Mallika Bt (1866 kg/ha), JK-99 Bt (1737 kg/ha) and Brahma Bt (1649 kg/ha).

In the present investigation, the bollgard genotypes JK-99 Bt and Brahma Bt recorded 23 and 26 per cent lower yield than the highest yielding MRC-6918 Bt (2257 kg/ha). The yielding ability of a hybrid is the reflection of yield attributing characters. The yield contributing factor in cotton is the sympodial branches which were found significantly higher in MRC-6918 Bt as compared to non-Bt hybrid DHH-11. MRC-6918 Bt produced 27.6 per cent higher sympodial branches than DHH-11.

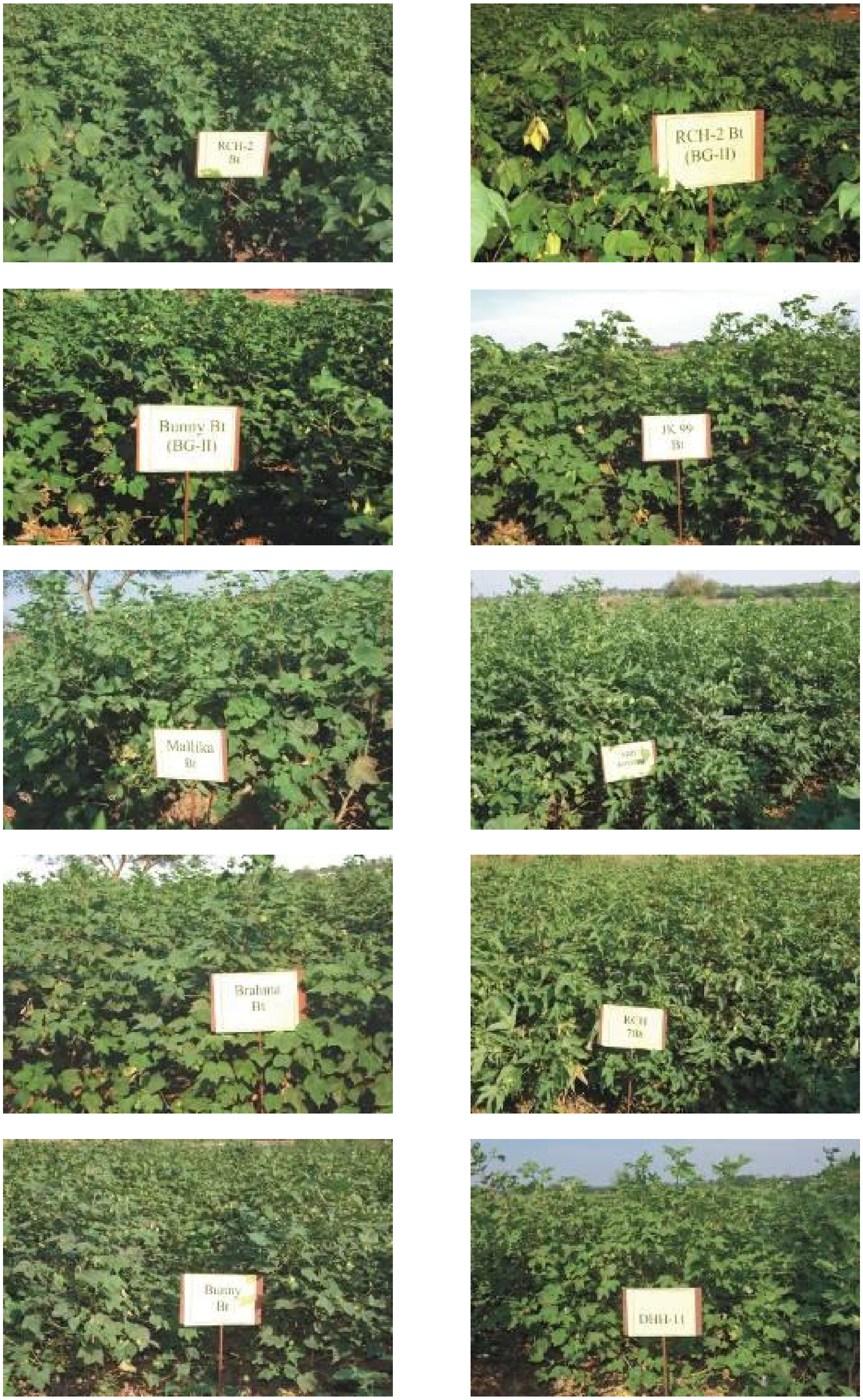

Plate 4: Different genotypes performance in red soil (Mother trial)

LAI also varied significantly and the higher LAI was noticed in Bunny BG-II which was 11.4 per cent higher than the DHH-11. Among the Bt cotton genotypes variations with respect to LAI were in the range of 4.0 to 18.0 per cent. Higher SPAD value of 40 was recorded with MRC-6918 Bt compared to other cotton genotypes.

The increase in yield of Bt cotton could be traced back to a significant increase in yield components *viz.,* number of bolls per plant, boll weight and seed cotton yield per plant by the Bt cotton hybrid as compared to non-Bt hybrid. Bt cotton genotypes recorded higher total number of bolls per plant compared to non-Bt hybrid. MRC-6918 Bt recorded significantly higher total number of bolls (35%) per plant compared to all other cotton genotypes and was found on par with RCH-708 (34%). Similar increase in number of bolls per plant of Bt cotton hybrids was observed by Biradar *et al.* (2003), Fitt *et al.* (1994), Bacheler and Mott (1996) and Harris *et al.* (1996). Mayee *et al.* (2004), who have reported that higher seed cotton yield was attributed to higher retention of bolls from the first flush of flowers. This signifies a very high level of physiological efficiency during the grand growth phase of the crop and obviously this enhanced efficiency was primarily due to effective development and retention of boll load with practically very little damage by bollworms. This was again due to the inbuilt resistance conferred by the Bt gene and Bt cotton hybrid either matures earlier or partitions more dry matter into the reproductive parts, finally resulting in higher seed cotton yield.

Higher number of total bolls and lower number of bad opened bolls per plant in these Bt genotypes reflected in their better performance compared to non-Bt hybrid. Boll weight was significantly higher with MRC-6918 Bt (5.50 g/boll) compared to non-Bt DHH-11 (4.29 g/boll).

Dry matter production in the different genotypes could be related to higher number of leaves per plant, leaf area and leaf area index. These growth parameters enable the plant to trap higher quantity of radiant energy with higher leaf surface area to convert into chemical energy. This helps in accumulation of higher dry matter in the reproductive parts which inturn might have led to the higher seed cotton yield and higher harvest index. Higher total dry matter production (296 g/plant) was recorded in MRC-6918 Bt and differed significantly to other cotton genotypes and was found on par with RCH-708 Bt (279 g/plant), JK-99 Bt (276 g/plant), Brahma Bt (274 g/plant) and Bunny BG-II (275). Higher harvest index of 0.29 was recorded in MRC-6918 Bt and differed significantly to DHH-11 (0.24).

The performance of different Bt cotton hybrids were compared in mother and baby trial mode to assess the potentiality under research managed Vs farmer growing practices in black soil. The study is first of its kind in cotton and was aimed to harness the complete potential of popular Bt cotton transgenic hybrids. The study also included conventional cotton hybrid DHH-11 though not widely cultivated presently. The comparison in the study is between respective genotypes. It was interesting to note that seed cotton yield of RCH-708 Bt, RCH-2Bt, JK-99 Bt and Brahma Bt could not vary significantly between mother and baby trials. These four genotypes have reached the maximum genetic potential in both researcher managed (mother) and farmers practice (baby trials). Thus, there is no scope for improving their yield potential through agronomic practices.

In all other rest of the genotypes, the seed cotton yield was significantly higher in mother trial indicating scope for improvement under farmers practice. These genotypes individually need to be addressed to tap the highest possible potential or atleast equivalent to one achieved in mother trial with respect to yield.

RCH-2 Bt, JK-99 Bt, DHH-11 and Brahma Bt were found on par with respective mother trial in red soil. These genotypes have reached the maximum potentiality in both research managed (mother trial) and under farmers practice (baby trials). In other Bt cotton genotypes (RCH-2 Bt BG-II, Bunny Bt, Bunny Bt BG-II, Mallika Bt, MRC-6918 Bt and RCH-708 Bt), the seed cotton yield was significantly higher in mother trial indicating scope for improvement under farmers practice. The results are similar to the findings of Bambawale *et al.* (2004), where under farmers participatory field trial in rainfed cotton. MECH162 Bt recorded highest yield (12.40 q/ha) and net returns (Rs. 16231) as compared to conventional cotton with a yield (7.10 q/ha) and net returns (Rs. 10507/ha).

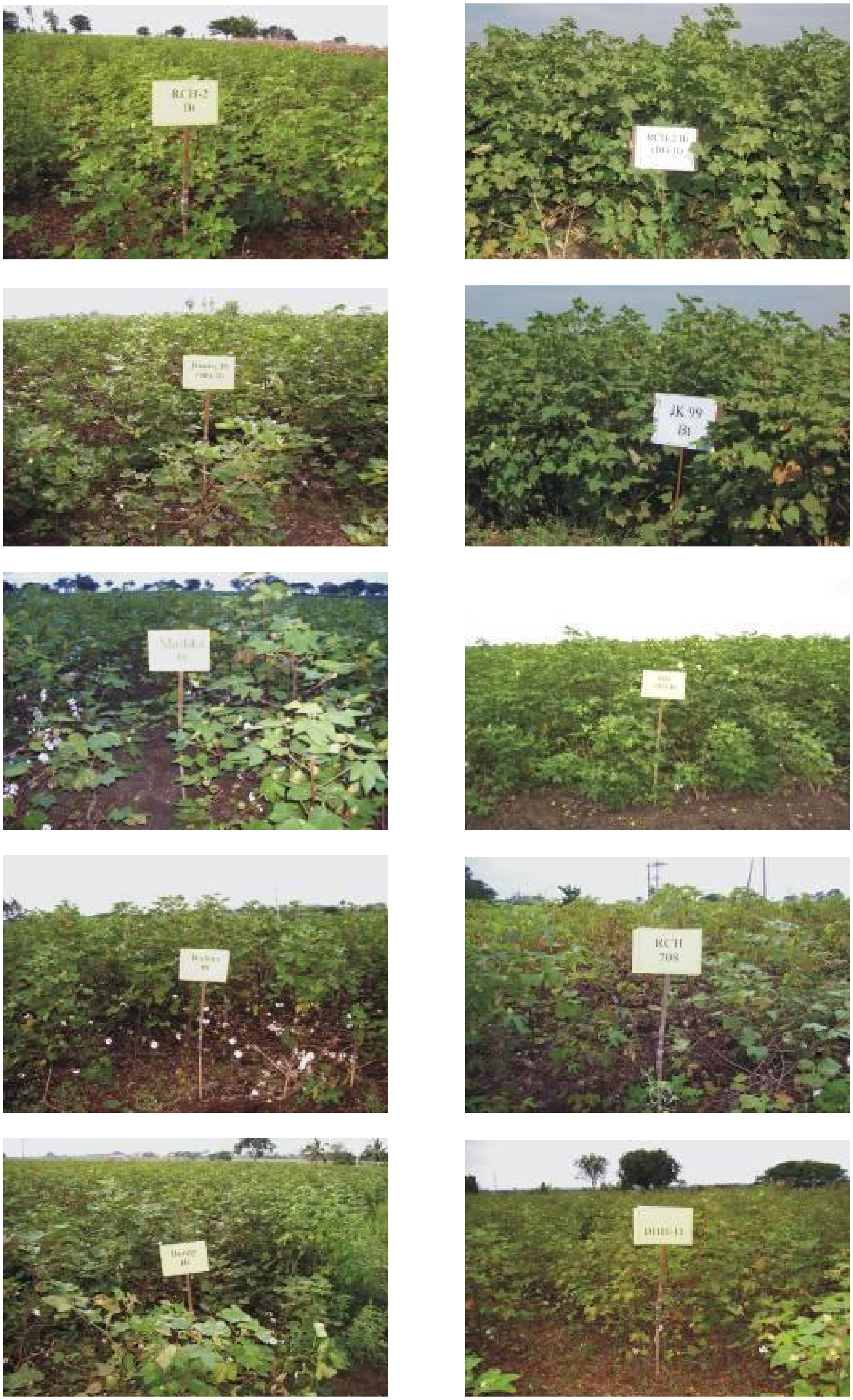

Plate 5: Different genotypes performance in black and red soil (Baby trial)

Comparison of seed cotton yield of different genotypes in black and red soils under both mother and baby trials (Fig. 7) indicates that the seed cotton yields were found to be higher in black soil as compared to red soil in mother trial and baby trial. This is due to increased availability of nutrients, moisture and decreased bulk density encouraged higher uptake by the crop and finally resulting in higher seed cotton yield compared to red soil where uptake of nutrients and moisture were limited account of shallow depth and less available moisture and limited root development on account of greater compaction.

The seed cotton yields in both black and red soils under researcher managed trial (mother trial) was found to be higher as compared to seed cotton yields in both black and red soils under farm managed trial (baby trial) (Plate 8). This indicates that the scope for improvement under farmers practice with respect to agronomic practices to harness the highest possible potential or yield or at least equivalent to one achieved in mother trial.

5.1.1 Economics

Bt cotton which offered resistance to bollworm not only decreased the cost of spraying on insecticides but it had offered a confidence of getting higher returns by producing higher yields. Decreased pest incidence of Bt cotton had increased the returns per unit of investment.

Higher gross returns (Rs. 90415/ha) and net returns (Rs. 67924/ha) was recorded with MRC-6918 Bt and differed significantly to other cotton genotypes and found on par with Brahma Bt. The higher gross and net returns from cultivar of Bt cotton mainly due to higher economic yield associated with that hybrid. Similar economic benefits from Bt cotton cultivation was obtained by Mehta *et al.* (2009). Where, the additional net returns from Bt cotton over non-Bt cotton was Rs. 8959 per ha. The significantly higher benefit:cost ratio was obtained in MRC-6918 Bt (4.02). This is due to higher economic yield and lower cost of cultivation as compared to non-Bt hybrid DHH-11.

The cost of cultivation in non-Bt cotton cultivar varied only with respect to plant protection against bollworm. On an average, DHH-11 has received three sprays against bollworm control and first generation Bt transgenics RCH-2 Bt, Bunny Bt, JK-99 and Brahma received one spray against bollworm control. Similarly, the additional cost of plant protection was Rs. 2300 and Rs. 3760 compared to BG-I and BG-II, respectively in DHH-11. This indicated existence of *Helicoverpa armigera* as key pest in the ecosystem even after eight years of transgenic cotton cultivation. The advantage of BG-II was also much pronounced in this phenomenon. The total cost of cultivation was higher in non-Bt cotton (Rs. 24241/ha). The similar findings were reported by Venugopal *et al.* (2002) that Bt cotton MECH-184 Bt, MECH-162 Bt and MECH-12 Bt required less insecticidal sprays, thus saving in plant protection and increase the total economic benefit from Bt cotton hybrid.

The higher gross returns of Rs. 89131 per ha and net returns of Rs. 64917 per ha was obtained in MRC-6918 and differed significantly to all other cotton genotypes in red soil. The higher gross and net returns from cultivation of Bt cotton mainly due to higher economic yield lower total cost of cultivation associated with that hybrid. The similar findings were recorded by Carlson *et al.* (1998), where Bt cotton plots received 75 per cent less insecticides and resulted in 155 per cent higher returns. The significantly higher benefit:cost ratio was obtained in MRC-6918 Bt (3.68) as compared to all other cotton genotypes.

The cost of cultivation in non-Bt cotton cultivation varied with only in plant protection against bollworm in red soil. On an average DHH-11 received three sprays against bollworm, whereas first generation Bt transgenics received one spray compared to control. Similarly, the additional cost of plant protection was Rs. 2300 and Rs. 3760 compared to BG-I and BG-II, respectively in DHH-11. The advantage of BG-II was also much pronounced in this phenomenon. The total cost of cultivation was higher in non-Bt cotton (Rs. 11401/ha). The similar finding was reported by Naik (2001), where 14.70 per cent reduction in the pesticide costs through the adoption of Bt cotton.

5.1.2 Uptake and nutrient status in cotton genotypes in black and red soils

The nutrient supply is the second most important limiting factor in cotton production only after water. Most often soils in the rainfed areas are not only thirsty but also hungry. It is a well established fact that adequate quantities of nutrients are needed for achieving high yields. The nutrient management in cotton is complex phenomenon due to simultaneous production of vegetative and reproductive structures during the active growth phase. Cotton is a heavy feeder, needs proper supply of nutrients for its successful cultivation.

The uptake of nutrients at different stages of growth showed a increasing trend from 60 DAS to 120 DAS with respect to all the nutrients *viz.,* major nutrients like nitrogen, phosphorus, potassium, secondary nutrients like calcium and magnesium and micronutrients like iron, copper, manganese and zinc uptake, whereas nutrient content of some of the nutrients at different growth stages showed a non-significant differences in black soil. The results are similar to the findings of Janat (2004), who reported the N uptake was 417 kg per ha for the crop yielding (2221 kg lint/ha), Dorahy *et al.* (2004), who found that the P uptake was 22 kg per ha for the cotton lint of 2221 kg lint per ha. Wang *et al.* (2003) observed the uptake of nutrients like N, P and K was 250 to 386, 38 to 107 and 285 to 283 kg per ha for the cotton lint yield of 2000 to 3000 kg per ha. The micronutrient content in crop dry matter at harvest was reported by Rochester (2007) revealed that iron content (91 mg/kg), manganese (38 mg/kg), boron (35 mg/kg), copper (6 mg/kg) and zinc (13.80 mg/kg) and the differences could be related to soil type and possibly to poor soil structure and water logging factors that were more common in some soils during the growth and development of the crop.

The uptake of major and micronutrients showed a increasing trend at 60 to 90 DAS and at 120 DAS by different cotton genotypes in red soil. Generally, the nutrient content of different elements (N, P, K, Ca, Mg, Zn, Cu, Mn, Fe) showed a non-significant differences at different stages (60, 90 and 120 DAS). The similar findings were reported by Srinivasan (2003), where the cotton lint yielding 1834 kg per ha removes 98 kg N per ha, 17 kg P per ha and 97 kg K per ha Nadanassababady and Kandasamy (2002) reported that 145 kg N per ha, 34 kg N per ha and 133 kg K per ha was removed by cotton lint yielding 1248 kg per ha and Rochester (2007) reported nitrogen content of 1.75 per cent phosphorus content (0.30%), potassium content of 1.89 per cent and calcium content of 1.73 per cent and magnesium content (0.38%) in the crop dry matter during harvesting stage of the crop.

The uptake of nitrogen increased progressively from 60 DAS to 120 DAS in both black and red soils. The significant variation in N uptake is due to significant variation in total dry matter production of plant and soil available nitrogen status. The uptake of nitrogen in black soil was found to be higher than in red soil at all stages of crop growth. This is attributed to better aggregation, increased porosity and higher availability of moisture associated with black soil. Further, continuous application of organics to cotton every year resulted in high organic matter status that led to slow breakdown of nitrogenous compounds making steady supply of N throughout the growth period and subsequent uptake of nutrient. Results obtained are in agreement with the findings of Chavan *et al.* (1997). Genotypes grown on red soils had low N uptake and this is attributed to low N availability on account of low organic matter content, shallow depth and coarse textured nature resulted in leaching losses. Further, higher compaction of red soils on account of high bulk density resulted in limited root spread leading to reduced N uptake.

Persual of data on phosphorus uptake reveals that irrespective of cultivars, plants grown on black soil recorded significantly higher P uptake than plants grown on red soil. This is attributed to extensive root development in black soil and increased availability of moisture, organic matter and porosity, which encouraged higher P uptake. Higher availability of organic matter in black soil led to solubilization of native phosphate due to the action of various organic acids liberated during decomposition to higher P availability and subsequent uptake. Results obtained are in agreement with the findings of Subbaiah *et al.* (1982). P uptake was found to be very low in red soil as compared to black soil and this might be due to low P availability on account of shallow depth, less available moisture and limited root development on account of greater compaction. P uptake increased significantly from 60 DAS to 120 DAS in all the genotypes because at later growth stages of crop growth to meet the needs of developing branches, leaves, flower and bolls etc. roots absorbed higher quantities of P uptake.

Similar to N and P uptake, potassium (K) uptake also differed significantly in black and red soils. Higher uptake of K was observed in black than red soil. This is attributed to high available K content in soil pedons and extensive root system of plants in the black soils and low K uptake by cotton genotypes in red soils attributed to shallow depth of red soils along with limited root development on account of high bulk density and low moisture status. K uptake increased significantly from 60 to 120 DAS in both soils.

Based on the results of uptake of calcium (Ca) and magnesium (Mg) in black and red soils it could be concluded that higher uptake of Ca and Mg in black soil. This is attributed to higher concentration of exchangeable Ca and Mg in black soil on account of higher clay content and higher CEC. Further, highly branched root system and higher availability of moisture favoured the uptake of Ca and Mg in black soil. Uptake of both Ca and Mg differed significantly at all growth stages in both the soil types and increased from 60 to 120 DAS. Increased uptake was attributed to increased dry matter production at later stages of crop growth from 90 to 120 DAS.

Now-a-days due to continuous and heavy application of chemical fertilizers, which are devoid of micronutrients, led to the appearance of micronutrient deficiency symptoms which influences the yield and quality of crop to some extent. The study of micronutrient uptake is very essential to know the possible role in influencing the yield and quality characters of cotton. The uptake of micronutrient by cotton genotypes in red and black soil types has been discussed at different stages of crop growth.

In black soil, increased availability of organic matter enhanced the availability of native micronutrient cations through the transformation of solid phase to soluble metal complexes. Further, extensive root system and availability of moisture enhanced the uptake of Cu, Fe, Mn and Zn in such soils.

5.1.3 Fibre quality parameters

All the Bt cotton genotypes recorded significantly higher 2.5 per cent span length than DHH-11 (29 mm) in black soil. MRC-6918 Bt recorded significantly higher fibre fineness, fibre maturity and bundle strength compared to all other Bt cotton genotypes. These results are in agreement with that of Hallikeri *et al.* (2004) and Halemani *et al.* (2004), who also reported that Bt cotton hybrids were superior in quality compared to non-Bt hybrids.

Genotypes exhibited significant differences among different cotton hybrids with respect to 2.5 per cent span length in red soil. RCH-708 Bt recorded significantly higher 2.5 per cent span length (37.05 mm) than non-Bt hybrid DHH-11 (29.05 mm). MRC-6918 Bt recorded higher fibre fineness and maturity ratio compared to all other Bt cotton genotypes and was found on par with DHH-11. There was significant difference recorded among different cotton genotypes on bundle strength in red soil.

5.1.4 Biological properties

The data indicated significant differences in population of methylotrophs, P-solubilizers and *Azospirillum* among different cotton genotypes at flowering and at harvest stages in the rhizosphere of black soil. At flowering stage, higher population of methylotrophs, P-solubilizers and *Azospirillum* were recorded and lower population of these organisms at harvest stage was due to prevalence of dry condition at that particular stage. The similar findings were recorded by Alagawadi *et al.* (2006), Biradar *et al.* (2006) and Alagawadi *et al.* (2008). Where, the results indicated a considerable increase in the population of bacteria, fungi, actinomycetes, P-solubilizers and free living nitrogen fixers in the rhizosphere soil of both Bt and non-Bt cotton upto 150 DAS which decreased slightly thereafter. The data indicated higher population of methylotrophs, P-solubilizers and *Azospirillum* in the rhizosphere of red soil at flowering and thereafter the population of these microorganisms decreased at harvest stage. This was due to higher availability of nutrients, moisture at flowering stage and thereafter at harvest stage, the availability of nutrients, moisture gets depleted that resulted in the lower population of microorganisms.

5.2 Soil fertility map and yield map of different soils of Bt cotton growing areas of Bailhongal taluk

Spatial yield variability is controlled by soil properties (Forcella, 1993). However, Mallarino *et al.* (1996) reported that when relating to crop yields to soil variables, it was found that not all yield variability could be explained by the variability of the measured soil factors and that high variations in soil factor can not always be correlated to high variations in yield. The soil factor that may affect yield in one area within a field is subject to change throughout the field and hence, its influence on yield can change. A number of studies have shown that soil factors other than soil fertility influence yield (Ciha, 1984; Manu *et al.*, 1996; Miller, 1998 and Wright *et al.*, 1990).

Perusal of the data on soil pH of the study area revealed that the pH values varied from 7.03 to 8.64 in black soil and the soils are neutral and tending slightly towards alkaline reaction. The results are in accordance with the findings of Satyanarayana and Biswas (1970) who opined that the high pH of black soils is due to calcareous nature and accumulation of bases in solum as they are poorly leached.

The results of the experiment indicated that the pH of the soil did not change significantly even after 35 years of intensive cultivation and application of chemical fertilizers and/or organic manures (Thakur *et al.*, 2009). This could be ascribed to the high buffering capacity of the soil and presence of appreciable amount of free calcium carbonate, which is about 4.60 per cent as reported by Tembhare *et al.* (1998).

In red soil, pH value ranged from 5.31 to 8.45 and the soils are slightly acidic to slightly alkaline. The similar findings were observed by Nanjundaswamy (1996), where surface soil pH ranged from 5.4 to 7.40 in the Alfisols of agro-climatic zone 8 (Kumbapur Farm, ARS, Hanumanamatti and ARS, Kanabargi). Low pH in red soil is due to leaching of bases on account of well drained conditions leaving behind iron and aluminium oxides (Manjunathaiah, 1981).

The electrical conductivity (EC) values of the study area were in the normal range (0.13 – 0.35) in black soil and (0.11 – 0.64) in red soil. Ashok (1996) and Binitha (2002) reported similar EC values ranging from 0.39 – 0.53 at surface soils in Ghataprabha Command Area in Belgaum (Karnataka). Dasog and Hadimani (1980) and Srinivasarao *et al.* (1995) reported similar EC values in swell-shrink soils. Nanjundaswamy (1996) reported EC values from 0.11 to 0.20 in Alfisols of agro-climatic zone 8. Black soils have higher soluble salts than red soils and this was due to restricted drainage in black soils which causes accumulation of salts in the soils, whereas lower EC values in red soil signifies extensive leaching of salts in the soil.

The organic carbon content in black soils ranged from 0.41 to 0.87 per cent and in red soils ranged from 0.20 to 0.49 per cent and organic carbon status is low to medium in black soils and low in red soils. The organic carbon in Indian soils ranges from 0.50 to 1.50 per cent (Dudal, 1965). The values obtained in the present study are similar with 0.40 to 0.90 per cent as reported by Ashok (1996) and slightly lower than 0.34 to 1.33 per cent as reported by Binitha (2002) and similar to the findings of Nanjundaswamy (1996), where organic carbon content in the surface soils ranged from 0.30 to 0.56 per cent in Alfisols. The lower organic carbon content in these soils may be attributed to the poor management practices such as lack of addition of crop residues and organic manures. Intensive cropping is also one of the reasons for low organic carbon content. Soils of semi-arid region have low organic carbon than sub-humid soils (Jagadish Prasad and Gajbhiye, 1998). The organic matter buildup in soils is related to natural vegetation, cropping history and temperature (Dudal, 1965). The high organic carbon content in black soil was due to intensive cultivation of cotton with heavy application of organic manures. Soil properties explained about 30 per cent of yield variability (5 – 71%) for different fields with organic matter content influencing the yield most (Kravchenko and Bullock, 2000). Similar findings were reported by Jibhakate *et al.* (2009a) where soils of Katol Tahasil were low in organic carbon.

The available nitrogen status ranged from 101 to 250 kg per ha in black soils of Bailhongal taluk and available nitrogen status are low in black soils and the available nitrogen status in red soils ranged from 100.8 to 260 kg per ha and found to be low in available nitrogen.

Nitrogen is the most limiting nutrient in black soils (Stewart, 1988), which is subjected to losses through leaching and volatilization. The total nitrogen content in the soils is dependent on temperature, rainfall and altitude (Biju Joseph, 1994). According to Shivaprasad *et al.* (1998), in Karnataka about 10.3 per cent soils fall under low category, 35.87 per cent under medium and 53.90 per cent under high category of available nitrogen status in most of the soils except in lateritic soils of coastal and black soils, whereas the soils of majority states of India belong to lower status of available nitrogen as reported by Ramamoorthy and Bajaj (1964). In Vertisols, there is a flush of nitrate formation with the onset of monsoon following hot and dry spell. The longer the dry spell, the higher is the formation of mineral and nitrate N (Stewart, 1988). Similar findings were observed by Jibhakate *et al.* (2009), where soils of Katol Tahasil were low in available nitrogen.

The available phosphorus status ranged from 12 to 39 kg per ha in black soil were low to medium in available phosphorus content.

The available phosphorus content in the red soils was found to be low to medium and the values ranged from 12 to 27 kg per ha. Total phosphorus content of soils is governed by the presence of organic matter and clay content (Yadav and Pathak, 1963). The retention of the nutrient increased with increase in the quantity of clay. The present findings are similar to the findings of Motsara (2002), Manju (2003) and Ravikumar *et al.* (2007) who reported that the majority of soils in Karnataka were medium in phosphorus content. Jibhakate *et al.* (2009) also observed medium in available phosphorus in Katol Tahasil in Nagpur district.

The soils in the study area were found to be very high in available potassium content ranging from 303 – 605 kg per ha in black soil and in red soil the available potassium status was found to low, medium and high ranging from 120 – 672 kg per ha. The vertisols maintains a sufficient or even high level of exchangeable K to provide a good supply of K to plants for many years (Finck and Venkateshwarlu, 1982). The higher content of available potassium in Vertisols may be due to the predominance of potash rich micaceous minerals (Kapoor *et al.*, 1991), Patil and Sonar (1993) recorded optimal availability of potash in Vertisols of Maharashtra.

The available magnesium content in the black soil ranged from 1.9 to 29.2 ppm and in red soil ranged from 2.2 to 11.2 ppm. Similar type of results were also reported by Krishnamurthy (1993), Alur (1994) and Gaddi (1995) reported that magnesium distribution in red soils followed the distribution of clay.

The available iron content in black soil ranged from 0.19 to 9.78 ppm and found to be low to high in available iron content. The available iron content was found low to high (0.32 – 15.61) in red soils. Yerriswamy (1995) reported the available iron ranged from 2.45 to 4.40 ppm in different soils of Malaprabha command area. Rajkumar (1994) recorded variation in available iron from 2.72 to 5.10 ppm in black soils of Tungabhadra Project (TBP) area of Karnataka.

Higher amount of available iron (Fe) content in some of the soils are due to high amount of native iron. These soils are derived from calcic gneiss which are rich in Fe (Anon., 1993). Similar results were also reported in case of soils which are derived from calcic gneiss which are rich in Fe (Fordham, 1969). The report of wide variation in available Fe was made by Devaraj Urs (1979) in soils of TBP area and Tiwari *et al.* (1995) in soils of Uttar Pradesh.

Critical limits of micronutrients vary from soil to soil and even crops within same soil. Critical limits are not universal. Since, several factors modify micronutrient availability. Katyal and Randhaw (1983) noticed that the majority of the crops respond to Fe application in soil at <2.5 ppm Fe, but only sensitive crops are likely to benefit from Fe treatment between 2.5 and 4.5 ppm Fe. Sakal *et al.* (1985) indicated the 6.95 ppm Fe as critical limit for calcareous soil. Kuldeep Singh and Hansraj (1996) reported 3.2 mg per kg of DTPA Fe as critical limits in alluvial soils of Haryana. The critical limit of Fe for red and black soils of Bailhongal taluk has to be worked out for efficient use of fertilizer.

The available manganese (Mn) content are found to be deficient and sufficient in black soils ranging from 0.53 to 14.65 ppm and in red soils, the available manganese content was found to be deficient and sufficient ranging from 1.22 to 33.56 ppm. Tolanur (1989) reported the available manganese ranged from 5.04 to 13.34 ppm in Vertisols soils series of Malaprabha command area. Rajkumar (1994) observed variation on the available manganese from 5.2 to 10.8 ppm in black soils of Tungabhadra Project area of Karnataka. The majority of the soils (97.10%) of Ghataprabha command area in Belgaum are sufficient in available manganese. These soils are derived from granite parent rock (Anon., 1993). Similar results were recorded by Rajkumar (1994), who reported that the black soils derived from granite parent rock had the highest available manganese. Higher exchangeable Mn (25.2 – 125.9 ppm) were reported by Durate *et al.* (1961), who have noticed higher Mn content in surface soils of Ratnagiri and Kolaba districts of Maharashtra.

Kuldeep Singh and Banerjee (1984) considered 3.0 ppm available Mn as critical for Haryana soils instead of <2 ppm as suggested by Lindsay and Norvell (1978). As low as 1.0 ppm available Mn was suggested as critical limit for Himachal Pradesh soils by Umapathy *et al.* (1994).

The available copper (Cu) content in black and red soils are sufficient ranging from 1.10 to 4.77 ppm in black soils and 0.91 to 6.33 in red soils. The range of 0.40 to 2.80 ppm of available Cu in Uttar Kannada district soils was observed by Kenchanagoudar (1984). Gopichand *et al.* (1985) recorded variation in available Cu from 1.45 to 5.70 ppm in Andhra Pradesh soils. Raghupathi (1989) reported that available copper content in North Karnataka soils ranged from 0.4 to 1.2 ppm. Murthy (1988) reported that the Vertisol of India derived from granite have higher amounts of available copper compared to soil derived from basalt. Katyal and Sharma (1991) found that the Vertisol exhibited higher content of DTPA copper than Entisol. Misra and Misra (1969), Arora and Sekhon (1981) and Raghupathi (1989) observed that surface soil contained highest quantity of available copper and this was attributed to the availability of organic matter. The critical limit of available copper suggested by Katyal and Randhawa (1983) as 0.2 ppm. Gopichand *et al.* (1985) considered 0.2 ppm available copper as critical limit for calcareous belt of Bihar. Tripathi *et al.* (1994) reported that 0.40 ppm copper was taken as critical limit for Himachal Pradesh soil.

The available zinc (Zn) content was found low to medium in black soils ranging from 0.21 to 1.59 ppm and in red soils, the available zinc content was found to low, medium and high ranging from 0.13 to 2.71 ppm. In soils of Andhra Pradesh, variation of available zinc ranged from 0.70 to 3.63 ppm as reported by Gopichand *et al.* (1985). Rajkumar (1994) found that the available zinc in black soil ranged from 0.20 to 2.20 ppm in TBP area of Karnataka. Tiwari *et al.* (1995) observed that the available Zn content in Uttar Pradesh soils to vary from 0.08 to 8.98 ppm. This is also in agreement with the work done by Chakraborthy *et al.* (1981) and Vinay Singh and Tripathi (1983) reported that available zinc increased with the increase in organic matter content of the soils. Available zinc was more in red soils than in black soils. Similar results were reported by Appavu and Sreeramulu (1981).

Katyal and Randhaw (1983) reported that soils having less than 0.60 ppm DTPA Zn considered as deficient in India and respond to the added Zn. Kuldeep Singh and Banerjee (1984) considered 0.70 ppm DTPA Zn for soils of Hisar district of Haryana as a critical limit.

The mean seed cotton yield (Table 78 and Fig.) obtained in all the selected villages Bt cotton growing areas of Bailhongal taluk under black soils were found to be higher than the national average (16 q/ha). Though the mean seed cotton yields in black soils were more than the national average but still scope lies for improvement in all these villages to reach the highest possible yield through agronomic practices.

The mean seed cotton yield (Table 79 and Fig.) in majority areas of red soils were found to be lower than the national average (16 q/ha) except in Bidargaddi and Jalikoppa villages under red soils of Bailhongal taluk. This is due to poor fertility status of these villages with respect to major nutrients nitrogen and phosphorus and micronutrients. In addition to this, there is scope for improvement in the seed cotton yield through agronomic practices.

5.3 Documentation of existing cultivation practices of cotton in different soil types of Bailhongal taluk

Cotton as a crop as well as commodity has a unique place in the economy of India as it plays an important role in the Agrarian and Industrial activities of the nation. Being grown in acreage of 8.4 million hectares with the production of 30.5 million bales and productivity of 568 kg per ha. The deployment of Bt cotton over the last eight years has resulted in India becoming the number one exporter of cotton globally as well as the second largest cotton producer in the world. India has a larger area of cotton than any country in the world. The productivity of India's average is low compared to first largest producer of Bt cotton. To overcome the productivity limitations under varied agro-climatic conditions on annual basis necessitates strategic and applied research on cotton.

Method of sowing : The survey on documentation of existing cultivation practices of Bt cotton in black and red soils of Bailhongal taluk reveals that dibbling is the common method of sowing (100%) in black and red soils. Lamani *et al.* (2004) reported early sowing with crowbar method of sowing during II fortnight of May registered higher seed cotton yield (1792 kg/ha)

Varieties used : In black soil, majority of the farmers (68%) and red soil (31%) have grown Bunny Bt. This is in conformity with the findings of Singh *et al.* (2003) and Giri *et al.* (2008), where the study indicated on clayey soil under rainfed conditions MECH-162 Bt, MECH-184 Bt and NCS-145 Bt recorded higher yields as against their non-Bt counter parts. Bt hybrids were found agronomically more efficient through the inbuilt resistance to *Heliothis* and consequently early built up by the crop. Brahma Bt recorded higher yield of 2950 kg per ha in Alfisols (sandy loam) (Raghu Rami Reddy and Dileep Kumar, 2010).

Seed rate and seed treatment : Farmers in both black and red soil have used the recommended seed rate to the extent of 450 g per acre (68%), lesser percentage of 20 and 22 per cent in both black and red soils have used more than the recommended seed rate.

Time of sowing : June I fortnight is the common time of sowing in black and red soil (42% and 46%, respectively). The similar findings were reported by Pettigrew (2002), Hanuman Prasad *et al.* (2000) and Subramanyam *et al.* (2004). Early planted plants in the normal planting, which contributed to a 55 per cent greater canopy, better light interception from the early planting and also due to earliness of Bt hybrid, which helped to mature early and thus avoided unfavourable weather during later phases.

Late planting of hybrids during July I fortnight was minimum 4 per cent in black and 2 per cent in red soils and delay in time of sowing resulted in reduced yield and this is due to production of less number of buds and bolls in addition to increased bollworms attack (Sankaranarayan *et al.*, 2004).

Time of sowing plays an important role in productivity of cotton through its effect on duration for vegetative and reproductive phases and thus total duration of crop. Sowings made from June to August produced significantly different seed cotton yield per ha. June sowing produced (2227 kg/ha) compared to July and August sowings. Yield decrease was to the extent of 18.8 and 54.9 per cent, when sowing was delayed one by one month from June to July and July to August, respectively as observed by Hallikeri (2008). Decreased in yield was mainly due to significant decrease in yield per plant, boll weight, number of bolls harvested per plant and growth parameters. Similar findings were reported by Ahuja (2006). Jutsi *et al.* (1999) stated that Bt cotton has a good fruit prolificacy at early stage and boll retention and concentrated in early planted cotton. Higher yields due to early planted cotton were also reported by Nuti *et al.* (2006) and Buttar *et al.* (2005). Planting cotton earlier in the season allows the crop to utilize early season sunlight. With the longest day light period of the year occurring on the summer solstice, potentially more sunlight is available for photosynthesis and growth (Pettigrew, 2002), early planted crop initiated reproductive growth earlier and produced more blooms (squares) earlier in the season and allowed the early planted crop to set more bolls utilizing the beneficial early season rains and sunlight to produce higher yield. Higher retention of bolls due to early sowing was quoted by several workers (Shah *et al.*, 2002; Srinivasan, 2001 and Pettigrew, 2002).

Gap filling : Eighty eight per cent in black and 74.1 per cent farmers in red soil have followed gap filling. Very less percentage of farmers (12%) in black soil and 30.9 per cent in red soil have not followed gap filling. Farmers in the black and red soil area, they take up gap filling by using non-Bt seeds (50 g), which were provided at the time of purchase of Bt cotton seeds (450 g), generally gap filling of seeds was done after 15 to 20 days after sowing.

Refugia : Percentage of farmers using refugia were found to be less in black (32%) and red (43%) soils. The farmers are not aware of the advantage of refugia all around the Bt crop which serves as a resistance management strategy in Bt crop. The seeds which were brought along with the Bt seeds are used either for gap filling and sometime not used by the farmer.

Plant density : The data on the plant density in black and red soils indicated that majority of the farmers in black (72%) and red soils (90%) have followed the spacing of 90 cm × 60 cm, 28 per cent of farmers in black soil and 15 per cent in red soil have followed the 120 cm × 60 cm. In black soil area, farmers have followed intercropping of soybean, groundnut or greengram in wider spacing. This is similar to the findings of Rout *et al.* (2001) reported significantly higher seed cotton yield of 19.58 q per ha with 90 cm × 60 cm spacing and Bastia (2000) also recorded seed cotton yield per ha (1940 kg/ha) and the harvest index (28.90%) for the spacing of 90 cm × 90 cm followed by 1795 kg seed cotton yield per ha and 27 per cent harvest index in 120 cm × 60 cm spacing. Field experiment with 90 cm × 90 cm spacing recorded higher number of sympodia and boll weight (Brar *et al.*, 2008a).

Nipping : The data on nipping in black and red soil is presented in Table 80. Nearly three-fourth (72%) of the farmers in black and 65 per cent of the farmers in red soil have not followed nipping. Nipping was done around 100 to 120 days after sowing, if they have followed. The results are similar to the findings of Brar *et al.* (2002) and Rao and Lakshminarayan (1985) indicated that the cotton crop canopy can be modified by reducing its spread and height without reducing the productivity of Bt cotton. No significant difference in the yield of cotton due to detopping was because there was no boll formation at later stages. Yield parameters of cotton *viz.,* yield per plant, boll weight, number of bolls per plant, number of green bolls per plant were also not significantly affected due to detopping. The effects of detopping are more pronounced in longer duration cottons with fruiting period extending beyond 150 to 180 DAS. Beneficial effect of detopping may not be possible in less luxuriant grown cotton crop (Rao and Lakshminarayan, 1985).

Hallikeri (2008) reported that detopping was seen at both vertical and horizontal growth of the cotton. But, the effect on the formation of bolls per plant, yield per plant and total yield per hectare were not changed due to detopping. Detopping of Bt cotton, wherein the plant type is condensed due to more retention of early formed bolls and hastening of maturity as compared to non-Bt cotton.

The recommended dose of fertilizer for Bt cotton in black and red soils was 80-40-40 kg NPK per ha. The survey data on usage of fertilizers indicated that majority of the farmers in black and red soils have used below the recommended dose of N, P and K (Table 80). During the survey it was expressed by the farmers that the yield levels are low in red and black and hence the farmers were using low quantity of fertilizers. The other possible reasons expressed by the farmers were poor knowledge about the use of right dose of fertilizer and right time of application of fertilizers and uncertainty of rainfall. The findings of Pawar *et al.* (2010) reveals that application of 100:50:50 kg NPK per ha recorded significantly more seed cotton yield (2214 kg/ha), gross monetary returns (Rs. 46865/ha) and net monetary returns (Rs. 31131/ha) than both the lower levels of fertilizer application 80-40-40 and 60:30:30 kg NPK per ha. In Vertisol under rainfed condition recommended dose (90-45-45 kg NPK/ha) was found to be optimum and all the growth and yield parameters recorded were non-significant amongst the three levels of fertilizers (Singh *et al.*, 2003). In Bt cotton hybrid (Brahma) response was observed upto 150 kg per ha (2928 kg/ha). Application of 60 kg P_2O_5 and K_2O per ha significantly recorded higher seed cotton yield over 30 kg per ha in Alfisols under irrigation (Raghu Rami Reddy and Dileep Kumar, 2010). Shamim Ansari and Mahey (2003) observed that crop responded upto 80 kg N per ha in increasing plant height, total leaf, root and reproductive dry matter production and seed cotton yield. But, LAI, stem dry matter and chlorophyll content increased significantly upto the application of 160 kg N per ha.

In the survey data, the method of application of fertilizers indicated that 82 per cent of the farmers in black soil and 79 per cent of the farmers in red soil have applied nitrogenous fertilizer as basal and top dressing. Similar trend has been observed for phosphorus fertilizers, where 78 per cent and 77 per cent of farmers in black and red soils, respectively have applied as basal and for top dressing. The potassium fertilizer was applied as only basal. Majority of the farmers in black and red soil, apply the fertilizers 15 to 20 DAS as basal dose and top dressing applied at 60 to 70 DAS. The study made by Srinivasan (2003) reveals that application of recommended dose of fertilizers by skipping basal and applying the same in two splits at 45 and 60 DAS registered highest number of sympodials per plant, yield per ha, boll weight and bolls per plant. Since, the crop with long duration, application of nutrients at later stages might helps in inducing more number of sympodial as compared to lower level of fertilizers at later stages. Studies made at Siruguppa (Anon., 2005) also revealed that split application of N and K produced higher yield over only N or NP or NPK split applications. Further, application of all these nutrients in three splits at basal (25%), 30 DAS (50%) and 60 DAS (25%) produced significantly higher yield over other treatments N in two equal splits at sowing and square formation gave significantly higher yield than all N at sowing or two equal splits at first irrigation and flowering (Nehra *et al.*, 1987). Application at 45 and 60 DAS (2 splits) coincide with peak demand for nutrients, facilitating increased uptake at flowering and boll bursting stage (Srinivasan, 2003). Application of K along with N resulted in better N uptake due to the reduced fixation of NH_4^{++} due to K and thereby there was higher utilization of N (Sengupta *et al.*, 1971).

The survey data indicated that 82 per cent of farmers in black soil and 78 per cent in red soil are using farmyard manure. The quantity of manures applied indicated that 84 and 85 per cent of farmers in black and red soil have used <2 t per ha. The quantity of manures applied appears to be less than the recommended dose (10 t/ha).

Halemani *et al.* (2004) indicated that application of FYM @ 10 t per ha decreased bulk density (1.21 g/cc) of soil but it increased the maximum water holding capacity (74.60%), aggregate stability (78.62%) and infiltration rate (1.22 cm/hr) of soil. Organic carbon content was also improved from 0.97 to 1.01 per cent with FYM and also higher population of bacteria, fungi and actinomycetes were noticed with 100 per cent RDF and FYM @ 10 t per ha and improved the yield (1594 kg/ha). The productivity was sustained when integrated nutrient supply through organic and inorganic fertilizer was practiced (Nambiar and Abrol, 1989). Organic manures are known to improve the physico-chemical properties of the soil and regulate the release of nutrients for plant growth and thus increase fertilizer use efficiency (Tisdale *et al.*, 1986).

The percentage use of two intercultivations was to the extent of 70 per cent in black and 68 per cent in red soil, 22 and 28 per cent of farmers have practiced three intercultivations. Four intercultivations were practiced in red soils (9%). Two hand weedings were done to the extent of 88 and 78 per cent in black and red soils, respectively and 12 per cent in black and 27 per cent in red soils have followed three hand weedings. The farmers in Bailhongal practiced intercultivations at an interval of 15 to 20 days starting from sowing. The number of intercultivations and hand weedings were more with the farmers who have the irrigation facilities in red soil. The similar findings were reported by Halemani *et al.* (2004), where two intercultivation followed by two hand weedings at 30 and 60 DAS were very effective for controlling the weeds in cotton and effective as herbicide treatment.

The data indicated that more percentage of pest load was observed in black and red soils. The major type of pest noticed in black and red soils were both sucking pests and boll worm (95% in black and 98% in red soils). Bt cotton had the incidence of both sucking pests and bollworms. Bollworm incidence was found more in BG I Bt cottons compared to BG II Bt cottons.

The percentage use of insecticides by the farmers in black and red soil was to the extent of 45 per cent in black soil and 37 per cent farmers in red soils have used insecticides acetamiprid, imidacloprid and acephate for the management of both sucking pests and bollworm. Gore *et al.* (2003) indicated that the supplemental insecticide applications may be necessary to prevent yield losses on bollgard cotton but bollgard II require minimal or no insecticide against bollworms. Bambawale *et al.* (2004) reported that under integrated pest management in MECH-162, 11.50 per cent less fruiting bodies were damaged and recorded higher seed cotton yield and net returns.

Fourty eight per cent in black and 37 per cent in red soil have gone for one spray with $MgSO_4$ for the management of leaf reddening, 26 per cent farmers in black soil and 37.50 per cent farmers in red soil have not taken up control measures for leaf reddening. For the management of leaf reddening the farmers are only practicing the $MgSO_4$ spray and not DAP, urea or potash fertilizers. Leaf reddening appears to be more in Bt cotton as compared to non-Bt cotton genotypes. The findings of Ikisan (2004) indicated that application of $MgSO_4$ at 20 to 25 kg per ha to the soil or foliar spray with 5 per cent $MgSO_4$ and 1 per cent urea as soon as the reddening symptoms appears in leaf reduces this disorder. Foliar application of urea (2-4%) with 15-20 ppm (chlormequate chloride) and 0.1 per cent citric acid, 2 to 3 times at weekly intervals resulted 70 to 80 per cent amelioration (Devendra Singh, 2004). Timely correction of N status either by optimum supply in the soil or through foliar application (DAP 2% or urea 1-2%) during boll development stage prevention of water logging and giving protective irrigation to avoid moisture stress helps in controlling leaf reddening in cotton (Devendra Singh, 2004).

The data on flower / fruit dropping management indicated that 83 and 91.70 per cent of farmers in black and red soil, respectively have not followed control measures for flower or fruit dropping in cotton. The causes for boll shedding explained by several workers. Shedding of about 60 per cent in the form of squares, 8 per cent in the form of flowers and 5 per cent in the form of bolls is common (Ikisan, 2004). Heitholt and Schmidt (1994) reported the variations in boll retentions due to genotypes and sympodial positions and the ovary carbohydrates. Abscission of squares flowers and young bolls are often encountered with heavy irrigation after water stress (Guinn, 1998). Moisture stress during flowering and boll development stages enhanced physiological shedding of boll and reduced cotton yield (Bhatt, 1978; Singh, 1980 and Singh and Sahay, 1982). High temperature can decrease the supply of photo assimilates to fruiting bodies by increasing the rate of photorespiration and dark respiration and causes a nutritional stress to developing bolls (Guinn, 1982 and Krieg, 1986). The deficiency of inorganic nutrients *viz.,* N, P, K, Mg, S, Fe and Zn might have increased shedding by decreasing photosynthesis and translocation of photo-assimilate or by directly affecting synthesis of hormones (Adicott and Lyon, 1973; Guinn, 1982 and Joham, 1986). Ca, K and B are required for the transport of assimilates from leaves to fruiting parts (Hodges, 1992). Zn deficiency also enhances shedding of bolls deficiency also enhanced shedding of bolls because Zn is required for IAA synthesis (Ohki, 1976).

For the management of flower / fruit dropping the following remedies have been reported. Foliar application of NAA (20 ppm) at flower initiation and subsequently after 3 weeks of first spray increased fruit setting and seed cotton yield (Sahay and Singh, 1983 and Jaganathan and Iruthayaraj, 1982) and foliar spray of DAP (2%) along with NAA (20 ppm) altered at 10 days interval during flowering reduced boll shedding and increased yield of cotton (Bhatt, 1978).

The survey data indicated that the yield levels are low in black soils (89%) and red soils (70%) of Bailhongal taluk. The major reasons attributed to the low yields are erratic monsoon, deficit moisture during dry spells, untimely sowing, not proper use of seed rate. Poor inherent fertility status of the soil particularly red soils is one of the major reason for the low productivity in both irrigated and as well as rainfed ecosystems. The soils of the cotton growing area are low in organic carbon, nitrogen and available P. Among secondary and micronutrients, sulphur and zinc deficiency is widespread and boron deficiency is on the rise (Paltan *et al.*, 1999). There is a wide gap between supply and the removal by crops (Tandon and Narayan, 1990).

5.4 Results of practical utility

1. MRC-6918 Bt in both black and red soils was well suited for cultivation in northern transition zone of Karnataka due to higher seed cotton yields and greater economic benefits.
2. RCH-708 Bt, RCH-2 Bt, JK-99 Bt and Brahma Bt were found yield advantageous in farmers field and well suited for wider scale adoption in black soils of Bailhongal taluk.
3. The seed cotton yield of RCH-2 Bt, JK-99 Bt, DHH-11 and Brahma Bt were found yield advantageous and well suited for wider scale adoption in red soils.
4. From this study, it is found that the black and red soils are low in N, P, Fe, Zn and the deficiency of these nutrients could be corrected with the application of manures and fertilizers at recommended dose.
5. Growing of refugia could be enhanced to cent per cent as refugia is good option for management of resistance to cry toxin.
6. Curative measures for physiological disorders like leaf reddening and square dropping are being ignored by major portion of the farmers. This could be corrected for better harvest in transgenic cotton.

5.5 Future line of work

1. Verification of new transgenic Bt cotton hybrids or new events with different genes in mother and baby trials mode before wider scale adoption in different agro-climatic zones.
2. Agronomic investigations with respect to major and micronutrients, foliar nutrition and use of growth regulators and correction of physiological disorders in mother and baby trial mode for more reliability and quick adoption by the farmers.
3. Preparation of soil fertility and nutrient index maps for all Bt cotton growing areas has to be prepared to make recommendations with precision.
4. Documentation of existing cultivation on black and red soils indicated that there is need to educate the farmers about recommended cultivation practices with respect to major and micronutrients, foliar nutrition and use of growth regulators and correction of physiological disorders

6. SUMMARY AND CONCLUSIONS

Two field experiments were conducted under rainfed condition during *kharif* 2008-09 and 2009-10 at two villages *viz*., Govankoppa and Budarkatti of Bailhongal taluk in black and red soils, respectively in the farmers field to assess the performance of Bt transgenic genotypes in two different soils. The experiment was carried in randomized complete block design with ten cotton genotypes (RCH-2 Bt, RCH-2 BG-II Bt, Bunny Bt, Bunny BG-II Bt, JK-99 Bt, Mallika Bt, DHH-11 non-Bt, MRC-6918 Bt, Brahma Bt and RCH-708 Bt).

The experiment was also carried out with a novel mother and baby trial design to systematically connect assessment of performance of Bt cotton genotypes under research managed mother trials and farmers managed baby trials.

The results of the experiments of mother and baby trials are presented in this chapter.

To prepare the soil fertility map and yield map for cotton growing areas of Bailhongal taluk, total 205 surface soil samples were collected randomly from different locations to demarcate soil fertility levels and respective cotton yields from these locations were collected to prepare the yield maps. The results are summarized in this chapter.

To document the existing farmers practice in the cultivation of cotton, the information was collected in different villages of Bailhongal taluk. The results of the investigation are summarized.

Bunny BG-II Bt recorded significantly higher seed cotton (2385 kg/ha) and it was found on par with RCH-2 BG-II Bt (2307 kg/ha), MRC-6918 Bt (2290 kg/ha), RCH-708 Bt (2225 kg/ha), Bunny Bt (2190 kg/ha), RCH-2 Bt (2110 kg/ha) and Mallika Bt (2055 kg/ha) in black soil.

RCH-2 BG-II Bt recorded significantly lower bad opened bolls per plant (1.40) and it was found on par with Bunny BG-II Bt (1.85). RCH-708 Bt recorded significantly higher total number of bolls per plant (37.95) compared to all other cotton genotypes and found on par with MRC-6918 Bt (37.20).

Mallika Bt recorded higher boll weight (5.62 g/boll) and differed significantly to other genotypes and was found on par with Brahma Bt (5.31 g/boll), Bunny BG-I Bt (5.20 g/boll) and MRC-6918 Bt (4.93 g/boll).

Significantly higher total dry matter production (318.07 g/plant) was recorded with MRC-6918 Bt compared to all other cotton genotypes and was found on par with RCH-708 Bt (311.25 g/plant) and JK-99 Bt (298 g/plant).

Higher harvest index was recorded with RCH-2 BG-II Bt (0.30) and differed significantly with JK-99 Bt (0.25) and Brahma Bt and DHH-11 non-Bt (0.24).

Higher gross returns (Rs. 90415/ha) and net returns (Rs. 67924/ha) was recorded with MRC-6918 Bt and higher benefit:cost ratio was also obtained in MRC-6918 Bt (4.02) compared to all other cotton hybrids.

The uptake of nutrients at different stages of growth showed a increasing trend from 60 to 120 DAS with respect to all the nutrients viz., major nutrients like nitrogen, phosphorus and secondary nutrients like calcium and magnesium and micronutrients like iron, copper, manganese and zinc uptake, whereas nutrient content of all these nutrients at different stages of growth showed a non-significant differences.

All the Bt cotton genotypes recorded significantly higher 2.5 per cent span length than DHH-11 (29 mm), MRC-6918 Bt recorded higher fibre fineness (4.60 micronaire), maturity ratio (0.76) and higher bundle strength (27.35 g/tex) compared to all other cotton genotypes.

Higher population of methylotrophs, P-solubilizers and Azospirillum were recorded at flowering stage and thereafter the population of these microorganisms was decreased at harvesting stage irrespective of Bt cotton genotypes and non-Bt hybrid (DHH-11).

The seed cotton yield of RCH-708 Bt, RCH2 Bt, JK-99 Bt and Brahma Bt in baby trials was found on par with mother trial.

The highest seed cotton yield of 2257 kg per ha was recorded with MRC-6918 Bt and was found on par with Bunny BG-II Bt (2196 kg/ha) and RCH-2 BG-II Bt (2090 kg/ha) in red soil.

The lower number of bad opened bolls per plant were recorded in RCH-2 BG-II Bt and differed significantly to all other cotton genotypes.

The higher number of total bolls per plant was recorded in MRC-6918 Bt (34.55) and differed significantly over other cotton genotypes and was found on par with RCH-708 Bt (34.45).

The higher boll weight was recorded in MRC-6918 Bt (5.50 g/plant) and was found on par with Mallika Bt (5.45 g/plant), Bunny BG-II Bt (5.12 g/plant), Bunny Bt (5.07 g/plant) and RCH-2 BG-II Bt (4.77 g/plant).

Higher total dry matter production (295.65 g/plant) was recorded in MRC-6918 Bt and differed significantly to other cotton genotypes and was found on par with RCH-708 Bt (279.15 g/plant), JK-99 Bt (275.60 g/plant), Brahma Bt (274.30 g/plant) and Bunny BG-II Bt (274.60 g/plant).

Higher harvest index of 0.29 was recorded in MRC-6918 Bt and differed significantly to DHH-11 (0.24).

Higher gross returns of Rs. 89131 per ha and net returns of Rs. 64917 per ha was recorded with MRC-6918 Bt and differed significantly to all other cotton genotypes. Higher benefit:cost ratio of 3.68 was recorded in MRC-6918 Bt and differed significantly to all other cotton genotypes.

The uptake of nutrients at different stages of growth showed a increasing trend from 60 to 90 DAS and then upto 120 DAS with respect to all other nutrients viz., major nutrients like nitrogen, phosphorus and secondary nutrients like calcium and magnesium and micronutrients like iron, copper, manganese and zinc uptake, whereas nutrient content of all these nutrients at different stages of crop growth does not differ significantly among different cotton genotypes.

RCH-708 Bt recorded significantly higher 2.5 per cent span length (37.05 mm) than non-Bt hybrid DHH-11 (29.05 mm). Higher fibre fineness (4.25 micronaire) and maturity ratio (0.76) was recorded in MRC-6918 Bt and was found on par with DHH-11 (4 micronaire) and maturity ratio (0.72). Higher bundle strength of 27.25 g per tex was recorded in MRC-6918 Bt and was found on par with other Bt and non-Bt cotton genotypes.

Higher population of methylotrophs, P-solubilizers and Azospirillum were recorded at flowering stage and thereafter the population of these microorganisms were decreased at harvest stage irrespective of Bt cotton and non-Bt cotton (DHH-11) hybrids.

The seed cotton yield of RCH-2 Bt, JK-99 Bt, DHH-11 Bt and Brahma Bt were found on par with mother trial.

The pH of the black soils ranges from 6.21 to 8.64 with a mean value of 7.50, whereas in red soil, the pH range was from 6.10 to 8.45 with a mean value of 7.26.

The electrical conductivity in the black soil ranged from 0.13 to 0.35 dS per m and with a mean value of 0.23 dS per m. The electrical conductivity in the red soil ranged from 0.11 to 0.64 dS per m and with a mean value of 0.26 dS per m.

The organic carbon content in the black soil ranged from 0.41 to 0.87 per cent with a mean value of 0.64 per cent and in the red soil ranged from 0.20 to 0.49 per cent with a mean value of 0.37 per cent.

The available nitrogen content in the black soil ranged from 103 to 250 kg per ha with a mean value of 177.70 kg per ha and in the red soils it ranged from 100.80 to 260 kg per ha with a mean value of 146.30 kg per ha.

The available phosphorus content in the black soil ranged from 12 to 39 kg per ha with a mean value of 23.40 kg per ha and in the red soils the available phosphorus content ranged from 12 to 27 kg per ha with a mean value of 16.80 kg per ha.

The available potassium content in the black soil ranged from 303 to 614 kg per ha with a mean value of 433 kg per ha and in the red soil, the value of available potassium content ranged from 120 to 672 kg per ha with a mean value of 314.30 kg per ha.

The exchangeable magnesium status in black soils ranges from 3.70 to 29.20 kg per ha with a mean value of 9.59 kg per ha and in red soil, the value ranges from 2 to 11.20 kg per ha with a mean value of 4.84 kg per ha.

The available micronutrients viz., in black soils ranged from 0.19 to 9.80 ppm with a mean value of 1.69 kg per ha and in the red soils the available iron ranged from 0.32 to 15.61 ppm with a mean value of 3.45 ppm.

The available zinc content in the black soils ranged from 0.25 to 0.98 ppm with a mean value of 0.80 and in the red soils ranged from 0.13 to 2.61 ppm with a mean value of 0.80 ppm.

The available copper content in the black soils ranged from 0.75 to 13.40 ppm with a mean value of 2.73 ppm and in the red soils, the value ranged from 0.91 to 5.90 ppm with a mean value of 2.70 ppm.

The available manganese status in the black soils ranged from 0.53 to 14.65 ppm with a mean value of 4.45 ppm and in the red soils, the value ranged from 1.22 to 33.56 ppm with a mean value of 14.73 ppm.

The seed cotton yield (q/ha) in the black soil ranges from 14 to 21 q per ha with a mean value of 17.60 q per ha and in the red soil, the seed cotton yield (q/ha) ranges from 10 to 18 q per ha with a value of 14.10 q per ha.

The survey on documentation of existing cultivation practices on cotton cultivation indicates that dibbling is a common practice of sowing in both black and red soils.

Majority of the farmers in black soil (68%) and red soils (30.50%) have grown Bunny Bt and other grown hybrids were Kanaka, MRC-6918, Tulsi, Neeraj, Brahma, Akka and JK-99. The farmers in both black (68%) and red soils (68.40%) have followed recommended seed rate (450 g/acre).

The time of sowing is during June I fortnight where 42 per cent in black and 45.60 per cent in red soils have sown the crop. The next is during May II fortnight, where 40 per cent in red and 32 per cent in black have sown the crop. The other time of sowings were June II fortnight and July I fortnight.

Eighty Eight per cent of farmers in black soil and 74.10 per cent in red soils have followed gap filling.

Majority of the farmers in black soil (68%) and red soil (62.20%) have not followed refugia.

Seventy two per cent of the farmers in black soil and 90.30 per cent of the farmers in red soil have followed 120 cm × 60 cm spacing. The other spacing followed was 90 cm × 60 cm.

Nipping practice is not followed by the farmers, 72 per cent of the farmers in black and 64.60 per cent of the farmers in red soil have not followed nipping.

The farmers in the black soil and red soil have used the fertilizer below to the recommended dose for all the fertilizers viz., nitrogenous, phosphorus and the potassium fertilizers.

In the method of fertilizer application, majority of the farmers have followed basal application and top dressing for nitrogenous and phosphorus fertilizers, 82 per cent in black soil and 79.40 per cent in red soils have followed nitrogenous fertilizers for both basal and top dressing, 78 per cent of the farmers in black soil and 77.40 per cent of the farmers in red soils have followed phosphorus fertilizers for both basal application and top dressing.

Potassium fertilizer was used only for basal application in both black and red soils.

82 per cent of the farmers in black soil and 78.90 per cent of the farmers in red soils have used organic manures. The quantity of manures used was <2 t per ha by 84 per cent of the farmers in black and 84.60 per cent of the farmers in red soil.

Farmers in the both black and red soils have followed weed control measures. And none of the farmers have used herbicides for weed control. Farmers have followed intercultivations and hand weeding for the control of weeds in both black and red soils. Majority of the farmers in both black and red soils have used two intercultivations, 78 per cent in black and 68.40 per cent in red soil and two hand weedings were used by 88 per cent in black soil and 77.90 per cent in red soils for the control of weeds.

The percentage use of pride, confider and acephate was more in black and red soils for the control of pests. The next percentage use of insecticides was confider and pride. The other insecticides used are acephate and monocrotophos.

For the management of leaf reddening the farmers in both black and red soils have not used either DAP or urea spray. The only used is $MgSO_4$. For the management of leaf reddening the farmers in red soil (37.10%) have used $MgSO_4$ only once, very few percentage (28% and 30.40%) of farmers in black and red soils have followed spraying of $MgSO_4$ twice. No spraying taken towards management of leaf reddening were to the extent of 26 per cent farmers in black soil and 37.50 per cent in red soil.

For the management of flower or fruit dropping, no sprays (83% and 91.70%) in black and red soils have followed by the farmers, 17 per cent of the farmers in black and 13.30 per cent in red soils have followed planofix spray.

The seed cotton yield obtained by the farmers in both black and red soils was in the range of 5-20 q per ha. Eighty nine per cent in black soil and 70 per cent in red soil, the farmers have obtained the seed cotton yield of 15- 20 q per ha.

Conclusions

1. Bunny BG II in black soil and MRC-6918 BT in both black and red soils gave higher yields and net returns.
2. RCH-708 Bt, RCH-2 Bt, JK-99 Bt and Brahma Bt performed well in farmers field in black soil.
3. RCH-2 Bt, JK-99 Bt, DHH-11 and Brahma Bt have given higher yields in farmers field in red soil.
4. The cotton growing areas of Bailhongal taluk were found to be deficit in N, P, Fe, Zn in both black and red soil.
5. Wider row spacing is followed in both black and red soils. Majority of the farmers are using below recommended dose of fertilizers, not following refuge crops around Bt cotton. Control measures towards management of leaf reddening and flower and fruit dropping is also limited.

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Appendix I: Plant protection interventions made in different treatments in different season (Experiment I and II)

Interventions	Treatments																			
	2008-09										2009-10									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
Seed treatment with imidacloprid 70 WS	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T
Sucking pests management by foliar insecticide spray with imidacloprid 200 SL (0.25 ml/l) at 30 and 100 DAS	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2 acetamiprid 20 SP 0.2 g/l at 50 DAS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Myrid bug management acephate 75 SP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Bollworm management with quinalphos 25 EC (2.5 ml/l at 65 DAS)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Chlorpyriphos 20 EC (2.5 ml/l at 90 DAS)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Cypermethrin 10 EC (0.5 ml/l at 105 DAS)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Profenophos 50 EC (2 ml/l at 120 DAS)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Profenophos 50 EC (2ml/l at 110 DAS)	1	-	-	1	1	1	1	1	1	-	1	-	-	1	1	1	1	1	1	-

Appendix II: Date of seed cotton picking during 2008-09 and 2009-10 (Experiment I)

Picking	**2008-09**	**2009-10**
1st picking	18-12-2008	29-12-2009
2nd picking	25-01-2009	31-01-2010
3rd picking	09-02-2009	16-02-2010

Appendix IIb: Date of seed cotton picking during 2008-09 and 2009-10 (Experiment II)

Picking	**2008-09**	**2009-10**
1st picking	25-12-2008	20-12-2009
2nd picking	30-01-2009	30-01-2010
3rd picking	18-02-2009	20-02-2010
4th picking	02-03-2009	08-03-2010

Appendix III: Media composition

1. Methylotrops (pH 6.8)

Ammonium mineral salt medium

1. NH_4Cl : 0.50 g
2. K_2PO_4 : 0.70 g
3. KH_2PO_4 : 0.54 g
4. $MgSO_4$: 1.0 g
5. $CaCl_2$: 0.2 g
6. $FeSO_4$: 4.0 mg
7. $ZnSO_4$: 100 µg
8. $MnCl_2$: 30 µg
9. H_3BO_3 : 300 µg
10. $COCl_2.6H_2O$: 200 µg
11. $CuCl_2.2H_2O$: 10 µg
12. $NiCl_2.6H_2O$: 20 µg
13. $Na_2MII_4.2H_2O$: 60 µg
14. Agar : 16 g
15. Distilled water : 1000 ml
16. pH : 6.8

Methanol @ 1.5% was added before plating

2. Azospirillim (pH 6.6 – 7.0)

1. Malic acid : 5.0 g
2. KOH : 4.0 g
3. $FeSO_4.7H_2O$: 0.05 g
4. K_2HPO_4 : 0.5 g
5. $MnSO_4.H_2O$: 0.01 g
6. $MgSO_4.7H_2O$: 0.10 g
7. NaCl : 0.02 g
8. $CaCl_2$: 0.01 g
9. Na_2MOO_4 : 0.002 g
10. Distilled water : 1000 ml

11. Bromothymil blue : 2.0 ml
    (0.5% alcoholic solution)

12. pH : 6.6 – 7.0

13. Agar : 2 g/l (semisolid)

The saturated KOH solution was added till the media turned yellowish green.

3. Modified Sperber's medium (pH 7.0 – 7.2)

1. Glucose : 10 g
2. Yeast extract : 0.5 g
3. $MgSO_4.7H_2O$: 0.25 g
4. $CaCl_2$: 0.10 g
5. Agar : 18 g
6. Distilled water : 1000 ml

Note : 10% $CaCl_2$ – 3 ml/100 ml and 10% K_2HPO_4 – 2 ml/100 ml was autoclaved separately and added just before pouring to the plates.

Appendix IV: Price of inputs and outputs

Sl. No.	Particulars	Price (Rs.)	
		2008	**2009**
I.	**Inputs**		
1.	RCH-2 Bt	750	650
2.	RCH-2 BG-II	950	750
3.	Bunny BG-II	950	750
4.	JK-99 Bt	750	650
5.	Mallika Bt	750	650
6.	MRC-6918 Bt	750	650
7.	Brahma Bt	750	650
8.	RCH-708 Bt	750	650
9.	Bunny Bt	750	650
10.	DHH-11	400	400
	Fertilizers		
1.	Urea	502/100 kg	502/100 kg
2.	Diammonium phosphate (DAP)	972/100 kg	972/100 kg
3.	Muriate of potash	462/100 kg	462/100 kg
	Labour		
1.	Man	60 /day	60 /day
2.	Woman	50 /day	50 /day
3.	Bullock pair	100 /day	100 /day
	Plant protection chemicals		
1.	Imidacloprid 200 SL (200 ml)	625	625
2.	Acetamiprid 20 SP (50 g)	199	199
3.	Acephate 75 SP (500 g)	295	295
4.	Quinalphos 25 EC (1 litre)	400	400
5.	Chlorpyriphos 20 EC (1 litre)	190	190
6.	Cypermethrin 10 EC (250 ml)	75	75
7.	Profenophos 50 EC (250 ml)	151	151
8.	Magnesium sulphate	50	50
	Output	**3300**	**3100**
	Cotton	4000	3900

Appendix V: Survey format for collecting the information on existing cultivation practices of cotton production

Name of the farmers and address :
Age :
Village / Taluk / District :
Educational status :
Land holding :

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

Family size : Male Female
Family income (Rs.) :
Area of cotton cultivation :
Irirgated / Rainfed :
Source of irrigation : Well / Canal / Others

Cotton cultivation details

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

Nutrition

a. Organic manures FYM / Compost used
   Own source / borrowed :
   Rate (if purcjased) :
   Quantity :
   Time of ap[placation :
b. Grene manuring : Yes / No
   If Yes, what species :
   Quantity :
c. Poultry manure used : Yes / No
   If Yes, what quantity :
d. Biofertilizers : Yes / No

If Yes, what biofertilizer used :
Quantity :

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

Irrigation

Interval of irrigation :
Method of deployed :
Source of irrigation :

Intercultivation and weeding

Intercultivation :
Weeding : Manual / Chemical

Intercropping : Yes / No

If Yes, what crop? Row proportion

Pest management

Pests

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

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

Yield kg/ha)

	First	**Second**	**Third**	**Total**
Picking				

Leaf reddening management :
Flower dropping management :
Bad opening of bolls :
Yield (kg/ha)

STUDIES ON PERFORMANCE OF Bt COTTON GENOTYPES IN DIFFERENT SOILS OF NORTHERN TRANSITION ZONE OF KARNATAKA UNDER RAINFED SITUATION THROUGH FARMERS PARTICIPATORY APPROACH

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ABSTRACT

The field experiments were conducted to evaluate the performance of Bt cotton genotypes in different soils under rainfed situation through farmers participatory approach in Govankoppa (black soil) and Budarkatti (red soil) villages of Bailhongal taluk of Belgaum district with mother and baby trial design during kharif 2008-09 and 2009-10. The experiments were laid out in a randomized complete block design with three replications. The treatment consisted of the Bt cotton genotypes RCH-2 Bt, RCH-2 BG-II Bt, Bunny BG-II Bt, JK-99 Bt, Mallika Bt, MRC-6918 Bt, Brahma Bt, RCH-708 Bt, Bunny Bt and DHH-11. Bunny BG-II Bt recorded significantly higher seed cotton yield (2385 kg/ha), while MRC-6918 Bt recorded higher benefit:cost ratio (4.02) in mother trial black soil. The seed cotton yield of RCH-708 Bt, RCH-2 Bt, JK-99 Bt and Brahma Bt in baby trial was found on par with those in mother trial black soil. MRC-6918 Bt recorded significantly higher seed cotton yield (2257 kg/ha) and benefit:cost ratio of 3.68 and significantly higher over other cotton genotypes in mother trial red soil. The seed cotton of RCH-2 Bt, JK-99 Bt, DHH-11 and Brahma Bt in baby trial was found on par with those in mother trial red soil. The soil fertility status of major cotton growing areas of Bailhongal taluk in different soil types revealed that mean pH of the black soil was 7.5, whereas in red soil was 7.26. The soils were found to be deficit in N, P, Fe and Zn in both black and red soils. The survey on documentation of cultivation practices on cotton indicated that Bunny Bt was the dominant Bt hybrid cultivated in both black and red soil with a spacing of 120 $\times$ 60 cm.