EFFECT OF IRON-EDTA ON YIELD AND QUALITY OF RED CHILLI (*Capsicum annuum* L.) IN A CALCAREOUS VERTISOL OF ZONE-8 OF KARNATAKA

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfillment of the requirement for the
Degree of

MASTER OF SCIENCE (AGRICULTURE)

IN

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

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JULY, 2008

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1. INTRODUCTION

Chilli (*Capsicum annuum* L.) is an important spice cum vegetable crop cultivated extensively in India. It was originated in South America and was introduced to India by Portuguese in the seventeenth century. Chilli belongs to the family Solanaceae with two main species viz., *Capsicum annuum* L. and *Capsicum frutescens* L. Chillies are used in salads, chutneys, sauces, pickles and form an indispensable ingredient of Indian diet in every home. Chillies stimulate saliva and gastric juices which help in digestion. They are used in the preparation of natural colouring agents, cosmetics and pain balms. The demand for natural pigments of chillies is increasing as it is extensively used in organic food colours and offer good potential for export. Chillies are rich source of vitamins C and A with plenty of minerals. The attractive red colour plays an important role in assessing the quality of chillies. The principle colouring matter is the carotenoid pigment viz., 'capsanthin and capsorubins constituting about 60-70 per cent of the total pigments. Oleoresin extracted from red chilli fruits is preferred against ground chillies in view of it's natural anti-oxidant, long shelf life under ideal conditions and less storage space. In food and beverage industries, chillies have acquired great importance in the form of oleoresins which permit uniform distribution of colour to food stuffs and characteristic flavour.

Share of spices in total agriculture export of India is around six per cent. India's share in world spices trade is 45 to 50 per cent by volume and 25 to 30 per cent by value (Anon., 2006). India is the major producer, consumer and exporter of chillies and contributes 25 per cent to total world production. India exported 1.69 lakh tonnes of chilli in April-February 2007-2008. The value of the export was Rs 906.44 crore (Anon., 2008). Export comprised of chilli powder, dried chillies, pickles and chilli oleoresins.

Chilli is generally adopted to tropical situation and major chilli growing countries are India, China, Indonesia, Korea, Pakistan, Turkey and Sri Lanka. Among different states, Andhra Pradesh ranks first in chilli production with 49 per cent of the total production, while Karnataka the second largest producer contributes 11 per cent followed by Orissa (7%), Maharashtra (6%) and Madhya Pradesh (4%).

In Karnataka, chilli occupies 1.72 lakh hectares of area with a production of 1.32 lakh tonnes (Anon., 2005). In northern Karnataka, Dharwad, Gadag and Haveri districts together account for 1.76 lakh hectares of area with a production of 1.31 lakh tonnes and productivity of 744 kg per hectare (Anon., 2007). Haveri and Dharwad districts themselves make up 72 and 60% of total area and production respectively (Anon.,2008) Byadgi chillies grown in these districts have known for their less pungency and high colour value which have promising export value.Deep black and medium black soils which occupy extensive area in these districts are put to chilli (Byadgi cultivars) cultivation every year.

Chilli is a long duration (180 - 200 days) and exhaustive crop. Unless the soils are replenished with all the nutrients, there will be persistent nutrient exhaustion posing a great threat to sustainable chilli production. In recent years, it is observed that chillies respond to the application of micronutrients which play role in improving the yield and quality of chillies.

Iron is indispensable for chlorophyll synthesis. It acts as an oxygen carrier and is a constituent of certain enzymes and proteins. It has an important role in carotenoid synthesis in red chillies indirectly improving the quality of paprika or red chillies or paprika. Martinez *et al.* (1990) observed that in *Capsicums* only iron concentration of stem and leaves significantly correlated with fruit red colour and has an important role in the carotenoid synthesis in red chillies.

The price of chillies in the national and international market is mainly judged by colour value, where in blood red coloured, wrinkled and shining fruits fetch highest prize. Byadgi chillies extensively grown on Vertisols/Vertic intergrades in northern Karnataka have unique property of low pungency and high colour value. These soils are slight to moderately calcareous and iron is likely to be deficient in these soils. The DTPA extractable iron in these soil ranged from 2.5 to 5.0 ppm.

To correct the deficiency of iron, the common practice is to apply Fe through $FeSO_4.7H_2O$ either by soil application or by foliar spray. But, the availability of Fe through this salt is not only slow but less due to its transformation to unavailable form. In this respect, if iron is applied in the form of chelate (Fe-EDTA) the efficiency will be high and response of crops would be quick. These chelating agents produced by either microorganisms or excreted by plant roots are shown to function as vehicles for the movement of micronutrients to roots. Soils amended with manures and other organic wastes may also be relatively rich in metal-binding biochemicals. Since chelating agents have the ability to transform solid phase micronutrients cations into soluble metal complexes, their production during decay of plant and animal residues may increase the availability of insoluble micronutrients to plants.

Concentration of iron in soil comparison with other plant micronutrients is high. Despite its high content, plants may suffer from iron deficiency especially when grown on calcareous soils which cover 30 per cent of the earth's land surface (Chen and Barak, 1982). This is not surprising if one considers the strong dependence of iron solubility on pH. So much so that one unit increase in pH can reduce the solubility of ferric iron by as much as 1000 times and ferrous iron by 100 times.

Since, Byadgi chillies are grown on deep black and medium black calcareous soils in Dharwad, Gadag and Haveri districts and iron appears to be limiting in these soils. Previous studies carried out on these soils indicated that iron appears to play some role in enhancing the colour value of fruits (Malawadi *et al.,* 2004). But, the exact mode of action and to what extent it influences colour synthesis in red chillies are not known. Hence, the present investigation was planned with the following objectives.

1. To study the methods, time and levels of Fe-EDTA application on yield and quality of chilli (Cv. Byadgi dabbi) in a calcareous black soil.
2. To study the effect of Fe-EDTA on the uptake of nutrients.
3. To relate the iron concentration of leaves and nutrients content of whole fruit and pericarp component to colour value and oleoresin content.

2. REVIEW OF LITERATURE

The importance of micronutrients, particularly iron as one of the essential plant nutrients is well established. Iron is involved in the activation of several enzymes, oxidation reduction reactions and is responsible for chlorophyll formation.

A continuous supply of iron is essential for good plant health. Any factor that interferes with the absorption of iron by plant roots or it's assimilation within the plants may result in yield reduction or quality deterioration. Iron deficiency is a common phenomenon particularly in calcareous Vertisols. Iron fertilization to these soils is necessary to obtain higher yields and good quality crop. The review of literature pertaining to the present investigation is presented in this chapter under the following headings.

2.1 Available iron status in soils.

2.2 Influence of iron application on growth and growth parameters.

2.3 Influence of iron application on yield and yield parameters.

2.4 Influence of iron application on quality parameters.

2.5 Influence of Fe on nutrient concentration in leaves and fruit components with colour value

2.6 Effect of iron nutrition on the uptake of nutrients.

2.1 AVAILABLE IRON STATUS

Yaalon (1957) reported that 10 per cent active lime is the critical level for sensitive crops and if exceeds 10 per cent shows the danger of iron chlorosis in different crops and even different varieties of same species. However vines are generally sensitive while olives are highly resistant.

The deficiency of iron is quite common in calcareous alkaline soils because of its low availability. Under conditions of satisfactory aeration, iron is found in most soils as precipitate of oxides and phosphates. The occurrence of iron oxides, magnetite, goethite, hematite, limonite and lepidocrocite has been recorded in soils (Brown, 1960). The availability of these oxides in soils is determined by the changes in pH, Eh and the presence of soluble complexing agents. Kanwar and Randhawa (1974) surveyed the available iron status in few Indian soils and was found to vary from 0.09 to 225 ppm.

Chaney *et al.* (1972) studied the transformation of iron and reduction of Fe^{3+} (ferric ion) to Fe^{2+} (ferrous ion) is found to be obligatory before its absorption by the plants.

Kanwar and Randhawa (1974) have reviewed that the main source of micronutrients in soils is the parent material and from the nature of parent material possible deficiency or toxicity of micronutrients in soil or plant can be predicted.

The availability of iron in soil is a function of number of properties viz., texture, lime content, organic matter and the amount of Fe in the soloid form which is in equilibrium with those in the soil solution. A very small proportion of total Fe is available for higher plants. The concentrations of ionic Fe^{3+} and Fe^{2+} are extremely low (10^{-10} M or lower) in the aerated media maintained in the physiological pH range (Lindsay, 1974). He categorized 77 colarado soils into deficiency and sufficiency categories and reported no response to iron application when DTPA-extractable iron exceeded 4.5 ppm.

A significant negative correlation was noticed between available iron and $CaCO_3$ by Singh and Patiram (1975). It was probably due to precipitation and adsorption of iron in the presence of $CaCO_3$.

As the soil pH increases beyond 6.5, soluble ferrous iron is oxidized to ferric oxides which being insoluble under neutral and alkaline conditions lead to iron deficiency (Shukla *et al.*, 1975). The deficiency of iron was attributed to non-availability of soluble iron in soil rather than total iron in the soil (Decock, 1978).

Lindsay and Norvell (1978) used a mixture of 0.005 M DTPA, 0.01 M $CaCl_2$ $2H_2O$ and 0.1 M triethanol amine adjusted to pH 7.3 ± 0.05 for the simultaneous extraction of available Fe and other micronutrients. According to them the critical level of Fe for corn was 4.5 ppm (<2.5 deficient, 2.5 – 4.5 marginal and >4.5 adequate).

Mann *et al.* (1978) conducted a field experiment in loamy sand soil of Fatehpur (Punjab) to know the effect of FYM and ferrous sulphate on residues of available iron after harvest of crop. The available iron was 10.8 mg per kg of soil for soil application of 25 ppm $FeSO_4$ along with 10 tonnes FYM per ha over 25 ppm of $FeSO_4$ alone (7.0 mg/kg) after maize crop harvested.

The iron level in sugarcane leaves is not an indicator of iron deficiency because in such cases the iron was physiologically inactive. This can be reversed by foliar spray of $FeSO_4$ (Naik and Joshi, 1979).

Cottenie *et al.* (1982) stated the critical level of DTPA-extractable soil iron was given as more than 4.5 ppm which is considered as adequate. Dubey *et al.* (1983) estimated the iron content in some salt affected black soils of western Madhya Pradesh. The total iron in these soils was fairly high which was attributed to the presence of iron bearing minerals and generally decreased with depth.

Welp *et al.* (1983) found that in soils with high organic matter (>2%) especially under alkaline conditions, the concentration of organic Fe-chelates can reach values upto 10^{-4} to 10^{-3} M. However, in well aerated soil, Fe concentration in the soil solution ranged from 10^{-8} to 10^{-7} M and this is lower than the required amount for adequate plant growth.

El-Gala *et al.* (1986) suggested the critical levels of iron in different Egyptian soil types and the values for alluvial, calcareous and sandy soils were 5.6, 3.4 and 3.8 ppm, respectively.

Mortvedt (1986) reported that most fertilizers are applied directly to soil and many iron sources have been applied alone or with NPK fertilizers. Soil application of inorganic iron sources were usually not effective unless high rates are applied because these iron sources are rapidly converted to forms which are not readily available to plants. Ferrous-Fe is rapidly oxidized to the ferric from in well aerated soil. Therefore, broadcasting fertilizers generally, are not as effective as band application because soil fertilizers contact is more limited with band application.

Papastylianou (1989) reported various degree of chlorosis based on survey conducted on peanut (*Arachis hypogea* L.) fields. In the area studied plant appearance was classified according to the 'chlorotic index' and corresponding soil samples were taken and analysed for free $CaCO_3$.

Patiram and Rai (1989) reported that, liming the soils decreased significantly the available Fe in the soil which was probably due to precipitation of Fe as carbonates, oxides or hydroxides resulting from increase in pH after liming.

Farrell (1990) elucidated the nutrient composition of chillies and stated that K concentration was highest followed by that of nitrogen, phosphorus, calcium, Mg, Fe, Mn, Zn and Cu. He further reported that varietal differences, fertilizer, soil and climatic conditions alter the composition of fruits.

Prasad and Sakal (1991) studied the available iron in calcareous soils extracted by different extractants (DTPA-$CaCl_2$, DTPA-NH_4HCO_3, EDTA-$(NH_4)_2$ CO_3 and EDTA-Ammonium acetate) and reported that, significant negative correlation with pH, free $CaCO_3$ and active $CaCO_3$, whereas positive correlation with organic carbon. Clay content showed a tendency of positive correlation with extractable and total iron.

Total Fe content in Indian soils varied from less than 1.3 per cent to more than 8 per cent with an average value of 3.3 per cent as mentioned by Katyal and Sharma (1991). But, iron chlorosis often occurs in alkaline calcareous soil. This lime induced chlorosis is not a consequence of too low availability of Fe in the soil, but is rather a physiological disorder influenced by $CaCO_3$. Despite physiological disorder some specific cultivars may not face iron chlorosis. So, it can be opined that there are some other factors which were related to iron chlorosis.

Singh *et al.* (1992) studied the kinetics of DTPA extractable iron in a sandy loam soil incubated with green manure. DTPA-Fe exhibited peak concentration at four weeks after incubation and declined later.

Calcareous soils are characterized by high carbonate bicarbonate and high pH. So, the pH of the plant system grown on these soils will increase resulting in lesser reduction of Fe^{3+} by Fe-reductase located in plasma membrane, which is pH dependent (Mengel, 1994). Similarly, Sahai (1999) reported that, in calcareous soils addiction of iron will be helpful in increasing the yields of few crops particularly pulses, oil seeds and other crops.

Rao and Rao (1994) in a hydroponic culture studied the effect of iron stress on growth and composition of groundnut (Cv. TMV-2), supplied with five ppm Fe at pH of 5.5, 6.5, 7.5 and 8.5. The seedlings grown at pH 7.5 and 8.5 exhibited severe chlorosis. Iron deficiency decreased with increased root growth than shoot growth and caused 3 to 4 fold reduction in photosynthetic rate and chlorophyll content in legumes. They also reported that physiologically active Fe^{3+} decreased markedly by increased pH but not total Fe.

A very small quantity of Fe^{+2} was found in the soil than Fe^{+3} due to its transformation into ferric forms (Thakur *et al.* 1995). The higher values in lower layers and reduction to ferrous ions from the higher total iron was observed in typic pellustents due to basaltic origin of soils of Narmada valley.

Mengel and Kirkby (1996) reported that iron chlorosis may result from the absolute Fe deficiency in the soil and such cases may occur on degraded sandy soils, but are not frequent. Iron chlorosis in calcareous soils is not caused by absolute Fe deficiency though they contained high levels of total Fe but in forms unavailable to plants. However owing to the nature and causes of Fe chlorosis, leaf Fe concentration is not necessarily related to degree of chlorosis. In chlorotic plants Fe concentration can be higher or lower than those in normal plants. Thus, this disorder on calcareous soils is not always attributed to Fe deficiency but is rather a physiological disorder.

Raut *et al.* (1998) conducted a survey work in groundnut growing areas of Jayakwadi command area of Maharashtra. They analysed one hundred surface soil samples for iron status differing in soil characteristics. They also determined correlation coefficients of total iron and available iron with pH, free lime, sand and organic carbon. It was found that pH, lime and sand bear significant negative correlation whereas organic carbon, clay and available N had significant positive correlation.

Bavaresco *et al.* (2003) reported that high lime content affected chlorophyll synthesis, mineral nutrition and dry matter partitioning of grape (Cv. Aurora). They attributed this to reduced development of leaves reduced photosynthesis and crop yields, while increasing the distribution of dry matter in the trunk and roots.

An incubation study was conducted to study the effect of applied iron in the form of ferrous sulphate along with FYM on the periodical changes of iron fraction content of soil at varying $CaCO_3$ levels. The gradual increase in water soluble and exchanged iron due to ferrous sulphate application was observed upto 30 days of incubation period. However, it started declining from the 45 day onwards irrespective of $CaCO_3$ levels (Hellal, 2004).

2.2 INFLUENCE OF IRON-EDTA ON GROWTH AND GROWTH PARAMETERS

Vine Cv. Saperavi showed 46.50 per cent chlorosis after fifteen years of planting and two iron sources viz., $FeSO_4$ and DTPA iron were used to correct this disorder. Foliar application of both iron sources decreased the chlorosis, augmented leaf chlorophyll content (Meshcheryakov and Alekhina, 1971).

Bakshi *et al.* (1973) found that soil application of Fe-EDDHA @ 50 g per plot to trifoliate orange seedlings grown on an alkaline soil showed good response to growth as compared to foliar spray of ferrous sulphate at 0.4 per cent.

Mallick and Muthukrishnan (1979) found that, soil application of Fe at higher concentration in the form of $FeSO_4$ produced more cluster and more number of flowers and non-significantly increased the plant height in tomato (Cv. CO-2). Similarly, Husain *et al.* (1989) reported that foliar application of iron in the form of ferrous ammonium citrate at 0.1%

along with Zn and Boron (0.1%) at 30, 60 and 75 DAT resulted in significant improvement in the plant height (cm) of chilli (Cv. X 235).

Suryanarayana and Rao (1981) studied the effect of foliar application of iron on growth of Okra. They reported that, application of iron along with Zn, Cu, Mn, Mg, B and Mo in a chelated form (Agromin) resulted in increased in plant height (cm).

Hooda and Pandita (1982) studied the foliar application of Agromin ($ZnSO_4$, $MnSO_4$, $FeSO_4$ and $CuSO_4$) at 1 kg per ha which recorded maximum plant height (cm) than control in potato (Cv. Kufri Chandramukhi).

El-Kassas (1984) reported that application of iron to the soil or to the foliage as either chelate or as sulphate improved the vegetative growth, gross yield and fruit quality of balady lime. Application of chelated iron (Fe-EDDHA) to the soil gave the highest response.

Jana and Kabir (1987) reported the effect of foliar application of micronutrients on growth of French bean. They found that, iron along with other micronutrients at 0.1 ppm concentration recorded highest plant height (cm) and number of branches.

Pant and Tewari (1987) studied the effect of foliar application of Agronomic no growth of apple Cv. Red pelicious. They observed that application of Agromin at 0.2 per cent recorded maximum growth and leaf area.

Hazra *et al.* (1987) studied the effect of foliar application of iron (0.1%) which recorded maximum plant height and number of primary branches than foliar application of iron at 0.2 per cent in okra (Cv. Pusa Savani).

Marschner (1991) highlighted the critical concentration of Fe in leaves as in the range of 50 to 150 mg per kg dry weight.

Four years old highly chlorotic blood red orange trees grown on an alkaline clay soil (pH 8.24) were given foliar spray in April and July containing (0.2%) $FeS0_4$, (0.5%) $ZnSO_4$ and (0.2%), $MnSO_4$ per 20 litres separately and also in all possible combinations. Applying all the three trace elements together had significant effect on tree growth (Ali *et al.*, 1992). Sanz *et al.* (1992) reported that iron chlorosis is one of the most important abiotic stresses in fruit trees grown on alkaline soils.

Kumbhar and Deshmukh (1993) reported the response of tomato Cv. Rupali to soil application of ferrous sulphate @ 80 kg per ha which significantly increased plant height (cm) followed by 120 kg Fe per ha over control.

Kundal *et al.* (1994) reported that foliar sprays of less than 0.6 per cent $FeSO_4$. $7H_2O$. Fe-EDTA and Fe-Citrate on peach root stock seedlings were effective in correcting iron chlorosis and increasing chlorophyll content in seedlings. The concentrations of 0.6 per cent and above caused phytotoxicity and subsequent mortality of seedlings.

Michael (1994) reported that chillies grown on deep black soils have deep root system extending the effective root zone upto 90 cm depth.

Palliotti *et al.* (1994) studied the effect of iron and non-iron compounds on chlorosis recovery of grape vine Cv. Trebbiano toscano. Three fertilizers were applied viz., foliar spray with sequestrene 330-Fe (4-0-14; 17% Fe) and soil application with sequestrene 138-Fe (3-0-15; 6% Fe). The results revealed significant increase in leaf chlorophyll content, photosynthetic activity, transpiration rates, total soluble solids, starch, dry matter, length of shoot and pruning weight over control.

Bhat and Jandial (1996) studied the effect of soil application of iron on growth of potato (Cv. Kufri Badshah). They observed that, application iron in the form of $FeSO_4$ at 5 kg per ha recorded higher plant height (cm), number of shoots per plant and number of leaves per plant.

Durga Devi *et al.* (1997) studied the effect of soil and foliar application of ferrous sulphate on Sathgudi orange in iron deficient soils of Coimbatore district in Tamil Nadu. Results revealed that 0.5 per cent foliar spray + 75 g of soil application of ferrous sulphate significantly decreased the chlorosis (58.4%) over control.

El-Shazly *et al.* (2000) studied the effect of Fe-EDDHA foliar sprays (0, 1.25, 2.5, 5 and 7.5 g/tree in 2 or 4 equal doses) on some physiological and biochemical indices on Norel orange grown on clay sodic soils. The results indicated that with increase in Fe-EDDHA rates and number of sprays there was marked was increase in vegetative growth parameters and yield compared to control.

Jadhao *et al.* (2002) reported the response of turmeric to soil application of $FeSO_4$ @ 30 kg per ha, which significantly increased the height of plant (96.62 cm) and number of leaves per plant (9.35) followed by 15 kg iron per ha over control.

Tamilselvi *et al.* (2002) reported that, foliar application of iron combined with other micronutrients (Zn, Cu, Mn, B and Mo) called Multiplex (100 ppm) significantly increased the plant height (cm), number of flowers per cluster and number of fruiting clusters in tomato (Cv. PKM-1).

Hatwar *et al.* (2003) reported the response of chilli (Cv. Jayanthi) to foliar application of micronutrients. They stated that, iron ($FeSO_4$) is a component of ferodoxin an electron transferring protein and is associated with chloroplast. Its application resulted in height of plant (cm), number of branches, diameter of stem, spread of plant, number of flowers and fruits per plant.

Sharma and Upadhyay (2003) conducted a field experiment on alkaline black soil of Pune to know the effect of ferrous sulphate and cow dung slurry on yield of one year old Thompson seedless vine. Application of 37.5 kg $FeSO_4$ per ha with cow dung slurry resulted in higher yield (4.47 kg/wine) over 37.5 kg per ha $FeSO_4$ applied alone (3.48 kg/ha).

A field experiment was conducted to study the effect of foliar application of micronutrients on growth and yield of tomato (Cv. Pusa Hybrid-1). It was observed that, foliar application of ferrous sulphate (100 ppm) resulted in maximum number of branches per plant (9.05), number of leaves (119.16), leaf area (80.27 cm^2), fresh weight per plant (757.8 g), dry matter content of shoot (25.15%) and fruit yield (242.1 q/ha) and were significantly superior over control (Lalit Bhatt *et al*., 2004).

Agarwal *et al.* (2004) reported the time of application of Fe in the form of $FeS0_4$ on growth of hybrid tomato (Cv. Avinash-2). $FeSO_4$ was applied at 0.5 per cent foliar spray at 30, 40 and 50 days after transplanting. There was maximum plant height (cm), number of primary branches and number of leaves.

2.3 INFLUENCE OF IRON (EDTA) ON YIELD AND YIELD PARAMETERS

Meshcheryakov and Alekhina (1971) reported that, application of ferrous sulphate as a foliar spray (0.5%) increased the yield of chlorotic vine Cv. Saperavi over control.

Mallick and Muthukrishnan (1980) reported that, soil application of Fe at 5 ppm in the form of $FeSO_4$, produced five to nine per cent more clusters, weight of fruits (1.86 kg), total and marketable yield (41.33 t/ha) of tomato (Cv. CO-2).

Suryanarayana and Subbarao (1981) studied the effect of foliar application of iron on yield of okra. They reported that foliar application of iron along with Zn, Cu, Mn, Mg, B and Mo in a chelated form (Agromin) resulted in significant increase in number of fruits per plant as well as yield per hectare (q) (Cv. Pusa Sawani).

Hooda and Pandita (1982) studied the effect of foliar application of Agromin on yield of potato (Cv. Kufri Chandramukhi). They observed that application of Agromin dosage ($ZnSO_4$, $MnSO_4$, $FeSO_4$ and $CuSO_4$) at 1 kg per ha recorded significant increase in tubers yield (419.6 q/ha) over control.

Prasad *et al.* (1984) reported that, poultry manure serves as source of zinc and iron and also as complexing agent in enhancing the yield in calcareous soil.

Jana and Kabir (1987) reported the effect of foliar application of micronutrients on yield of French bean (Cv. Contender) under polyhouse condition. They observed that, application of iron combined with other micronutrients at 0.1 ppm recorded maximum number of pods per plant, length of pod and pod yield.

Pant and Tewari (1987) studied the effect of foliar application of Agromin (Borax, $ZnSO_4$, $MnSO_4$, $FeSO_4$ and $CuSO_4$) on yield of apple (Cv. Red Delicious). They observed that application of Agromin at 0.2 per cent recorded higher fruit yield (250.98 kg/tree) and fruit weight (283.0 g).

Hazra *et al.* (1987) studied the effect of foliar application of iron at 0.1 per cent in okra (Cv. Pusa Sawani). There was maximum fruit number per plant, fruit length (13.52 cm), fruit weight (15.47 g) and fruit yield (109.24 q/ha) than foliar application of iron at 0.2 per cent.

Velu (1988) reported that, application of 20 t FYM per ha plus monthly foliar spray of one per cent $FeSO_4$ recorded highest yield of jasmine (3132 g/plant) over control (1413 g/plant) in iron deficient soil of Coimbatore.

Venu (1988) studied soil and foliar application of $FeSO_4$ on the yield of rhizomes in turmeric grown on calcareous soil. He observed that, soil application of $FeSO_4$ (50 kg/ha) was found to be superior in influencing the rhizome yield compared to 1% $FeSO_4$ foliar spray.

Husain *et al.* (1989) studied the time of application of Fe in the form of ferrous ammonium citrate on yield of green chillies (Cv. X.235). It was observed that, foliar application of iron along with Zn and B (0.1%) at 30, 60 and 75 DAT resulted in significant improvement in the yield of green chillies (13.19 t/ha).

Nair and Peter (1990) recorded the highest fruit number, fruit weight per plant and yield of chilli per hectare with combined application of organic or inorganic sources and concluded that only organic or inorganic fertilizer sources will not increase yield of chilli.

Kumbhar and Deshmukh (1993) reported the response of tomato (Cv. Rupali) to soil application of ferrous sulphate @ 80 kg per ha which significantly increased fruit yield (1138.29 g/plant) followed by @ 120 kg per ha (1084.57 g/plant) and control recorded lowest yield (997.35 g/plant).

Sindhu and Tiwari (1993) noticed highest bulb yield in onion (Cv. Pusa red) with the foliar application of Fe (100 ppm), Cu (1 ppm), Zn (3 ppm) and B (0.5 ppm) sprayed twice at 15 days intervals.

Singh and Dixit (1994) highlighted that, cauliflower responded favourably to Fe ($FeSO_4$) application. Application of 10 mg Fe /kg of kg soil resulted in highest curd yield 270.8 and 275.0 q per ha during 1988-89 and 1989-90, respectively.

Bacha *et al.* (1995) reported that, spraying of chelated iron on Thompson seedless and Loamy fed grape cultivars once before flowering, twice before flowering or after fruit set or three times before flowering or after fruit set and during berry development resulted in significant increase in weight, size, length and diameter of the berries in both cultivars as compared to control.

Bhat and Jandial (1996) studied the effect of soil application of iron on yield of potato (Cv. Kufri Badshah). They observed that application of iron in the form of $FeSO_4$ at 15 kg per ha recorded higher tuber yield (190.0 q/ha) over control.

Bose and Tripathi (1996) reported the effect of time of application of iron in the form of $FeSO_4$ on yield of tomato (Cv. Pusa ruby). It was observed that, foliar application of iron ($FeSO_4$) along with Zn, Mn, B at 0.2 per cent at 30 and 60 DAT resulted in higher fruit yield (1.40 yield/plant) and reduced the extent of fruit cracking (4.76%) than control.

Durga Devi *et al.* (1997) found that, foliar application of 0.5 per cent $FeSO_4$ + soil application of 75 g $FeSO_4$ per vine increased the yield of Sathgudi orange (24.36 kg/tree) as compared to 0.5 per cent foliar application (23.66 kg/tree) and 150 g soil application per tree (21.44 kg/tree).

The effect of amending a foliar applied spray containing (N, P, K, Mg, Zn, Fe, Mn, Cu and B) with glycerol (0.05%) or active dry yeast (0.1%) on its efficiency were investigated on grapes cv. Red Roumy in Egypt. All the treatments improved the growth, yield, fruit quality and nutritional status of vines (Ahmed *et al*., 1997).

Alva and Obreza (1998) reported that, application of iron humate (22 g Fe / tree / year) increased the fruit yield after the first year of application to Hemlin orange and flame grape fruit trees over control planted in alkaline soil which typically showed iron chlorosis.

Further, annual increase in the rate of Fe from 22 to 352 g per tree per year as FeH (iron humate) did not significantly increased the tree growth or fruit yield or fruit quality.

Cavuto and Santoferrara (1999) reported that, application of 5 g iron as Fe chelate per vine at the start of berry growth and again at fruit colouring stages gave the best results interms of yield, quality and earliness of grape vines.

Palaniappan *et al.* (1999) reported that, three sprays of polyfeed (19:19:19, Fe 1000 ppm, Mn 500, B-200, Zn-150, Cu-110 and Mo 70 ppm) recorded higher number of fruits per plant (84.6) and dry fruit yield (45.0 q/ha) in chillies. Similar observations were also reported in tomato but in this two spray of polyfeed recorded highest fruit yield (71.15 q/ha).

Ram and Bose (2000) reported that foliar spray of 0.25 per cent $FeSO_4$ during May and September increased the weight of individual fruit (97.84 g) and fruit yield (42.16 kg/plant) of mandarin orange over control in sandy loam soils of Kalyani (West Bengal).

Dongre *et al.* (2000) reported that in chilli (Cv. Jayanti) foliar sprays of iron at various concentrations (0.1%, 0.25% and 0.5%) in the form of iron sulphate showed superiority in improving the fruit yield, fruit length (cm), fruit diameter (cm) and weight of 500 seeds (g) of chilli.

Singh *et al.* (2002) reported that foliar application of iron at 0.2% ($FeSO_4$) along with other micronutrients (Cu, Mn, Zn, B etc.) recorded higher fruit weight per bunch and number of berries per bunch in grape (Cv. Perlette).

Jadhao *et al.* (2002) reported the response of turmeric to soil application of $FeSO_4$ @ 30 kg per ha which significantly increased the number of mother rhizomes (2.32/plant), number of fingers (14.09/plant), weight of fresh fingers (444.64 q/ha), dry yield of fingers (79.50 q/ha) followed by 15 kg of Fe per ha over control.

Tamilselvi *et al.* (2002) reported that, foliar application of iron combined with other micronutrients (Zn, Cu, Mn, B and Mo) called Multiplex (100 ppm) significantly increased the number of fruits per plant, fruit setting percentage, single fruit weight (35.2 g), yield per plant (0.82 kg) of tomato (Cv. PKM-1) and seed yield (kg/ha) of tomato. Similarly for onion (Cv. Baswant-750) foliar application of micronutrients (Zn, Cu and Mn) along with Fe in the form of $FeSO_4$ at 2.0 per cent significantly increased the seed yield per plant (684.5 g) and seed yield per ha (1520.3 kg) as observed by Khalate *et al.* (2002).

Hatwar *et al.* (2003) reported the response of chilli (CV. Jayanti) to foliar application of micronutrients. It was observed that, iron ($FeSO_4$) as a component of feradoxin an electron transferring protein is associated with chloroplast. It helps in photosynthesis, resulting in increased yield and yield attributes.

Agarwal *et al.* (2004) reported the time of application of Fe on yield of tomato hybrid (Cv. Avinash-2). Iron in the form of $FeSO_4$ was applied at 0.5 per cent concentration as foliar spray at 30, 40 and 50 days after transplanting and observed to produce higher yield (77.39 t/ha).

Bhatt *et al.* (2004) studied the effect of foliar application of micronutrients on yield and economics of tomato. They reported that foliar application of $FeSO_4$ at 0.01 per cent resulted in significant improvement in yield per ha which might be attributed to increased photosynthetic activity and increased production and accumulation of carbohydrates.

Malawadi *et al.* (2004) studied the effect of soil application of micronutrients on yield and quality of chilli (Cv. Byadgi dabbi). They observed that, application of iron in the form of iron chloride at 12 kg per ha along with primary and secondary nutrients recorded hundred fruit weight (198.1 g) and yield (843.86 kg/ha).

Highest seed (17.72 q/ha), oil (7.08 q/ha) and stover yields (59.12 q/ha) in mustard were observed with the application of 20 kg $FeSO_4$/ha in comparison to control (Kumar *et al.*, 2006). Similarly, Mishra *et al.* (2003) reported that, foliar application of Fe (0.4%) along with Zn (0.5%) and B (0.2%) significantly increased the fruit yield (kg/plant) and fruit weight (g) of kinnow mandarin.

2.4 INFLUENCE OF IRON (EDTA) ON QUALITY PARAMETERS

2.4.1 Ascorbic acid and other parameters

Chillies are rich source of ascorbic acid. Ripe chillies are known to have higher vitamin-C content than tomatoes. Chillies tend to accumulate higher ascorbic acid when fruits turn towards maturity. Ascorbic acid content in chilli fruits ranges from 100 to 320 mg per 100 g of fruits.

Dixit *et al.* (1977) found that, among foliar applications of ferrous sulphate @ 0.5, 0.75 and 1.0 per cent in April and September (coinciding with growth flushes) on trees of kinnow a mandarin hybrid, 0.5 per cent $FeSO_4$ foliar spray increased significantly TSS, ascorbic acid and total sugar content of the hybrid over other treatments.

Sooch *et al.* (1977) reported ascorbic acid content in few genotypes and it ranges from 21.69 to 117.31 mg per 100 g of fresh fruit. With the advance of fruit maturation and ripening, ascorbic acid concentration increases and was highest in the fully ripened stage (Rahman *et al.*, 1978; Shukla and Pandey, 1967). Similarly, Saimbhi *et al.* (1972), Bajaj *et al.* (1977) and Awasthi and Singh (1979) reported higher ascorbic acid in turning red stage than present in green fruit. Chillies usually contain 5 to 10 times more ascorbic acid than fresh tomatoes which usually contain 12 to 19 mg per 100 g of fruit (Rahman, 1970). Pankar and Magar (1978b) also studied ascorbic acid content in matured red chillies and it varied from 37.9 mg per cent of 86.5 mg per cent in different varieties. Maurya *et al.* (1984) while studying vitamin-C content in different chilli varieties at different stages of maturity inferred that, it decreases slightly when fruits passed from green to red stage, contrary to the observations made by earlier workers.

Pankar and Magar (1978a) studied the physico-chemical characteristics along with nutrient composition of ten important commercial chilli varieties extensively cultivated in India. Accordingly, the average length and breadth of chilli fruits ranged from 2 cm to 17 cm and 0.5 to 2.0 cm, respectively. The length/breadth (L/B ratio) ranged from 1.10 to 30.00. They also studied the contribution of pericarp, seed and pedicel to total fruit weight for the selected varieties. Accordingly, pericarp seed and pedicel per cent ranged from 43.44 to 62.30. Among the chemical properties, crude fibre percentage was highest, which ranged from 31.00 to 35.00 and carbohydrates ranged from 18.95 to 23.38 per cent. They also gave ranges for protein (13.46 to 15.00), total ether extracts (14.80 to 18.02) and total ash content (5.32 to 6.33). Further, they studied the proximate mineral composition of fruits and their partitioning within fruit components (pericarp and seed). They stated that, fruit invariably contain highest potassium followed by phosphorus, silica, magnesium, calcium and sodium. The partitioning of these nutrients within fruit components revealed that, irrespective of cultivar, K and Ca get partitioned more in pericarp than in seed, whereas other nutrients get partitioned more in seed than in pericarp. They attributed this differential partitioning of nutrients to genetic nature of crop and their specific role in influencing the quality and chemical constituents of fruits.

Rana and Sharma (1979) studied the effect of Fe spray on quality of grapes. Results revealed that, application of 0.5 per cent ferrous sulphate at the pre-blossom and post-fruit set stages significantly increased juice percentage and TSS content over control. Similarly, Daulta *et al.* (1983) reported that foliar application of ferrous sulphate significantly increased TSS content of grapes (Cv. Beauty seedless) over control.

Mallick and Muthukrishnan (1980) reported the effect of foliar application of iron on quality of tomato (Cv. CO-2). It was observed that at 3000 and 5000 ppm of Fe ($FeSO_4$) sprayed on 30^{th} and 60^{th} days after transplanting resulted in higher titratable acidity (0.704%), total sugars (25 to 29%), ascorbic acid content (29 to 39%) and reducing sugars (51%).

Elabdeen and Metwally (1982) studied the effect of foliar spraying of micronutrients on quality of tomato and pepper. They stated that, micronutrients enhance juice content in tomato and carbohydrate content in pepper.

Hooda and Pandita (1982) studied the effect of foliar application of Agromin on quality of potato (Cv. Kufri Chandramukhi). They reported that, Agromin ($ZnSO_4$, $MnSO_4$, $FeSO_4$ and

$CuSO_4$) at 1 kg per ha recorded maximum TSS (5.1%) and maximum ascorbic acid (19.2 mg/100 g) was recorded in $MnSO_4$ @ 0.05% than control.

Pant and Tewari (1987) studied the effect of foliar application of Agromin (Borax, $ZnSO_4$, $MnSO_4$, $FeSO_4$ and $CuSO_4$) on quality of apple Cv. Red delicious. They observed that application of Agromin at 0.2 per cent recorded maximum fruit TSS (13.5%) anthocyanin pigment (6 $OD/cm^2 \times 10^2$) and ascorbic acid (9.2%) in apple.

Jawaharlal and Veerarangavathatham (1988) studied the effect of soil and foliar application of zinc and iron on quality of onion (Cv. Pusa red) bulbs. They reported that, soil and foliar application (50 kg/ha) of iron in the form of $FeSO_4$ resulted in significant increase in total soluble solids (11.67° Brix) in onion bulbs. Further, soil application of $FeSO_4$ (50 kg/ha) also resulted in increased ascorbic acid (10.02 mg/100 g) and pyruvic acid (2.46 mM/g) content in onion bulbs.

Koo (1988) conducted a long-term experiment on the effect of iron on growth, fruit production and quality of citrus. The results revealed that soil application of iron significantly increased the concentration of total soluble solids in fruit juice over control.

Husain *et al.* (1989) studied the time of application of Fe in the form of ferrous ammonium citrate on quality of green chillies (Cv. X.235). It was observed that, foliar application of iron at 0.1 per cent along with Zn and B (0.1%) at 30, 60 and 75 DAT resulted in significantly improvement in chillies, but non-significant improvement in ascorbic acid (95 mg/100 g) content of fruits.

Pant and Lavania (1989) studied the effect of foliar application of iron on quality of papaya. They observed that application of iron in the form $FeSO_4$ at 0.15 per cent recorded maximum TSS (14.3%).

Kumbhar and Deshmukh (1993) conducted a pot culture experiment on calcareous Vertisol of Pune and reported that, soil application of 80 kg $FeSO_4$ per ha significantly increased the vitamin-C (33.6%) and crude protein content (2.17%) in tomato (Cv. Rupali) over control (28.71% and 1.95%, respectively).

Sindhu and Tiwari (1993) noticed maximum TSS and total sugars in onion (Cv. Pusa red) with the foliar application of Fe (100 ppm) + Cu (1 ppm) + Zn (3 ppm) + B (0.5 ppm) sprayed twice at 15 days intervals.

Bacha *et al.* (1995) conducted a field experiment on calcareous soil of Riyadh region to know the effect of Fe on quality parameters of grapes. Results revealed that foliar application of iron chelate once, twice and thrice significantly increased the total soluble solids, while the percentage of acidity decreased as number of foliar sprays increased.

Bose and Tripathi (1996) reported the effect of time of application of iron as $FeSO_4$ on quality of tomato (Cv. Pusa ruby). It was observed that application of iron ($FeSO_4$) at 30 and 60 DAT resulted in significant improvement in the quality of fruits which reduced the fruit cracking.

Dongre *et al.* (2000) reported that, foliar application of Fe at 0.25 per cent concentration in the form of iron sulphate showed superiority in improving the fruit quality. The possible reason might be stimulated vegetative growth which ultimately beneficial for improving the quality of chilli fruits.

El-Shazly *et al.* (2000) studied the effect of Fe-EDDHA foliar spray (0., 1.25, 2.5, 5.0 and 7.5 g/tree) in 2 or 4 equal doses on orange (Cv. Washington Novel) grown on clay sodic soil. The results indicated that, with increase in Fe-EDDHA rates, quality parameters particularly TSS and Vitamin C contents significantly increased over control.

Sourour (2000) conducted an experiment to study the effect of iron nutrition on quality of orange trees. Results revealed that, foliar application of 2 per cent $FeSO_4$ significantly increased juice percentage and vitamin-C compared to control. It also significantly increased reducing, non-reducing and total sugars over control.

Singh *et al.* (2002) reported that, foliar application of iron in the form of $FeSO_4$ at 0.2 per cent along with other macronutrients recorded maximum TSS (15%), acidity (0.88%), juice (64.0%) and tannin (0.19%) in grape (Cv. Perlette).

Mishra *et al.* (2003) reported that, foliar application of Fe (0.4%) along with Zn (0.5%) and B (0.2%) significantly increased the juice, acidity (0.77%), TSS (9.6%), ascorbic acid (21.70%) content in kinnow orange over control. Similarly, foliar application of iron as ferrous sulphate significantly increased the sugar content in grape (Cv. Saperavi) over control as reported by Meshcheryakov and Alekhina (1971).

Malawadi *et al.* (2004) studied the effect of soil application of micronutrients on quality of Byadgi chillies. They observed that, application of iron in the form of iron chloride at 12 kg per ha along with primary and secondary nutrients recorded maximum ascorbic acid (81.67 mg/100 g) content and oleoresin content (109.41 kg/ha) in chilli.

Pauline Alila *et al.* (2004) observed that, the reducing sugar (6.56%), total sugar (7.28%) and TSS contents (9.92°Brix) in papaya cv. Ranchi were recorded highest with the application of Fe in the form of $FeSO_4$ @ 0.1 per cent. Further, β-carotene increased with application of $FeSO_4$ (0.1%) + $ZnSO_4$ (0.2%).

Batra *et al.* (2006) reported that, foliar application of iron in the form of iron sulphate 5 g per litre at 40, 50 and 60 days after transplanting resulted in significant improvement in ascorbic acid content (25.29 mg/100 g) in tomato fruits. The most probable reason for increased Vitamin C content might be due to increase in the activity of ascorbic acid oxidase enzyme causing the marked improvement in Vit-C content.

Tamilselvi *et al.* (2002) observed maximum TSS (3.4°Brix), acidity (0.51%), ascorbic acid (27.22 mg/100 g) and lycopene contents (5.5 mg/100 g) with the application of micronutrients combination viz., Multiplex (100 ppm) along with NPK in tomato.

2.4.2 Colour value

Natarajan *et al.* (1968) stated that, pigments found in chillies are mostly in easter forms and only a small percentage of these caretonoids are in non-esterified forms. Further, they extracted these pigments with different organic solvents and found that ether and acetone extracted nearly 65 to 70 per cent of colouring matter whereas alcohol extracted only 20 per cent.

Kanner *et al.* (1977) reported that, moisture level and ripening stage of fruit considerably affected the deterioration rate of colour in stored chilli powder. Initial colour intensity was highest in powder produced from dry chilli fruits left to dry on the plant itself (270 ASTA units). Whereas, in succulent red fruits having 80 to 85 per cent moisture, the colour intensity was only 160 ASTA units and in half dry fruits, it was 265 ASTA units. They clarified that, certain amount of moisture (about 14%) in powder is necessary for the stability of colour and this is related to the differences in the composition and contents of the lipids in fruits harvested at different stages of maturity. When the fruit is allowed to dry in the plant itself, there is increase in the lipid level in the fruit viz., linoleic acid, which is a stable unsaturated fatty acid at certain degree of moisture. Similarly Rahman *et al.* (1978) reported that, in all the chilli cultivars they studied, total pigment contents increased by several fold as the fruit advanced from immature to fully ripened stage. Similarly, the quantitative distribution of chlorophylls and carotenoids at four stages of maturation and ripening was also established using chromatographic, spectroscopic and chemical methods (Rahman and Buckle, 1980). It was found that, at the immature stage of green fruits, chlorophylls a and b are major pigments, at the half ripened stage, chlorophylls a and b decreased significantly. At the mature green stage, lutein appears in high concentration followed by decreasing concentration of β-carotene, violaxanthin, neoxanthin and zeaxanthin. At the fully ripened stage, lutein disappears and appearance of antheraxanthin and crytoxanthin occurs and significant increase in the levels of zeaxanthin and violaxnthin lead to red pigments viz., capsanthin and capsorubin.

Pankar and Magar (1978b) evaluated ten commercial chilli varieties for their total colouring matter and found that in whole chillies it ranged from 117.7 to 537.7 mg per 100 g and 269.8 and 924.4 mg per 100 g in pericarp alone. Byadgi variety of Karnataka has highest colouring matter and can be employed for extracting coloured oleoresin. Cazi (1961) stated that, application of potash makes chilli fruits to give attractive red colour, glossiness and luster. Similarly Teotia and Raina (1987) also evaluated capsicums grown in Haryana for their extractable colour and it ranges from 0.22 to 0.56 per cent for whole chillies.

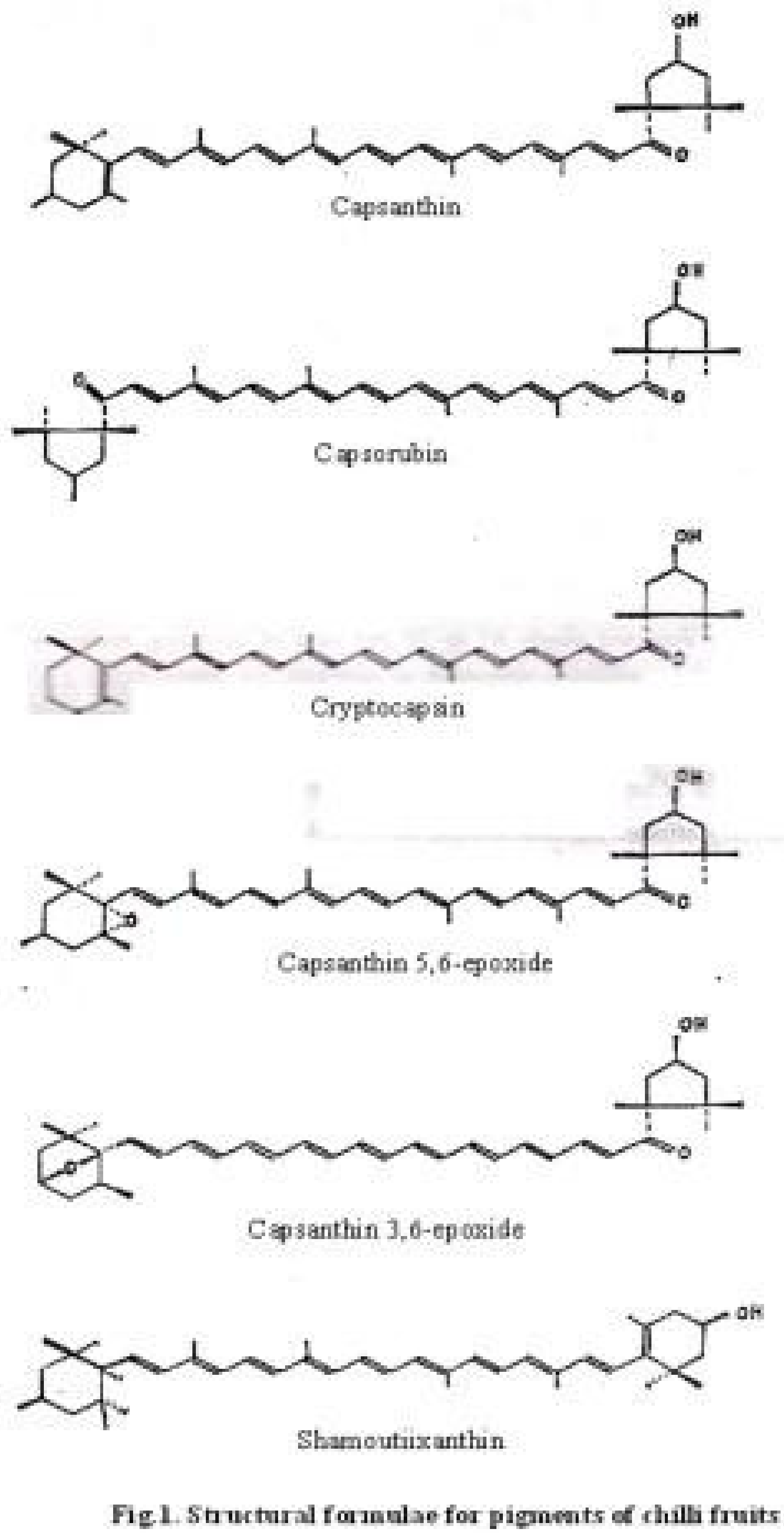

Fig. 1. Structural formulae for pigments of chili fruits

Chillies occur in different shades of colour ranging from yellow to blood red. Colour of chilli is due to the presence of carotenoid pigments. Pigment content of chilli is 0.2 to 0.5 per cent. The principal colouring matter is carotenoid pigment capsanthin constituting about 35 per cent of the total pigment. Others present are β-carotene, capsorubin, zeaxanthin, cryptoxanthin and violaxanthin. Nearly 37 pigments have been isolated from capsicum (Sumathykutty and Mathew, 1984).

Martinez *et al.* (1990) established the relationship between micronutrients composition in several portions of chilli plants to red colour of fruits. It was found that, only iron concentration in stem and leaves is significantly correlated with fruit red colour. It was concluded that iron has an important role in carotenoid synthesis in red pepper crops. Manganese and zinc have no relation with red colour of fruits.

Carotenes are isoprenoid polyenes formed by the joining of eight C_5 isoprene units (Gross, 1991). These isoprene units are linked in a regular head to tail manner except in the centre of molecule, where the order is inverted tail to tail so that, the molecule is symmetrical. Carotenes are divided into two groups (i) carotenes that are hydrocarbons ($C_{40}H_{56}$) and (ii) their oxygenated derivatives (xanthophylls).

Now-a-days chillies have acquired great importance owing to their attractive red colour. Chillies with bright red colour command higher prices than those which are dull red or orange or yellow in colour and deep red fruits tend to retain their colour in storage longer than those which are of lighter shade (Hosmani, 1993).

Carotenoids are lipids, soluble in organic solvents such as acetone, alcohol, ether and chloroform. Carotenes can be crystallized into various forms, coloured from orangered to dark violet, carotenoids can absorb light in the ultraviolet (UV) and visible region of the spectrum. The structural feature responsible for light absorption is chromophore, a system of conjugated double bonds in carotenoids. Because of these conjugated double bonds in the molecule, carotenoids are easly destroyed by oxidative degradation. Chemical oxidation, autoxidation and photooxidation of carotenoids lead to bleaching of colour. Chilli fruits stored for long time in controlled atmosphere loose colour mainly because of autoxidation where oxygen of air at root temperature combines with some substances and attacks free radical chain. This process is stimulated by temperature, light, humidity and some metals.

Chilli fruits dried in sunshine in the open yards are subjected to bleaching or decoloration because of photo oxidation. Carotenoid biosynthesis in higher plants involves six stages (i) formation of mevalonic acid (ii) formation of geranyl geranyl pyrophosphate (iii) formation of phytoene (iv) desaturation of phytoene (v) cyclization and (vi) formation of xanthophylls.

Carotenes serve as accessory pigments in photosynthesis and absorb light at different wave lengths and transfer the absorbed light to chlorophylls. They act as protective agents of photosynthetic apparatus against potential damage from UV rays. In human nutrition, carotenoids act as precursors of vitamin-A.

In carotenogenic fruits that synthesize large amounts of carotenoids during ripening, such as tomato and chillies chloroplasts change into chromoplasts.

The important carotenoids found in chillies are (i) capsanthin (ii) capsorubin (iii) cryptocapsin (iv) capsanthin 5, 6-epoxide (v) capsanthin 3, 6-epoxide and (vi) tetrol.

Among these, capsanthin is the most abundant one closely followed by capsorubin and cryptocapsin. Structural formula of these are furnished in Fig. 1.

Owing to the importance of these carotenoids, several workers have studied the nature and chemistry of carotenoids occurring in chllies and being reviewed here.

Sweet pepper fruits are often affected with colour spots on the surface of the fruit. The spots may occupy a large area of the fruit surface and yellowish or white in colour, thereby reducing the value of the fruits. Aloni *et al.* (1994) stated that, colour spot incidence increases with increasing nitrogen application and it is more pronounced in densely planted peppers due to shading effect. The probable reason for this disorder in shaded and high nitrogen supplied plants is due to imbalance between the nitrogen and carbon assimilates accumulated in fruits. They further analysed the colour spot affected pericarp for nutrient content and found that, calcium concentration was higher in this portion than the unaffected tissue. Increasing N supply to plant leads to synthesis of high levels of oxalic acid in fruit tissues. High calcium concentration in fruits chelates with oxalic acid and forms calcium oxalate which affects normal cellular function resulting in cell rupture. Usually shading of plants reduces N accumulation in fruits because of lower synthesis of sugars and their transportation to fruits. This leads to imbalance between nitrogen and carbon assimilates in fruits, leading to golden coloured spots on pericarp.

Spices Board has given the specifications for grading chillies based on pungency and total extractable colour. Accordingly chillies are classified as first grade, if their colour units are greater than 200 ASTA units and capsaicin per cent between 1.00 to 1.50, second grade, if colour units are between 100 to 200 ASTA units and capsaicin between 0.25 to 0.75 per cent and third grade if ASTA units are below 100 with capsaicin per cent between 0.11 to 0.25. But for paprikas, these values of colour units are still higher.

2.4.3 Oleoresin

It is the extract or essential volatile oil derived from spice. It is viscous semi solid gel like substance free from bacteria, spores and molds. It contains all the important quality characters present in chillies. In nut shell, oleoresin is the sum and substance of chillies. Freshly prepared oleoresin has deep blood red colour and has it's own flavour. Oleoresin permits uniform distribution of colour and flavour to the food. The yield of oleoresin from different chilli varieties ranges from 8 to 17.5 per cent and it can be stored for long time without any change in its composition unlike whole chillies. Oleoresin contains essential oils and non-volatile resins, which are very important for its flavour. Govindarajan and Ananthakrishna (1970) made observations on the separation of oleoresin from capsicums including capsaicin. They highlighted the importance of utilizing different organic solvents for oleoresin extraction and concluded that, ethylene dichloride in the best solvent to get high oleoresin recovery from fruits.

Similarly Tandon *et al.* (1964) stated, that it is better to separate seeds from fruits before oleoresin extraction, because chilli seeds are rich in fatty oil (25.7%), which is unsaturated and affects the quality of oleoresin. He also advocated the use of pericarp alone for oleoresin extraction because of its high concentration of colour and pungency.

It is found that 100 kg of dry chillies can be converted to 5 kg of oleoresin. Byadgi chilli extensively cultivated in Dharwad district yields good quantity and quality oleoresin having high clour and low pungency. Because of this, it has export value and extensively used in food industry for colouring food stuffs.

2.5 INFLUENCE OF Fe-EDTA ON NUTRIENT CONCENTRATION IN LEAVES AND FRUIT COMPONENTS WITH COLOUR VALUE

Martinez *et al.* (1990) established the relationship between micronutrients composition in several portions of chilli plants to red colour of fruits. It was found that, only iron concentration in stem and leaves was significantly correlated with fruit red colour. It was concluded that iron has an important role in carotenoid synthesis in red pepper crops. Manganese and zinc have no relation with red colour of fruits.

2.6 EFFET OF IRON NUTRITION ON THE UPTAKE AND CONCENTRATION OF NUTRIENTS

Mortvedt and Giordano (1971) reported that the dry matter and iron uptake by grain sorghum were higher with the application of Fe-EDDHA than with $FeSO_4$ or $Fe_2(SO_4)_3$ in calcareous soil having pH 7.5 with low available iron. Application of iron decreased the uptake of zinc, possibly due to interference of iron in translocation of zinc. Mortvedt *et al.* (1972) reported that, application of iron to soil and plant cause synergistic relationship between Fe and K.

Manchanda (1974) studied the effect of foliar spray of iron sulphate at three growth stages in pineapple. Results showed that, there was a significant increase in leaf iron, phosphorus and potassium content over control.

Khader *et al.* (1979) observed that, application of chelated Fe sources in the growth media of citrus rootstocks increased Fe content in leaves, stems and roots more than as observed by inorganic iron salts. The increase of iron content was associated with an increase in dry matter and a decrease in Mn content.

Samui *et al.* (1981) reported that application of iron 10 kg/ha in the form of FeSO4 recorded highest nitrogen (67.40 kg/ha), phosphorus (20.04 kg/ha), potassium (45.58 kg/ha) and iron (180.00 ppm) uptake by mustard.

Acid forming materials like pyrites as a source of Fe and S has been used to increase availability of nutrients and to improve soil properties by reducing the pH and creating favourable conditions for the growth of rice. Sedimentary iron pyrite was considered as a multipurpose sol amendment, an acidifier, plant, nutrients mobilizer and a co-fertilizer to supply sulphur and iron to plants in soils deficient in these nutrients (Tiwari *et al.*, 1984). Further Aiyer (1984) also reported highest uptake of nitrogen and potassium by application of soil + foliar application of $FeSO_4$ in bengalgram.

Jawaharlal *et al.* (1988) reported that, soil and foliar application of iron in the form of $FeSO_4$ significantly increased the nitrogen and potassium uptake by onion especially at bulb initiation stage. Soil application of 50 kg $FeSO_4$ registered the maximum phosphorus content both in leaves and bulbs. This might be due to the synergistic effect of iron with phosphorus.

Jawaharlal *et al.* (1988) reported that, soil application of iron in the form of $FeSO_4$ at 50 kg per ha registered the highest sulphur content in bulb over control.

Velu (1988) highlighted that, foliar application of $FeSO_4$ at 1 per cent increased the available Fe content of post harvest soil indicating that all most all Fe applied were removed either by plant or fixed in soil, whereas foliar spray of $FeSO_4$ resulted in slight increase in available Fe content in soil. In the rhizomes, higher dose of $FeSO_4$ application resulted in higher Fe content.

Field experiment was carried out by Rashid and Din (1992) to investigate the cause for chlorosis in some varieties of chickpea grown on calcareous soils of pathwar region of Pakistan. The results indicated that total Fe content of leaf tissue was not related with chlorosis, but orthrophenanthroline extractable ferrous (Fe^{2+}) content of fresh leaves was more related to the severity of chlorosis.

Soil application of ferrous sulphate at 80 and 120 kg per ha significantly increased the uptake of iron over control and also significantly increased the uptake of phosphorus and potassium by tomato grown on calcareous soil but uptake of N was not significantly influenced by the addition of ferrous sulphate (Kumbhar and Deshmukh, 1993).

Singh and Dixit (1994) reported that, in a pot culture study soil application of 10 mg Fe per kg of soil along with 0.5 mg B per kg of soil caused significantly higher uptake of iron (6.11 mg/kg) over control in cauliflower (Cv. Snow ball).

Veliksar *et al.* (1995) reported that, foliar application of Fe containing compounds to chlorotic grape vines increased the iron content in grape leaves and improved the general health of the plant.

An investigation was carried out to study the effect of foliar application of Fe chelate on leaf mineral composition of grapes (Cv. Thompson seedless). Results revealed increase in iron content of leaves with increase in number of foliar sprays but no definite trend was observed for macronutrient composition (Bacha *et al.*, 1995).

Das (1996) reported that applied Fe is known to help in the uptake of other nutrients including nitrogen, phosphorus and potassium by plants.

Durga Devi *et al.* (1997) conducted an experiment on six year old chlorotic orange trees (Cv. Sathugudi) to know the effect of soil, foliar and combination of soil and foliar applications of ferrous suphate on leaf nutrient composition. Results revealed that, soil (75 g/tree) + foliar spray (0.5%) recorded significantly higher nutrient content in leaves (2.81% of N, 0.19% of P, 2.51% of K, 14.5 ppm of Zn, 210.5 ppm of Fe and 19.2 ppm of Mn) over control.

Bidari (2000) studied that irrespective of the cultivar and fruit quality, the order of nutrient concentration in whole fruit followed the order of K > N > S > P > Fe > Mn > Zn > Cu. Among these micronutrients, iron content was maximum irrespective of cultivar and fruit grade. This might be due to its preferential absorption by plants and its possible role in the development of red colour in fruits by activating few enzymes.

El-Shazly *et al.* (2000) studied the effect of Fe-EDDHA foliar spray (0, 1.25, 2.5, 5.0 and 7.5 g/tree) in 2 equal doses on orange (Cv. Washington novel) grown on clay sodic soils. Foliar spray of Fe-EDDHA markedly increased leaf K and Fe content but, decreased leaf Mn, Zn and Cu contents.

Agarwal *et al.* (2004) reported that, foliar spray of Fe @ 0.5 per cent along with other micronutrients at 30, 40 and 50 days after planting recorded maximum uptake of N, P, K, Zn, B, Fe and Cu by hybrid tomato (Cv. Avinash-2).

A field experiment was conducted to study the effect of iron application on content and uptake of nutrients by chickpea (*Cicer arietinum* l.). The results indicated that soil application of 50 kg FeSO4 per ha significantly increased content and uptake of Fe, P and N by chickpea over control (Singh *et al.,* 2004).

Malawadi *et al*. (2004) studied the effect of soil application of iron in the form of iron chloride $FeCl_2.6H_2O$ at 12 kg per ha along with primary nutrients which was found to be on the uptake of iron by chillies (Cv. Byadgi dabbi).

Kumar *et al.* (2006) reported that, soil application of Fe in the form of $FeSO_4$ (40 kg/ha) caused significant higher uptake of iron (524.1 g/ha) over control and soil application of iron 20 kg per ha resulted in maximum uptake of sulphur (15.5 kg/ha) in mustard, but was non significant.

Prabhavathi (2007) reported that the application of potassium through sulphate of potash as recorded significantly higher sulphur uptake (15.30 kg/ha) at 150 per cent RDF as SOP in 2 split doses.

3. MATERIAL AND METHODS

A field experiment was conducted during the kharif season of 2007-08 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad under protective irrigation to investigate the influence of Fe-EDTA on yield and quality parameters of chilli (Cv. Byadgi dabbi). The details of material used and methods adopted are described in this chapter.

3.1 LOCATION OF THE EXPERIMENTAL SITE

The experiment was laid in a Vertisol of Main Agricultural Research Station (Plot No. 126 of Block E), University of Agricultural Sciences, Dharwad. The station is situated in the northern transitional zone (Zone-8) of Karnataka at a latitude of 15°26' North, a longitude of 75°07' East and at an altitude of 678 m above mean sea level.

3.2 CLIMATIC CONDITIONS

The data on climatic parameters viz., rainfall, maximum and minimum temperatures recorded during the year of experimentation (2007-08) and the average data for the past 57 years (1950-2007) recorded at the meteorological observatory of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad are presented in Table 1 and Fig. 2.

The average rainfall of Dharwad is 726.81 mm, which is received through south-west and north-east monsoons. However, during 2007, the total rainfall received was 1081.1 mm and was 291.47 mm more than the average of past 58 years. March, April and May are the months of maximum temperature which ranges from 34.6 to 36.7°C, while November, December and January are the months of minimum temperature, with a range of 14 to 15.1°C. June, July and August recorded higher relative humidity (80 to 85%). In general, the relative humidity during the experimental year was slightly lower compared to 58 years annual average values.

3.3 SOIL CHARACTERISTICS OF THE EXPERIMENTAL SITE

The soil of the experimental site is Typic chromustert. A composite surface soil sample from 0-20 cm depth was collected from the experimental area (Plot No. E-126) before initiating the experiment and was analysed for physical and chemical properties. The analytical results are presented in Table 2.

Table 1. Mean monthly meteorological data for the experimental year (2007-08) and the mean of past 58 years (1950-2007) of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Month	Rainfall (mm)		Temperature (^{0}C)				Relative humidity (%)	
			Mean maximum		Mean minimum			
	2007-08	1950-2007	2007-08	1950-2007	2007-08	1950-2007	2007-08	1950-2007
April, 2007	86.4	48.50	36.7	37.36	21.4	19.86	55	75.53
May, 2007	65.0	81.06	34.6	33.73	21.3	21.39	61	65.91
June, 2007	220.1	112.38	29.7	28.88	21.3	21.47	80	80.95
July, 2007	211.2	151.30	27.0	29.09	21.1	21.00	85	87.00
August, 2007	176.0	97.17	27.1	26.99	20.5	20.29	85	85.98
September, 2007	180.8	103.63	27.2	28.57	20.3	19.90	83	81.91
October, 2007	74.8	127.83	29.7	30.08	19.4	18.43	68	75.84
November, 2007	54.0	32.62	29.5	30.15	15.1	15.90	53	68.04
December, 2007	Trace	5.32	29.0	29.38	14.6	12.52	65	62.96
January, 2008	0.0	0.69	29.7	29.62	12.9	14.62	46	62.81
February, 2008	0.0	1.09	31.1	32.52	16.3	16.42	49	51.19
March, 2008	111.0	0.45	32.4	36.41	18.9	19.56	53	55.81
April, 2008	29.2	26.80	34.7	34.52	20.4	17.62	57	59.62
Total	1208.5							

Table 2. Initial physical and chemical properties of the soil of experimental site

Sl. No.	Particulars	Value
I.	**Physical properties**	
1.	Particle size analysis (% oven dry basis)	
	Coarse sand	7.12
	Fine sand	12.62
	Silt	28.25
	Clay	52.01
2.	Texture	Clay
3.	Bulk density (Mg m^{-3})	1.32
4.	Particle density (Mg m^{-3})	2.62
5.	Porosity (%)	45.12
II.	**Chemical properties**	
1.	pH_W (1:2.5 soil water suspension)	7.49
2.	EC_W (1:2.5 soil water extract) dSm^{-1}	0.42
3.	Organic carbon (g kg^{-1})	6.10
4.	Free lime content (g kg^{-1})*	4.70
5.	Available Nitrogen (kg ha^{-1})	298.90
6.	Available Phosphorus (kg ha^{-1})	23.50
7.	Available Potassium (kg ha^{-1})	410.90
8.	Available Sulphur (kg ha^{-1})	24.45
III.	**Micronutrients**	
8.	DTPA –extractable Zn (mg kg^{-1})	0.47
9.	Iron (mg kg^{-1})	3.10
10.	Manganese (mg kg^{-1})	7.25
11.	Copper (mg kg^{-1})	0.68

* Weighted average upto 90 cm soil depth.

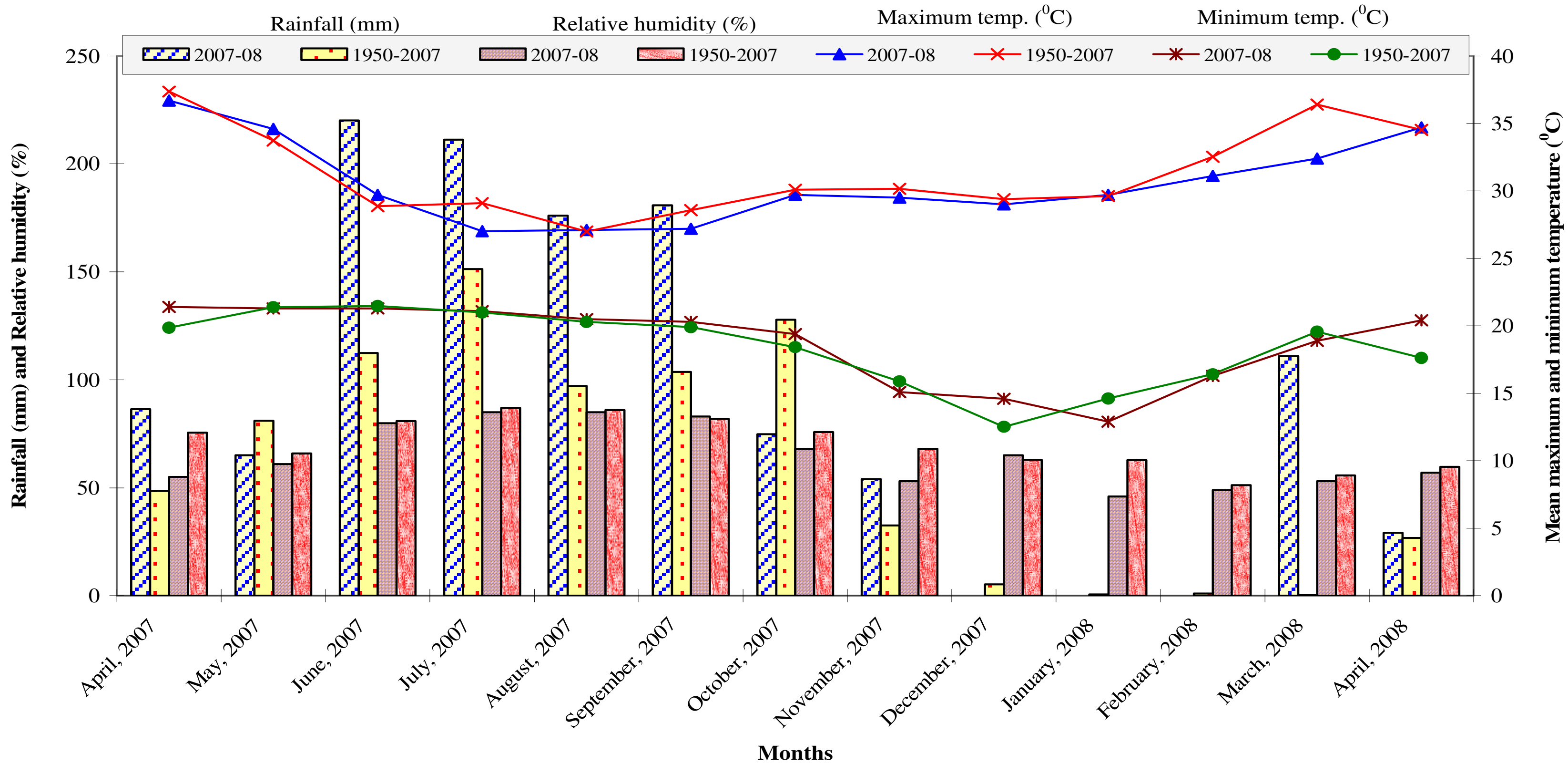

Fig. 2: Mean monthly meteorological data for the experimental year (2007-08) and the mean of past 56 years (1950-2007) of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

Fig. 2: Mean monthly meteorological data for the experimental year (2007-08) and the mean of past 56 years (1950-2007) of Main Agricultural Research Station, University of Agricultural Sciences, Dharwad

3.4 EXPERIMENTAL DETAILS

The experimental details like the crop, the design adopted and plot size, etc., are given below.

3.4.1 Treatments

T_1 - Control (only RDF)

T_2 - FYM @ 10 t/ha

T_3 - Water spray at 50 and 90 DAT

T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT

T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT

T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT

T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT

T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT

T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT

T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

T_{12} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

Note :

- RDF – Recommended dose of fertilizer (100 : 50 : 50 N, P_2O_5 and K_2O kg/ha)
- FYM – Farm yard manure (Spot application)
- EDTA – Ethylene Diamine Tetra Acetic Acid.
- DAT – Days After Transplanting.
- RDF + FYM were common for all the treatments.

Nitrogen was supplied partly through urea and DAP while, entire dose of phosphorus and potash were supplied through DAP and muriate of potash respectively. Iron was supplied according to the treatments in the form of Fe-EDTA (chelate).

3.4.2 Design and layout

The experiment was laid out in randomized block design (RBD) with three replications. The plan of layout of the field experiment is shown in Fig. 3.

3.4.3 Plot size

Gross plot : 6.00 m x 5.25 m

Net plot : 4.5 m x 3.75 m.

3.4.4 Crop details

Test crop : Chilli (*Capsicum annuum* L.)

Variety : Cv. Byadgi dabbi

Spacing : 75 cm x 75 cm

Date of transplanting : 24-07-2007.

3.5 CULTURAL PRACTICES

All the cultural practices were followed as per the recommended package of practices for rainfed chilli grown in transitional zone (Zone-8).

3.5.1 Land preparation

The experimental site was ploughed, harrowed and levelled properly. The plots were then demarcated with the help of marker, furrows were opened at 75 cm spacing in both directions to mark the spots for transplanting.

3.5.2 Transplanting

Four weeks old chilli seedlings were procured from the nursery maintained by the Department of Horticulture, University of Agricultural Sciences, Dharwad and transplanted in the main field, fifteen days after the application of well decomposed FYM. Two seedlings were planted per hill at 75 cm x 75 cm spacing. Gap filling was done within a week after transplanting wherever necessary in all the plots.

LEGEND

LEGEND

T_1 - Control (only RDF)

T_2 - FYM @ 10 t/ha

T_3 - Water spray at 50 and 90 DAT

T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT

T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT

T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT

T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT

T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT

T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT

T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

T_{12} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

Note :

- RDF – Recommended dose of fertilizer (100 : 50 : 50 N, P_2O_5 and K_2O kg/ha)
- FYM – Farm yard manure (Spot application)
- EDTA – Ethylene Diamine Tetra Acetic acid.
- DAT – Days After Transplanting.
- RDF + FYM were common for all the treatments.

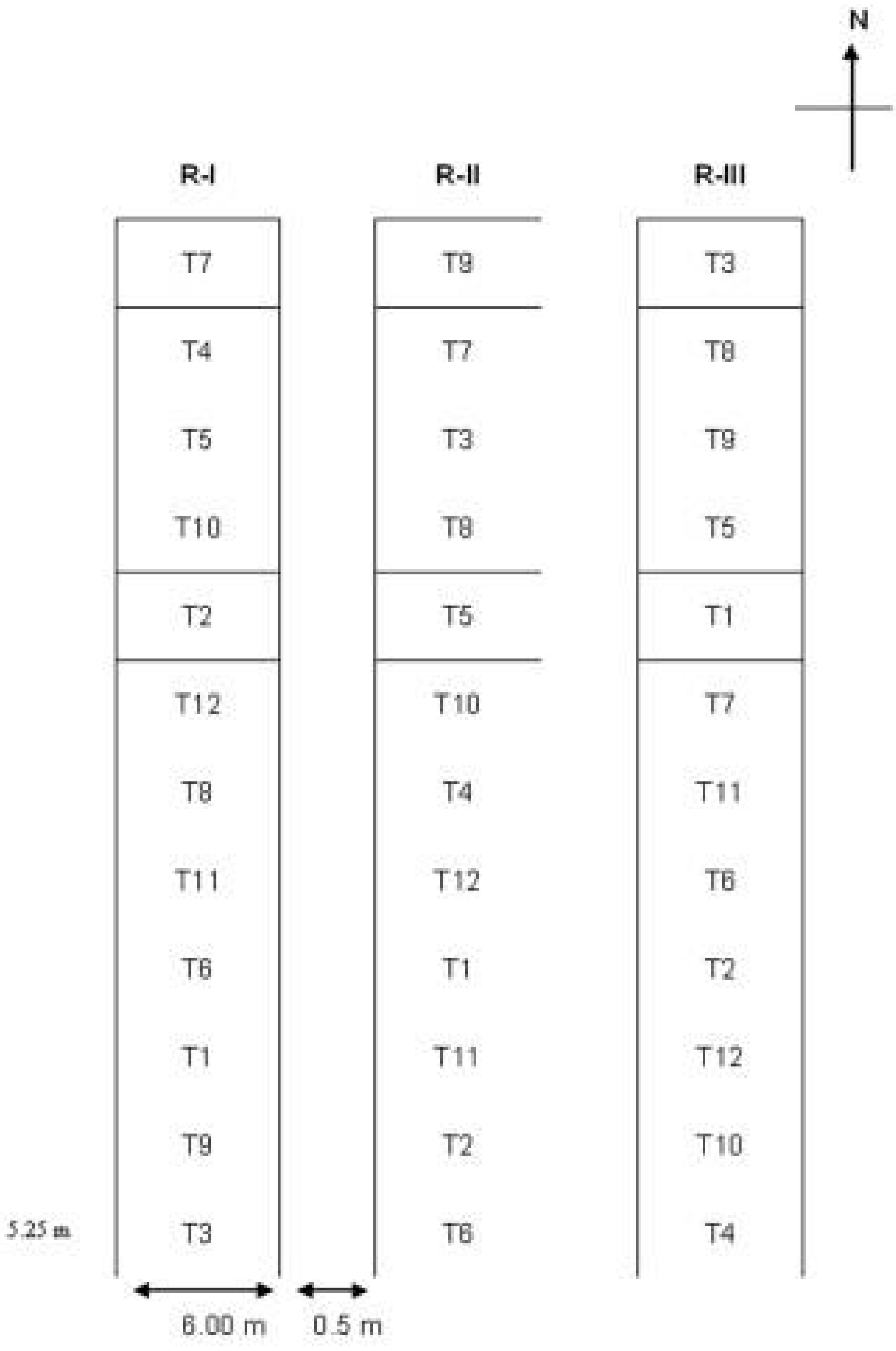

Fig 2. Plan of layout of the experimental site

Fig 2. Plan of layout of the experimental site

5.5.3 Fertilizer application

3.5.3.1 NPK application

Half dose of nitrogen and full dose of phosphorus and potassium were applied as basal application one week after transplanting. The crop was top dressed with remaining half dose of N at 45 days after transplanting.

3.5.3.2 Soil and foliar application of Fe-EDTA

Based on the Fe content in Fe-EDTA, the quantity of Fe-EDTA required to equate Fe content in 10 and 20 kg per ha was worked out $FeSO_4.7H_2O$ and applied as per the scheduled treatments. Since the quantity of Fe-EDTA required for soil application was very small, it was mixed with sand to ensure uniform distribution to plants in the plot. Fe-EDTA was applied to soil after 20 days of transplanting along with fertilizer dose in the form of ring around chilli plants. 0.5 per cent foliar spray of Fe-EDTA was given after dissolving the requisite quantity of fertilizer in water and adjusting the pH of solution to neutrality.

3.5.4 After care

3.5.4.1 Intercultivation and weeding

Intercultivation was carried out twice at 30 and 60 days after transplanting and hand weeding was takenup as and when required.

3.5.4.2 Plant protection measures

The schedule of different plant protection measures taken against pests and diseases during the period of experimentation is as follows.

Sl. No.	Chemicals sued	Dosage	Against pest/ diseases
1.	Furadon application (soil drenching)	5 g/spot	Cutworms
2.	Monocrotophos	@ 2 ml/l	Aphids
3.	Confidor	@ 0.25 ml/l	Sucking pest
4.	Dicofol	@ 2.5 ml/l	Mites
5.	Magister	@ 0.5 ml/l	Murda

3.5.5 Picking of fruits

Matured red ripened fruits were harvested in three pickings. Fruits were sundried for 15 days till they became brittle and stored in polythene bags.

3.6 COLLECTION OF EXPERIMENTAL DATA

In the net plot area, five plants were randomly selected and tagged for recording biometric observations as well as yield parameters.

3.6.1 Growth parameters

Among the growth parameters, plant height and number of branches per plant were measured at 45, at 50 per cent flowering and at the time of final picking (140 DAT). Dry matter production per plant was recorded at 75 DAT and at the time of final picking (140 DAT).

3.6.1.1 Plant height

Height was measured from the base of the plant to the growing tip by holding the plant vertically. The mean plant height was expressed in centimeter (cm).

3.6.1.2 Number of branches per plant

Total number of secondary branches were counted in randomly selected five plants at 45, at 50 per cent flowering and at final picking stage and average was worked out to get number of branches per plant.

3.6.1.3 Dry mater yield per plant

Three chilli plants were selected randomly in each treatment in the net plot area. The fruits were separated from shoot and both the components were dried in air and then in hot air oven at 65-70°C to constant weight. The dry weight was recorded and expressed in grams per plant.

3.6.2 Yield parameters

3.6.2.1 Dry weight of 100 chilli fruits

Fruits were harvested as and when they turn bright red and sundried for 15 days till they become brittle. Fruits from all the pickings were pooled and sundried 100-fruits were selected randomly from each treatment and their weight was recorded expressed in grams (g).

3.6.2.2 Dry chilli yield per plot

The fruits harvested from net plot area in each picking were dried in partial shade and sun dried till they become brittle. They were pooled and total weight per plot was recorded in kgs.

3.6.2.3 Length and breadth of fruit

Five sundried fruits were collected randomly from the composite sample of each treatment. Fruit length was measured from base to tip of the fruit excluding pedicel. Breadth was measured at the base of the fruit and expressed in centimeter (cm).

3.6.3 Quality parameters

Representative composite samples of sundried red chilli fruits were collected from each treatment, depediceled, powdered and used for the analysis of colour value and oleoresin.

3.6.3.1 Ascorbic acid (mg/100 g)

Ascorbic acid content in fresh green fruits was determined using 2, 6-dichlorophenol indophenol dye by visual titration method (Sadasivam and Manickam, 1992).

3.6.3.2 Colour value

It was done by measuring the absorbance of chillies alcoholic extract at 450 nm. 100 mg of finely powdered chilli sample was taken in a 250 ml conical flask, 100 ml of isopropanol was added and the flask was stoppered tightly. The contents were swirled and kept for at last 3 hrs at 70°C or over night (16 hours at room temperature). In the former case the extract was cooled to room temperature and filtered through Whatman No. 12 filter paper. The first 10 ml of extract was discarded 25 ml of ensuring extract is transferred into 50 ml volumetric flask and volume made upto with isopropanol. The thoroughly mixed solution was transferred to the cell and its absorbance determined at 450 µm (Mahindru, 1987).

$$\text{Absoorptivity of standard} = \frac{\text{Absorbance of standard } K_2Cr_2O_7 \text{ solution at 450 µm}}{\text{Cell length (cm) x concentration (mg/ml)}}$$

Denoted as A

$$\text{Extractable colour as per ASTA units} = \frac{\text{Absorbance of extract at 450 µm x 200}}{\text{Cell length (cm) x (A)}}$$

If the concentration of $K_2Cr_2O_7$ and the sample is 0.500 mg/ml and the same length cell are the extractable colour as per ASTA units is calculated as

$$= \frac{\text{Absorbance of chilli extracted at 450 µm x 200}}{\text{Absorbance of } K_2Cr_2O_7 \text{ solution at 450 µm}}$$

3.6.3.3 Oleoresin content

Twenty five grams of powdered chilli sample was taken in chromatographic column, plugged with aluminium foil. Fifty ml of acetone was added and allowed to stand overnight. The slurry was collected in pre-weighed beaker and solvent was evaporated over water bath. The collected slurry was cooled and weighed. Difference in weight over sample weight gives per cent oleoresin content (AOAC, 1997).

3.6.3.4 Per cent discoloured fruits

Number of white fruits harvested per plant from five selected plants were recorded from all pickings. By summing up the values of individual pickings, the total number of white fruits was calculated. The percentage of discoloured fruits was calculated by expressing them as a fraction of total number of fruits harvested per plant and multiplying by 100.

3.7 COLLECTION AND PREPARATION OF SOIL SAMPLES

Soil samples were collected to a depth of 0-20 cm from each treatment after the final picking (140 DAT). The collected soil samples were shade dried ground in wooden pestle and mortar, sieved by passing through 2 mm sieve, mixed thoroughly to get a composite working soil sample for analysis.

3.8 ANALYSIS OF SOIL SAMPLES

Details of the methods followed are given in Table 3a.

3.9 COLLECTION AND PREPARATION OF PLANT SAMPLES

The plant samples collected for recording the dry matter yield at 75 DAT and at final picking stage (140 DAT) were oven dried and ground in willey mill. The powered plant samples were stored in butter paper bags for nutrient analysis. Further few sundried red fruits were partitioned into pericarp and seed components which were used for nutrient content.

3.9.1 Collection of green leaves and green fruits for ferrous iron estimation

Leaves samples were collected 5 days before and after foliar and soil application of Fe-EDTA. For ferrous iron estimation in green fruits, fruits were collected 2 days before and 10 days after foliar spray of EDTA for the treatment receiving Fe-EDTA foliar spray at 50^{th} DAT. But for treatment receiving foliar spray at 90 DAT, green fruits were collected 5^{th} day before and after Fe-EDTA application.

For treatment receiving soil application of Fe-EDTA, as well as those treatments they did not receive Fe-EDTA (T_1, T_2 and T_3) leaves samples were collected before and after 5^{th} day of Fe-EDTA application.

3.10 ANALYSIS OF PLANT SAMPLES

3.10.1 Digestion of plant and fruit samples

For estimating total nitrogen content, shoot and fruit samples were digested with concentrated sulphuric acid and digestion mixture in micro Kjeldahl's assembly. For phosphorus and potassium determinator, plant samples were digested with diacid mixture (HNO_3 : $HClO_4$ in 10:4 ratio), after predigesting with concentrated nitric acid, till colourless white precipitate is obtained. The precipitate was dissolved in 6N HCl and filtered. The filterate was made upto 100 ml using distilled water.

Table 3a. Methods employed for the analysis of soil samples

Sl. No.	Properties	Methods employed	Reference
I.	**SOIL SAMPLE**		
	A. Physical properties		
1.	Particle size analysis	International Pipette Method	Piper (2002)
2.	Bulk density	Core sampler method	Black (1967)
3.	Particle density	Pycnometer method	Black (1967)
	B. Chemical properties		
1.	pH (1:2.5 soil water ratio)	Potentiometric method	Sparks (1996)
2.	Electrical conductivity (1:2.5 soil water ratio)	Conductometric method	Sparks (1996)
3.	Organic Carbon	Walkley and Black's wet oxidation method	Sparks (1996)
4.	Free lime content	Acid neutralization method	Piper (2002)
5.	Available Nitrogen	Alkaline potassium permanganate method	Subbaiah and Asija (1956)
6.	Available Phosphorus	Olsen's method	Sparks (1996)
7.	Available Potassium	Flame photometer method	Sparks (1996)
8.	Available Sulphur	Turbidimetric method	Tandon (1998)
9.	DTPA extractable Zn, Fe, Mn and Cu	Atomic absorption spectrophotometer method	Lindsay and Norvell (1978)

Table 3b. Methods employed for the analysis of plant samples

Sl. No.	Properties	Methods employed	Reference
II.	PLANT SAMPLE		
1.	Nitrogen	Micro Kjeldahl method	Tandon (1998)
2.	Phosphorus	Vanado molybdo phosphoric yellow colour method	Tandon (1998)
3.	Potassium	Flame photometer method	Tandon (1998)
4.	Sulphur	Turbidimetric method	Tandon (1998)
5.	Micronutrients	Atomic Absorption Spectrophotometer method	Tandon (1998)
6.	Ferrous Iron	1, 10 orthrophenanthroline method	Katyal and Sharma (1980)
7.	Total iron	Atomic Absorption Spectrophotometer method	Tandon (1998)

3.10.2 Estimation of nutrients

Details of the methods followed for the estimation of N, P, K and micronutrients in plant samples are presented in Table 3b.

3.10.3 Nutrient uptake studies

The uptake of nutrients at 75 DAT and at final picking stages (140 DAT) worked out using the formulae.

Biomass yield (kg/ha) = Dry matter yield/plant (kg) x Plant population/ha

Nutrient uptake (kg/ha) = Nutrient concentration (%)/100 x Biomass yield (kg/ha)

3.10.4 Preparation of plant samples for estimation of ferrous iron (Fe^{2+}) in fresh leaves

The fresh leaves and green fruits collected were washed with running tap water, followed by 0.1N HCl and then by distilled water. The samples were wiped with clean blotting paper to remove adhered water droplets.

3.10.5 Extraction and estimation of ferrous iron

Two grams of fresh samples of chilli plant were weighed immediately and transferred to 100 ml capacity conical flasks. Simultaneously, another two grams of sample were transferred into cleaned pre-weighed moisture bottles to estimate moisture content in the samples. 20 ml of ortho-phenathroline solution (1.5%) to the conical flask and gently stired. The flasks were stoppered and allowed to stand for about 16 hours at room temperature. The contents were filtered through Whatman No. 1 filter paper. Ferrous iron content was determined by measuring the transmittancy at 510 nm. Interference of chlorophyll pigments while estimating Fe^{2+} extracted by pH-3 distill water is removed by extracting the sample with pH-3 distill water and adjusting the solution to 100 per cent transmittance. The concentration of Fe^{2+} was derived from the standard curve.

$$\text{Percentage of } Fe^{2+} \text{ in fresh sample} = \frac{\text{ml of 0-pH added} \times \text{ppm of Fe from standard curve}}{\text{Wt. of fresh sample taken}} \times 100$$

3.10.6 Total iron

Plant samples were digested in diacid mixture (HNO_3 : $HClO_4$ in 9:4) and the solution was used for estimation of iron by AAS (Tandon, 1998).

3.11 STATISTICAL ANALYSIS

The experimental data was analysed statistically following the procedure as described by Gomez and Gomez (1984). The level of significance used in ‘F’ and ‘t’ tests was five per cent. Critical differences were calculated wherever ‘F’ test was significant.

3.12 CORRELATION STUDIES

Simple correlation analysis was done to understand some of the interrelationships between nutrient composition of whole red fruits and red pericarp with quality attributes particularly ascorbic acid, colour value and oleoresin contents. Correlation coefficients (r) were calculated in SPSS package and tests of significance were applied as per the procedure outlined by Snedecor and Cochran (1956).

3.13 ECONOMIC ANALYSIS

Based on the prevailing price of inputs at the time of their use and existing price of chilli produce in the market (2007-08), the net profit per hectare and benefit cost ratio were worked out using the following formulae.

Net profit per hectare = Gross returns (Rs.) - Cost of cultivation (Rs.)

$$\text{Benefit : Cost ratio} = \frac{\text{Net profit ha}^{-1}\text{ (Rs.)}}{\text{Cost of cultivation ha}^{-1}\text{ (Rs.)}}$$

4. EXPERIMENTAL RESULTS

A field experiment was conducted to study the effect of Fe-EDTA on yield and quality attributes of chillies (Cv. Byadgi dabbi) at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during kharif 2007 on a calcareous Vertisol (Plate1). Results of the experiment are presented in this chapter.

4.1 GROWTH PARAMETERS

Data on the effect of Fe-EDTA on plant height, number of branches and total dry matter production are presented in the Tables 4, 5 and 6 respectively.

4.1.1 Plant height (cm) (Table 4)

Application of Fe-EDTA either through soil or foliar spray did not significantly influenced the plant height. However, highest plant height (38.01, 72.22 and 83.12 cm at 45, at 50% flowering and at final picking stage, respectively) were recorded in the treatment (T_8) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha at planting + 0.5% Fe-EDTA foliar spray at 50 DAT. This was closely followed by treatment (T_{12}) that received Fe-EDTA soil application at planting + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT (37.52, 70.18 and 82.55 cm at 45, at 50% flowering and at final picking stage respectively). Lowest plant height 35.79, 63.49 and 70.98 cm at 45, at 50% flowering and at final picking stage respectively were recorded in control (only RDF) closely followed by treatment (T_2) receiving NPK + FYM (35.89, 61.11 and 71.10 cm at 45, at 50% flowering and at final picking stage respectively).

4.1.2 Number of branches (Table 5)

Data revealed that at 45 DAT non-significant difference existed between different treatments with respect to number of branches. However highest number of branches (9.24) were recorded in the treatment T_8 that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 DAT. This was closely followed by treatment T_{12} (8.77) and T_{10} (8.75). Lowest number of branches (6.07) were recorded in control (only RDF).

At both at 50 per cent flowering and at final picking stage treatments differed significantly with respect to number of branches. Highest number of branches (14.51 and 17.92 at 50 per cent flowering and at final picking stage respectively) were recorded in treatment T_8 which differed significantly from control (T_1) that recorded lowest number of branches (9.11 and 12.91 at 50 per cent flowering and final picking stage respectively). Treatments T_8, T_9, T_{10}, T_{11} and T_{12} were on par with each other with respect to number of branches at 50 per cent flowering. But at final picking stage, treatment T_8 that recorded highest number of branches (17.92) differed significantly from T_9 (14.52) and T_{11} (14.63) treatments but was on par with T_{10} (15.73) and T_{12} (16.27) treatments.

Critical examination of the data revealed that in general treatments receiving soil + foliar application of Fe-EDTA (T_7 to T_{12}) recorded numerically higher number of branches than foliar application *per se*. Data also revealed that treatments receiving only foliar spray of Fe-EDTA (T_4, T_5 and T_6) recorded higher number of branches than control (T_1) and treatments T_2 and T_3 which did not receive any iron application.

4.1.3 Total dry matter production

Perusal of data presented in Table 6 revealed that significant difference existed between different treatments with respect to total dry matter production both at 50 per cent flowering and at final picking stage. Treatment (T_8) receiving Fe-EDTA soil application at Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT recorded highest dry matter production (62.82 and 114.32 g/plant at 50 per cent flowering and at final picking stage respectively) which was on par with T_7, T_{10}, T_{11} and T_{12} treatments, but differed significantly from control (T_1), T_2 (RDF + FYM), T_3 (RDF + FYM + water spray), T_4, T_5 and T_6 (0.5% foliar spray of Fe-EDTA either at 50 or 90 DAT or both). Lowest dry matter production (35.21 and 73.13 g/ plant at 50 per cent flowering and at final picking stage respectively) was recorded in control (RDF), which was on par with treatments did not receiving Fe-EDTA application and only foliar application of Fe-EDTA, but differed significantly from T_7 treatment.

Table 4. Methods and time of application of Fe-EDTA levels on plant height of chilli (Cv. Byadgi dabbi)

Treatments	Plant height (cm)		
	45 DAT	At 50% flowering	At final picking sage
T_1 - Control (only RDF)	35.79	63.49	70.98
T_2 - FYM at 10 t/ha	35.89	61.11	71.10
T_3 - Water spray at 50 and 90 DAT	35.95	61.85	72.22
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	36.29	63.05	73.52
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	36.03	62.42	72.35
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	36.41	64.01	74.65
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	37.19	68.94	77.50
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	38.01	72.22	83.12
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	36.94	67.42	76.52
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	37.64	69.90	80.52
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	37.25	69.18	80.02
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	37.52	70.18	82.55
SEm±	3.107	5.255	4.560
CD (0.05)	NS	NS	NS

NS – Non significant
DAT – Days after transplanting
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 5. Methods and time of application of Fe-EDTA levels on number of branches of chilli (Cv. Byadgi dabbi)

Treatments	Number of branches		
	45 DAT	At 50% flowering	At final picking sage
T_1 - Control (only RDF)	6.07	9.11	12.91
T_2 - FYM at 10 t/ha	6.38	9.98	13.81
T_3 - Water spray at 50 and 90 DAT	7.12	10.67	14.08
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	8.09	12.18	13.97
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	7.33	11.01	14.04
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	8.07	11.72	14.12
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	8.44	13.12	14.85
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	9.24	14.51	17.92
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	8.33	12.53	14.52
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	8.75	13.51	15.73
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	8.42	12.92	14.63
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	8.77	14.00	16.27
SEm±	0.659	0.896	0.811
CD (0.05)	NS	2.630	2.381

NS – Non significant.
DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 6. Methods and time of application of Fe-EDTA levels on total dry matter production of chilli (Cv. Byadgi dabbi)

Treatments	Total dry matter production (g/plant)	
	At 50% flowering	At final picking sage
T_1 - Control (only RDF)	35.21	73.13
T_2 - FYM at 10 t/ha	36.43	74.72
T_3 - Water spray at 50 and 90 DAT	39.48	76.18
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	43.72	85.92
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	41.31	84.37
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	44.22	88.32
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	54.98	99.56
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	62.82	114.32
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	50.99	90.51
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	58.42	105.93
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	52.42	98.84
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	60.84	111.29
SEm±	3.188	5.925
CD (0.05)	9.351	17.380

DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

Plate 1: General view of the experimental site

Data also revealed that at both 50 per cent flowering and at final picking stage, treatment T_8 recorded significantly higher dry matter production than treatment T9, but was on par with treatment T_{10} and T_{12}.

It was observed that treatments receiving both soil + foliar application of Fe-EDTA recorded higher dry matter yield than treatments receiving only foliar application. Among Fe-EDTA supplemented treatments, combined application of Fe-EDTA (soil + foliar spray) recorded numerically higher dry matter yield at both 50 per cent flowering and at final picking stage. Higher yield was recorded in plots added with 20 kg of Fe-EDTA in soil than 10 kg application.

Critical examination of the data also revealed that, treatments receiving foliar spray of Fe-EDTA either at 50 or 90 DAT recorded higher dry matter yield than those treatments that did not receive Fe-EDTA foliar spray (T_1, T_2 and T_3). It was also observed that treatment (T_6) that received two foliar sprays of Fe-EDTA (50 and 90 DAT) recorded numerically higher dry matter yield (44.22 and 88.32 g/plant at 50 per cent flowering and at final picking stage, respectively) than treatments receiving one foliar spray (T_4 and T_5).

4.2 YIELD PARAMETERS AND YIELD (Plates 2, 3 and 4)

4.2.1 Weight of 100-dry fruits (g)

Treatments differed significantly by the application of Fe-EDTA with respect to dry weight of 100 fruits. However treatment T_8 (Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + Fe-EDTA foliar spray at 50 DAT) recorded numerically highest weight (162.65 g), closely followed by T_{12} (159.89 g), T_{10} (158.53 g) and T_7 (154.10 g). It was observed that, all treatments that received soil + foliar application of Fe-EDTA (T_7 to T_{12}) recorded higher fruit weight than treatments receiving only foliar application of Fe-EDTA (T_4, T_5 and T_6). It was observed that, higher dose of Fe-EDTA application through soil (Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha) recorded higher fruit weight than lower dose of Fe-EDTA application (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha). Data also revealed that, treatments receiving foliar spray of Fe-EDTA either at 50 or 90 DAT or at 50 + 90 DAT, recorded higher fruit weight than treatments that did not receive foliar spray of Fe-EDTA (T_1, T_2 and T_3).

Plate 2: External view of plot receiving only RDF

Plate 3: External view of plot receiving Fe-EDTA soil application equivalent to FeSO4 at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT

Plate 4: External view of plot receiving 0.5% Fe-EDTA foliar spray at 50 DAT

4.2.2 Dry fruit yield/plot (kg)

Perusal of data presented in Table 7 highlighted that, application of Fe-EDTA either through soil application or foliar spray significantly influenced the fruit yield per plot. Highest fruit yield per plot (2.15 kg) was recorded in treatment T_8, which differed significantly from treatments T_1 (only RDF), T_2 (RDF + FYM), T_3 (RDF + FYM + two water sprays), T_5 (0.5% Fe-EDTA spray at 90 DAT) and T_6 (0.5% Fe-EDTA spray at 50 and 90 DAT). But it was on par with other treatments that received soil + foliar spray of Fe-EDTA as well as with treatment that received only foliar spray of Fe-EDTA at 50 DAT (T_4). Non-significant difference existed between different treatments that received soil + foliar application of Fe-EDTA with respect to fruit yield per plot (T_7, T_8, T_9, T_{10}, T_{11} and T_{12}). It was observed that, treatments that received Fe-EDTA through foliar spray (T_5 and T_6) recorded significantly higher fruit yield per plot when compared to control (1.50 kg/plot).

4.2.3 Dry fruit yield (q/ha)

Perusal of data presented in Table 7 and Fig. 4 indicated that application of Fe-EDTA either through soil application or foliar spray significantly influenced the fruit yield. Highest fruit yield (10.5 q/ha) was recorded in treatment T_8, that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha which differed significantly from treatments control (only RDF), NPK + FYM, NPK + FYM + water spray at 50 and 90 DAT, 0.5% Fe-EDTA spray at 50 DAT, 0.5% Fe-EDTA spray at 90 DAT and 0.5% Fe-EDTA spray at 50 and 90 DAT. But it was on par with other treatments that received soil + foliar spray of Fe-EDTA. Non-significant difference existed between different treatments that received soil + foliar application of Fe-EDTA with respect to fruit yield (T_7 - T_{12}) which ranged from 9.54 to 10.50 q/ha. It was observed that, treatments that received Fe-EDTA through foliar spray at 50 or 90 or 50 or 90 DAT recorded significantly higher fruit yield when compared to control (7.65 q/ha).

4.2.4 L/B ratio

Application of Fe-EDTA either through soil or foliar spray did not significantly influenced the L/B ratio. However, highest L/B ratio (6.36) was recorded in the treatment (T_{12}) that received soil application of Fe-EDTA at planting + 0.5% Fe-EDTA spray at 50 and 90 DAT. This was closely followed by (T_8) treatment that received soil application of Fe-EDTA at planting + 0.5% Fe-EDTA spray at 50 DAT (6.24). Lowest L/B ratio (6.06) was recorded in control (only NPK) followed by T_2 (NPK + FYM) (6.08).

4.3 QUALITY PARAMETERS

Data pertaining to quality parameters of chilli fruits is presented in Table 8.

4.3.1 Ascorbic acid in green fruits (mg/100 g)

Significant difference existed between different treatments with respect to ascorbic acid content in green chilli fruits (Table 8 and Fig. 5). Highest ascorbic acid content (178.90 mg/100 g) was recorded in treatment (T_8) receiving Fe-EDTA in both soil (at 20 kg $FeSO_4$/ha) and foliar spray (0.5% Fe-EDTA) at 50 DAT. Similar observations were made with other treatment combination of soil and foliar applications and they were found par with T_8. Lowest ascorbic acid content (127.61 mg/100 g) was recorded in control (only RDF) and it was on par with treatments receiving only foliar sprays (T_2, T_3, T_4 T_5 and T_6). However, they differed significantly from the treatments receiving both soil and foliar application.

Critical examination of the data also revealed that all treatments receiving soil + foliar spray of Fe-EDTA recorded higher ascorbic acid content than treatments receiving only foliar spray. It was also observed that, all treatments receiving higher dose of Fe-EDTA application through soil (T_8, T_{10} and T_{12}) recorded higher ascorbic acid content than treatments (T_7, T_9 and T_{11}) receiving lower dose (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha). Comparison among treatments receiving only foliar spray of Fe-EDTA (T_4, T_5 and T_6) revealed that, foliar spray once at 50 DAT recorded slightly higher ascorbic acid content (152.02 mg/100 g) closely followed by foliar spray twice (149.67 mg/100 g). In general treatments receiving Fe-EDTA application either through soil or foliar spray recorded higher ascorbic acid content than treatments that did not receive any Fe-EDTA application (T_1, T_2 and T_3).

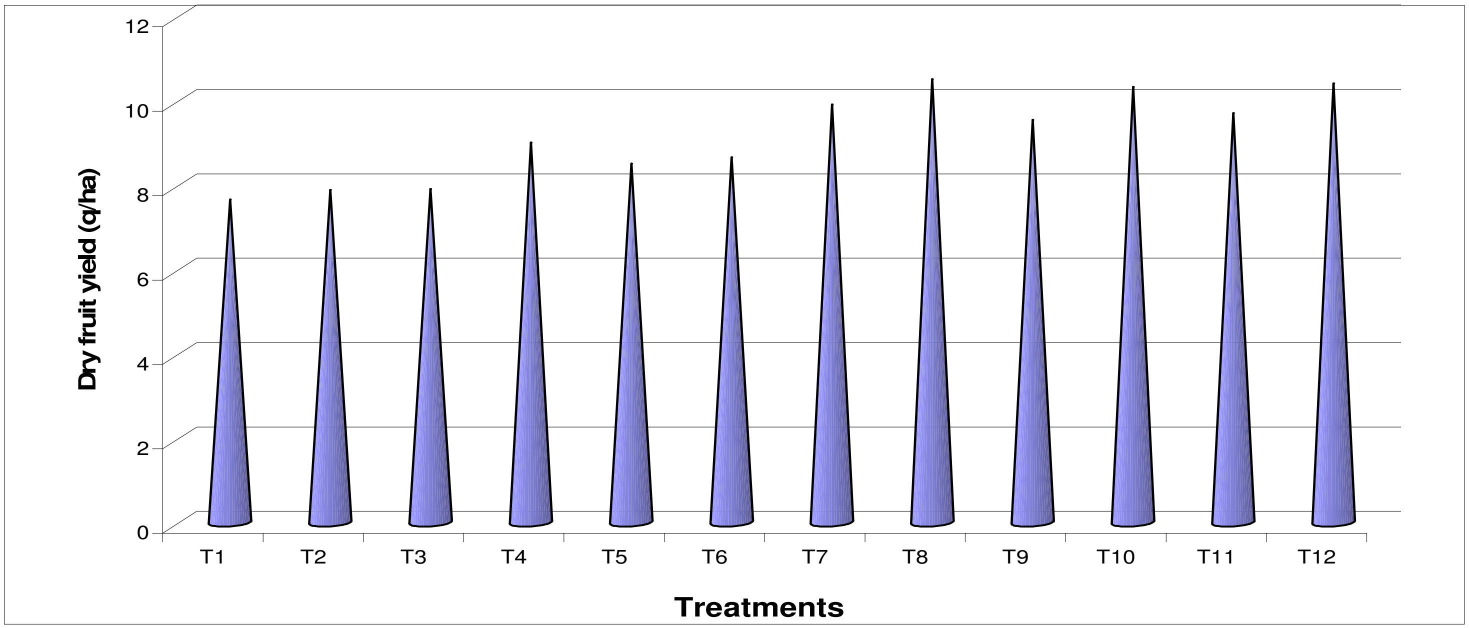

Fig. 4. Methods and time of appliation of Fe-EDTA levels on dry fruit yield (q/ha) of chilli

Fig. 4. Methods and time of appliation of Fe-EDTA levels on dry fruit yield (q/ha) of chilli

Table 7. Methods and time of application of Fe-EDTA levels on yield attributes, yield and L/B ratio of fruits (Cv. Byadgi dabbi)

Treatments	Weight of 100-dry fruits (g)	Dry fruit yield/ plot (kg)	Dry fruit yield (q/ha)	L/B ratio
T_1 - Control (only RDF)	136.30	1.50	7.65	6.06
T_2 - FYM at 10 t/ha	138.12	1.61	7.88	6.08
T_3 - Water spray at 50 and 90 DAT	141.24	1.62	7.90	6.11
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	149.96	1.89	9.00	6.15
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	143.01	1.74	8.50	6.07
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	145.01	1.77	8.65	6.13
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	154.10	2.02	9.90	6.10
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	162.65	2.15	10.50	6.32
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	149.00	1.95	9.54	6.10
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	158.53	2.11	10.32	6.24
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	150.59	1.98	9.70	6.22
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	159.89	2.13	10.40	6.36
SEm±	6.698	0.076	0.439	0.27
CD (0.05)	19.62	0.225	1.288	NS

NS – Non significant.
DAT – Days after transplanting.
L/B ratio – Length/Breadth
RDF + FYM were common for all the treatments (T_3 to T_{12})

4.3.2 Colour value (Plates 5, 6 and 7)

Perusal of data presented in Table 8 and Fig. 6 revealed that treatments differed significantly with respect to colour value of fruits. Highest colour value (228.73 ASTA units) was recorded in the treatment (T_{12}) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT which differed significantly from control (only RDF) that recorded lowest colour value (163.16 ASTA units). Treatment T_{12}, that recorded highest colour value was on par with T_8 (223.41 ASTA units), T_{11} (207.72 ASTA units), T_{10} (211.62 ASTA units) and T_7 (208.43 ASTA units) treatments with respect to colour value but differed significantly from T_9 treatment (194.64 ASTA units). Further all treatments receiving soil + foliar application (T_7 to T_{12}) of Fe-EDTA recorded higher colour value than treatments receiving only foliar application (T_4 to T_6). Comparison among (T_7 to T_{12}) treatments revealed that treatments receiving higher dose of Fe-EDTA (T_8, T_{10} and T_{12}) through soil application (equivalent to $FeSO_4$ at 20 kg/ha) recorded higher colour value than treatments (T_7, T_9 and T_{11}) receiving lower dose. Non-significant difference existed among the three treatments (T_4, T_5 and T_6) that received Fe-EDTA application through foliar spray with colour value ranging from 178.76 to 179.38 ASTA units. These treatments recorded numerically higher colour value than treatments that did not receive Fe-EDTA foliar spray (T_1, T_2 and T_3). It was also observed that, application of FYM along with RDF (T_2) and water spray at 50 and 90 DAT (T_3) recorded slightly higher colour value of fruits (170.94 for T_2) and (175.32 for T_3) when compared to control (only RDF) but the differences between the treatments were non-significant.

4.3.3 Per cent oleoresin

Perusal of data presented in Table 8 and Fig. 5 revealed that treatments differed significantly with respect to per cent oleoresin content in fruits. Highest oleoresin content (16.76%) was recorded in the treatment (T_{12}) that received Fe-EDTA soil application equivalent to FeSO4 at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT, which differed significantly from control (only RDF) that recorded lowest oleoresin content (13.03%). Treatment T_{12}, that recorded highest oleoresin content was on par with T_8 (16.52%), T_{11} (16.03%), T_{10} (16.34%) and T_7 (15.42%) treatments with respect to oleoresin content but differed significantly from T9 treatment (15.03%). All treatments receiving soil + foliar application of Fe-EDTA (T_7 to T_{12}) recorded higher oleoresin content than treatments receiving only foliar application of Fe-EDTA (T_4 to T_6). Comparison among treatments (T_7 to T_{12}) revealed that, treatments receiving higher dose of Fe-EDTA application (T_8, T_{10} and T_{12}) through soil recorded higher oleoresin content than treatments (T_7, T_9 and T_{11}) receiving lower dose. Non-significant difference existed among the three treatments (T_4, T_5 and T_6) that received Fe-EDTA application through foliar spray either once or twice (14.06 to 14.35%). These treatments recorded numerically higher oleoresin content than treatments that did not receive Fe-EDTA application (T_1, T_2 and T_3). It was also observed that application of FYM along with RDF (T_2) and water spray at 50 and 90 DAT (T_3) recorded slightly higher oleoresin content in fruits 13.34% (T_2) and 13.72% (T_3) but differences between the treatments were non significant.

4.3.4 Per cent discoloured fruits

The percentage of discoloured fruits in various treatments differed significantly with respect to both soil and foliar application of Fe-EDTA (Table 8). The highest per cent discoloured fruits (7.93) was recorded in control receiving only NPK which was found to be on par with the treatments (T_2 to T_6).

In general treatments receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha registered low per cent discoloured fruits compared to soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha. Lowest per cent discoloured fruits (5.53%) was observed in the treatment (T_8) receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 DAT.

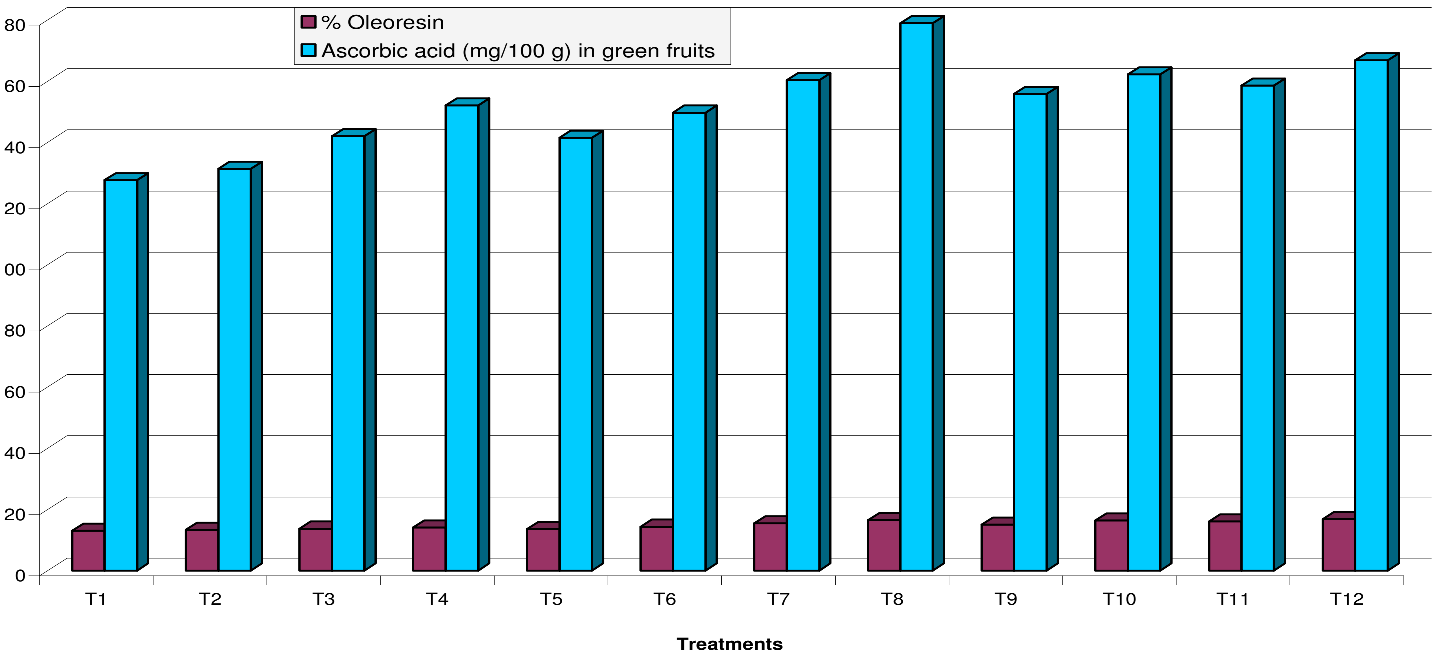

Fig. 5. Methods and time of application of Fe-EDTA levels on per cent oleoresin and ascorbic acid content (mg/100 g) of chilli fruits

Fig. 5. Methods and time of application of Fe-EDTA levels on per cent oleoresin and ascorbic acid content (mg/100 g) of chilli fruits

Table 8. Methods and time of application of Fe-EDTA levels on quality parameters of sundried red chilli fruits (Cv. Byadgi dabbi)

Treatments	Ascorbic acid* (mg/100 g)	Colour value (ASTA units)	Oleoresin (%)	Discoloured fruits (%)
T_1 - Control (only RDF)	127.61	163.16	13.03	7.93
T_2 - FYM at 10 t/ha	131.34	170.94	13.34	7.83
T_3 - Water spray at 50 and 90 DAT	141.99	175.32	13.72	7.59
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	152.02	178.76	14.06	6.94
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	141.48	177.57	13.54	7.42
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	149.67	179.38	14.35	7.13
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	160.26	208.43	15.42	6.33
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	178.90	223.41	16.52	5.53
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	155.79	194.64	15.03	6.53
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	162.20	211.62	16.34	6.24
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	158.52	207.72	16.03	6.44
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	166.76	228.73	16.76	5.59
SEm±	7.937	9.412	0.490	0.442
CD (0.05)	23.278	27.605	1.438	1.296

DAT – Days after transplanting.
ASTA – American Spice Trade Association
* Fresh green chilli fruits
RDF + FYM were common for all the treatments (T_3 to T_{12})

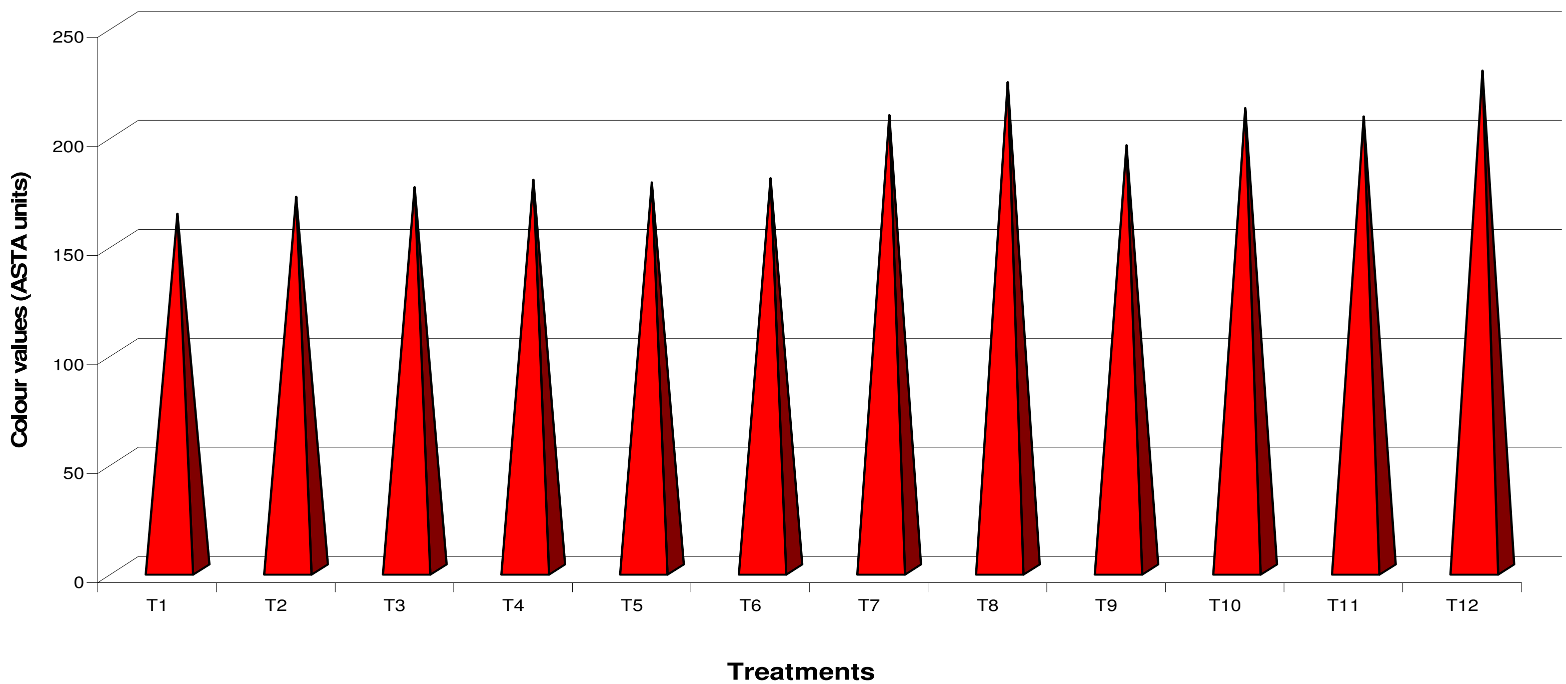

Fig. 6. Methods and time of application of Fe-EDTA levels on colour value (ASTA units) of sundried red chilli fruits

Fig. 6. Methods and time of application of Fe-EDTA levels on colour value (ASTA units) of sundried red chilli fruits

Plate 5: Control (only RDF)

Plate 6: 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

Plate 7: Fe-EDTA soil application (equivalent to FeSO4 20 kg/ha) + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT

Effect of Fe-EDTA foliar spray and soil application on colour value of chilli fruits

(Cv. Byadgi dabbi)

4.4 NUTRIENT COMPOSITON OF RED CHILLI FRUITS (SUNDRIED)

4.4.1 Nitrogen

Significant difference existed between different treatments with respect to nitrogen content in whole red fruits (Table 9). Highest N content (2.15%) was recorded in the treatment (T_8) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT. This was on par with all treatments except control (1.71), T_2 (1.72), T_3 (1.80) and T_4 (1.90). All treatments (T_7 to T_{12}) receiving combined application of Fe-EDTA (soil + foliar spray) recorded marginally higher N content in whole fruits (1.98% to 2.15%) than treatments (T_4 to T_6) receiving iron only through foliar spray (1.87 to 1.95%). Comparison among treatments T_7 to T_{12} indicated that treatments receiving higher dose of Fe-EDTA application through soil recorded slightly higher N content in fruits than treatments receiving lower dose (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha). No significant difference were existed among treatments T_4, T_5 and T_6 with respect to N content in whole fruits that received iron through foliar spray only. But these treatments recorded marginally higher N content in fruits (1.87 to 1.95%) than treatments (T_1, T_2 and T_3) that did not receive any Fe application (1.71 to 180%) either soil or foliar spray.

4.4.2 Phosphorus

Application of Fe-EDTA either through soil or foliar spray did not significantly influenced the phosphorus content in whole chilli fruits. It was observed that treatments receiving soil + foliar application of Fe-EDTA recorded slightly higher P content in fruits (0.31 to 0.33%) than treatments receiving only foliar spray of Fe-EDTA (0.27 to 0.30%). Control (only RDF) recorded lowest P content (0.26%) which was on par with rest of the treatments.

4.4.3 Potassium

Data presented in Table 9 highlighted that treatment (T_{12}) that received Fe-EDTA application through soil + foliar spray twice (equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 and 90 DAT) recorded highest K content (3.42%) in fruits, which differed significantly from treatments did not receiving Fe-EDTA application. But was on par with remaining treatments. Critical examination of the data also indicated that, treatments receiving soil + foliar spray of Fe-EDTA recorded numerically higher K content in fruits (3.21 to 3.42%) than treatments (T_4 to T_6) receiving only foliar spray of Fe-EDTA (3.09 to 3.13%). Comparison among treatments T_7 to T_{12} indicated that soil application of Fe-EDTA (T_7 to T_{12}) at higher dose Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha recorded marginally higher K content in fruits than treatment receiving Fe-EDTA at lower dose (equivalent to $FeSO_4$ at 10 kg/ha). All the three treatments receiving Fe-EDTA foliar spray either at 50 or 90 or at 50 + 90 DAT recorded slightly higher K content in fruits when compared to treatments (T_1, T_2 and T_3) that did not receive any iron application.

4.5 MICRONUTRIENT COMPOSITON OF RED CHILLI FRUITS (SUN DRIED)

4.5.1 Zn, Mn and Cu content in red fruits

Application of Fe-EDTA either through soil or foliar spray did not significantly influenced the Zn, Mn and Cu contents in red chilli fruits (Table 10). It was observed that treatments receiving soil + foliar application of Fe-EDTA recorded slightly higher Zn (24.51 to 26.65 ppm), Mn (33.28 to 34.92 ppm) and Cu (9.35 to 9.50 ppm) content in fruits than treatments receiving only foliar spray of Fe-EDTA (22.98 to 23.92 ppm of Zn), (32.30 to 32.93 ppm of Mn) and (9.12 to 9.23 ppm of Cu). Control recorded lowest Zn (21.88 ppm), (30.98 ppm) of Mn and Cu (9.05 ppm) content in fruits, but was non-significant when compared to rest of the treatments.

Table 9. Methods and time of application of Fe-EDTA levels on major nutrient concentration of whole red chilli fruits (sun dried)

Treatments	N	P	K
	(%)		
T_1 - Control (only RDF)	1.71	0.26	2.37
T_2 - FYM at 10 t/ha	1.72	0.26	2.98
T_3 - Water spray at 50 and 90 DAT	1.80	0.27	2.94
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	1.90	0.29	3.13
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	1.87	0.27	3.09
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	1.95	0.30	3.09
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	2.00	0.32	3.29
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	2.15	0.33	3.36
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	1.98	0.31	3.21
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	2.08	0.33	3.32
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	2.02	0.32	3.25
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	2.11	0.33	3.42
SEm±	0.08	0.01	0.126
CD (0.05)	0.26	NS	0.371

NS – Non significant.
DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 10. Methods and time of application of Fe-EDTA levels on micronutrient concentration of whole red chilli fruits (sun dried)

Treatments	Zn	Fe	Mn	Cu
	(ppm)			
T_1 - Control (only RDF)	21.88	121.70	30.98	9.05
T_2 - FYM at 10 t/ha	22.92	128.72	31.52	9.08
T_3 - Water spray at 50 and 90 DAT	22.61	125.32	31.25	9.12
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	23.92	138.32	32.93	9.32
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	22.98	130.32	32.30	9.25
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	23.54	135.91	32.61	9.29
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	25.17	152.91	33.93	9.38
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	26.65	163.71	34.92	9.50
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	24.51	143.72	33.28	9.35
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	25.38	160.31	34.10	9.40
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	24.98	147.23	33.81	9.36
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	25.98	165.10	34.52	9.50
SEm±	1.04	6.12	1.30	0.34
CD (0.05)	NS	17.94	NS	NS

NS – Non significant.
DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

4.5.2 Iron content in red fruits

Significant difference existed between different treatments with respect to iron content in whole red fruits (Table 10). Highest Fe content (165.10 ppm) was recorded in treatment (T_{12}) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 and 90 DAT. This was on par with all the treatments except T_1 to T_6. All treatments (T_7 to T_{12}) receiving combined application of Fe-EDTA (soil + foliar spray) recorded marginally higher Fe content in whole fruits (143.72 to 165.10 ppm) than treatments (T_4-T_6) receiving iron only through foliar spray (130.32 to 138.32 ppm). Comparison among treatments T_7 to T_{12} indicated that, treatments receiving higher dose of Fe-EDTA application (Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha) through soil recorded slightly higher Fe content in fruits than treatments receiving lower dose (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha). Non-significant difference existed between treatments T_4, T_5 and T_6 with respect to Fe content in whole fruits that received iron through foliar spray only. But these treatments recorded marginally higher Fe content (130.32 to 138.32 ppm) than treatments (T_1, T_2 and T_3) that did not receive Fe application (121.70 to 128.72 ppm).

4.6 NUTRIENT COMPOSITION OF FRUIT COMPONENTS VIZ., PERICARP AND SEED

4.6.1 Nitrogen content in pericarp and seed

Application of Fe-EDTA either through soil or foliar spray did not significantly influenced the nitrogen content in pericarp and seed components (Table 11). It was observed that treatments receiving soil + foliar application of Fe-EDTA (T7 to T12) recorded slightly higher N content in pericarp (1.30 to 1.41%) and seed component (1.65 to 1.72%) than treatments receiving only foliar spray of Fe-EDTA (1.21 to 1.25% in pericarp and 1.60 to 1.63% in seed component). Control recorded lowest N content in both pericarp (1.09%) as well as in seed component (1.52%), which was on par with rest of the treatments.

4.6.2 Phosphorous content in pericarp and seed

Data revealed that, non-significant difference existed between different treatments with respect to P content in pericarp and seed components. It was observed that, treatments receiving soil + foliar application recorded slightly higher P content in pericarp (0.22 to 0.26%) and seed components (0.342 to 0.354%) than treatments receiving only foliar spray of Fe-EDTA (0.20 to 0.21% in pericarp and 0.331 to 0.337% in seed). Control recorded lowest P content (0.20 and 0.315% in pericarp and seed components respectively) but was non significant when compared to rest of the treatments.

4.6.3 Potassium content in pericarp and seed component

Data presented in Table 11 highlighted that, treatment (T_{12}) that received Fe-EDTA through soil application (equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 and 90 DAT) recorded highest K content (3.58%) in pericarp and in seed component (1.34%), which differed significantly from control, T_2 and T_3 treatments who recorded 3.06, 3.08 and 3.12 in pericarp and 1.11, 1.11 and 1.12 per cent K in seed component. Critical examination of the data also indicated that, treatments receiving soil + foliar spray of Fe-EDTA recorded numerically higher K content in pericarp (3.32 to 3.58%) and in seed (1.21 to 1.34%) than treatments (T_4 to T_6) receiving only foliar spray of Fe-EDTA (3.12 to 3.29% in pericarp and 1.13 to 1.18% in seed component). Comparison among treatments T_7 to T_{12} indicated that soil application of Fe-EDTA at higher dose recorded numerically higher K content in pericarp and seed component than treatments receiving Fe-EDTA at lower dose. All the three treatments receiving Fe-EDTA through foliar spray either at 50 or 90 or at 50 + 90 DAT recorded slightly higher K content in pericarp and seed component, when compared to treatments (T_1, T_2 and T_3) that did not received any iron application.

4.7 MICRONUTRIENT COMPOSITION IN PERICARP

4.7.1 Zn, Mn and Cu content in pericarp

Application of Fe-EDTA either through soil or foliar spray did not significantly influenced Zn, Mn and Cu content in pericarp (Table 12). It was observed that treatments receiving soil + foliar application of Fe-EDTA recorded slightly higher Zn (16.75 to 17.90 ppm), Mn (25.02 to 26.90 ppm) and Cu (6.10 to 6.62 ppm) content in pericarp than treatments receiving only foliar spray of Fe-EDTA (15.29 to 15.61 ppm of Zn), (23.90 to 24.65 ppm of Mn) and (5.50 to 5.92 in Cu). Control recorded lowest Zn (14.72 ppm), Mn (22.22 ppm) and Cu (5.31 ppm) in pericarp.

4.7.2 Iron in pericarp

Significant difference existed between different treatments with respect to iron content in pericarp (Table 12). Highest Fe content (160.12 ppm) was recorded in treatment (T_{12}) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 + 90 DAT. This was on par with T_7 (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha soil application + 0.5% Fe-EDTA spray at 50 DAT), T_8 (Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 DAT) and T_{10} (20 kg soil application + 0.5% Fe-EDTA spray at 90 DAT. All the treatments (T_7 to T_{12}) receiving combined application of Fe-EDTA (soil + foliar spray) recorded marginally higher Fe content in pericarp (142.54 to 160.12 ppm) than treatments (T_4-T_6) receiving iron only through foliar spray (123.71 to 133.41 ppm). Comparison among treatments T_7 to T_{12} indicated that, treatments receiving higher dose of Fe-EDTA application through soil recorded slightly higher Fe content in pericarp than treatments receiving lower dose. Non-significant difference existed among the treatments T_4, T_5 and T_6 with respect to Fe content in pericarp who received iron through foliar spray only. But these treatments recorded marginally higher Fe content (123.71 to 133.41 ppm) than treatments (T_1, T_2 and T_3) that did not receive Fe application (116.71 to 123.71 ppm).

4.8 UPTAKE OF NUTRIENTS BY CHILLI PLANTS

4.8.1 Nitrogen

Data presented in Table 13 and 14 elucidated that, treatments differed significantly with regard to N uptake by chilli at both at 50 per cent flowering and at final picking stage (140 DAT).

At 50 per cent flowering treatment receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 DAT recorded highest N uptake (58.02 kg/ha) and was on par with T_{12} treatment, but differed significantly from control, RDF + FYM, RDF + FYM + water spray, 0.5% foliar spray of Fe-EDTA either at 50 or 90 DAT or both and soil + foliar application of Fe-EDTA. Lowest N uptake (27.45 kg/ha) was recorded in control.

Similarly, at final picking stage, treatment receiving Fe-EDTA soil application + 0.5% Fe-EDTA spray at 50 DAT recorded highest N uptake (81.49 kg/ha) which was on par with T_{10} and T_{12} treatments, but differed significantly from control (only RDF), RDF + FYM, RDF + FYM + water spray, 0.5% Fe-EDTA spray either at 50 or 90 DAT or both and soil + foliar spray of Fe-EDTA. Lowest N uptake (39.80 kg/ha) was recorded in control.

It was observed that, treatments receiving soil + foliar application of Fe-EDTA recorded higher N uptake than treatments receiving only foliar application. Among the treatments (T_7 to T_{12}) that received combined application of Fe-EDTA (soil + foliar spray) treatments receiving higher dose of Fe-EDTA application (T_8, T_{10} and T_{12}) through soil (Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha) recorded numerically higher N uptake at both at 50 per cent flowering and at final picking stage than the treatments receiving lower dose (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha).

Critical examination of data also revealed that treatments receiving foliar spray of Fe-EDTA either at 50 or 90 or at 50 + 90 DAT recorded higher N-uptake (T_4, T_6 and T_6) those treatments that did not receive Fe-EDTA foliar spray (T_1, T_2 and T_3). It was also observed that treatment (T_4) that received foliar spray of Fe-EDTA at 50 DAT recorded numerically higher N uptake (36.23 and 58.93 kg/ha at 50 per cent flowering and at final picking stage respectively) than treatments receiving spray at 90 DAT or 50 + 90 DAT.

4.8.2 Phosphorus

Perusal of data presented in Table 13 and 14 highlighted that, application of Fe-EDTA either through soil + foliar spray significantly influenced P uptake by chilli.

Table 11. Methods and time of application of Fe-EDTA levels on major nutrient composition in pericarp and seed components of red chilli fruits (Cv. Byadgi dabbi)

Treatments	Nitrogen		Phosphorus		Potassium	
	Pericarp	Seed	Pericarp	Seed	Pericarp	Seed
	(%)		(%)		(%)	
T_1 - Control (only RDF)	1.09	1.52	0.20	0.31	3.06	1.11
T_2 - FYM at 10 t/ha	1.15	1.55	0.20	0.32	3.08	1.11
T_3 - Water spray at 50 and 90 DAT	1.19	1.58	0.20	0.32	3.12	1.12
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	1.23	1.62	0.21	0.32	3.29	1.18
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	1.21	1.60	0.20	0.33	3.15	1.13
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	1.25	1.63	0.21	0.33	3.25	1.15
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	1.30	1.66	0.22	0.34	3.41	1.28
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	1.41	1.72	0.26	0.35	3.52	1.33
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	1.27	1.65	0.22	0.33	3.32	1.21
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	1.36	1.68	0.23	0.34	3.48	1.31
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	1.32	1.67	0.23	0.34	3.37	1.25
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	1.39	1.70	0.24	0.34	3.58	1.34
SEm±	0.065	0.075	0.016	0.012	0.109	0.050
CD (0.05)	NS	NS	NS	NS	0.321	0.148

NS – Non significant DAT – Days after transplanting
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 12. Methods and time of application of Fe-EDTA levels on concentration of micronutrients in pericarp component of red chilli fruits (Cv. Byadgi dabbi)

Treatments	Zn	Fe	Mn	Cu
	(ppm)			
T_1 - Control (only RDF)	14.72	116.71	22.22	5.31
T_2 - FYM at 10 t/ha	14.91	120.30	22.55	5.39
T_3 - Water spray at 50 and 90 DAT	14.62	123.71	22.27	5.31
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	15.90	133.41	23.90	5.92
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	15.29	125.21	24.29	5.50
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	15.61	130.92	24.65	5.62
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	17.13	147.92	25.96	6.25
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	17.90	157.36	26.90	6.62
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	16.75	137.71	25.02	6.10
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	17.30	155.30	26.12	6.50
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	16.99	142.54	25.85	6.12
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	17.68	160.12	26.22	6.56
SEm±	0.79	5.93	1.09	0.34
CD (0.05)	NS	17.41	NS	NS

NS – Non significant.
DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

At 50 per cent flowering, treatment (T_8) receiving Fe-EDTA soil application + foliar spray at 50 DAT recorded higher P uptake (8.20 kg/ha), which was on par with T_7, T_{10} and T_{12} (soil + foliar application of Fe-EDTA), but differed significantly from control, RDF + FYM, RDF + FYM + water spray, 0.5% Fe-EDTA spray at 50 or 90 DAT or 50 + 90 DAT and soil + foliar spray of Fe-EDTA. Lowest P uptake (4.10 kg/ha) was recorded in control that did not receive Fe application.

Similarly, at final picking stage, treatment recorded highest P uptake (14.85 kg/ha) which was on par with T_{12} treatment, but differed significantly from rest of the treatments. Lowest P uptake (7.24 kg/ha) was recorded in control.

4.8.3 Potassium

Perusal of data presented in Table 13 and 14 revealed that significant difference existed between different treatments with respect to K uptake at both at 50 per cent flowering and at final picking stage.

At 50 per cent flowering treatment (T_8) receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 DAT recorded highest K uptake (84.06 kg/ha), which was on par with T_{10} and T_{12} treatments, but differed significantly from rest of the treatments. Lowest K uptake (39.42 kg/ha) was recorded in control (only RDF). But at final picking stage, treatment (T_{12}) receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 and 90 DAT recorded highest K uptake (134.37 kg/ha) and was on par with T_8 and T_{10} treatments. Lowest K uptake (75.40 kg/ha) was recorded in control (only RDF). Further it was observed that treatments receiving soil + foliar application of Fe-EDTA recorded higher K uptake than treatments receiving only foliar application. Among the treatments (T_7 to T_{12}) that received combined application of Fe-EDTA (soil + foliar spray) treatments receiving higher dose of Fe-EDTA application (T_8, T_{10} and T_{12}) through soil recorded numerically higher K uptake at both 50 per cent flowering and at final picking stage than the treatments receiving lower dose (T_7, T_9 and T_{11}).

Critical examination of the data also revealed that treatments receiving foliar spray of Fe-EDTA either at 50 or 90 DAT recorded higher K-uptake (T_4, T_6 and T_6) that treatments lack of Fe-EDTA foliar spray (T_1, T_2 and T_3) did not receive Fe-EDTA foliar spray (T_1, T_2 and T_3).

It was also observed that treatment (T_4) that received foliar spray of Fe-EDTA at 50 DAT recorded numerically higher K uptake (52.01 and 96.77 kg/ha at 50 per cent flowering and at final picking stage respectively) than treatments receiving Fe-EDTA 90 or 50 and 90 DAT.

4.8.4 Sulphur

The sulphur uptake by chilli plants in various treatments differed significantly with respect to both soil and foliar application of Fe-EDTA (Table 13 and 14).

At 50 per cent flowering DAT treatment (T_8) receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha foliar spray at 50 DAT recorded highest S uptake (9.26 kg/ha), which differed significantly from T_1 to T_{12} treatments except T8. Lowest S uptake (3.95 kg/ha) was recorded in control (RDF only). Rest of the treatments were on par with each other.

At final picking stage, treatment (T_{12}) receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + foliar spray at 50 + 90 DAT recorded highest S uptake (15.22 kg/ha), and was on par with T_{10} and T_{12} treatments, which differed significantly from rest of the treatments. Lowest S uptake (7.70 kg/ha) was recorded in control.

4.9 IRON

Data presented in Table 15 and Fig. 7 revealed that significant difference existed between different treatments with respect Fe uptake by chilli plants both at 50 per cent flowering and at final picking stage.

At 50 per cent flowering, T_8 treatment recorded highest Fe uptake (24.73). It was on par with T_{12} treatment (soil + foliar spray of Fe-EDTA at 50 and 90 DAT), but differed significantly from rest of the treatments. Lowest Fe uptake (8.74 ppm) was recorded in control (only RDF).

Table 13. Methods and time of application of Fe-EDTA levels on nutrients uptake at 50% flowering by chilli plants (Cv. Byadgi dabbi)

Treatments	N	P	K	S
	(kg/ha)			
T_1 - Control (only RDF)	27.45 (2.22)	4.47 (0.30)	39.42 (3.19)	3.95 (0.32)
T_2 - FYM at 10 t/ha	28.65 (2.24)	4.64 (0.31)	41.19 (3.22)	4.22 (0.33)
T_3 - Water spray at 50 and 90 DAT	31.19 (2.25)	5.06 (0.31)	44.92 (3.24)	4.57 (0.33)
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	36.02 (2.36)	5.74 (0.33)	52.01 (3.35)	5.43 (0.35)
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	33.36 (2.30)	5.31 (0.31)	47.59 (3.28)	4.78 (0.33)
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	36.23 (2.32)	5.66 (0.32)	50.67 (3.30)	5.22 (0.34)
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	48.60 (2.50)	7.18 (0.35)	69.53 (3.60)	7.14 (0.36)
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	58.02 (2.65)	8.20 (0.39)	84.06 (3.18)	9.26 (0.42)
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	42.80 (2.38)	6.64 (0.31)	60.90 (3.40)	5.90 (0.33)
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	51.71 (2.52)	7.60 (0.37)	74.89 (3.65)	8.00 (0.39)
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	44.55 (2.42)	7.00 (0.36)	63.90 (3.47)	6.90 (0.38)
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	55.55 (260)	8.00 (0.38)	80.13 (3.75)	8.54 (0.40)
SEm±	1.93	0.39	4.32	0.29
CD (0.05)	5.68	1.16	12.69	0.86

DAT – Days after transplanting.
Figures in the parentheses indicate nutrient concentration in dried chilli plants.
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 14. Methods and time of application of Fe-EDTA levels on nutrient uptake at final picking stage by chilli plants (Cv. Byadgi dabbi)

Treatments	N	P	K	S
	(kg/ha)			
T_1 - Control (only RDF)	39.80 (1.55)	7.44 (0.29)	75.90 (2.90)	7.70 (0.30)
T_2 - FYM at 10 t/ha	43.30 (1.65)	7.87 (0.30)	77.41 (2.94)	8.13 (0.31)
T_3 - Water spray at 50 and 90 DAT	45.48 (1.77)	8.05 (0.30)	80.72 (2.97)	8.02 (0.30)
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	58.93 (1.91)	9.64 (0.31)	96.77 (3.08)	9.65 (0.32)
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	54.42 (1.80)	8.88 (0.30)	89.83 (3.00)	9.18 (0.31)
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	56.42 (1.97)	9.64 (0.31)	93.24 (3.04)	9.92 (0.32)
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	70.82 (1.95)	11.80 (0.34)	112.85 (3.20)	12.14 (0.35)
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	81.49 (2.03)	14.85 (0.37)	132.87 (3.27)	14.85 (0.37)
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	63.36 (1.93)	10.17 (0.32)	101.09 (3.17)	10.49 (0.33)
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	75.31 (1.98)	13.01 (0.35)	120.88 (3.24)	13.38 (0.36)
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	68.44 (2.00)	11.54 (0.33)	112.20 (3.19)	11.80 (0.34)
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	78.25 (2.01)	14.05 (0.36)	134.37 (3.30)	15.22 (0.39)
SEm±	4.43	0.49	6.71	0.45
CD (0.05)	13.00	1.43	19.70	1.33

DAT – Days after transplanting.
Figures in the parentheses indicate nutrient concentration in dried chilli plants.
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 15. Methods and time of application of Fe-EDTA levels on iron uptake by chilli plants at 50% flowering and final picking stage (140 DAT) Cv. Byadgi dabbi)

Treatments	Iron uptake (mg/plant)	
	At 50% flowering	At final picking (140 DAT)
T_1 - Control (only RDF)	8.74 (70.70)	16.87 (65.72)
T_2 - FYM at 10 t/ha	9.97 (71.23)	17.30 (66.70)
T_3 - Water spray at 50 and 90 DAT	9.11 (70.96)	17.68 (66.10)
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	11.93 (76.82)	21.21 (70.31)
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	10.75 (74.12)	21.12 (71.30)
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	12.03 (78.38)	22.68 (73.15)
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	17.20 (89.12)	27.80 (80.12)
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	24.73 (112.12)	35.85 (89.32)
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	15.57 (86.98)	25.11 (79.02)
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	22.10 (107.72)	32.47 (87.31)
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	16.97 (92.19)	29.07 (83.14)
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	24.61 (115.21)	36.64 (93.83)
SEm±	0.70	1.16
CD (0.05)	2.06	3.42

Figures in the parentheses indicate iron concentration (ppm) in dried chilli plants.
DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

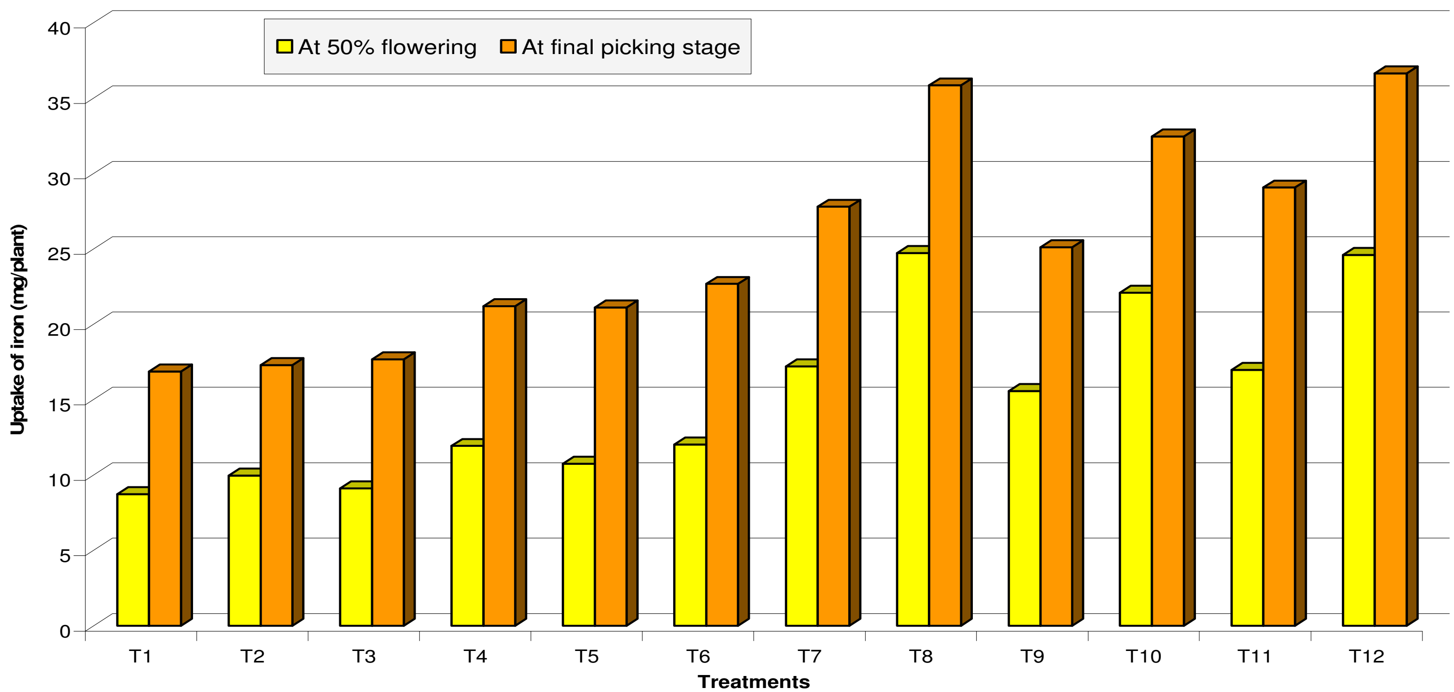

Fig. 7. Methods and time of applciation of Fe-EDTA levels on uptake of iron by chilli at 50% flowering and at final picking stage

Fig. 7. Methods and time of applciation of Fe-EDTA levels on uptake of iron by chilli at 50% flowering and at final picking stage

But, at final picking stage, T_{12} treatment recorded highest Fe uptake (36.64 ppm), which was on par with T_8 treatment. Lowest Fe-uptake (16.87 ppm) was recorded in control.

It was observed that, treatments receiving soil + foliar application of Fe-EDTA recorded higher Fe uptake than treatments receiving only foliar application. Among the treatments (T_7 to T_{12}) that received combined application of Fe-EDTA (soil + foliar spray) treatments receiving higher dose of Fe-EDTA application (T_8, T_{10} and T_{12}) through soil (Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha) recorded numerically higher Fe uptake at both 50 per cent flowering and at final picking stage than the treatments receiving lower dose (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha).

Critical examination of data also revealed that, treatments receiving foliar spray of Fe-EDTA either at 50 or 90 DAT recorded higher Fe-uptake (T_4, T_6 and T_6) than those treatments that did not receive Fe-EDTA foliar spray (T_1, T_2 and T_3). It was also observed that treatment (T_6) that received foliar spray of Fe-EDTA twice (50 and 90 DAT) recorded numerically higher Fe uptake (12.03 and 22.68 ppm at 75 and 140 DAT respectively) than treatment receiving one spray (50 or 90 DAT).

4.10 TOTAL IRON CONTENT IN GREEN LEAVES AS INFLUENCED BY SOIL AND FOLIAR APPLICATION OF Fe-EDTA

Data pertaining to total iron content in chilli leaves (Cv. Byadgi dabbi) as influenced by methods and time of application of Fe-EDTA are presented in Table 17.

4.10.1 Soil application of Fe-EDTA

Data presented in Table 16 and Fig. 8 clearly showed that, leaf samples collected from different treatments before soil application of Fe-EDTA did not differ significantly with respect to total iron content. Total iron content in leaves before application of Fe-EDTA to soil ranged from 94.00 to 103.12 ppm. But, leaf samples of different treatments differed significantly with respect to total iron content in leaves after soil application of Fe-EDTA. Highest total iron content (362.87 ppm) in leaves was recorded in treatment that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha $FeSO_4$, which was on par with treatments T_{10} (360.96 ppm) and T_{12} (361.92 ppm) which received soil application. Lowest iron content (94.00 ppm) was recorded in control (only RDF), which was on par with rest of the treatments. Critical examination of the data revealed that, all treatments receiving soil application of Fe-EDTA recorded significantly higher total iron content 259.63 to 262.87 ppm in leaves than other treatments (T_1 to T_6). Further, treatments receiving higher dose of Fe-EDTA application through soil recorded higher total iron (360.96 to 362.87 ppm) and differed significantly from treatments receiving lower dose (259.63 to 260.90 ppm).. Irrespective of the dose of Fe-EDTA application to soil, there was marked increase in total iron content in leaves after soil application of Fe-EDTA.

4.10.2 Before and after foliar spray at 50 DAT

Data presented in Table 16 and Fig. 8 indicated that leaf samples collected from different treatments either before or after foliar spray with EDTA differed significantly with respect to total iron content.

Treatment (T_8) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 DAT recorded highest total iron content (356.71 and 368.81 ppm before and after foliar spray respectively) which was on par with treatments T_{10} (349.71 and 340.63) and T_{12} (354.72 and 365.43 ppm) receiving soil application of Fe-EDTA (equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 90 and at 50 + 90 DAT respectively). Lowest iron content either before or after foliar spray (101.21 and 99.72 ppm) with Fe-EDTA was noticed in control which was on par with treatments T_2 (110.39 and 106.78 ppm), T_3 (104.52 and 101.71 ppm), T_4 (108.71 and 118.81 ppm), T_5 (110.41 and 106.79 ppm) and T_6 (110.81 and 120.91 ppm). Critical examination of the data revealed that all treatments (T_7 to T_{12}) receiving soil + foliar application of Fe-EDTA recorded significantly higher total iron content (251.81 to 356.71 before foliar application and 258.83 to 368.81 ppm after foliar spray) in leaves than treatments (T_4, T_5 and T_6) receiving only foliar spray of Fe-EDTA either at 50 or 90 DAT or at 50 + 90 DAT (108.71 to 110.81 ppm and 118.81 to 120.91 ppm).

Comparison among treatments receiving soil + foliar spray of Fe-EDTA revealed that, treatments receiving higher dose of Fe-EDTA application through soil (Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha) recorded significantly higher total iron (354.72 to 356.71 ppm), than treatments receiving lower dose (equivalent to FeSO4 at 10 kg/ha). Similar trend in total iron content in leaves was observed after foliar spray also in the same treatments (T_7 to T_{12}). Similarly comparison between treatments (T_4, T_5 and T_6) that received foliar spray and treatments that did not receive any spray (T_1, T_2 and T_3) revealed that, treatments receiving foliar spray recorded marginally higher total iron content in leaves sampled before (108.71 to 110.81) and after (118.81 to 120.91) foliar spray with Fe-EDTA. Further, all treatments which received Fe-EDTA foliar spray at 50 DAT recorded higher iron content after foliar spray. Same treatments recorded lower iron in before foliar spray.

4.10.3 Before and after foliar spray at 90 DAT

Data presented in Table 16 and Fig. 8 indicated that, leaf samples collected from different treatments either before or after foliar spray with Fe-EDTA at 90 DAT differed significantly with respect to total iron content. Before foliar spray at 90 DAT, treatment (T_8) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 DAT recorded highest total iron content (363.71 ppm) and was on par with treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 + 90 DAT (360.63 ppm). But after foliar spray, treatment (T_{12}) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 and 90 DAT that recorded highest total iron content (370.82 ppm), was on par with T_8 treatment (357.91 ppm). Lowest iron content either before or after foliar spray (95.34 and 90.13 ppm) was noticed in control. Critical examination of the data revealed that, all treatments (T_7 to T_{12}) receiving soil + foliar application of Fe-EDTA recorded significantly higher total iron content (231.93 to 363.71 ppm before foliar application and 241.24 to 370.82 ppm after foliar spray) than treatments (T_4, T_5 and T_6) receiving only foliar spray of Fe-EDTA either at 50 or 90 DAT or at 50 + 90 DAT (101.79 to 115.32 and 105.33 to 126.72 ppm). Comparison among T_7 to T_{12} treatments revealed that, treatments receiving higher dose of Fe-EDTA application through soil ($FeSO_4$ at 20 kg/ha) recorded significantly higher total iron 363.71 (T_8), 335.72 (T_{10}) and 360.63 (T_{12}) ppm than treatments receiving lower dose of Fe-EDTA soil application (FeSO4 at 10 kg/ha). Similar trend in total iron content in leaves was observed after foliar spray also in the same treatments. Similarly comparison between treatments (T_4, T_5 and T_6) that received foliar spray of Fe-EDTA and treatments that did not receive Fe-EDTA application revealed that, treatments receiving foliar spray recorded higher total iron content in leaves sampled before and after foliar spray than treatments that did not receive any spray (T_1, T_2 and T_3). Further, treatments (T_5 and T_6) which received Fe-EDTA foliar application at 50 and 50 + 90 DAT recorded higher iron content after foliar spray than treatment receiving foliar spray at 50 DAT. Same treatments recorded lower iron content before foliar spray.

4.11 FERROUS IRON CONTENT IN FRESH GREEN CHILLI LEAVES AS INFLUENCED BY SOIL AND FOLIAR APPLICATION OF Fe-EDTA

4.11.1 Soil application of Fe-EDTA

Data presented in Table 17 and Fig. 9 clearly showed that leaf samples collected from different treatments before soil application did not differ significantly with respect to ferrous iron content which ranged from 5.31 to 5.39 ppm. But after soil application of Fe-EDTA, treatments differed significantly with respect to ferrous iron content in leaves. Treatment (T_8) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha recorded highest iron content (20.37 ppm) and was on par with T_{12} (20.25 ppm) and T_{10} (20.10 ppm) treatments, but differed significantly from T_7, T_9 and T_{11} treatments which recorded 12.20, 12.17 and 12.19 ppm ferrous iron respectively. Lowest iron content (5.24 ppm) was recorded in control, which was on par with treatments that received FYM (T_2), water spray (T_3) and foliar spray of Fe-EDTA either once or twice. Comparison among treatments (T_7 to T_{12}) that received soil application of Fe-EDTA revealed that, treatments receiving higher dose of EDTA application through soil recorded higher ferrous iron content (20.10 to 20.25 ppm) than treatments receiving lower dose (12.10 to 12.19 ppm).

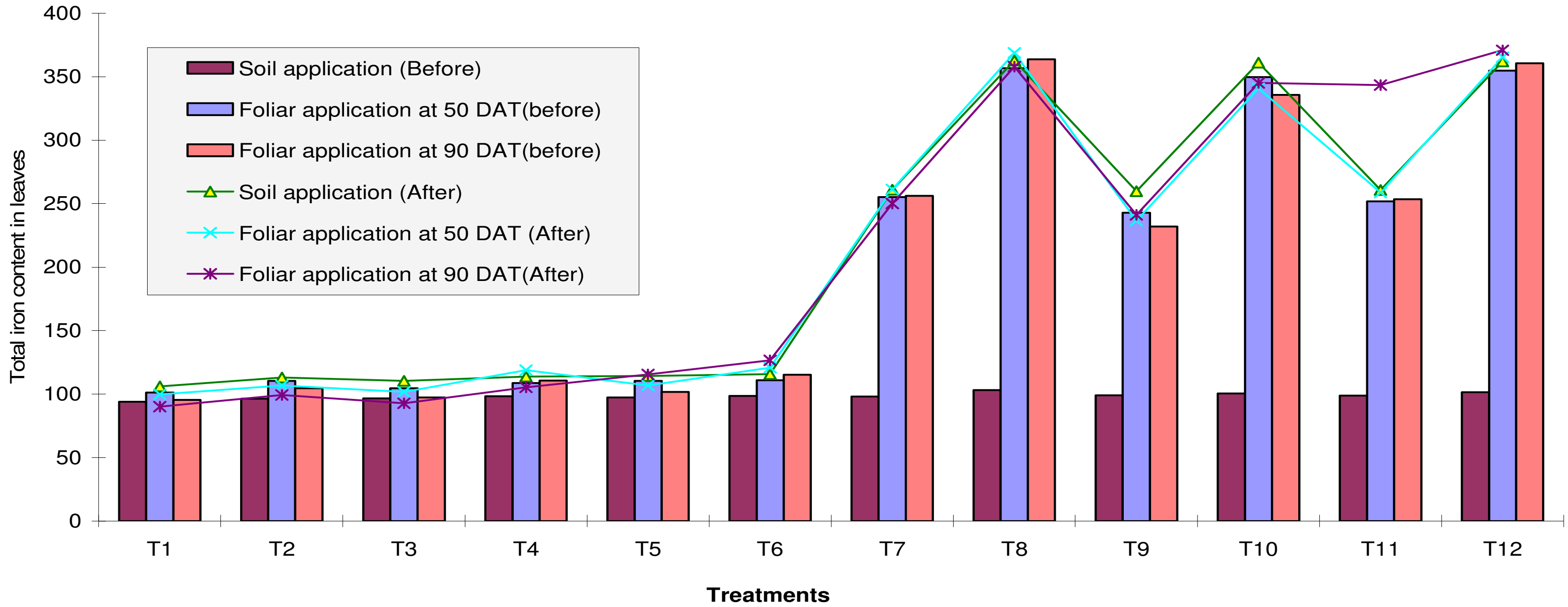

Fig. 8. Methods and time of applciation of of Fe-EDTA levels on total iron content in chilli leaves

Fig. 8. Methods and time of applciation of of Fe-EDTA levels on total iron content in chilli leaves

Table 16. Methods and time of application of Fe-EDTA levels on total iron content in dry chilli leaves

Treatments	Soil application		Foliar application at 50 DAT		Foliar application at 90 DAT	
	Before	After	Before	After	Before	After
	(ppm)		(ppm)		(ppm)	
T_1 - Control (only RDF)	94.00	106.00	101.21	99.72	95.34	90.13
T_2 - FYM at 10 t/ha	96.30	113.21	110.39	106.78	104.57	99.39
T_3 - Water spray at 50 and 90 DAT	96.72	110.42	104.52	101.71	97.38	92.72
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	98.23	113.74	108.71	118.81	110.73	105.33
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	97.28	114.23	110.41	106.79	101.79	115.48
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	98.65	115.85	110.81	120.91	115.32	126.72
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	98.20	260.90	255.21	261.31	256.23	250.23
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	103.12	362.87	356.71	368.81	363.71	357.91
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	98.98	259.63	242.91	236.71	231.93	241.24
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	100.36	360.96	349.71	340.63	335.72	345.08
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	98.76	260.71	251.81	258.83	253.56	343.39
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	101.58	361.92	354.72	365.43	360.63	370.82
SEm±	3.47	8.70	8.34	7.61	7.71	8.34
CD (0.05)	NS	25.52	24.48	22.33	22.64	24.48

NS – Non significant DAT – Days after transplanting

RDF + FYM were common for all the treatments (T_3 to T_{12})

4.11.2 Before and after foliar spray at 50 DAT

Data presented in Table 17 and Fig. 9 indicated that leaf samples collected from different treatments either before or after foliar spray with Fe-EDTA differed significantly with respect to ferrous iron content. Treatment that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 DAT recorded highest ferrous iron content (19.25 and 23.66 ppm before and after foliar spray respectively), which was on par with treatments T_{10} (19.10 ppm) and T_{12} (19.20 ppm) before foliar spray, but differed significantly from treatments T_{10} (18.20 ppm) that received foliar spray at 90 DAT along with soil application equivalent to $FeSO_4$ at 20 kg/ha. Further, all treatments (T_7 to T_{12}) receiving soil + foliar spray of Fe-EDTA recorded significantly higher ferrous iron content (11.25 to 19.25 ppm before spray and 10.10 to 23.66 ppm after spray) in leaves than treatments receiving only foliar spray of Fe-EDTA at 50 DAT (5.13 to 5.16 ppm and 5.02 to 9.13 ppm). Further, treatments receiving higher dose of Fe-EDTA application through soil recorded significantly higher total ferrous iron content (19.10 to 19.25 ppm before foliar spray and 18.20 to 23.66 ppm after spray) than treatments receiving lower dose of Fe-EDTA soil application. Similar trend in ferrous content in leaves was observed after foliar spray also in the same treatments. Lowest ferrous iron content in leaves either before or after foliar spray with Fe-EDTA (5.12 and 4.98 ppm) was recorded in control which was on par with treatments T_2, T_3, T_4, T_5 and T_6 (5.13 to 5.16 ppm before spray). But after foliar spray, treatments T_4 and T_6 who recorded higher ferrous iron content (9.10 and 9.13 ppm) respectively were on par with each other but differed significantly from T_1, T_2, T_3 and T_5 treatments who recorded lower content (4.97 to 5.02 ppm).

4.11.3 Before and after foliar spray at 90 DAT (Table 17 and Fig. 9)

Perusal of data indicated that leaf samples collected from different treatments either before or after foliar spray with Fe-EDTA differed significantly with respect to ferrous iron content. It was observed that, before foliar spray at 90 DAT, treatment (T_8) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha along with foliar spray at 50 DAT recorded higher ferrous content (21.70 ppm and differed significantly from leaf samples of T_7, T_9, T_{10} and T_{11} treatments as well as from those treatments that did not receive Fe-EDTA soil application (T_1 to T_6). Comparison among treatments that received foliar spray of Fe-EDTA only (T_4 to T_6) revealed that, there was marked increase in ferrous content in leaves in treatments T_5 and T_6 after foliar spray (7.61 and 9.90 ppm for T_5 and T_6 respectively) from the initial concentrations of 4.92 ppm (T_5) and 8.10 ppm. The three treatments that did not receive any Fe-EDTA application either through soil or foliar spray recorded very low ferrous iron content in leaves and were on par with each other. Treatments receiving higher dose of Fe-EDTA application through soil (T_8, T_{10} and T_{12}) recorded significantly higher ferrous iron content in leaves (21.70, 16.90 and 21.50 ppm before spray and 19.80, 18.8 and 23.50 ppm after spray) than treatments (T_7, T_9 and T_{11}) receiving lower dose analysed either before or after foliar spray at 90 DAT.

4.12 FERROUS IRON CONTENT IN FRESH GREEN FRUITS AS INFLUENCED BY FOLIAR SPRAY OF IRON-EDTA

4.12.1 Before and after foliar spray at 50 DAT (Table 18 and Fig. 10)

Significant difference existed between different treatments with respect to ferrous iron content in fresh green fruits analysed before and after foliar spray with Fe-EDTA (Table 18 and Fig. 10). Highest ferrous contents (15.82 and 18.10 ppm before and after foliar spray with Fe-EDTA respectively) were recorded in treatment (T_8) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT, which differed significantly from all the treatments except T_{10} and T_{12} that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + foliar spray of Fe-EDTA at 90 and 50 + 90 DAT. Control recorded lowest ferrous content (4.33 and 4.10ppm before and after spray respectively) in green fruits which was on par with those treatments that did not receive any Fe-EDTA application (T_1 and T_2) as well as with treatments that received Fe-EDTA through foliar spray either at 50 or 90 DAT or at 50 + 90 DAT (T_4, T_5 and T_6) analysed before spray.. But green fruit samples of T_4 and T_6 treatments collected after foliar spray at 50 DAT recorded significantly higher ferrous iron content (7.10 and 7.12 ppm for T_4 and T_6 respectively) than fruit samples of T_1, T_2, T_3 and T_5 treatments (4.10 to 4.30 ppm). Treatments receiving soil +

foliar spray of Fe-EDTA (T_7 to T_{12}) recorded significantly higher ferrous content in green fruits analysed either before or after foliar spray with Fe-EDTA at 50 DAT than treatments receiving only foliar spray of Fe-EDTA. Further, treatments (T_8, T_{10} and T_{12}) receiving higher dose of Fe-EDTA application to soil recorded significantly higher ferrous content in fruits analysed before and after foliar spray with Fe-EDTA than treatments receiving lower dose.

4.12.2 Before and after foliar spray at 90 DAT

Significant difference existed between different treatments with respect to ferrous iron content in fresh green fruits analysed before and after foliar spray with Fe-EDTA. Before foliar spray at 90 DAT treatment (T_8) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha at planting + 0.5% Fe-EDTA spray at 50 DAT recorded higher ferrous iron content (16.35 ppm), and was on par with treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 + 90 DAT (16.30 ppm) but differed significantly from all other treatments. But after foliar spray at 90 DAT treatment (T_{12}) recorded highest ferrous iron content (19.25 ppm) which differed significantly from all the treatments. Lowest ferrous iron content in green fruits either before or after foliar spray at 90 DAT was noticed in control (3.92 and 3.75 ppm). All treatments (T_7 to T_{12}) receiving soil + foliar application of Fe-EDTA recorded significantly higher ferrous iron content (8.60 to 16.35 ppm before and 10.10 to 19.25 ppm after foliar spray) in green fruits than treatments (T_4, T_5 and T_6) receiving only foliar spray of Fe-EDTA either at 50 or 90 DAT or 50 + 90 DAT. Further, treatments receiving higher dose of Fe-EDTA application through soil ($FeSO_4$ at 20 kg/ha) recorded significantly higher ferrous iron in fruits than treatments receiving lower dose ($FeSO_4$ at 10 kg/ha). Similar trend in ferrous iron content in green fruits was observed after foliar spray also in the same treatments (T_7 to T_{12}). Similarly treatments that received foliar spray recorded higher ferrous iron content in green fruits analysed either before and after foliar spray than treatments that did not receive any spray (T_1, T_2 and T_3).

4.13 FERTILITY STATUS OF SOIL

The available nutrient status of the experimental site was analsyed treatments at final picking stage (140 DAT) to know the nutrient balance in soil. The data on fertility status of soils are presented in Table 19.

4.13.1 Available nitrogen and phosphorus

The available nitrogen and phosphorus content of the soil was non significantly influenced by iron nutrition (Fe-EDTA). However, lowest available nitrogen (305.39) and phosphorus (22.04 kg/ha) were recorded in the treatment (T_8) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 DAT. Which was closely followed by treatment T_{12} that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 and 90 DAT (312.75 and 23.00 kg/ha). Highest available nitrogen and phosphorus (350.53 and 27.88 kg/ha) were recorded in control (only RDF) followed by T_2 (NPK + FYM) (348.19 and 25.88 kg/ha nitrogen and P respectively).

4.13.2 Available potassium

Significant difference existed between different treatments, with respect to available potassium status in soil at final picking stage (Table 19). However, treatment T_{12} (Fe-EDTA soil application at planting + Fe-EDTA foliar spray at 50 + 90 DAT) recorded lowest available potassium (335.63 kg/ha), closely followed by treatment (T_8) received Fe-EDTA soil application at planting + 0.5% Fe-EDTA spray at 50 DAT (338.13 kg/ha). The treatments receiving higher dose of Fe-EDTA application through soil (Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha) recorded lowest available K than lower dose of Fe-EDTA application (Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha). Data also revealed that treatments receiving foliar spray of Fe-EDTA either at 50 or 90 DAT or at 50 + 90 DAT (T_4, T_5 and T_{10}) recorded lowest available K than treatments that did not receive any foliar spray of Fe-EDTA (T_1, T_2 and T_3).

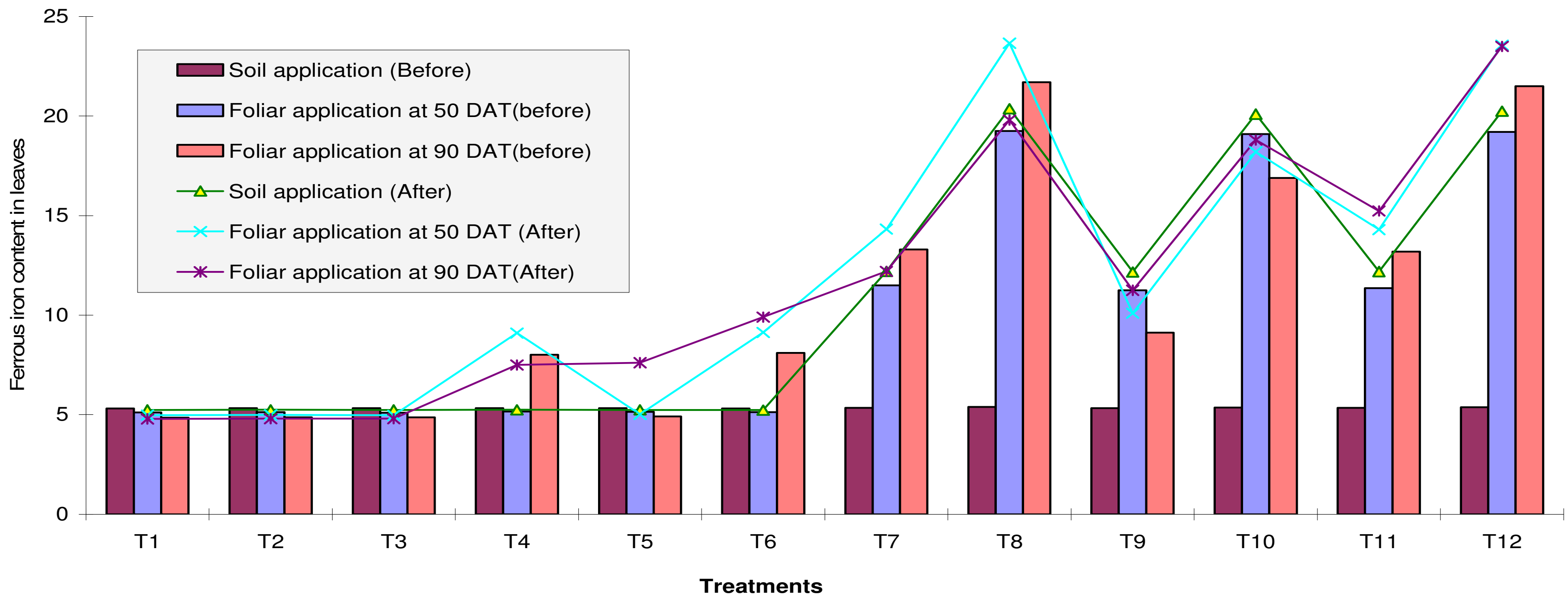

Fig. 9. Methods and time of application of Fe-EDTA levles on ferrous iron content in chilli leaves

Fig. 9. Methods and time of application of Fe-EDTA levles on ferrous iron content in chilli leaves

Table 17. Methods and time of application of Fe-EDTA levels on ferrous iron content in fresh chilli leaves

Treatments	Soil application		Foliar application at 50 DAT		Foliar application at 90 DAT	
	Before	After	Before	After	Before	After
	(ppm)		(ppm)		(ppm)	
T_1 - Control (only RDF)	5.31	5.24	5.12	4.98	4.85	4.79
T_2 - FYM at 10 t/ha	5.33	5.25	5.13	4.99	4.86	4.80
T_3 - Water spray at 50 and 90 DAT	5.32	5.24	5.1	4.97	4.86	4.80
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	5.33	5.25	5.16	9.10	8.01	7.50
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	5.32	5.24	5.15	5.02	4.92	7.61
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	5.31	5.23	5.13	9.13	8.10	9.90
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	5.35	12.20	11.50	14.32	13.30	12.20
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	5.39	20.37	19.25	23.66	21.70	19.80
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	5.32	12.17	11.25	10.10	9.12	11.25
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	5.37	20.10	19.10	18.20	16.90	18.80
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	5.35	12.19	11.35	14.30	13.20	15.23
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	5.38	20.25	19.20	23.56	21.50	23.50
SEm±	0.24	0.52	0.45	0.47	0.49	0.47
CD (0.05)	NS	1.52	1.34	1.39	1.46	1.39

NS – Non significant DAT – Days after transplanting
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 18. Methods and time of application of Fe-EDTA levels on ferrous iron content in green chilli fruits

Treatments	Foliar application at 50 DAT		Foliar application at 90 DAT	
	Before	After	Before	After
	(ppm)		(ppm)	
T_1 - Control (only RDF)	4.33	4.10	3.92	3.75
T_2 - FYM at 10 t/ha	4.56	4.25	3.94	3.80
T_3 - Water spray at 50 and 90 DAT	4.45	4.18	3.93	3.78
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	4.75	7.10	6.50	5.95
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	4.60	4.30	4.00	6.20
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	4.98	7.12	6.30	8.12
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	9.98	12.25	10.75	10.10
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	15.82	18.10	16.35	15.25
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	9.95	9.40	8.60	11.10
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	15.81	14.80	13.70	15.20
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	9.97	12.21	10.60	13.10
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	15.80	18.08	16.30	19.25
SEm±	0.36	0.38	0.34	0.37
CD (0.05)	1.07	1.13	1.01	1.10

NS – Non significant DAT – Days after transplanting

RDF + FYM were common for all the treatments (T_3 to T_{12})

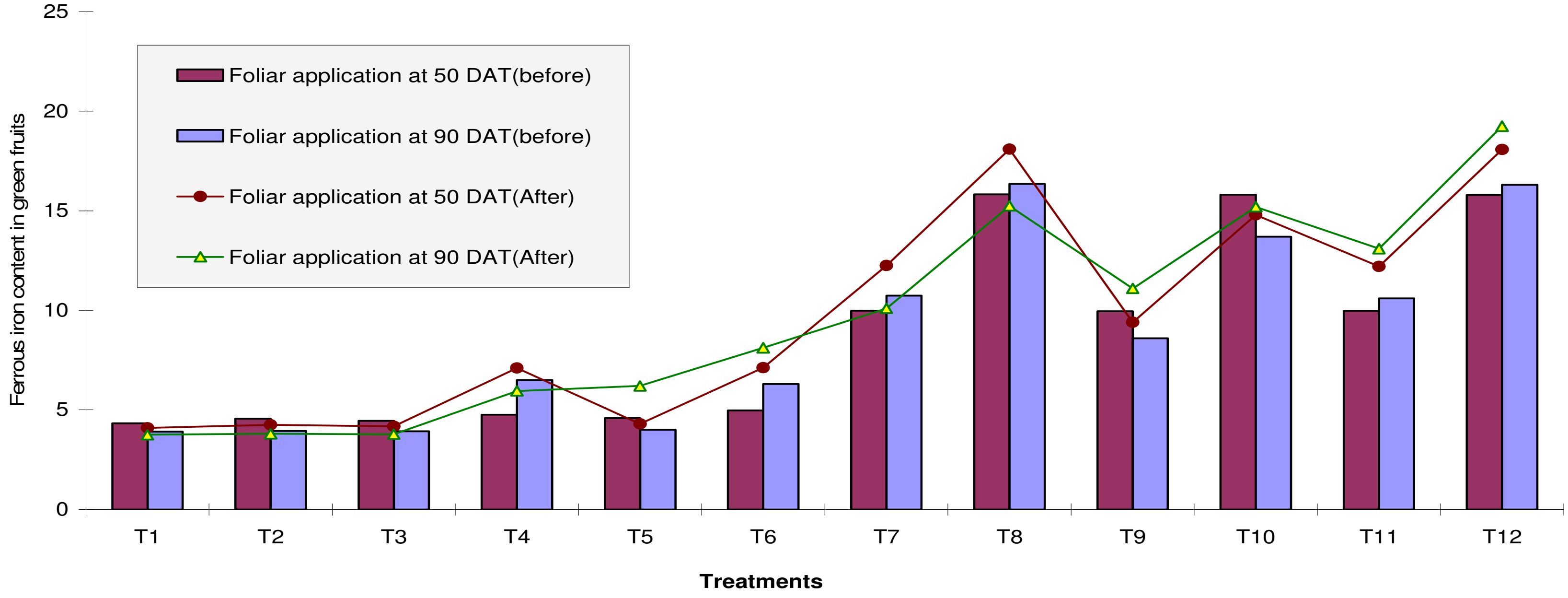

Fig. 10. Methods and time of application of Fe-EDTA levels on ferous iron content in green fruits

Fig. 10. Methods and time of application of Fe-EDTA levels on ferous iron content in green fruits

4.13.3 Available sulphur

Application of Fe-EDTA either through soil or foliar spray did not significantly influenced the sulphur content in soil at harvest. It was observed that treatments receiving soil + foliar application of Fe-EDTA (T_7 to T_{12}) recorded slightly lower sulphur (23.91 to 25.36 kg/ha) content in soil than treatments receiving only foliar spray (25.57 to 26.73 kg/ha). Control recorded highest (28.75 kg/ha) sulfur content in soil at harvest.

4.13.4 DTPA-extractable micronutrients (mg/kg)

The results of investigation indicated that, DTPA-extractable micronutrients (Zn, Cu and Mn) in post harvest soil were non-significantly influenced by iron nutrition in the form of Fe-EDTA (Table 20).

4.13.5 Available iron

Significant difference existed between different treatments with respect to available iron content in soil at final picking stage (Table 20). Highest Fe content (2.71 mg/kg) was recorded in the treatment (T_{12}) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT. This was on par with other treatments receiving both soil + foliar application of Fe-EDTA. Lowest Fe (2.28 mg/kg) was recorded in control (RDF), followed by T_2 (RDF + FYM), T_3 (RDF + FYM + water spray), T_4, T_5 and T_6 (0.5% foliar spray of Fe-EDTA at 50 or 90 DAT or both). All treatments (T_7 to T_{12}) receiving combined application of Fe-EDTA (soil + foliar spray) recorded marginally higher Fe in soil (2.49 to 2.71 mg/kg) than treatments (T_4-T_6) receiving iron only through foliar spray (2.43 to 2.47 mg/kg). Comparison among treatments T_7 to T_{12} indicated that, treatments receiving higher dose of Fe-EDTA application through soil recorded slightly higher Fe content in soil than treatments receiving lower dose of Fe-EDTA. Non –significant difference existed among treatments T_4, T_5 and T_6 with respect to Fe content in soil that received iron through foliar spray only. But these treatments recorded marginally higher Fe in soil (2.43 to 2.47 mg/kg) than treatments (T_1, T_2 and T_3) that did not receive Fe application (2.28 to 2.35 mg/kg).

4.14 CORRELATION STUDIEES

4.14.1 Relationship of nutrient concentration of whole red fruit and pericarp component with quality attributes (sundried)

In order to know whether any relationship existed between nutrient concentration of whole red fruits or pericarp component and quality attributes of red chilli fruits (sundried), simple correlation studies were made by working out the correlation coefficient values (r) taking quality attributes as dependent variable and nutrient concentrations as independent variable (Table 21).

Correlation coefficient values clearly indicated that iron and potassium contents of pericarp component bear significant positive relationship with colour value and oleoresin content (r = 0.978**, 0.967**, 0.970** and 0.973**). Similarly nitrogen, phosphorus and iron contents of whole red fruit bear significant positive relationship with colour value and oleoresin content. Though potassium content of whole red fruits bears the same relationship with quality attributes, but ‘r’ values are marginally lower (r = 0.825** and r = 0.814** for colour value and oleoresin contents respectively) than remaining values. Phosphorus content of pericarp also bears positive relationship with colour value (r = 0.924**) and oleoresin yield (r = 0.925**) which are slightly lower than the values recorded for remaining three nutrients (N, K and Fe).

Table 19. Methods and time of application of Fe-EDTA levels on available nutrients status of soil (0-20 cm) after the harvest of chilli

Treatments	Nitrogen	Phosphorus	Potassium	Sulphur
	(kg/ha)			
T_1 - Control (only RDF)	350.53	27.24	410.52	28.75
T_2 - FYM at 10 t/ha	348.19	25.88	402.09	26.88
T_3 - Water spray at 50 and 90 DAT	343.70	25.42	394.80	26.45
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	327.58	24.71	366.58	25.57
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	335.47	25.13	383.34	26.73
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	330.07	25.00	378.28	26.23
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	320.18	24.74	347.65	24.96
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	305.39	22.04	338.13	24.25
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	324.67	23.88	359.41	25.36
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	315.69	23.29	344.64	24.39
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	317.72	23.69	350.30	24.79
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	312.75	23.00	335.63	23.91
SEm±	13.48	1.10	14.63	0.96
CD (0.05)	NS	NS	6.89	NS

NS – Non significant.
DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 20. Methods and time of application of Fe-EDTA levels on DTPA extractable micronutrients (mg/kg) of soil after harvest of chilli (Cv. Byadgi dabbi)

Treatments	Zn	Fe	Mn	Cu
	(mg/kg)			
T_1 - Control (only RDF)	0.48	2.25	7.15	0.65
T_2 - FYM at 10 t/ha	0.46	2.36	7.12	0.64
T_3 - Water spray at 50 and 90 DAT	0.46	2.32	7.12	0.63
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	0.43	2.45	7.11	0.59
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	0.45	2.47	7.12	0.62
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	0.44	2.43	7.11	0.60
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	0.41	2.49	7.08	0.58
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	0.39	2.61	7.05	0.56
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	0.42	2.51	7.03	0.58
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	0.40	2.51	7.07	0.57
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	0.41	2.50	7.07	0.58
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	0.39	2.71	7.06	0.57
SEm±	0.02	0.08	0.20	0.02
CD (0.05)	NS	0.23	NS	NS

NS – Non significant.
DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

Table 21. Relationship of nutrient concentration of whole red fruit component with quality attributes of chilli (sun dried)

Nutrient concentration	'r' value	
	Colour value	Oleoresin
Nitrogen	0.938** (0.963)**	0.954** (0.969)**
Phosphorus	0.937** (0.924)**	0.970** (0.925)**
Potassium	0.825** (0.967)**	0.814** (0.970)**
Iron	0.951** (0.978)**	0.949** (0.975)**

Figures in the parentheses indicate correlation values between nutrients concentration in pericarp and quality attributes.

** Significant at both 5% and 1% level.

Table 22. Relationship of total iron (dry leaves) and ferrous iron content (fresh leaves) with quality attributes of red chilli fruits (sun dried)

Iron concentration and forms	Growth stage #	'r' value	
		Colour value	Oleoresin
Ferrous	After 50 DAT	0.963**	0.956**
Ferrous	After 90 DAT	0.962**	0.967**
Total	After 50 DAT	0.974**	0.962**
Total	After 90 DAT	0.960**	0.971**

Analysed on 5^{th} day after Fe-EDTA foliar spray.

** Significant at both 5% and 1% level.

Table 23. Methods and time of application of Fe-EDTA levels on economics of chilli cultivation

Treatments	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	B:C ratio
T_1 - Control (only RDF)	14485	45900	31415	2.16
T_2 - FYM at 10 t/ha	18085	47280	29195	1.61
T_3 - Water spray at 50 and 90 DAT	18365	47400	29035	1.52
T_4 - 0.5% Fe-EDTA foliar spray at 50 DAT	19125	63700	44575	2.27
T_5 - 0.5% Fe-EDTA foliar spray at 90 DAT	20025	51000	30975	1.54
T_6 - 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	21365	60550	39185	1.85
T_7 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	24485	69000	44515	1.81
T_8 - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT	29685	73500	43815	1.47
T_9 - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	25085	66780	41695	1.66
T_{10} - Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 90 DAT	30285	72240	41955	1.38
T_{11} - Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	26285	67900	41615	1.58
T_{12}– Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT	31485	72800	41315	1.31

DAT – Days after transplanting.
RDF + FYM were common for all the treatments (T_3 to T_{12})

4.14.2 Relationship of total iron (dry leaves) and ferrous iron (fresh leaves) content of leaves with quality of chilli fruits (Table 22)

Data indicated that total and ferrous iron contents of leaves analysed on 5^{th} day after Fe-EDTA spray at 50 DAT bears significant positive relationship with colour value (r = 0.974** and r = 0.963** for total iron and ferrous iron respectively). Similarly total and ferrous iron contents of leaves analysed on 5^{th} day after Fe-EDTA spray at 90 DAT bear significant positive relationship with oleoresin content (r = 0.971** and r = 0.967** for total and ferrous iron respectively). Similarly at 95 DAT total and ferrous iron contents of leaves bear significant positive relationship the colour value of fruits (r = 0.960** and 0.962** for total and ferrous iron respectively). Further oleoresin content of fruits also bears significant positive relationship with total iron and ferrous iron contents of leaves at 55 DAT (r = 0.962** and 0.956** for total iron and ferrous iron respectively) (Table 22).

4.15 ECONOMIC ANALYSIS

The data on economic analysis of the present study involving the effect of Fe-EDTA application on chilli crop (cv. Byadgi dabbi) are presented in Table 23.

The acceptance of any generated technology is ultimately based on the cost of cultivation involved and net returns obtained from it. In the present investigation, cost of cultivation was maximum for the treatment (T_{12}) receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT (Rs. 31485/ha) while minimum was (Rs. 14485/ha) for control (only RDF).

Treatment (T_8) receiving soil application of Fe-EDTA ($FeSO_4$ at 20 kg/ha) + 0.5% Fe-EDTA foliar spray at 50 DAT recorded highest gross income (Rs.73500/ha) closely followed by treatment (T_{12}) with Rs. 72800/ha. Lowest gross income (Rs.45900) was recorded in control. The maximum net income of Rs. 44575/ha recorded in the treatment (T_4) that received 0.5 per cent Fe-EDTA spray at 50 DAT followed by treatment (T_7) that received both soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% foliar application of Fe-EDTA. Lowest net income of Rs. 29035/ha was recorded in treatment that received two water sprays along with RDF + FYM.

The B:C ratio was highest (2.27in treatment (T_4) that received 0.5 per cent foliar application of Fe-EDTA at 50 DAT. While the lowest (1.31) was observed in the treatment that received soil application of Fe-EDTA ($FeSO_4$ at 20 kg/ha) + 0.5% Fe-EDTA spray at 50 + 90 DAT. In general, the B:C ratio was lower in treatments receiving soil + foliar application of Fe-EDTA compared to control or foliar spray of Fe-EDTA alone.

5. DISCUSSION

The results of the present investigation pertaining to the study methods and time of application of Fe-EDTA levels on yield and quality attributes of chilli (Cv. Byadgi dabbi) are discussed in this chapter.

5.1 GROWTH PARAMETERS

5.1.1 Plant height (cm)

Application of Fe-EDTA either through foliar spray or through soil + foliar spray did not significantly influenced the plant height when compared to control (RDF) (Table 4). This is obvious because of the greater role of Fe in chlorophyll synthesis and other metabolic activities of the plant with little role in cell elongation leading to increased plant height. However all the treatments receiving Fe-EDTA recorded numerically higher plant height compared to treatments that did not receive any Fe-EDTA application (T_1, T_2 and T_3), which might be due to the role of Fe in influencing the uptake of other nutrients. Similar results were also reported by Bhat and Jandial (1996) for potato and Mallick and Muthukrishnan (1979) for tomato.

5.1.2 Number of branches

Number of branches in chilli at 45 DAT were non-significantly influenced by Fe-EDTA application (Table 5). At 45 DAT there was not much uptake of Fe due to the absence of foliar spray of Fe-EDTA and Fe being immobile in the plant there might not be substantial uptake and translocation of Fe to the shoots through it was applied to soil at planting time. Hence number of branches produced at 45 DAT were limited. The results are in concordance with Hazra *et al.* (1987) in okra. The number of branches was significantly increased at 50 per cent flowering and at final picking stage by the application of Fe-EDTA either through foliar spray or through soil + foliar spray. This was mainly due to increased uptake of Fe supplied either through soil or foliar spray in the form of Fe-EDTA. This assimilated Fe in plant might have increased cell division, chlorophyll synthesis leading to increased number of branches. At 50 per cent flowering and at final picking stage highest number of branches (14.51 and 17.92) were recorded in T_8 (soil + foliar application of Fe-EDTA) which was 10.59 and 20.67 per cent higher than T_7 treatment receiving soil application of Fe-EDTA + 0.5% Fe-EDTA spray at 50 DAT. This might be due to increased uptake of iron due to increased vegetative growth on account of Fe-EDTA application through soil and foliar application. Assimilated iron might have increased photosynthesis leading to better vegetative growth. The results obtained in the present investigation are in accordance with findings of Hatwar *et al.* (2003) in chilli and Bose and Tripathi (1996) in tomato.

5.1.3 Dry matter production

The total dry matter yield was significantly influenced by the application of iron in the form of Fe-EDTA either through soil or soil + foliar spray (Table 6). The highest dry matter yield at 50 per cent flowering and at final picking stage (62.82 and 114.32 g/plant) was recorded in T_8 (Fe-EDTA soil application + 0.5% Fe-EDTA foliar spray at 50 DAT), which was 14.25 and 14.82 per cent higher than (T_7) treatment receiving soil application of Fe-EDTA + 0.5% Fe-EDTA spray at 50 DAT. This is attributed to the beneficial effect of soil application of Fe-EDTA along with foliar spray which has increased iron availability in soil and ferrous iron absorption by chilli leaves resulting in better absorption and translocation of iron, which in turn might have enhanced metabolic processes (oxidation reduction reaction) in plants and also chlorophyll formation leading to increased photosynthesis. The present findings corroborated the findings of Kumbhar and Deshmukh (1993) in tomato, Rana and Sharma (1979) in grape and Hellal (2004) in groundnut.

5.2 YIELD PARAMETERS AND YIELD

5.2.1 Weight of 100 dry fruits (g)

100-fruit weight was significantly influenced by Fe-EDTA. The reason for increased fruit yield might be attributed to enhanced photosynthetic activity due to increased chlorophyll content in leaves. This has resulted in the production and accumulation of carbohydrates in fruits and fruit development. Hatwar *et al.* (2003) reported similar findings in chilli.

5.2.2 Dry fruit yield/plot (kg)

Highest fruit yield per plot (2.15 kg) was observed in the treatment (T_8) that received Fe-EDTA soil application + 0.5% Fe-EDTA foliar spray at 50 DAT, which was 6.43 per cent higher than T_7 (Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 DAT). The reason for increased fruit yield might be attributed to enhanced photosynthetic activity due to increased chlorophyll content in leaves. This has resulted in the production and accumulation of carbohydrates in fruits and fruit development. These results are in consonance with the findings of Bose and Thripathi (1996) in tomato, Dongre *et al.* (2000) in chilli and Tamilselvi *et al.* (2002) in tomato.

5.2.3 Dry fruit yield (q/ha)

The results presented in Table 7 and Fig.4 indicated the significant effect of iron nutrition (EDTA) on yield of chilli. Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha proved its superiority over Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha. The highest yield (10.5 q/ha) was observed in (T_8) Fe-EDTA soil application + 0.5% foliar spray at 50 DAT) and was 6 per cent higher than the yield obtained in T_7 and 37.50 per cent higher than control (NPK alone). The increased yield might be attributed to enhanced photosynthetic activity and increased vegetative growth leading to more number of branches, more number of flowers, more number of fruits and fruit development. Iron applied through chelate also increased the sink size by the pre-anthesis assimilation of reduced nitrogen. Further applied farm yard manure also contributed to increased yields through improvement in soil physical condition leading to increased uptake of nutrients. Further decomposition of FYM in soil led to chelation and solubilization of native iron resulting in increased availability and uptake of iron. Fe-EDTA foliar spray given at 50 DAT might have brought in increased vegetative growth and plants might be more tolerant to diseases and insects resulting in increased yields (Dongre *et al*., 2000). Hatwar *et al.* (2003) reported increased yields in chillies as related to iron nutrition because of its role in chlorophyll synthesis indirectly enhancing photosynthesis. Similar observations were also reported by Bhat and Jandial (1996) in tomato.

It was observed that, treatments (T_7 to T_{12}) receiving soil + foliar application of Fe-EDTA produced more yield than treatments receiving Fe-EDTA foliar spray *per se* (T_4 -T_6). Soil application of Fe-EDTA at planting has resulted in increased uptake of other nutrients along with Fe. Further applied FYM has chelating effect with native soil iron due to its decomposition. Further, the organic acids produced during decomposition of FYM might have solubilized native iron thus there is increased availability of iron to plant roots from applied (Fe-EDTA) as well as native sources (Kumbhar and Deshmukh, 1993). Further, chilli being a deep rooted crop with effective root zone depth of 90 cm (Michael, 1994), it might have absorbed iron from deeper layers also because of chelation of native iron in subsoil an account of root exudates. Treatments (T_8, T_{10} and T_{12}) that received higher dose of Fe-EDTA application through soil recorded higher yield than treatments (T_7, T_9 and T_{11}) receiving lower dose of Fe-EDTA (equivalent to $FeSO_4$ at 10 kg/ha). This might be due to greater uptake of other nutrients and higher dose of Fe-EDTA has resulted in increased photosynthesis an account of high chlorophyll content in green leaves (Hellal, 2004). This has further resulted in increased metabolites synthesis and their translocation to developing fruits.

Critical examination of the data also revealed that, treatments receiving foliar spray of Fe-EDTA either at 50 or 90 DAT or at 50 + 90 DAT recorded higher yield than treatments that did not receive any foliar spray. This might be due to direct entry of iron through stomata of leaves leading to enhanced ferrous iron content in leaves. This has resulted in increased chlorophyll content in leaves leading to enhanced photosynthesis and assimilation of photosynthates in fruits (Kumbhar and Deshmuk (1993).

5.2.4 Length and Breadth ratio (L/B ratio)

L/B ratio of chilli fruits was non-significantly influenced by the methods, time and doses of Fe-EDTA application. Applied iron in the form of Fe-EDTA might have played greater role in improving colour value and oleoresin content in fruits rather than improving cell division and cell elongation influencing L/B ratio of fruits. The present results are in conformity with the findings of Husain *et al.* (1989) in chilli.

5.3 QUALITY ATTRIBUTES

5.3.1 Ascorbic acid content

Application of Fe-EDTA had shown significant effect in increasing the ascorbic acid content of green chillies (Table 8 and Fig. 5). The highest ascorbic acid content (178.90 mg/100 g) was recorded in the treatment (T_8) that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT. This was 11.63 per cent higher than recorded in T_7 treatment that received Fe-EDTA soil application equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT. This might be due to increase in the activity of ascorbic acid oxidase enzyme causing the marked improvement in vitamin C content as iron is an activator of many enzymes. Similar findings were also reported by Batra *et al*. (2006) in tomato.

5.3.2 Colour value

Significant and positive influence of iron nutrition (Fe-EDTA) was observed on the total extractable colour value of red chillies (Table 8 and Fig.6). Highest colour value (228.83 ASTA units) was noticed in treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha at planting + 0.5% foliar spray of Fe-EDTA at 50 and 90 DAT. This treatment (T_{12}) recorded 9.73 per cent higher colour value than treatment (T_{11}) that received Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT and 65.37 per cent more than control (NPK alone). Red colour in chilli fruits is mainly due to capsanthin and capsorubins- which constitute 60-70 per cent of β-carotene. It was reported by Gross (1991) that capsanthin and capsorubins are made up of porphyrin molecules viz., hamatin, ferrichrome and leghaemoglobin and iron is a structural component of all these molecules. There exist synergistic relationship between K and Fe and application of Fe either through soil or foliar spray in the form Fe-EDTA might have increased K uptake leading to increased colour value. Cazi (1961) reported a direct relationship between colour value of chilli fruits and K supply to plants. Thus the colour value in chilli fruits is closely related to K and Fe content of fruits. Further, foliar spray of Fe-EDTA at 90 DAT has closely synchronised with colour development in fruits. Martinez *et al.* (1990) reported a positive relationship between ferrous iron content in leaves and colour value in red pepper. Hence, the role of iron in red colour synthesis in chillies is quite evident from the above observations.

Fe supplied through foliar spray helps mainly in improving quality attributes particularly colour value and oleoresin. Since iron is immobile in the plant, the iron absorbed by plant roots may not get timely translocated to chilli fruits to improve the quality attributes. In this context, soil + foliar spray may be more beneficial than foliar spray alone and soil application of Fe-EDTA helps in the absorption of other nutrients also. Further treatments receiving only foliar application of Fe-EDTA (T_4 to T_6) recorded higher colour value than treatment (T_1 to T_3) that did not receive any spray. Among the treatments receiving foliar spray (T_4 to T_6) T_6 treatment that received 0.5% Fe-EDTA spray at 50 and 90 DAT recorded higher colour value than treatments receiving foliar spray either at 50 or 90 DAT. This might be due to the direct absorption of iron by leaves and green chilli fruits leading to enhanced synthesis of haematin, ferrichrome and leghaemoglobin the essential constituents of capsanthin and capsorubin. Thus, the foliar spray of Fe-EDTA at 50 and 90 DAT is more beneficial to enhance colour value of fruits than treatments receiving one foliar spray Mallick and Muthukrishnan, (1980) reported lycopene content in tomato fruits related to Fe concentration.

5.3.3 Oleoresin content

Oleoresin is the extract or essential volatile oil derived from spice. It is viscous semisolid gel like substance free from bacteria, spores and molds.

Oleoresin content in red chilli fruits was significantly influenced by the iron nutrition (Fe-EDTA) (Table 8 and Fig.5). The treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 and 90 DAT recorded highest oleoresin (16.75%) and was 4.49 per cent higher than T_{11} treatment receiving Fe-

EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% foliar spray at 50 and 90 DAT and 22.23 per cent higher than control. Higher oleoresin content in the above treatments was attributed to greater synthesis and translocation of ferrodoxin photosynthates to developing fruits which are the iron-sulfur proteins that constitute chilli oleoresin on account of increased uptake of nutrients particularly K, S and Fe. Similar observations were reported by Malawadi *et al.* (2004) in chilli.

Treatments receiving soil + foliar spray of Fe-EDTA (T_7 to T_{12}) recorded greater uptake of nutrients particularly Fe and K due to synergistic effect between them in soil which has lead to greater uptake of K that has played greater role in oleoresin synthesis. But foliar spray of Fe-EDTA alone either at 50 or 90 DAT or at 50 and 90 DAT might not appreciably increased the uptake of other nutrients through roots because of absorption of Fe directly by green fruits and leaves. The application of Fe-EDTA either through foliar spray or soil application significantly increased the oleoresin content in fruits over control. This is attributed to increased Fe-supply to plants through Fe-EDTA that has resulted in greater synthesis of ferredoxins (iron-sulfur proteins) which are the molecules of oleoresin (Hosmani, 1993). Control (only RDF), T_2 (RDF + FYM) and T_3 (RDF + FYM + water spray) recorded lower oleoresin yield when compared to all other treatments. These three treatments received only small quantity of Fe through FYM which might not be sufficient to meet the plant requirements for producing photosynthates leading to oleoresin yield.

5.3.4 Per cent discoloured fruits

The treatment (T_1) that received NPK alone recorded highest per cent discoloured fruits (7.93), while lowest per cent discoloured fruits (6.33) was recorded in the treatment (T_8) receiving Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 DAT (Table 8). This was due to greater partitioning of iron of whole fruit towards pericarp component and this increased iron concentration might have protected β-carotenoid against photo decomposition during drying of fruits. The present observations are also in accordance with Nair and Peter (1990) in chilli.

5.4 NUTRIENT CONTENT IN WHOLE CHILLI FRUITS

5.4.1 Nitrogen content

Fruit samples of different treatments differed significantly with respect to N content (Table 9). Highest N content (2.15%) was observed in treatment T_8 that received Fe-EDTA soil application equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 DAT. This was attributed to higher uptake of N due to high dry matter production and its further translocation to fruits. Further, applied Fe is known to help in the uptake of other nutrients including N, through activation enzymes in soil (Das, 1996). Application of Fe-EDTA either through soil or foliar spray in different doses influenced the uptake and assimilation of N by plant as nitrogen plays role in ascorbic acid and capsaicin synthesis. Similar observations were reported by Bidari (2000) in chilli.

5.4.2 Phosphorus content

Irrespective of the method, dose and time of Fe-EDTA application, fruit samples of different treatments did not differ significantly with respect to P content (Table 9). This might be due to low P uptake by plants because of low to medium P availability in soils and greater P fixing capacity due to their fine textured nature and calcareousness. Further, the role of P in influencing the quality attributes of fruits is not exactly known and only small amount of absorbed P might have been translocated to fruits. Further the interactions between Fe and P either in soil or in plant is not exactly known. Values of P content in fruits are in consonance with the results reported earlier by Pankar and Magar (1978a) and Farrell (1990).

5.4.3 Potassium content

Highest K content in chilli fruits was noticed in T_{12} receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 and 90 DAT (Table 9). Fruit samples of different treatments recorded more K content than corresponding N and P contents and treatments differed significantly with respect to K content. High K content in fruits is attributed to greater uptake of K due to synergistic relation between applied Fe and K (Mortvedt, 1986). Further absorbed K is being translocated to developing fruits as it plays a vital role in colour development (Bidari, 2000) as well as oleoresin synthesis (Malawadi *et al.*, 2004). Treatments receiving soil + foliar spray of Fe-EDTA recorded higher K content in fruits than treatments receiving foliar spray alone. This might be due to synergistic relation between Fe and K both in soil and plants.

It might also be due to higher uptake of K by plants and timely application of Fe-EDTA through foliar spray which closely synchronized with iron requirement for red colour development in fruits. The variation in K content might be attributed to size and weight of fruits along with distribution of pericarp and seed components in whole fruits. Similar observations were also reported by Pankar and Magar (1978a).

5.4.4 Zn, Fe, Mn and Cu contents

Zinc content follows Fe and Mn contents in fruits. Low Zn content in fruits might be due to its limited role in influencing the quality attributes. Mallick and Muthukrishnan (1980) reported that low Zn content in tomato fruits to its role in inducing pollen growth which results in increased fruit set and ultimately yield. Hence, its role in improving the quality attributes of fruits is negligible as such its content is less in fruits.

In chillies, the role of micronutrients in influencing the quality attributes is not well understood although they have a role to play in enhancing the fruit yield (Table 10). Among these micronutrients, iron content is significantly highest in red fruits followed by manganese, zinc and copper contents. This might be due to its preferential absorption by plants due its role in the synthesis of porphyrin molecules (haematin, ferrichrome leghaemoglobin) the structural components of capsanthins and capsorubins. Similar findings were also reported by Martinez *et al.* (1990) and Gross (1991) in case of paprika. Fruit samples of different treatments did not differ significantly with regard to Mn content. Further, low Mn content in fruits compared to Fe content might be due to slightly lower uptake of Mn although soils have higher DTPA-Mn than Fe and absorbed Mn might have limited role in influencing the quality attributes. Mallick and Muthukrishnan (1980) reported that, Mn played important role in synthesis of carbohydrates in tomato rather than its role in improving ascorbic acid content and red colour synthesis. These observations lend support to present investigation of low Mn in chilli fruits.

Copper content was lowest in fruits compared to other micronutrients might be due to its limited role in influencing the quality attributes. The results obtained with respect to copper content are in conformity with findings of Mallick and Muthukrishnan (1980) who stated that, in tomato absorbed Cu played role in influencing the retention of flowers and fruits on plants rather than in influencing the juice and ascorbic acid content.

5.5 NUTRIENT COMPOSITION OF FRUIT COMPONENTS VIZ., PERICARP AND SEED

5.5.1 N, P and K

It was observed that, irrespective of the method and time of application of Fe-EDTA N and P contents were low in pericarp component compared to the respective seed components whereas K content was very high in pericarp (Table 11). This elucidated the differential partitioning of nutrients between the two fruit components. Lower N and P contents in pericarp compared to respective seed component might be due to greater partitioning of assimilated N and P of whole fruits towards developing seeds to meet the immediate needs of embryo in the event of germination and to support vegetative growth of seedlings. Greater partitioning of K into pericarp component compared to respective seed portion might be due to synergistic relationship between Fe and K within plant. It is also attributed to its probable role in the synthesis of red colour. The present observations on differential partitioning of nutrients are in conformity with the findings of Pankar and Magar (1978a) and Bidari (2000).

5.5.2 Zn, Fe, Mn and Cu composition in periarp

Application of Fe-EDTA either through soil or foliar spray resulted in lower . Zn, Cu and Mn contents in pericarp portion when compared to Fe content (Table 12). Higher Fe content in pericarp portion might be due to its probable role in the synthesis of capsanthin and capsorubins which are made up of porphyrin molecules (ferrichrome, hematin and leghaemoglobin), which possess red colour because of the presence of Fe (Pankar and

Magar, 1978a). Further foliar spray of Fe-EDTA either at 50 or 90 DAT has further resulted in its greater accumulation because of its readily available form required by the plant that has closely synchronized with red colour development in the pericarp. The present observations lend support to the findings of Martinez *et al.* (1990).

5.6 EFFECT OF Fe-EDTA ON THE UPTAKE OF NUTRIENTS

Table indicated that at 50 per cent flowering and at final picking stage, treatments differed significantly with respect to uptake of all the five nutrients (N, P, K, S and Fe) (Table 13 and 14). The uptake of all the nutrients was significantly higher at 140 DAT (final picking stage) compared to 75 DAT (at 50 per cent flowering). This is obvious because of more dry matter yield on account of increased number of branches, plant height and fruit number at final picking stage as chilli is an indeterminate crop.

5.6.1 Nitrogen

Combined application of Fe-EDTA (soil + foliar spray) had significantly increased nitrogen uptake by chilli. Treatment (T_8) receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha at planting + 0.5% foliar spray of Fe-EDTA at 50 DAT recorded highest nitrogen uptake compared to all other treatments. Further, treatments receiving Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha recorded higher nitrogen uptake than treatments receiving Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha. This might be due to increased iron availability in soil because of applied Fe-EDTA and the direct uptake of ferrous iron by leaves due to foliar spray of Fe-EDTA resulting in higher production of chlorophyll, dry matter and higher uptake of nitrogen by plants. Similar findings were reported by Aiyer (1984) in Benalgram. The uptake of nitrogen increased with advancement in growth stages due to production of higher biomass at later stages and is reflected in the increased uptake of nitrogen. Results obtained with respect to uptake of nitrogen closely resemble the observations made by Samui *et al.* (1981) in mustard crop.

5.6.2 Phosphorus

The iron nutrition (Fe-EDTA) significantly increased the P uptake by plants at 50 per cent flowering and at final picking stage. Highest P uptake was observed in treatment (T_8) receiving soil application of Fe-EDTA at planting + 0.5% foliar spray of Fe-EDTA at 50 DAT.

Soil or foliar application of Fe-EDTA resulted in enhanced chlorophyll synthesis in leaves leading to increased photosynthesis and ultimately dry matter yield. This has resulted in higher phosphorus uptake by plants. Further applied Fe to soil or plant might not interfere with P uptake by plants because of the cationic (Fe) and anionic (P) nature absorbed by plants. Das (1996) reported the differential uptake of P and Fe as related to nature of ions.

5.6.3 Potassium

Highest K uptake was recorded in the treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha at planting + 0.5% Fe-EDTA spray at 50 and 90 DAT. This is obvious because of the increased dry matter yield that has resulted in higher uptake. Further the synergistic relationship between Fe and K both in soil and plant (Mortvedt, 1972) has resulted in greater uptake of K from soil. Similar observations were also reported by Samui *et al.* (1981) in mustard.

5.6.4 Sulphur

The sulphur uptake was significantly influenced by the application of Fe-EDTA. The highest sulphur uptake (8.54 kg/ha) was recorded in treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha at planting + 0.5% Fe-EDTA spray at 50 and 90 DAT compared to treatments receiving foliar application alone as well as control. Increased sulfur uptake by chilli plants was mainly due to the role of sulfur in the synthesis of ferrodoxins (iron-sulfur proteins) the essential molecules of chilli oleoresin. Hence application of Fe-EDTA either through soil or foliar spray has stimulated the uptake of sulfur as iron and sulfur are the constituents of ferrodoxins. The present results are in conformity with the observations made earlier by Prabhavathi (2007) in chilli.

5.7 IRON

Application of Fe-EDTA through soil + foliar spray had significantly increased iron uptake by chilli (Table 15). Treatment (T_{12}) receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA foliar spray at 50 and 90 DAT has recorded highest uptake of iron and was significantly higher than either foliar spray alone or control. Higher uptake of iron was mainly due to its increased availability in soil due to application of iron-chelate and absorption of Fe directly by leaves through foliar spray of Fe-EDTA. This absorbed Fe appears to play role in chlorophyll synthesis in leaves leading to enhanced photosynthesis ultimately dry matter yield. Further, stimulated growth of chilli plants due to applied RDF and FYM has further increased dry matter yield resulting into increased uptake of iron. The results of present investigation are in accordance with the results of Hellal (2004) in groundnut, Malawadi *et al.* (2004) in chilli, Jawaharlal and Veeraragavathatham (1988) in onion.

5.8 TOTAL IRON CONTENT IN CHILLI LEAVES AS INFLUENCED BY SOIL AND FOLIR APPLICAITON

5.8.1 Soil application of Fe-EDTA

Leaf samples of different treatments did not differ significantly with respect to total iron content analysed before soil application of Fe-EDTA (Table 16). This articulates the negligible effect of native soil iron as well as iron present in applied FYM (10 t/ha) in influencing the total iron concentration in leaves. But the same treatments differed significantly with respect to total iron content in leaves analysed after 5 days of application of Fe-EDTA to soil. Further treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha at planting recorded highest (363.25 ppm) total iron in leaves which was 39.20 per cent higher than T_7 that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha and 242.6 per cent higher than control (only RDF). This was mainly due to different doses of Fe-EDTA applied to soil coupled with chelation and solubilization of native iron by decomposing products of FYM resulting into differential uptake and assimilation of iron to produce chlorophyll and dry matter yield. The results of present investigation are in accordance with the reports of Basappa (1990) in groundnut and Hellal (2004) in groundnut.

5.8.2 Foliar application of Fe-EDTA at 50 DAT

Significant influence of Fe-EDTA foliar spray was noticed on the total iron content in leaves. Before and after 50 DAT spraying (Table 16). Treatment (T_8), receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha at planting + 0.5% foliar spray at 50 DAT recorded highest total iron (356.71 and 368.81 ppm before and after spray respectively) which was 39.7 and 41.1 per cent higher than treatment T_7 receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% foliar spray at 50 DAT. This might be due to higher iron availability in soil due to higher dose of Fe-EDTA applied and the direct uptake of ferrous iron by leaves through stomata resulting in higher production of chlorophyll and dry matter resulting in higher total iron content in leaves. It was observed that higher dose of Fe-EDTA application to soil resulted in higher iron content in leaves, which might be due to increased uptake of Fe on account of stimulated growth. Results of present investigation are in agreement with the observations made by Hellal (2004) in groundnut crop.

5.8.3 Foliar application of Fe-EDTA at 90 DAT

Significant influence of Fe-EDTA application on the total iron content in leaves was observed. Before foliar spray at 90 DAT highest total iron (363.71 ppm) was recorded in (T_8) receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + foliar spray at 50 DAT, which was 41.9 per cent more than T_7 receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% foliar spray at 50 DAT. But after foliar spray, highest total iron content (370.82 ppm) was recorded in treatment (T_{12}) receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar application of Fe-EDTA at 50 + 90 DAT which was 7.98 per cent higher than T_{11} receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% spray at 50 + 90 DAT. The higher total iron content in the treatments receiving soil + foliar application of iron could be due to increased iron availability in soil and the direct uptake of ferrous iron by leaves through stomata resulting in the higher chlorophyll synthesis, dry matter production and higher total iron content in leaves. Results of higher total iron content in leaves due to application of iron carriers was also reported by Katyal and Sharma (1980) in maize.

5.9 FERROUS IRON CONTENT IN CHILLI LEAVES AS INFLUENCED BY SOIL AND FOLIAR APPLICATION

5.9.1 Soil application of Fe-EDTA

Before soil application of Fe-EDTA, fresh leaf samples of different treatments did not differ significantly with respect to ferrous iron content (Table 17). This highlights the negligible effect of RDF and FYM in influencing the uptake of native iron from soil. But fresh leaf samples collected after 5^{th} day of soil application of Fe-EDTA differed significantly with respect to ferrous content in different treatments. The treatment that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha (T_8) recorded highest (20.37 ppm) ferrous iron in leaves, which was 66.90 per cent higher than treatment that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha. This could be due to increased iron availability in soil and the direct uptake of ferrous iron by leaves due to foliar spray resulting in higher production of chlorophyll, dry matter and higher ferrous iron content in leaves Similar observations were also reported Hellal (2004) in groundnut, crop grown on vertisol.

5.9.2 Foliar application of Fe-EDTA at 50 DAT

Significant influence of foliar nutrition of Fe-EDTA was observed on the ferrous iron content in leaves (Table 17). At 50 DAT before and after spraying with Fe-EDTA, highest ferrous iron (19.25 and 23.66 ppm before and after foliar spray respectively) were recorded in treatment T8 which was 67.3 and 65.2 per cent higher than T_7 treatment. This could be due to increased iron availability in soil on account of increased iron content in soil due to solubilization of native iron by organic acids produced during decomposition of FYM and chelation of native iron coupled with direct uptake of ferrous iron by leaves resulting in higher production of chlorophyll, dry matter and higher ferrous iron content in leaves (Kumbhar and Deshmukh, 1993).

5.9.3 Foliar application of Fe-EDTA at 90 DAT

Significant influence of iron nutrition (Fe-EDTA) was observed on the ferrous iron content in leaves (Table 17). However, before spraying at 90 DAT highest ferrous iron (21.70 ppm) content was recorded in T_8 receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 DAT, but was 63.1 per cent more than T_7 receiving soil application Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% foliar spray at 50 DAT. But after spraying at 90 DAT highest ferrous iron (23.50 ppm) was recorded in treatment (T_{12}) receiving soil application of EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 + 90 DAT, which was 54.3 per cent higher than treatment T_{11} receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% spray at 50 + 90 DAT. This could be due to increased iron availability in soil due to its soil application and the direct uptake of ferrous iron by leaves.

5.10 FERROUS IRON CONTENT IN FRESH GREEN FRUITS AS INFLUENCED BY FOLIAR APPLICATION

5.10.1 Foliar application of Fe-EDTA at 50 DAT

Significant difference existed between different treatments with respect to ferrous iron content in fresh green fruits (Table 18). At 50 DAT before and after spraying with Fe-EDTA, highest ferrous iron contents in fruits (15.82 and 18.10 ppm) was recorded in T_8 treatment, which was 58.5 and 47.7 per cent higher than T_7 treatment. This could be due to increased iron availability in soil on account of higher dose of Fe-EDTA applied to soil which supplies readily available form of Fe to plants coupled with direct uptake of ferrous iron by leaves given through foliar spray. This absored Fe either through soil or leaf has increased ferrous iron content in leaves.

5.10.2 Foliar application of Fe-EDTA at 90 DAT

Significant difference existed between different treatments with respect to ferrous iron content in green fruits (Table 18). However before spraying at 90 DAT, highest ferrous iron content (16.35 ppm) was recorded in T8 treatment which was 52.0 per cent more than T7 treatment. But after foliar spray at 90 DAT, treatment (T_{12}) receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray at 50 + 90 DAT recorded highest ferrous iron in fruits (19.25 ppm) and was 46.94 per cent higher than T_{11} receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 10 kg/ha + 0.5% Fe-EDTA spray at 50 + 90 DAT. This was attributed to greater translocation of iron from leaves to developing fruits because of greater availability of Fe through Fe-EDTA applied to soil along with direct absorption of Fe applied through foliar spray. Further ferrous iron present in green chilli fruits helps in improving quality attributes of red chilliles particularly oleoresin and colour value as discussed earlier. Hence high content of ferrous iron in green chillies is favourable for producing good quality fruits. Martinez *et al.* (1990) reported the role of ferrous iron content of leaves as closely related to colour value of fruits.

5.11 NUTRIENT STATUS OF SOIL

5.11.1 Available nitrogen, phosphorus and sulphur

The data presented in Table 19 revealed that, application of iron in the form of Fe-EDTA did not significantly influenced the available nitrogen, phosphorus and sulphur content in soil in different treatments at final picking stage. This was mainly due to the uniform dose of RDF (100:50:50 kg N, P_2O_5 and K_2O/ha) and FYM (10 t/ha) applied to all the plots as per package of practices. Further, Fe-EDTA applied to soil might not have significantly enhanced or decreased the uptake of N, P and S which are taken up by the plants in anionic forms. While iron is absorbed by plant in cationic form. Hence the interaction of Fe with N, P and S was not felt in influencing their uptake and indirectly their status in soil at harvest.

5.11.2 Available potassium

Available potassium content in soil samples of different treatments at final picking stage was significantly influenced by Fe-EDTA application (Table 19). The lowest available potassium content (335.63 kg/ha) was observed in T_{12}. This might be due to greater uptake of potassium (K) by plants and its further translocation to various parts including seed. Further FYM improved physico-chemical properties in the root environment that has resulted in increased vegetative growth, yield and yield component there by decreasing available K in soil. In addition to this, synergistic relation existed between Fe and K which resulted in enhanced uptake of K by plants due to application of Fe-EDTA (Mortvedt, 1986).

5.11.3 Available Zn, Mn and Cu

No marked differences were noticed with respect to DTPA-extractable Zn, Cu and Mn in soil at final picking stage of chilli as influenced by application of Fe-EDTA (Table 20). This might be due to the fact that, the applied Fe-EDTA either through soil or foliar spray might not significantly influenced the uptake of Cu, Zn and Mn by plants. This indicated that, these three micronutrients were taken by plants independent of Fe-EDTA application. The dose method and time of Fe-EDTA application might not have influenced the availability of these micronutrients in soil.

5.11.4 Available Fe

Available Fe content in soil in different treatments at final picking stage was significantly influenced by Fe-EDTA application (Table 20). Increase in DTPA-extractable Fe content with Fe-EDTA application might be due to formation of stable complexes of different stability with organic ligands. This has decreased their susceptibility for adsorption or fixation or precipitation reaction in soil, which has helped in keeping micronutrient (Fe) elements soluble and consequently more available to plants for longer period. The results of this investigation are in consonance with findings of Mann *et al.* (1978) in maize and wheat and Hellal (2004) in groundnut. The lowest Fe was obtained in treatment receiving no iron, due to more vegetative growth and root growth which released hydrogen ions, phenolic compounds and organic acids leading to increased availability and uptake of iron by chilli plants. Similar observations were recorded by Tiwari *et al*. (1984) and Papastylianou (1989).

5.12 CORRELATION STUDIES

5.12.1 Nutrient concentration of whole red fruit and pericarp component with quality attributes of red chilli fruits

Iron content of pericarp component bear significant positive relationship with colour value and oleoresin (r = 0.978** and r = 0.975**). This highlighted that there exist direct relationship between iron concentration in pericarp and quality attributes. This might be due to the role of iron in the synthesis of porphyrin molecules (ferrichrome, haematin and leg haemoglobin) which are structural components of capsanthin and capsorubins which constitutes 60-70 per cent of red colour pigment in chillies (Table 21) (Gross, 1991).

Oleoresin content of fruits is also related to iron concentration of pericarp component. This might be due to the role of iron in the synthesis of ferrodoxins (iron-sulfur proteins), this is essential constituent of oleoresin. Due to this reason iron present in whole red fruit get partitioned more in pericarp component compared respective seed component and higher concentration of potassium in whole fruit might have activated few enzymes leading to the synthesis of red colour pigments. Similarly, N and P contents of both whole fruit as well as pericarp component possessed the same relationship with both quality attributes. This might be probably due to their role in the synthesis of amino acids and other essential metabolites. However, further investigation is required to understand exact role of N and P in influencing the quality attributes.

5.12.2 Relationship of total iron and ferrous iron content of leaves with quality of chilli fruits

Ferrous iron content of fresh green leaves analysed after foliar spray with Fe-EDTA bears a direct and positive relationship with both quality attributes this was mainly due to the role of ferrous iron in the synthesis of chlorophyll leading to increased photosynthesis and inturn enhanced metabolites manufacture in leaves. Martinez *et al.* (1990) reported the positive relationship between iron (ferrous) concentration in leaves and colour value of fruits in chillies.

Similarly both the quality attributes were positively related to total iron content of leaves (dried). This is mainly due to the role of total iron in the synthesis of chlorophyll leading to increased photosynthesis and translocation of photosynthates to developing fruits. Similar findings were also made by Martinez *et al.* (1990).

5.13 ECONOMIC ANALYSIS

The highest B:C ratio (2.27) and net income (Rs.44575/ha) were obtained in the treatment (T_4) that received only 0.5% Fe –EDTA foliar spray at 50 DAT over rest of the treatments. The highest gross income (Rs. 73500/ha) was recorded in treatment (T_8) received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA spray at 50 DAT and highest cost of cultivation (Rs. 31485/ha) was observed in the treatment (T_{12}) that received soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 + 90 DAT. From Table 25, it was observed that, the B:C ratio was low for all the treatments that received soil + foliar application of Fe-EDTA. This was mainly due to the higher quantity of Fe-EDTA required for soil application coupled with foliar spray of EDTA. Thus the high cost of Fe-EDTA (Rs. 130/100 g) applied through soil as well as foliar spray has resulted in increased cost of cultivation. This also involves increased expenditure on labour because of EDTA application to soil as well as through foliar spray once or twice. Further the lower B:C ratio in these treatments (T_7 to T_{12}) might be due to the reason that the increased fruit yield and quality of these fruits have not appreciably compensated the cost of Fe-EDTA applied through soil and foliar spray.

5.14 RESULTS OF PRACTICAL UTILITY

Based on the present investigation it can be recommended that, application of Fe-EDTA to chilli crop through foliar spray at 0.5% concentration at 50 and 90 days after transplanting results in significant improvement colour value and oleoresin content in red chillies. It should be noted that the spray solution should be neutralized before spraying. This recommendation is best suited for chillies grown on Vertisol. If the soil contain lower content of Fe (<2.5 ppm) application of Fe through soil + foliar spray (0.5% at 50 DAT) is recommended to increase the colour value and oleoresin of fruits.

5.15 FUTURE LINE OF WORK

- Investigation needs to be carried out to study the role of iron on pungency and other chemical characteristics of chilli.
- These studies can also be taken up in performance of crops like tomato, carrot and beetroot on calcareous Vertisol.
- Effect of iron nutrition can also be studied using other chelating agents like EDDHA, NIT, Citric acid and HEDTA as sources of Fe.

6. SUMMARY AND CONCLUSIONS

A field investigation was conducted to study the method and time of application of Fe-EDTA levels on yield and quality attributes of chillies (Cv. Byadgi dabbi) at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad on a Vertisol during kharif 2007. The experiment comprised of totally twelve treatments with two methods of application (soil + foliar and foliar spray) and two doses of soil application with 0.5% foliar spray of Fe-EDTA given on 50 and 90 DAT. The experiment was laid out in randomized block design with three replications. The results of present investigation are summarized in this chapter.

- Growth attributes :

Among the growth attributes, number of branches and dry matter yield were significantly influenced by the methods and time of application of Fe-EDTA. Treatments receiving soil + foliar application of Fe-EDTA recorded higher dry matter yield than treatments receiving only foliar spray. Among the treatments receiving only foliar spray of Fe-EDTA, foliar spray twice (50 and 90 DAT) recorded higher dry matter yield than foliar spray once.

- Fruit yield :

Treatment that received Fe-EDTA soil application equivalent to Fe in 20 kg/ha $FeSO_47H_2O$ + 0.5% Fe-EDTA foliar spray at 50 DAT recorded highest fruit yield (10.5 q/ha). Treatments receiving only foliar spray of Fe-EDTA recorded significantly lower fruit yield when compared to treatments receiving soil + foliar spray. It was observed that foliar application of Fe-EDTA either once or twice recorded higher fruit yield than control.

Quality attributes :

Quality parameters differed significantly with Fe-EDTA application. Highest ascorbic acid content (178.90 mg/100 g) and lowest per cent discoloured fruits (5.53%) were recorded with Fe-EDTA soil application equivalent to Fe in 20 kg/ha $FeSO_47H_2O$ + 0.5% Fe-EDTA spray at 50 DAT, while highest colour value (228.73 ASTA units) and oleoresin content (16.76%) were observed in the treatment receiving soil application of Fe-EDTA equivalent to Fe in 20 kg/ha $FeS0_4.7H_2O$ + 0.5% foliar spray twice at 50 and 90 DAT. Soil + foliar application of Fe-EDTA resulted in higher quality attributes of chillies than foliar spray alone.

- Nutrient composition of whole chilli fruits and fruit components (pericarp and seed) :

Application of Fe-EDTA significantly influenced the concentration of nutrients in whole chilli fruits. Soil + foliar application of Fe-EDTA resulted in higher concentration of N, P, K and S in whole chilli fruits than foliar spray per se.. Further, higher dose of Fe-EDTA application to soil recorded higher assimilation of nutrients in fruits than lower dose. In addition to this, foliar spray twice (50 and 90 DAT) recorded higher concentration of nutrients in fruits than foliar spray once. Irrespective of the method, time and dose of Fe-EDTA application, only K and Fe nutrients get partitioned more in pericarp component compared to seed portion, while reverse is true with respect to other nutrients.

- Uptake studies :

Highest uptake of N and P were recorded with soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + foliar spray of Fe-EDTA at 50 DAT. Similarly highest uptake of K, S and Fe were registered with soil application of Fe-EDTA equivalent to Fe in 20 kg/ha $FeSO_4.7H_2O$ + 0.5% foliar spray of Fe-EDTA at 50 and 90 DAT at final picking stage.

- Total Fe content in leaves :

There was significant increase in total iron concentration in leaf samples after soil application or foliar spray with Fe-EDTA. Further soil + foliar spray of Fe-EDTA resulted in higher concentration of total Fe in leaves than foliar spray per se. Further higher dose of Fe-EDTA application to soil resulted in higher concentration of total Fe in leaves than lower dose and foliar spray twice recorded higher concentration than spraying once.

- Ferrous iron content in fresh leaves

After foliar spray or soil application there was significant increase in ferrous iron content in leaves and foliar spray twice recorded highest ferrous iron concentration than spraying once. Further, higher dose of Fe-EDTA application to soil resulted in higher concentration of ferrous iron in leaves than lower dose. Combined application of Fe-EDTA (soil + foliar spray) resulted in higher concentration of ferrous iron in leaves than foliar application per se.

- Nutrient status of soil at harvest

Neither the methods (soil or foliar application) nor the time, nor doses significantly influenced the available soil nutrient status particularly N, P and S at final harvest of chilli. This indicated the maintenance of nutrient balance in soil. But available potassium and iron contents were significantly lowered by iron nutrition.

B:C ratio

Treatment (T_4) receiving 0.5% Fe-EDTA foliar spray at 50 DAT recorded highest B:C ratio compared to treatments received Fe through soil or foliar.

CONCLUSIONS

- In a calcareous Vertisol soil application of Fe-EDTA equivalent to $FeSO_4$ @ 20 kg/ha at planting along with 0.5 per cent foliar spray at 50 days after transplanting is highly beneficial in terms of yield.
- 0.5 per cent spray of Fe-EDTA at 50 and 90 days after transplanting along with soil application and planting (equivalent to FeSO4 @ 20 kg/ha) produced chilli fruits of highest colour value and oleoresin content.
- Based on B:C ratio it can be concluded that one foliar spray of Fe-EDTA at 50 DAT is highly economical.

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* Original not seen.

APPENDIX-I

Prices of inputs and outputs

Sl. No.	Particulars	Price (Rs.)
I.	**INPUTS**	
1.	Seedlings	120.00 bed^{-1}
2.	Inorganic fertilizers	
a.	Urea (46% N)	5.00 kg^{-1}
b.	DAP (18% N and 46% P_2O_5)	9.90 kg^{-1}
c.	Muriate of potash (60% K_2O)	4.60 kg^{-1}
d.	Fe-EDTA	130.00/100 g
3.	Organic manures	
a.	FYM	450.00 t^{-1}
4.	Plant protection	
a.	Furadon	60.00 kg^{-1}
b.	Monocrotophos	260.00 l^{-1}
c.	Confidor	540.00/250 ml
d.	Dicofol	320.00 l^{-1}
e.	Magister	240.00/100 ml
5.	Labour charges	
a.	Men	70.00/day
b.	Women	50.00/day
c.	Bullock pair	200.00/day
II.	**OUTPUTS**	
a.	Red chillies (dried)	60.00 kg^{-1} and 70 kg^{-1} (Based on quality)

EFFECT OF IRON-EDTA ON YIELD AND QUALITY OF RED CHILLI (*Capsicum annuum* L.) IN A CALCAREOUS VERTISOL OF ZONE-8 OF KARNATAKA

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ABSTRACT

A field experiment was conducted to study the effect of iron-EDTA on yield and quality of red chilli (*Capsicum annuum* L.) in a calcareous Vertisol at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif* 2007. The experiment was laid out in a randomized block design with twelve treatments and three replications.

Soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% Fe-EDTA foliar spray at 50 DAT recorded highest fruit yield (10.5 q/ha), ascorbic acid (178.90 mg/100 g) and highest uptake of nitrogen and phosphorus at final picking stage. This was on par with all treatments receiving soil + foliar application of Fe-EDTA but differed significantly from control which recorded lowest values (7.65 q/ha, 127.61 mg/100 g).

Highest colour value (228.73 ASTA units), oleoresin (16.76%), potassium, sulphur and iron uptake were recorded in treatment receiving soil application of Fe-EDTA equivalent to $FeSO_4$ at 20 kg/ha + 0.5% foliar spray of Fe-EDTA at 50 and 90 DAT. This was on par with all treatments receiving both soil + foliar application of Fe-EDTA but differed significantly from control (163.16 ASTA units and 13.03%).

Total and ferrous iron contents analysed in dry and fresh green leaves on 5^{th} day after Fe-EDTA foliar spray respectively indicated a significant positive relationship with colour value and oleoresin contents.