YIELD AND PHYSIOLOGICAL RESPONSES TO NITROGEN LEVELS AND MICRONUTRIENTS IN CROSSANDRA (*Crossandra infundibuliformis* (L.) Nees)

Thesis submitted in part fulfillment of the requirements for the degree of Doctor of Philosophy in Horticulture to the Tamil Nadu Agricultural University, Coimbatore

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CERTIFICATE

This is to certify that the thesis entitled **"Yield and physiological responses to nitrogen levels and micronutrients in Crossandra (Crossandra infundibuliformis (L.) Nees)"** *submitted in partial fulfilment of the requirements for the award of the degree of* **Doctor of Philosophy (Horticulture)** *to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by* **Ms .P. Aruna** *under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.*

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(P.ARUNA)

Abstract

ABSTRACT

YIELD AND PHYSIOLOGICAL RESPONSES TO NITROGEN LEVELS AND MICRONUTRIENTS IN CROSSANDRA
(*Crossandra infundibuliformis* L. (Nees))

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In order to assess the influence of various nitrogen levels and micronutrients on the yield and physiological responses of crossandra, experiments were conducted during 1997-98 at Botanic gardens, Department of Floriculture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The field experiment was laid out in a split plot design with twenty five treatmental combinations replicated twice.

Nitrogen levels *viz.*, 0, 90, 120, 150, 180 kg ha-1 were assigned to main plots and micronutrients to subplots *viz.*, $ZnSO_4$ (25 kg ha^{-1}), $FeSO_4$ (50 kg ha^{-1}), soil application of

$ZnSO_4$ (25 kg ha^{-1}) along with the combination of $FeSO_4$ (50 kg ha^{-1}), foliar spray of $ZnSO_4$ (0.5 per cent) + $FeSO_4$ (1.0 per cent).

The results revealed that the treatment N_4M_4 (Combination of nitrogen 180 kg ha^{-1} along with combination of foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) recorded increased growth and yield. Yield increase is through increase in growth and other yield attributing characters like number of flowers per spike, number of spikes per plant, spike length, stalk length, diameter of flower and weight of flowers. Most of the physiological and biochemical constituents and nutrient contents was high in the treatment N_4M_4 contributing significantly towards yield.

Correlation analysis revealed that yield was significantly associated with most of the biometric characters.

Regarding multiple regression, the linear additive equations were fitted relating to growth characters, yield attributing characters, physiological and biochemical constituents and nutrient contents in crossandra. The linear additive equations are very much useful for predicting the yield of flowers.

The study clearly revealed that the treatment 180 kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) and $FeSO_4$ (1.0%) recorded the highest flower yield in crossandra.

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CHAPTER I

INTRODUCTION

Crossandra (***Crossandra infundibuliformis*** (L.) Nees.) is one of the important commercial flower crops cultivated in India, Tropical Africa and Madagascar. In India it is cultivated in an area of 1,716 ha producing 4.33 million kg of flowers. It is a common commercial flower in Tamil Nadu and Karnataka. The flowers are mainly used for personal adornment. Though non-fragrant, flowers are very popular, because of its attractive bright colour, light weight and good keeping quality. These are used for making garland either alone or in combination with Jasmine and other flowers.

Crossandra belongs to the family Acanthaceae. There are 20-25 species, but only a few like ***Crossandra infundibuliformis, C. guineensis, C. mucronata*** and ***C. sabaculis*** are cultivated. The species grown for commercial flower production is ***Crossandra infundibuliformis***. It is a small evergreen shrub producing flowers in dense sessile spikes. 0range, Delhi, yellow and sebaculis red are four different cultivars of the species. Orange crossandra is a tetraploid (2n=40); sets seeds profusely, breeds true due to apomictic nature and produces bright and orange coloured flowers. The cultivar Delhi is a triploid (2n=30) and produces more attractive flowers of bright deep orange colour. Propagation is done by means of cuttings. The Orange and Delhi are two types cultivated for higher flower production. To obtain economic yield in crossandra, optimum nutritional studies is more essential. It is necessary to maintain the fertility of the field to provide a continuous supply of nutrients to the plants to produce sufficient growth and flower spikes. Hence a systematic study is essential to assess the nutritional requirement of the crossandra to maintain productivity. It is necessary to find the optimum nutritional requirement of this high yielding variety.

The present study is taken up in crossandra cv. Delhi with the following objectives.

1. To assess the effect of graded levels of nitrogen on the growth, nutrition and yield of flowers.
2. To study the influence of micronutrients with different levels of N on the growth and yield attributes.
3. To fix the optimum and economic level of nitrogen for crossandra.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

Proper growth and yield expression in plants are influenced by the availability of essential macro and micronutrients. Nitrogen plays a major and important role in metabolism, growth and reproduction. It is an important constituent of proteins, nucleic acids, alkaloids, some vitamins and co-enzymes.

The supply of micronutrients in adequate amounts and in proper proportion is one of the many factors which control the growth of the plants. In the absence of these micronutrients, the plants are known to suffer from what are called physiological disorders which eventually lead to unbalanced growth, low crop yield and loss of quality. The role of micronutrients in various metabolic processes and the enzymes involved in these processes are elucidated by Zende (1990).

Micronutrients also affect the activities of several group of microorganisms thereby modifying the microbial processes influencing the supply of micronutrients in available forms in one way or the other. The importance of micronutrients in Indian Agriculture is fairly well recognized and their use has significantly contributed to the increase in crop productivity. It is necessary to recognize that micronutrients are as essential as major nutrients. Several crops respond well to application of micronutrients. Micronutrients have to be necessarily taken up by plants from soil/supplemented through soil/foliar/seed/root treatments for good growth and yield of crops and for achieving maximum use efficiency of applied N, P and K fertilizers. According to Natesan (1995), micronutrients though required in small quantities are as important and indispensable as any other essential nutrient for the plant. Application of nitrogen and micronutrients are very much essential for proper growth of the plant. The review of the available literature on these aspects has been presented in this chapter.

2.1. Effect of nitrogen and micronutrients on growth

2.1.1. Nitrogen

Kyle (1958) reported in chrysanthemum that ample supply of N ensures adequate size of the plant, length of stem and size of the leaf. Fernandes *et al.* (1974) stated in gladiolus that ammonium sulphate (15 and 20 g/sq. m) promoted vegetative growth. Nanjan and Muthuswamy (1974) obtained more number of shoots per plant (31.75) by application of 90 g N/plant in Edward rose. Increasing the levels of nitrogen had greater beneficial effect on stem height (Young *et al.*, 1976 and Niijar and Rehalia, 1977 in rose). Natarajan (1977) reported that application of 120 g of nitrogen per plant significantly increased the primary shoot leaf production in ***Jasminum grandiflorum***. Arora and Jhon (1978) found that increased levels of nitrogen increased the plant height and production in ***Zinnia elegans***.

Arora and Jaswinder Singh (1980) obtained increased plant height (76.00 cm) in african marigold by application of 40 g nitrogen per m^2. Increased amount of nitrogen produced large number of branches in ***Jasminum auriculatum*** (Muthuswamy and Pappiah, 1980). Abdul Khader *et al.* (1985) reported in crossandra that application of

N (62.5 kg ha^{-1}) in three split doses increased the plant height (91.36 cm) and number of branches per plant (6.97). Similar findings were reported by Barnett and Ornod (1985) and Yadav *et al.* (1985) in tuberose. Pal *et al.* (1985) observed that plant height was increased (68.9 cm) with the highest dose of nitrogen (35 g/sq.m) in ***Jasminum sambac.*** Tandon (1987) registered improved growth of the plants by nitrogen application through sheep manure (25 t ha^{-1}) and urea (75 kg ha^{-1}) which significantly increased the plant height, number of laterals and number of leaves in chrysanthemum. Similar trend was observed by Arulmozhiyan (1988) in marigold by the application of nitrogen at 120 kg ha^{-1}.

Hipp *et al.* (1988) obtained maximum growth of rooted cuttings of ***Salvia gregsii*** in pots with 200 ppm of nitrogen which was supplied at weekly intervals. High levels of nitrogen favourably influenced the production of flowering shoots, secondary and tertiary shoots.

Srinivasan (1988) observed in ***Jasminum sambac*** that application of nitrogen at 90 g per plant significantly increased the length of primary and secondary lateral shoots, length and width of the leaf.

Balasubramanian (1989) found that the application of three fourth of recommended dose of nitrogen (93.75 kg ha^{-1}) resulted in an increased growth in french marigold. Srinivasan *et al.* (1989) reported increase in length of primary and secondary laterals due to nitrogen at 60 g in ***Jasminum sambac***. Anamica and Lavania (1990) were of the opinion that application of 25 g nitrogen per plant recorded the best growth in terms of plant height and spread in marigold.

Jayanthi and Narayana Gowda (1990) reported in chrysanthemum that the highest plant height was recorded with 40 g of nitrogen (47.93 cm) compared to control (35.80 cm).

Prince *et al.* (1990) reported in chrysanthemum cvs. Bright Golden Anne and Torch that application of 200 ppm N produced vigorous plants with greater spread. Sindhu and Yamdagni (1990) found that 60 g nitrogen in combination with 30 g phosphorus gave the maximum plant height (80.80) and stem diameter (16.17). Avari and Patel (1991) reported that application of 200 kg N ha^{-1} produced maximum plant height, stem diameter, number of lateral branches in african marigold. John *et al.* (1991) suggested that application of 150 kg N ha^{-1} resulted in increased plant height and production of branches in ***Zinnia elegans***. Narayana Gowda *et al.* (1991) obtained increased plant height in tuberose with nitrogen at 120 kg ha^{-1}. Similar finding was reported by Sigedar *et al.* (1991) *in* ***Calendula officinalis***. Manonmani (1992) reported that application of twenty five per cent reduced dose of N and P increased the plant height, number of primary, secondary and tertiary branches in ***Jasminum sambac***. According to Mariappan (1992), maximum plant height and number of leaves were obtained with N at 120 kg ha^{-1} in marigold. Vasanthi (1994) observed increased plant height, number of primary, secondary and tertiary branches in ***Jasminum grandiflorum*** with nitrogen at 45 g per plant.

Naglaa and Hassan (1995) observed in ***Dracena*** species that slow release fertilizer sticks (containing N, P, K, Mg, S, Fe, Zn and Cu), one stick per pot (100 g per plant) every 6 months resulted in increased leaf number. Swaminathan (1995) obtained increased plant height (39.20 cm), number of branches (11.33), number of leaves (307.33), fresh weight of the shoot (281.67 g) and dry weight of the shoot (80.37 g) by application of nitrogen at 120 kg ha^{-1} applied once in 2 months in crossandra.

Ryagi and Nalawadi (1996) reported in Golden Rod (***Solidago canadensis*** L.) that the highest level of nitrogen (100 kg N ha^{-1}) recorded the maximum plant height (75.37 cm) and number of leaves per plant (54.40) whereas, minimum plant height (65 cm) and number of leaves (43.60) were recorded with no nitrogen. Suhuch *et al.* (1996) reported in poinsettia that leaf area and dry weight increased linearly in response to increasing fertilizer concentrations.

According to Muhammod Qshtiaq *et al.* (1998) reported maximum number of leaves per plant (13.91), number of roots per plant (22), root length (34.33 cm) and root weight (2.63 g) for plants given 19 g nitrogen + 16 g phosphorus in ***Ficus macrophylla***. Maximum plant height (33 cm) was reported for plants given 28 g N + 16 g P.

2.1.2. Micronutrients on growth

Sharova *et al.* (1977) reported in gladiolus that improvement in plant growth including leaf size was obtained by treatment of corms and corm lets with zinc. Absence of zinc resulted in decreased growth. Koriesh (1984) studied in chrysanthemum cv. Forester which were sprayed 4 times at monthly intervals. The best results with regard to growth was obtained with Fully Fertile (containing NPK + Zn + Fe and other micronutrients) at 0.3 per cent. Abdul Khader *et al.* (1985) studied on the effect of micronutrients on crossandra. The treatment T_3 [NPK (25:20:45 kg/acre) + FYM (20 t/acre)+ $ZnSO_4$ (0.5%)] was found superior. It increased the height (91.36 cm) and number of branches (6.97 cm).

2.2. Effect of nitrogen and micronutrients on yield

2.2.1. Nitrogen

Muthuswamy (1974) reported in roses that application of 120 g nitrogen in six split doses recorded the highest yield (1.89 kg of flower buds). Increase in size of flowers was noticed with nitrogen at 20 g/m^2 in carnation cv. Marguerite Scarlet (Arora and Saini, 1976). According to Muthuswamy and Pappiah (1976), application of nitrogen at 120 g per bush registered better yield in ***Jasminum auriculatum***.

Muthuswamy and Pappiah (1977) studied in ***Jasminum grandiflorum*** and found that 120 g of nitrogen per plant per year produced the maximum flower yield. Natarajan (1977) recorded highest flower yield with nitrogen at 60 g per plant applied in 12 split doses of ***Jasminum grandiflorum***. Nijjar and Rehalia (1977) also reported in rose cv. super star that nitrogen at 50 g significantly increased flower number, weight and diameter of flowers.

Application of nitrogen (15 g per plant) was found optimum for 5 year old bushes of red rose to obtain maximum flower yield of number and weight (Nanjan, 1979).

Similar result was observed by Pappiah *et al.* (1980) in jasmine. Rober *et al.* (1980) suggested in stock plants that optimum yield was obtained by weekly nitrogen application of 20 mg per litre. Yasui *et al.* (1980) found in carnation that the plants grew well with nitrogen at 75-125 ppm. The best results were obtained with nitrogen at 75 ppm. In ***Jasminum sambac***, application of 240 g of nitrogen per plant at bimonthly interval recorded the highest flower yield of 12.19 t ha^{-1} (Natarajan *et al.*, 1981).

According to Muthuswamy and Shanmugavelu (1982), good yield was obtained in ***Jasminum sambac*** with application of nitrogen and 240 g/plant/year at bimonthly intervals.

Natarajan and Madhava Rao (1983) reported that application of 60 g nitrogen in twelve split doses showed early flower bud emergence and maximum hundred bud weight in ***Jasminum grandiflorum***. Ramesh Kumar and Gill (1983) carried out a trial on the application of nitrogen to young plants of ***Jasminum sambac***, highest yield of 635.84 g of flower buds per plant was obtained with the application of 30 g of nitrogen applied in 2 equal split doses.

Pal *et al.* (1985) concluded in ***Jasminum sambac*** that application of higher dose of nitrogen (35 g per sq.m) increased the number of flowers and weight of flowers. Thus application of nitrogen significantly increased the flower production.

Higher doses of nitrogen significantly increased the number of flowers in african marigold (Rathore *et al.*, 1985). Arora and Khanna (1986) reported that nitrogen at 20 g per m^2 was found to be optimum which recorded flower yield of 7.06 kg per m^2, whereas control recorded only 4.16 kg per m^2 in marigold of single flower significantly in african marigold. Chezhiyan *et al.* (1986) obtained highest yields of 16.85 tonnes ha^{-1} in chrysanthemum with nitrogen at 20 g per plant. According to Mukhopadhyay and Banker (1986), nitrogen at 20 g m^{-2} recorded an increase in flower yield of 21.42 and 51.26 per cent over control in tuberose. Ravindran *et al.* (1986) obtained highest flower yield (142.48 q ha^{-1}) with the highest nitrogen rate (90 kg ha^{-1}) in african marigold.

Uma and Narayana Gowda (1987) reported that nitrogen at 16 g per plant recorded the maximum marketable flowers in rose cv. Super Star. Anuradha *et al.* (1988) registered increased flower production under increased level of nitrogen. Nitrogen was found to cause earliness in flowering and maximum number of big sized flowers and improved yield in marigold. The optimum dose recommended for crop production was nitrogen at 60 kg ha^{-1}.

Vijayakumar *et al.* (1988) suggested better response from China aster to increasing doses of nitrogen from 180 to 300 kg ha^{-1}. Highest flower yield i.e. 7.55 t ha^{-1} was recorded due to application of 300 kg N ha^{-1} in China aster. Application of nitrogen at 120 kg ha^{-1} recorded highest number of flowers per plant (152.2) and yield (53.41 tonnes ha-1) (Arulmozhiyan and Pappiah, 1989). Balasubramanian (1989) registered more number of spikes in tuberose with increase in the level of nitrogen up to

100 kg ha^{-1}. Anuradha *et al.* (1990) revealed that increasing levels of nitrogen increased the number of flowers per plant, single flower weight and flower yield in african marigold.

Banker and Mukhopadhyay (1990) studied in tuberose and found that nitrogen had significantly advanced (24.74 days) the days to emergence of flower spike in tuberose. Preethi (1990) opined that application of nitrogen at 37.5 kg ha^{-1} recorded more number of flowering shoots, less number of blind shoots, flower diameter and increased flower yield in Edward roses.

Yassin and Pappiah (1990) concluded in chrysanthemum that the highest flower yield of 253.82 g per plant was obtained with plants pinched on the 60^{th} day and fertilized with sheep manure and urea. Nadia Roude *et al.* (1991) opined that the visual grade of chrysanthemum increased with concentration of nitrogen from 225 to 337 mg/l. The maximum production of flowers and seeds was obtained with the application of 20 g N in cosmos (Jana and Pal, 1991) in Calendula (Sigedar *et al.*, 1991) with 100 kg N. Parthiban and Abdul Khader (1991) found maximum number of spikes/clump with 100 kg N respectively in tuberose.

Venkatesh and Nalawadi (1991) reported that N at 150 kg/ha recorded maximum flower yield (10.07 q/ha) on crossandra. Bhujbal *et al.* (1992) indicated that in rose cv. Gladiator, number of flowers/plant increased significantly with the increase in levels of NPK. Highest number of flowers (yield) was obtained with the combination of 60:10:20 g NPK along with the basal dose of 10 kg FYM/sq.m. Higaki *et al.* (1992) studied in anthurium and reported that maximum production of flowers and seeds were obtained with application of 312 kg N/ha. Increased N influenced the flower size and stem length.

Mariappan (1992) observed in marigold that N at 90 kg showed higher yield with increase in diameter. N at 60 kg ha^{-1} showed early flowering. Berlorkar *et al.* (1993) reported that N at 70 kg ha^{-1} produced the highest number of rachis ha^{-1} (132444), flowers per stalk (40.65) and flower yield (63.1 q ha^{-1}). Flower yield were higher with 400 kg N ha^{-1} than with 200 kg ha^{-1} in tuberose.

Sindhu and Gupta (1993) reported that yield of hybrid Tea Rose cv. Super Star was maximum (12.17 g) with N at 60 g/plant. Hazan *et al.* (1994) found in rose that flower stalk length was greater at 90 or 180 ppm N (159 and 172 cm respectively). Singh and Gupta (1995) found in ***Dahlia variablis*** that N at 75 mg/kg produced the highest number of tubers/plant (6.70) and the highest yield of tubers/plant (104.34 g) compared with control.

Swaminathan (1995) reported in crossandra increased spike length (20.67cm), number of flowers/spike (84.33), number of spikes/plant (94.33), and hence highest yield (192.03 g/plant) in the treatment 120 kg N/ha applied once in 2 months along with 70 kg K/ha. Zile Singh and Gupta (1995) observed in tuberose that nitrogen 75 mg/kg of soil proved to be most effective producing more number of tubers/plant (6.7), greater diameter (4.90 cm) and increased weight of tubers per plant (104.34 gm) as compared to control and other levels of nitrogen. Ryagi and Nalawadi (1996) supplied plants with 0, 25, 50, 75 or 100 kg N/ha. Flower yield was increased with increasing nitrogen application rate in Golden Red (from 6.41 to 6.85 t/ha at 0 and 100 kg N/ha). Singh *et al.* (1996) opined that bulb yields increased as N rate increased up to 30 g/plant in tuberose.

2.2.2. Micronutrients on yield

Boyarkiya and Klebenova (1973) were of the view that yield of flowers would decrease unless Fe-DTPA was applied at 0.3-0.4 cm^3/litre nutrient solution on growing roses in hydroponics. The application were made at 3 or 4 week intervals in the spring, 6 to 7 week intervals in the autumn and were discontinued during September. Sharova *et al.* (1977) reported in gladiolus that number of corms was increased by treatment of corms and cormlets with micronutrient solution.

Subramaniam (1982) observed in crossandra that foliar application of ferrous sulphate was beneficial in increasing flower yield of 67.6 per cent over control. Foliar application was found to be more effective than the soil application. Ferric citrate was better than ferrous sulphate. Koriesh (1984) found that in chrysanthemum cv. Forester, best flower quality was obtained with Fully Fertile at 0.3% which contains NPK+ Zn + Fe and other micronutrients.

According to Abdul Khader *et al.* (1985), increased spike length (10.70), greater number of flowers/spike (41.00) and hence increased yield (8.68 tonnes/ha) was obtained by application of $ZnSO_4$ (0.5%) + NPK (25:20:45 kg/acre) + FYM (20t/acre) in crossandra.

Roy Chowdhury and Sarkar (1995) observed in gladiolus that treatments with $FeSO_4$ and $AgNO_3$ hastened flower opening. Singh and Bhattacharjee (1997) opined that ferrous sulphate (2.0%) was the best treatment for promoting early flower opening and increased flower diameter and longevity. The plant had largest flower buds at harvest in rose.

2.3. Effect of nitrogen and micronutrients on growth and yield

2.3.1. Nitrogen

Fernandes *et al.* (1974) reported in gladiolus that ammonium sulphate (15 and 20 g/sq.m) has significantly promoted vegetative growth and yield. According to Jana *et al.* (1974), branching and flowering was increased in tuberose by increased nitrogen and suppressed by decreased nitrogen. He also further reported that increasing nitrogen and phosphorus increased number of leaves, bulbs, spikes and flowers.

Nijjar and Rehalia (1977) reported increased flower number (5), flower stem length (66.32 cm), flower diameter (10.90 cm) and flower weight (6.80 g) with increase in levels of N (50 g per plant) in rose.

Bose and Jana (1978) in the case of Bougainvillea and Gerbera have reported that NPK application markedly improved the growth and flowering. Bhattacharjee (1981) found that ***Dendrobium moschatum*** orchids grown in blocks of hardwood charcoal were fertilized fortnightly with N, P_2O_5 and K_2O at 0, 500 and 1000 ppm. He found that with increasing nitrogen level, there was marked improvement in vegetative growth and flowering. The earliest flower buds appeared with 500 ppm N.

Borelli (1984) observed in gladiolus that application of 30 g N/m^2 as NH_4 NO_3 increased the number of flowering shoots, corms and cormlets and improved all qualitative characters. High rates of N are needed to counteract the decline in spike quality. Jhon *et al.* (1981) studied the effect of nitrogen on growth and flowering of pansy (**Viola tricolor** L. var. Hiemalis). They found that the plants receiving 20 g N/m^2 were taller with greater spread over 10 g N/m^2 or control. Diameter of flowers, increased height and increased flower production were noted with N application at higher levels (20 g/m^2) in pansy.

Abdul khader *et al.* (1985) reported in crossandra that the treatment T_3 (NPK + FYM + $ZnSO_4$ (0.5%) was found superior. It increased the height, number of branches and yield/plant. Besides a greater number of branching shoots and increased height, this treatment recorded a greater number of flowers/spike.

Pal *et al.* (1985) studied the effect of nitrogen on growth and yield of flowers in ***Jasminum sambac***. Increased plant height and highest flower yield were recorded by application of N at 350 kg/ha.

Yadav *et al.* (1985) observed in tuberose that good plant growth and highest flower yield was obtained with N: P_2O_5 at 300:200 kg/ha. Chaturvedi *et al.* (1986) treated gladiolus with single or double sprays of Agromin (containing Zn, Fe + 2% N) at 0, 1000, 2000, 3000 and 4000 ppm were applied to the cv. Sylvia. Application at 3000 ppm improved plant height, increased the number of leaves and the floret size but delayed spike formation. Double sprays at 4000 ppm were most effective for longest duration of flowers with the longest spikes.

Chezhiyan *et al.* (1986) reported in ***Chrysanthemum indicum*** increase in number of branches, number of flowers/plant and yield under N_{20}, P_{20} and K_{20} levels of fertilizer application along with 5 kg FYM for CO-1 chrysanthemum. Ravindran *et al.* (1986) reported that in local cv. of african marigold, nitrogen levels (90 kg/ha) significantly increased the plant height (101.72cm) and earlier flowering (48.46 days). Size (7.38 cm), fresh weight of flower (6.97 cm) and pedicel length (8.7 cm) increased with increasing levels of nitrogen. According to Neumaier *et al.* (1987), the optimum conditions for growth of high quality plants was with fertilizer combination of 200 ppm N. Number of buds and flowers, plant size and flower diameter was increased in hibiscus.

Anuradha *et al.* (1988) revealed that high levels of N, increased the number of flowers/plant, single flower weight and flower yield in african marigold. Jana and Pal (1991) reported that in cv. Super Sunset, seedlings were transplanted in to sandy loam soil and treated with N at 0, 5, 10 or 20 g/m^2. Plant height (95.9 cm), number of leaves (18.22), number of branches (16.6), number of flowers per plant (354.4), flower stalk length (25.1 cm), flower diameter (5.8 cm), total flower weight (390.5 g/plant) and seed yield/plant (9.1 q/ha) was greatest with 20 g N/m^2 in cosmos.

Sigedar *et al.* (1991) reported in ***Calendula officinalis*** that application of 100 kg N had shown maximum growth and higher yield. Application of 100 kg N/ha had better effect in respect to number of leaves, height, spread, number of leaves and weight of flowers.

Barman and Pal (1994) reported in ***Calendula officinalis*** that plant height, number of leaves and seed yield was highest with 180 g N/plant.

Swaminathan (1995) observed in triploid crossandra, increased response to higher doses of N expressed as increase in plant height (39.20 cm), number of branches (11.33), number of leaves (307.33), number of flowers/spike (84.33) and spike length (20.67 cm).

El-Saeid *et al.* (1996) found that the number of flowers/plant were greatest with 60 kg N/ha in french marigold.

Belgaonkar *et al.* (1997) studied in annual chrysanthemum that when 200 kg N and 200 kg P_2O_5/ha were applied, the plant height were tallest (118.89 cm), had more primary and secondary branches (34.47 and 182.95) and took fewer days for flowering.

Smith and Elliot (1998) determined the effects of Ca and nitrogen for cut flower production of alstroemaria cv. Parigo Pink, flower production was not affected by

Ca supply, but increased with nitrogen supply to a maximum of 4 stems/plant on a weekly basis at 28.5 m mol N/litre.

2.3.2. Micronutrients

Koriesh (1984) reported that chrysanthemum cv. Forester were sprayed 4 times at monthly intervals. The best results with regard to growth and flower quality were obtained with Fully Fertile (containing NPK + Zn + Fe and other micronutrients) at 0.3%.

Abdul Khader *et al.* (1985) observed in crossandra that application of $ZnSO_4$ (0.5%) + NPK (25 : 20: 45 kg/acre) + FYM (20 tonnes/acre) were found to increase the height (91.36 cm),number of branches (6.97 cm) and yield/plant (8.68 t/ha). The spike length (10.70 cm) and number of flowers per spike (41.00) were also high in this treatment.

Leaf growth and flowering was improved by Fe application in ***Vinca rosea*** (Abo-Rady, 1988).

Lawfix (1997) reported in ***Lupinus hartweggii*** that foliar application of Fe or the mixture of Fe + Mn + Zn significantly increased number of branches per plant and yield etc.

2.4. Effect of nitrogen and micronutrients on growth, yield and physiology

2.4.1. Nitrogen

Thomas and Teoh (1983) studied in ***Ficus macrophylla*** that plants grown in peat: sand medium receiving three nitrogen levels (225, 300 or 375 g/m^2) recorded increased plant height, internode length, stem diameter, leaf area and foliar dry matter with 300 – 375 g N/m^3. Canover and Poole (1984) found that increasing N levels from 500 to 1500 kg/ha raised numbers and fresh weight in croton stock plants.

Dahab *et al.* (1987) observed in ***Aspidistra lucida*** that the total number of leaves increased steadily with increasing fertilizer rates and the highest rate (3.6 gm NPK/pot) gave the best results. However, fresh weight and dry weight reached their highest values when the plants were supplied with NPK at the lower rates (0.9 and 1.8 gm/pot). Combined application of sheep manure (25 t/ha) and urea (75 kg/ha) had significantly increased the plant height, number of laterals, number of leaves, leaf area and dry matter production in chrysanthemum (Mohammed Yassin, 1987).

Guistianiani (1988) reported in lilium that leaf area index, net assimilation rate, crop growth rate and uptake rates were found to be high with the application of 16 gm N/m^2 and it also gave better quality flowers. According to Srinivasan (1988), application of nitrogen at 90 g/plant significantly increased the length of primary and secondary lateral shoots, length and width of the leaf and leaf area in ***Jasminum sambac***. Vijayakumar *et al.* (1988) obtained better response from China aster by increasing doses of N from 180-300 kg/ha at 30 x 10 cm spacing with highest yield of 75 t/ha at 300 kg/ha and higher leaf area,Leaf area index, crop growth rate, net absorption rate, relative growth rate were the maximum with the application of 246 kg N/ha. Anamica and Lavania (1990) were of the opinion that application of 25 mg N/plant recorded the best growth in terms of plant height and spread, total leaf area, stem diameter and flower diameter. Daniel *et al.* (1992) reported in plants of ***Tagetes patula*** L. Honey comb and ***Impatiens walleriana*** 'Norette Red" that 100 mg N/litre produced maximum height after 55 days of planting. Chlorophyll content was significantly higher at 200 mg N/litre than at 100 mg N/litre treatment. Swaminathan (1995) observed higher Leaf area, Leaf area index, Crop growth rate and Relative growth rate in the treatment with 120 kg N/ha in crossandra.

Micronutrients

Abo-Rady (1988) found in ***Vinca rosea*** that soil treatments containing Fe (as EDDHA) were effective in overcoming chlorosis. Chlorophyll content, leaf growth and flowering were improved by Fe application.

Lee *et al.* (1996) studied in geranium and found that plant height were not affected by Fe until the concentration exceeding 5 mM (258 mg/litre). Fresh and dry weights of plants remained unaffected until solution Fe concentrations exceeding 3 mM (167 mg/litre). Leaf chlorophyll 'a' and chlorophyll 'b' as well as total chlorophyll contents increased at a greater ratio (85%) than chlorophyll 'a' (24%) up to 4 mM Fe.

Lawfix (1997) concluded in ***Lupinus hertweggi***, that foliar application of Fe or the mixture of Fe + Mn + Zn significantly increased plant dry weight, number of branches per plant, seed yield or weight of 100 pods.

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The experiment "Yield and physiological responses to nitrogen levels and micronutrients in Delhi crossandra (***Crossandra infundibuliformis*** (L.) Nees)" was carried out at the University Botanic Garden, Department of Floriculture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during the year 1997-98. The materials and methodology adopted are described below.

3.1. Location of the experimental site

The study was conducted as field experiment in the Botanic Garden, Department of Floriculture which is geographically situated at 11°02" north latitude and 76°57" east longitude at an altitude of 426.76 m above mean sea level, with an average annual rainfall of 631 mm, and mean maximum and minimum temperatures of 30°C and 26°C respectively. The relative humidity ranges between 75 and 89 per cent.

The chemical analysis of the soil in the experimental plot is furnished below.

Available Nitrogen	-	201.50 ppm
Available Phosphorus	-	10.02 ppm
Available Potassium	-	403.21 ppm
pH	-	8.5
EC	-	3 ds m^{-1}
Available Fe	-	8.22 ppm
Available Zn	-	0.32 ppm

3.2. MATERIALS

3.2.1. Cultivar

Crossandra infundibuliformis cv. Delhi was utilized for this study. It is a triploid (2n=30) and produces more attractive flowers of deep orange colour.

3.2.2. NPK and Micronutrients

The N, P and K were applied in the form of urea (46 per cent N), super phosphate (16 per cent P_2O_5) and muriate of potash (60 per cent K_2O). In case of micronutrients, Fe was applied in the form of Ferrous sulphate and Zn was applied in the form of zinc sulphate.

3.3. METHOD

3.3.1. Experimental design and layout

The experimental design and layout details are as follows.

Cultivar	-	Crossandra (*Crossandra infundibuliformis* L. (Nees)) cv. "Delhi"
Design	-	Split Plot Design
Number of treatments	-	25
Replication	-	2

3.3.2. Experimental details

Trial was laid out in Split-Plot Design with two replications. The lay out of the experimental field is presented in Fig.1

FIG.1 FIELD PLAN

N_0	M_1	M_4	M_2	M_3	M_0	M_1	M_2	M_3	M_4	M_0	N_1
N_1	M_2	M_3	M_1	M_0	M_4	M_2	M_1	M_0	M_3	M_4	N_4
N_2	M_3	M_2	M_4	M_1	M_0	M_1	M_0	M_2	M_4	M_3	N_3
N_3	M_0	M_1	M_2	M_4	M_3	M_4	M_3	M_2	M_1	M_0	N_2
N_4	M_4	M_2	M_0	M_3	M_1	M_3	M_4	M_2	M_0	M_1	N_0

Nitrogen with four levels along with the recommended dose of P and K of 50 kg ha^{-1} and 125 kg ha^{-1} respectively were assigned to the main plots and micronutrients were given as sub-plot treatments. In all, there are 25 treatment combinations. The details of the treatments are given below.

A. Main plot – Nitrogen

Treatments	Notation
1. 0 kg ha^{-1}	N_0
2. 90 kg ha^{-1}	N_1
3. 120 kg ha^{-1}	N_2
4. 150 kg ha^{-1}	N_3
5. 180 kg ha^{-1}	N_4

B. sub plot - Micronutrients

Treatments	Notation
1. 0 kg ha^{-1}	M_0
2. $ZnSO_4$ – 25 kg ha^{-1}	M_1
3. $FeSO_4$ – 50 kg ha^{-1}	M_2
4. $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})	M_3
5. Foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)	M_4

Treatment combinations (5 x 5 = 25)

1) N_0M_0
2) N_0M_1
3) N_0M_2
4) N_0M_3
5) N_0M_4
6) N_1M_0
7) N_1M_1
8) N_1M_2
9) N_1M_3
10) N_1M_4
11) N_2M_0
12) N_2M_1
13) N_2M_2
14) N_2M_3
15) N_3M_4
16) N_3M_0
17) N_3M_1
18) N_3M_2
19) N_3M_3
20) N_3M_4
21) N_4M_0
22) N_4M_1
23) N_4M_2
24) N_4M_3
25) N_4M_4

3.3.3. Production practices

In case of triploid crossandra cv. Delhi, plants were raised by rooting of herbaceous cuttings in the mist chamber. The experiment was laid out as split plot design. The rooted cuttings were planted at a spacing of 60 x 60 cm. Potassium and phosphorus at 125 kg ha^{-1} and 50 kg ha^{-1} respectively were applied as basal dose. Nitrogen was applied at four split doses *viz.*, initial, third month, sixth month and ninth month after planting. Micronutrients were given as soil and foliar applications. Foliar application of micronutrients were given 20^{th} day after planting . Two sprays were given at fortnightly intervals. The following observations were recorded.

3.4. BIOMETRIC CHARACTERS

3.4.1. Growth parameters

The observations were recorded at third month, sixth month, ninth month and twelfth month after planting. Five plants were selected at random and the following observations were recorded.

3.4.1.1. Plant height

The height of five randomly selected plants was measured at four stages as above and the mean height was expressed in cm.

3.4.1.2. Number of branches

The number of branches was counted at four stages and the mean value was calculated.

3.4.1.3. Number of leaves

The number of leaves was counted at four stages and the mean value was calculated.

3.4.1.4. Stem girth

The girth of the stem was calculated for five plants at four stages and the mean value was expressed in cm.

3.4.1.5. Leaf area

The leaf area was determined by the non-destructive method and the total leaf area was computed with the total number of leaves per plant and expressed in cm^2 (Swaminathan *et al.*, 1994).

3.4.1.6. Leaf area index (LAI)

The LAI was determined using the formula of Williams (1946).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Spacing}}$$

3.4.1.7. Specific leaf area (SLA)

Employing the formula of Kvet *et al.* (1971), SLA was calculated by using leaf area and leaf dry weight and expressed in cm^2/mg.

$$SLA = \frac{\text{Leaf area per plant}}{\text{Leaf dry weight per plant}}$$

3.4.1.8. Specific leaf weight (SLW)

Specific leaf weight was calculated by using the formula of Pearce *et al.* (1968) and expressed in mg/cm^2.

$$SLW = \frac{\text{Leaf dry weight per plant}}{\text{Leaf area per plant}}$$

3.4.1.9. Fresh weight of the shoot

The plants were uprooted at 3 months interval and the above ground portion was cut and weighed. Mean was calculated and expressed in g per plant.

3.4.1.10. Dry weight of the shoot

The fresh shoots were initially sun dried and then dried in hot air oven at 60°C for 24 hours. The dry weight was recorded and mean dry weight was expressed in g per plant.

3.4.1.11. Fresh weight of the root

The plants were uprooted at 3 months interval and below ground portion was cut and weighed. Mean was calculated and expressed in g per plant.

3.4.1.12. Dry weight of the root

The fresh roots were initially sun dried and then in hot air oven at 60°C for 24 hours. The dry weight of the root was recorded and expressed in g per plant.

3.4.1.13. Shoot-root ratio

Shoot-root ratio was calculated on weight basis taking in to account the dry weights of shoot and root.

$$\text{S/R ratio} = \frac{\text{Shoot dry weight}}{\text{Root dry weight}}$$

3.4.1.14. Dry matter production

Whole plant samples were first sun dried and then kept in an oven at 60°C for complete drying. The dry weight of the whole plant was recorded and expressed in g per plant.

3.4.2. Yield attributing characters

3.4.2.1. Time taken for spike emergence

The number of days taken for spike emergence from the data of transplanting was recorded and expressed as mean number of days.

3.4.2.2. Time taken for first harvest in a spike

The number of days taken from the date of transplanting to first harvest was recorded and expressed as mean number of days.

3.4.2.3. Time taken for completion of harvest in a spike

The number of days taken by a spike to complete harvesting of flowers was recorded and expressed as mean number of days.

3.4.2.4. Number of flowers per spike

The total number of flowers produced in each spike was recorded and the mean was computed and expressed as number of flowers per spike.

3.4.2.5. Number of spikes per plant

The total number of spikes produced by the plant was recorded for five plants and the mean was computed.

3.4.2.6. Spike length

The length of the spike was measured in the five randomly selected plants and their mean was computed and expressed in cm.

3.4.2.7. Stalk length

The length of the flower stalk was measured in the five randomly selected plants and their mean was computed and expressed in cm.

3.4.2.8. Weight of 100 flowers

The weight of 100 randomly selected flowers was recorded and expressed in g.

3.4.2.9. Yield per plant

The fully opened flowers were harvested from each treatment of the randomly selected five plants and weighed. The mean value was worked out per plant and expressed in grams. The yield per hectare was computed and expressed in kg per hectare.

3.4.3. Physiological and biochemical constituents

3.4.3.1. Chlorophyll contents

Chlorophyll 'a', 'b' and total chlorophyll contents of leaves were estimated as per the method suggested by Wellbern and Lichtenthaler (1984).

3.4.3.2. Crop growth rate (CGR)

The CGR was estimated by adopting the formula of Watson (1958) and expressed in $g/m^2/day$

$$CGR = \frac{W_2 - W_1}{P(t_2 - t_1)}$$

W_1	-	Whole plant dry weight at t_1
W_2	-	Whole plant dry weight at t_2
P	-	Land area occupied by the plant
$(t_2 - t_1)$	-	Time interval in days between stages

3.4.3.3. Relative growth rate (RGR)

The RGR was determined on the basis of the formula suggested by Williams (1946) and expressed in $g/m^2/day$.

$$RGR = \frac{Log_e W_2 - log_e W_1}{(t_2 - t_1)}$$

where,

W_1	-	Whole plant dry weight at t_1
W_2	-	Whole plant dry weight at t_2
$(t_2 - t_1)$	-	Time interval in days between stages

3.4.3.4. Net assimilation rate (NAR)

The net assimilation rate was calculated using the formula of Williams (1946) and expressed in $mg/m^2/day$

$$NAR = \frac{\log_e L_2 - \log_e L_1}{L_2 - L_1} \times \frac{W_2 - W_1}{t_2 - t_1}$$

W_1 and W_2 - Dry weight of the whole plant at t_1 and t_2 respectively

L_1 and L_2 - Leaf area at time intervals of t_1 and t_2 respectively

t_1 and t_2 - Time in days.

3.4.3.5. Soluble protein content

Estimation of soluble protein content was carried out according to Lowry's method (1951) and expressed as mg/g of fresh leaf.

3.4.3.6. Nitrate reductase (NRase)

Nirtate reductase activity in leaf was determined by the method of Nicholas *et al.* (1976). The enzyme activity was expressed in µg/g/hr.

3.4.3.7. Catalase

Catalase activity of the leaf was expressed as per the method suggested by Gopalachari (1963) and expressed in µ moles of H_2O_2 100 g^{-1} of fresh weight hr^{-1}.

3.4.3.8. IAA oxidase

IAA oxidase activity was assessed calorimetrically as proposed by Parthasarathy *et al.* (1970) and expressed in µ gm of unoxidised auxin g^{-1} hr^{-1}.

3.4.3.9. Peroxidase

The peroxidase activity was determined by the method suggested by Perur (1962). The activity was expressed in µg g^{-1} hr^{-1}.

3.4.3.10. Tryptophan content

The method outlined by Bernandez and Bates (1969) was followed and the values were expressed in µg g^{-1}.

3.4.4. Nutrient contents

3.4.4.1. Foliar and flower analysis

Total nitrogen, phosphorus and potassium in the leaf samples and flower samples were estimated by the following methods and expressed in per cent.

The estimation was done on 3rd, 6th, 9th and 12th month of planting.

Total nitrogen	-	Micro kjeldhal method (Humphries,1956 and Yoshida *et al.*,1971)
Total phosphorus	-	Triacid extract digestion following vanadomolybdate phosphoric acid yellow colour method (Jackson, 1973)
Total potassium	-	Triacid extract flame photometric method (ELICO), Jackson (1973)
Iron and Zinc	-	Triacid extract fed in to atomic absorption spectrophotometer (Lindsay and Norvell, 1978)

3.4.4.2. Soil analysis

Composite soil samples were taken from the experimental plots up to a depth of 30 cm. The samples were analysed and expressed as kg/ha. The estimations were done on 3rd, 6th, 9th and 12th month of planting.

Available Nitrogen (Subbiah and Asija, 1956)

Available Phosphorus (Olsen *et al.*, 1954)

Available Potassium (Stanford and English, 1949)

Iron and Zinc : Triacid extract fed in to atomic absorption spectrophotometer (Lindsay and Norvell, 1978).

3.5. Economics

The economics of the different treatments were worked out in order to compare the efficacy of the treatments and cost benefit ratio was worked out from the net return and gross cost accounting for variable cost only.

3.6. Statistical analysis

The data collected from the above experiments were subjected to statistical analysis as per Gomez and Gomez (1984) using the PC-AT computer.

Experimental Results

CHAPTER IV

EXPERIMENTAL RESULTS

The results obtained in the study on yield and physiological responses to nitrogen levels and micronutrients on crossandra (***Crossandra infundibuliformis*** L. (Nees)) are presented below

4.1. Growth characters

The growth attributes such as plant height, number of branches, number of leaves, stem girth, leaf area, leaf area index, specific leaf area, specific leaf weight, fresh and dry weight of the shoot, fresh and dry weight of the root, shoot root ratio and dry matter production at four stages of growth (3^{rd} month, 6^{th} month, 9^{th} month and 12^{th} month after planting) due to the application of nitrogen and micronutrients are presented.

4.1.1. Plant height (Table 1, Fig. 1a)

The plant height showed progressive increase during the study.

With increasing levels of N, there was significant increase in plant height. Treatment N_4 registered increased plant height of 19.44, 23.85, 24.91 and 32.56 cm at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month of planting respectively.

Application of micronutrients recorded significant effects at all stages of crop growth. Foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) recorded increased plant height at 3^{rd} (15.64 cm), 6^{th} (21.44 cm), 9^{th} (22.80 cm) and 12^{th} month (29.61 cm) respectively

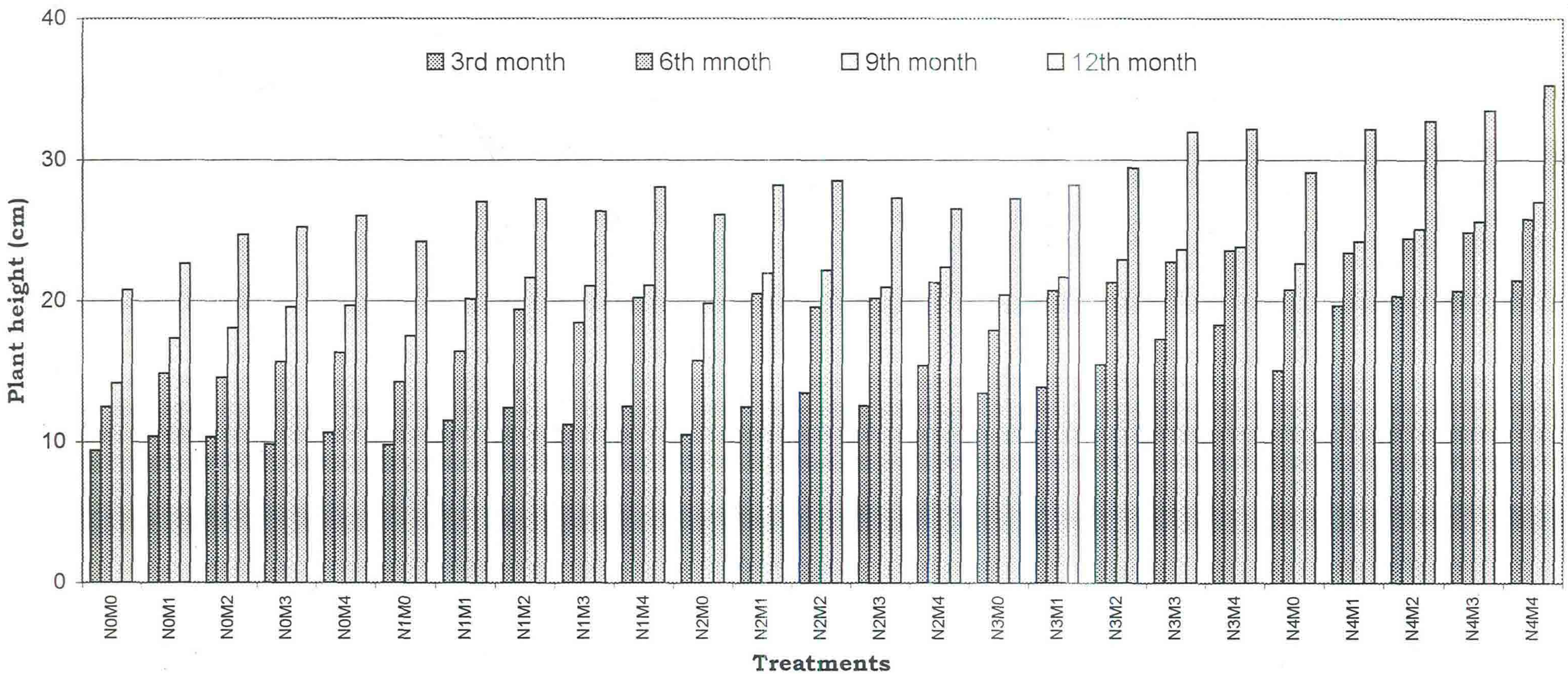
Table 1. Effect of nitrogen and micronutrients on plant height (cm) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	9.36	10.39	10.25	9.79	10.63	10.09	12.46	14.86	14.58	15.68	16.35	14.79
N_1	9.78	11.49	12.41	11.20	12.53	11.49	14.25	16.42	19.38	18.45	20.21	17.74
N_2	10.50	12.47	13.55	12.55	15.39	12.90	15.77	20.50	19.56	20.17	21.31	19.46
N_3	13.45	13.87	14.48	17.27	18.20	15.46	17.89	20.72	21.30	22.75	23.56	21.25
N_4	15.07	19.68	20.31	20.70	21.43	19.44	20.80	23.39	24.41	24.86	25.78	23.85
Mean	11.63	13.58	14.20	14.31	15.64	13.87	16.24	19.18	19.85	20.38	21.44	19.42
	9th month						12th month					
N_0	14.18	17.36	18.10	19.56	19.68	17.78	20.75	22.63	24.66	25.20	26.06	23.86
N_1	17.53	20.14	21.62	21.06	21.08	20.29	24.19	27.01	27.18	26.32	28.02	26.55
N_2	19.83	21.95	22.17	20.98	22.40	21.47	26.09	28.18	28.51	27.26	26.50	27.31
N_3	20.43	21.65	22.90	23.61	23.81	22.48	27.25	28.22	29.41	31.92	32.16	29.80
N_4	22.63	24.19	25.08	25.01	27.01	24.91	29.08	32.16	32.72	33.50	35.30	32.56
Mean	18.92	21.06	21.98	22.17	22.80	21.39	25.48	27.64	28.50	28.84	29.61	28.01

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.087	0.240	0.170	0.471
M	0.068	0.142	0.143	0.298
N at M	0.161	0.368	0.332	0.752
M at N	0.152	0.317	0.319	0.665

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.112	0.311	0.312	0.867
M	0.177	0.370	0.223	0.466
N at M	0.372	0.800	0.545	1.260
M at N	0.397	0.827	0.500	1.042

Fig.1.Effect of nitrogen and miconutrients on plant height (cm)



followed by soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1}) which recorded increased plant height of 14.31, 20.38, 22.17, 23.84 cm at different stages of crop growth respectively.

The treatment N_4 (180 kg N ha^{-1}) with M_4 [foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] showed increased plant height of 21.43, 25.78, 27.01 and 35.30 cm during 3rd, 6th, 9th and 12th month after planting respectively. The control recorded lowest plant height *viz.*, 9.36, 12.46, 14.18 and 20.76 cm during 3rd, 6th, 9th and 12th month after planting respectively.

4.1.2 Number of branches

The data on number of branches per plant are presented in Table 2.

Application of different levels of nitrogen along with micronutrients showed significant results on number of branches at different growth stages. Among different levels of N, treatment N_4 registered increased number of branches at 3rd month (4.20), 6th month (12.31), 9th month (16.45) and 12th month (17.87). Treatment M_4 recorded increase in number of branches at all stages of crop growth.

The treatment N_4M_4 recorded maximum number of branches at 3rd (4.80), 6th (13.51), 9th (17.69) and 12th month (19.60). The treatment N_4M_3 (16.85) was statistically on par with N_4M_2 at 9th month (16.85).

Table 2. Effect of nitrogen and micronutrients on number of branches per plant during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.35	2.71	2.82	2.79	3.05	2.75	6.25	7.75	8.25	7.87	8.82	7.79
N_1	3.06	3.10	3.09	3.16	3.19	3.12	7.69	9.50	10.41	9.60	10.79	9.60
N_2	3.15	3.42	3.73	3.69	3.77	3.55	8.76	10.40	9.29	9.80	10.19	9.69
N_3	3.39	3.79	3.88	3.84	3.82	3.75	9.78	10.39	11.49	11.10	11.21	10.80
N_4	3.29	4.19	4.40	4.32	4.80	4.20	10.11	11.21	13.86	12.82	13.51	12.31
Mean	3.05	3.44	3.59	3.56	3.73	3.47	8.52	9.85	10.66	10.24	10.91	10.04
	9th month						12th month					
N_0	8.12	10.42	11.14	9.80	11.35	10.17	8.70	11.05	11.66	11.12	12.30	10.97
N_1	10.00	11.30	13.18	12.18	13.49	12.04	11.00	12.45	14.08	14.23	15.37	13.43
N_2	10.41	13.42	12.80	12.68	13.75	12.62	11.42	13.91	13.08	12.41	14.35	13.04
N_3	11.76	13.85	14.16	14.10	14.15	13.61	12.39	14.20	14.99	15.10	15.19	14.38
N_4	15.20	15.67	16.85	16.85	17.69	16.45	16.23	17.09	17.86	18.56	19.60	17.87
Mean	11.10	12.93	13.63	13.13	14.09	12.98	11.95	13.75	14.34	14.29	15.37	13.94

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.012	0.034	0.026	0.071
M	0.017	0.036	0.027	0.056
N at M	0.037	0.079	0.060	0.132
M at N	0.039	0.080	0.060	0.126

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.026	0.072	0.147	0.407
M	0.036	0.075	0.122	0.254
N at M	0.077	0.166	0.284	0.645
M at N	0.081	0.169	0.272	0.568

4.1.3 Number of leaves (Table 3, Fig. 2)

The number of leaves were high with increase in levels of nitrogen. Among different levels of N, the treatment N_4 registered increased number of leaves at 3rd (24.43), 6th (135.76), 9th (221.00) and 12th month (270.27).

Number of leaves due to the application of micronutrients varied significantly. Treatment M_4 recorded the highest number of leaves at different stages of growth.

The highest number of leaves was recorded in the treatment N_4M_4 at 3rd month (25.33) followed by N_4M_3 (24.56) which was on par with N_4M_2 (24.50) and N_4M_1 (24.26). N_4M_4 recorded higher value at 6th month (149.80), 9th month (224.69) and 12th month (281.95). N_4M_3 (222.17) and N_4M_2 (221.80) were on par at 9th month and N_4M_3 (273.60) and N_4M_2 (276.25) were on par at 12th month of planting respectively.

4.1.4. Stem girth

Application of nitrogen and micronutrients exhibited significant differences at all stages of crop growth (Table 4).

Treatment N_4 recorded significant results at 3rd month (2.05 cm), 6th (3.30 cm), 9th (7.90 cm) and 12th month (7.96 cm).

Foliar application of Micronutrients (M_4) also exerted significant influence at 3rd (1.91 cm), 6th (3.17 cm), 9th (7.32 cm) and 12th month (7.34 cm). M4 was on par with M_3 (7.20 cm) at 9th month.

Fig.2.Effect of nitrogen and micronutrients on number of leaves per plant

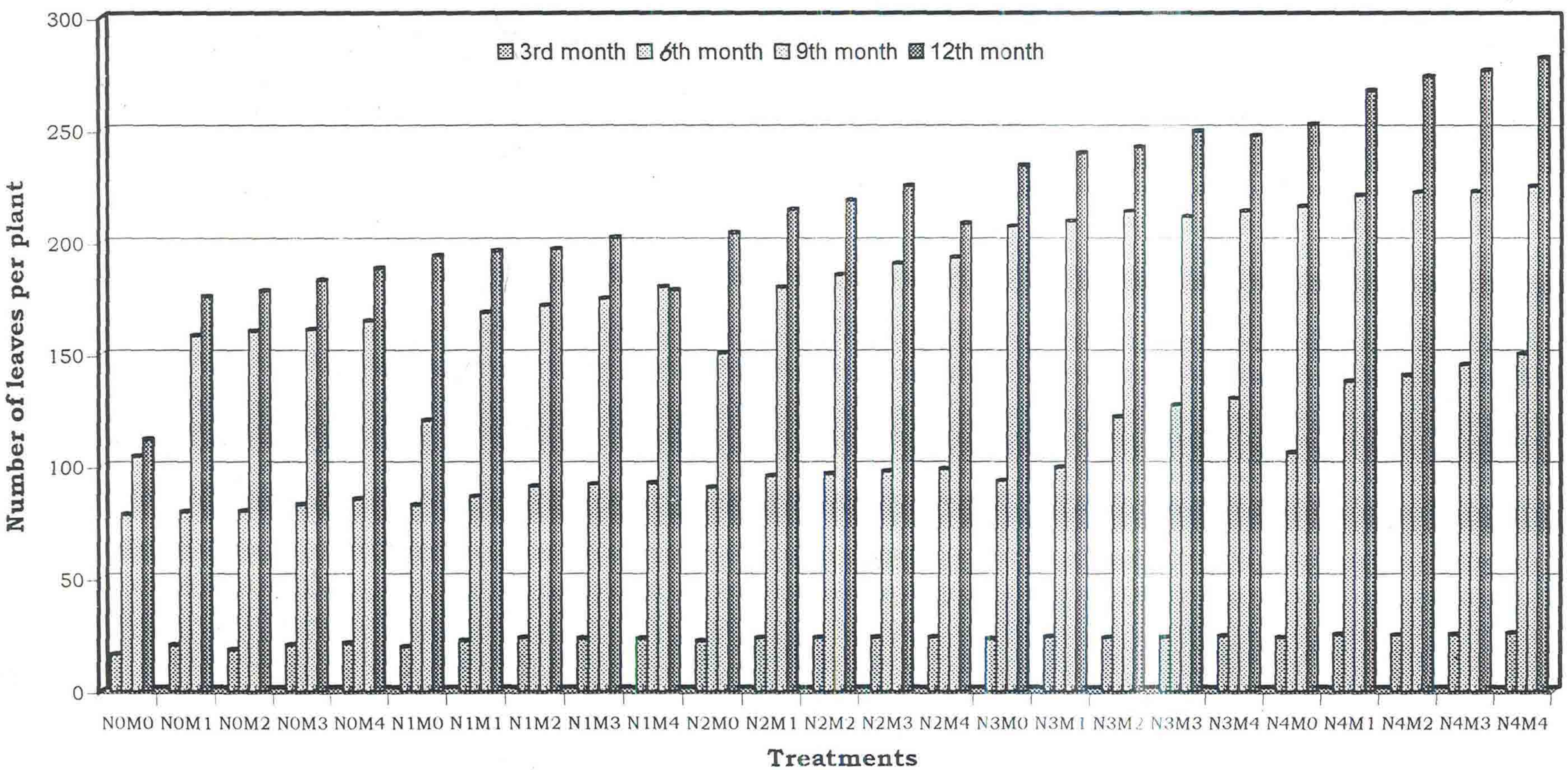


Table 3. *Effect of nitrogen and micronutrients on* number of leaves per plant during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	16.21	20.11	18.20	20.15	21.17	19.17	78.17	79.41	79.55	82.70	85.20	81.01
N_1	19.35	22.24	23.38	23.11	23.18	22.26	82.36	86.27	90.57	91.80	92.18	88.64
N_2	21.93	23.49	23.49	23.66	23.64	23.24	90.45	95.50	96.55	97.45	98.37	95.67
N_3	22.96	23.83	23.41	23.69	24.10	23.60	93.29	99.21	121.69	127.17	129.92	114.26
N_4	23.47	24.26	24.50	24.56	25.33	24.43	105.74	137.67	140.45	145.15	149.80	135.76
Mean	20.79	22.79	22.61	23.03	23.49	22.54	90.00	99.61	105.76	108.86	111.09	103.07
	9th month						12th month					
N_0	104.32	158.15	160.21	160.81	164.79	149.66	111.85	175.75	178.16	182.90	188.30	167.39
N_1	120.21	168.49	171.81	174.70	180.08	163.06	146.55	193.80	196.05	196.70	202.00	187.02
N_2	150.31	179.74	185.19	190.20	193.09	179.71	178.45	204.05	214.45	218.45	224.90	208.06
N_3	206.71	209.07	213.47	211.10	213.50	210.78	232.90	239.40	242.45	249.25	247.10	242.22
N_4	215.66	220.68	221.80	222.17	224.69	221.00	252.20	267.35	273.60	276.25	281.95	270.27
Mean	159.45	187.23	190.50	191.80	195.23		184.39	216.07	220.94	224.71	228.85	214.99

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.203	0.564	0.401	1.115
M	0.070	0.145	0.297	0.618
N at M	0.246	0.629	0.716	1.649
M at N	0.156	0.325	0.663	1.383

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.153	0.424	0.616	1.709
M	0.279	0.583	0.592	1.234
N at M	0.579	1.236	1.334	2.979
M at N	0.625	1.302	1.323	2.760

Table 4. Effect of nitrogen and micronutrients on stem girth per plant (cm) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.90	1.60	1.55	1.61	1.74	1.48	2.03	2.08	2.50	2.67	2.65	2.39
N_1	1.58	1.78	1.80	1.86	1.88	1.78	2.46	2.95	3.14	3.13	3.15	2.97
N_2	1.80	1.85	1.86	1.90	1.92	1.87	2.66	3.12	3.14	3.17	3.20	3.06
N_3	1.90	1.90	1.84	1.93	1.92	1.90	3.01	3.25	3.30	3.45	3.48	3.20
N_4	2.02	2.01	2.05	2.07	2.08	2.05	3.06	3.33	3.34	3.35	3.36	3.30
Mean	1.64	1.83	1.82	1.82	1.91	1.82	2.65	2.95	3.09	3.16	3.17	3.00
	9th month						12th month					
N_0	5.02	6.00	6.12	6.23	6.33	5.95	5.11	6.15	6.20	6.27	6.45	6.04
N_1	6.15	6.80	6.72	6.86	6.88	6.68	5.80	6.80	6.82	6.84	6.80	6.61
N_2	6.13	7.02	7.11	7.15	7.20	6.93	6.10	7.00	7.13	7.18	7.21	6.93
N_3	6.78	7.30	7.46	7.52	7.82	7.38	6.80	7.34	7.49	7.54	7.85	7.41
N_4	7.04	7.85	8.03	8.20	8.35	7.90	7.07	7.88	8.19	8.27	8.37	7.96
Mean	6.23	7.00	7.09	7.20	7.32	5.95	6.18	7.04	7.17	7.22	7.34	6.99

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.002	0.004	0.004	0.010
M	0.002	0.004	0.004	0.009
N at M	0.004	0.009	0.009	0.020
M at N	0.004	0.009	0.009	0.019

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.052	0.145	0.003	0.009
M	0.068	0.142	0.002	0.005
N at M	NS	NS	0.006	0.013
M at N	NS	NS	0.005	0.011

The interaction between N and M did not show significant effects during 9th month. At 3rd month and 6th month, the treatment N_4M_4 registered increased stem girth of 2.08 cm and 3.36 cm respectively followed by N_4M_3 which recorded stem girth of 2.07 and 3.35 cm respectively. At 12th month, treatment N_4M_4 recorded increased stem girth of 8.37 cm, followed by N_4M_3 (8.27) and the least increase was recorded by control (N_0M_0) with 5.11 cm.

4.1.5 Leaf Area

The data on leaf area per plant are presented in Table 5. Leaf area increased with increased nitrogen and micronutrient levels.

N application influenced the leaf area at different stages of growth. At 3rd month, the treatment N_4 (543.80 cm^2) recorded the highest leaf area followed by treatment N_3 (526.81 cm^2). Treatment N_4 registered the highest leaf area at 6th month (2989.67 cm^2), 9th month (4842.61 cm^2) and 12th month (5890.67 cm^2).

Leaf area exhibited significant differences for application of micronutrients. Treatment M_4 recorded the highest leaf area at 3rd month (517.14 cm^2), 6th month (2439.23 cm^2), 9th month (4281.19 cm^2) and 12th month (4987.66 cm^2).

The plants receiving 180 kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) recorded the highest leaf area of 572.15 and 3222.28 cm2 at 3rd and 6th month respectively. At 9th month, the treatment N_4M_2 recorded the highest leaf area

Table 5. Effect of nitrogen and micronutrients on leaf area per plant (cm^2) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	394.79	424.61	411.04	421.04	439.67	418.23	1731.22	1760.27	1764.11	1834.83	1886.55	1793.40
N_1	471.70	493.15	519.20	513.35	515.36	502.55	1821.81	1912.74	2007.51	2034.72	2043.15	1963.99
N_2	484.74	431.58	521.55	525.49	523.78	497.43	2004.76	2116.84	2140.86	2160.91	2163.55	2117.39
N_3	523.21	529.29	520.66	526.17	534.73	526.81	2117.31	2199.23	2697.43	2686.06	2880.62	2516.14
N_4	519.13	538.15	545.36	544.21	572.15	543.80	2344.10	3051.38	3113.18	3217.37	3222.28	2989.67
Mean	478.71	483.35	503.56	506.05	517.14	497.77	2003.84	2208.10	2344.62	2386.78	2439.23	2276.52
	9th month						12th month					
N_0	2311.81	3507.16	3552.55	3561.19	3602.70	3307.08	2478.95	3881.24	3932.07	4004.99	4095.37	3678.53
N_1	2666.21	3727.71	3819.52	3874.16	3993.41	3616.20	3361.51	4296.78	4306.72	4340.72	4461.17	4153.38
N_2	3341.80	3984.92	4101.83	4206.98	4280.91	3983.29	3955.12	4504.40	4701.68	4804.02.	4901.51	4573.35
N_3	4581.96	4637.15	4646.93	4602.66	4702.76	4634.29	5162.20	5252.75	5275.56	5501.69	5453.60	5329.16
N_4	4783.20	4873.85	4908.16	4821.65	4826.19	4842.61	5444.64	5911.41	6045.86	6024.80	6026.64	5890.67
Mean	3536.99	4146.16	4205.80	4213.33	4281.19	4076.69	4080.48	4769.31	4852.38	4935.24	4987.66	4725.02

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.318	0.881	6.436	17.870
M	0.515	1.074	6.197	12.926
N at M	1.078	2.312	13.965	31.178
M at N	1.151	2.402	13.856	28.903

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.648	1.800	0.626	1.739
M	0.448	0.934	0.729	1.522
N at M	1.105	2.567	NS	NS
M at N	1.001	2.089	NS	NS

(4908.16 cm^2) followed by N_4M_1 (4873.85 cm^2). N_4M_4 (6045.86 cm^2) recorded the highest value followed by N_4M_3 (6026.64 cm^2) at 12th month.

4.1.6 Leaf area index

The data on leaf area index are presented in Table 6.

Application of different levels of nitrogen and micronutrients showed significant results on leaf area index at different growth stages.

Treatment N_4 recorded the highest LAI at 3rd month (0.151 cm^2), 6th month (0.831 cm^2), 9th month (1.346 cm^2) and 12th month (1.489 cm^2).

Micronutrient application did not show significant effects at 3rd and 12th month. Treatment M_4 registered increase in leaf area index at 6th month (0.678 cm^2) and 9th month (1.192 cm^2).

The interaction effect between N x M was non significant at 3rd and 12th month. At 6th month, N_4M_4 recorded increased leaf area index of 0.901 cm^2 followed by N_4M_3 (0.895 cm^2). At 9th month N_4M_2 registered the highest leaf area index of 1.365 cm^2 followed by N_4M_1 (1.355 cm^2).

4.1.7 Specific leaf area

The data on specific leaf area are presented in Table 7.

Application of nitrogen and micronutrients had significant influence on specific leaf area at 3rd, 9th and 12th month respectively. Among the different nitrogen levels,

Table 6. Effect of nitrogen and micronutrients on leaf area index during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.109	0.118	0.114	0.061	0.122	0.105	0.482	0.489	0.490	0.510	0.525	0.499
N_1	0.132	0.137	0.144	0.144	0.143	0.140	0.507	0.532	0.558	0.566	0.568	0.546
N_2	0.134	0.119	0.144	0.145	0.145	0.137	0.556	0.588	0.595	0.600	0.603	0.588
N_3	0.145	0.146	0.144	0.146	0.148	0.146	0.575	0.611	0.750	0.746	0.800	0.696
N_4	0.144	0.149	0.151	0.151	0.158	0.151	0.651	0.848	0.867	0.895	0.901	0.831
Mean	0.133	0.134	0.139	0.129	0.143	0.136	0.554	0.614	0.652	0.663	0.678	0.632
	9th month						12th month					
N_0	0.641	0.975	0.988	0.990	1.015	0.922	0.680	1.079	1.093	1.057	1.137	1.009
N_1	0.780	1.039	1.062	1.076	1.104	1.012	0.935	1.194	1.197	1.212	1.244	1.156
N_2	0.924	1.124	1.142	1.171	1.191	1.110	1.092	1.255	1.307	1.340	1.325	1.264
N_3	1.276	1.294	1.321	1.279	1.310	1.296	1.442	1.464	1.472	1.539	1.527	1.489
N_4	1.324	1.355	1.365	1.339	1.344	1.346	1.521	1.641	1.684	1.676	0.850	1.474
Mean	0.989	1.157	1.175	1.171	1.192	1.137	1.134	1.326	1.351	1.365	1.216	1.278

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.007	0.020	0.00033	0.00091
M	NS	NS	0.00038	0.00080
N at M	NS	NS	0.00084	0.00183
M at N	NS	NS	0.00086	0.00179
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.005	0.013	0.110	0.304
M	0.007	0.014	NS	NS
N at M	0.014	0.031	NS	NS
M at N	0.015	0.031	NS	NS

Table 7. Effect of nitrogen and micronutrients on specific leaf area (cm^2/mg) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.241	0.287	0.286	0.288	0.287	0.278	0.167	0.288	0.287	0.288	0.287	0.261
N_1	0.242	0.285	0.266	0.268	0.277	0.267	0.273	0.278	0.280	0.278	0.279	0.277
N_2	0.280	0.276	0.278	0.277	0.277	0.277	0.276	0.278	0.280	0.281	0.282	0.279
N_3	0.270	0.278	0.278	0.278	0.278	0.276	0.276	0.278	0.279	0.278	0.279	0.278
N_4	0.280	0.276	0.281	0.278	0.290	0.280	0.275	0.280	0.279	0.278	0.288	0.280
Mean	0.261	0.280	0.278	0.278	0.281	0.276	0.253	0.280	0.281	0.280	0.283	0.275
	9th month						12th month					
N_0	0.272	0.286	0.285	0.287	0.286	0.283	0.275	0.288	0.290	0.289	0.288	0.286
N_1	0.276	0.277	0.271	0.278	0.278	0.276	0.281	0.272	0.276	0.277	0.278	0.277
N_2	0.276	0.273	0.281	0.275	0.273	0.275	0.280	0.278	0.276	0.277	0.275	0.276
N_3	0.275	0.277	0.272	0.273	0.276	0.274	0.276	0.276	0.274	0.278	0.277	0.276
N_4	0.274	0.276	0.277	0.274	0.288	0.278	0.270	0.278	0.277	0.276	0.288	0.277
Mean	0.274	0.278	0.277	0.277	0.280	0.277	0.276	0.278	0.279	0.280	0.281	0.279

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.00033	0.00092	NS	NS
M	0.00042	0.00088	NS	NS
N at M	0.00091	0.00198	NS	NS
M at N	0.00094	0.00197	NS	NS

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.00048	0.00134	0.00033	0.00090
M	0.00053	0.00110	0.00059	0.00122
N at M	0.00116	0.00257	0.00122	0.00260
M at N	0.00118	0.00247	0.00131	0.00274

N_4 application recorded the highest SLA of 0.280, 0.278 and 0.277 $cm^2\ mg^{-1}$ at 3rd, 9th, 12th month respectively. Application of fertilizers did not show significant effects during 6th month.

Among the different micronutrients, the treatment M_4 recorded the highest SLA of 0.281 $cm^2\ mg^{-1}$ 3rd and 12th month and 0.280 $cm^2\ mg^{-1}$ 9th month respectively.

Treatment N_4M_4 recorded the highest SLA of 0.290 $cm^2\ mg^{-1}$ at 3rd month and 0.288 $cm^2\ mg^{-1}$ at 9th and 12th months.

4.1.8.Specific leaf weight

The specific leaf weight (SLA) as a measure of leaf assimilating efficiency was influenced significantly by the stages of growth (Table 8).

Application of different levels of N and micronutrients showed significant results in stages of crop growth. SLW increased from 3rd month to 12th month. Treatment N_4 registered increase in specific leaf weight at 3rd (3.65 mg cm^{-2}), 6th (3.63 mg cm^{-2}), 9th and 12th month (3.65 mg cm^{-2}).

Treatment M_4 registered increase in specific leaf weight of 3.66 mg cm^{-2} at 3rd month. M_4 recorded higher value of 3.68 mg cm^{-2} at 6th, 9th and 12th months. M_4 was on par with M_3 and M_2 (3.66 mg cm^{-2}) at 9th month.

Among the interaction effect, the treatment N_4 (180 kg N ha^{-1}) with M_4 [Foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest SLW of 3.73 and 3.75 mg cm^{-2} at 3rd and 6th month and 3.74 mg cm^{-2} at 9th and 12th month respectively.

Table 8. Effect of nitrogen and micronutrients on specific leaf weight (mg cm^{-2}) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	3.15	3.75	3.73	3.74	3.73	3.62	3.52	3.74	3.72	3.75	3.73	3.69
N_1	3.12	3.70	3.47	3.47	3.60	3.47	3.55	3.61	3.61	3.63	3.64	3.60
N_2	3.60	3.59	3.61	3.60	3.62	3.60	3.59	3.62	3.64	3.65	3.66	3.63
N_3	3.51	3.62	3.60	3.62	3.59	3.59	3.60	3.63	3.63	3.62	3.64	3.62
N_4	3.65	3.57	3.64	3.61	3.73	3.65	3.55	3.63	3.61	3.62	3.75	3.63
Mean	3.41	3.64	3.61	3.60	3.66	3.58	3.56	3.64	3.64	3.65	3.68	3.64
	9th month						12th month					
N_0	3.57	3.72	3.74	3.73	3.72	3.69	3.58	3.76	3.75	3.74	3.75	3.71
N_1	3.55	3.62	3.64	3.61	3.61	3.60	3.55	3.61	3.64	3.63	3.63	3.61
N_2	3.55	3.62	3.62	3.64	3.65	3.61	3.60	3.62	3.65	3.64	3.67	3.64
N_3	3.60	3.62	3.67	3.67	3.66	3.64	3.62	3.65	3.68	3.63	3.63	3.64
N_4	3.61	3.62	3.63	3.68	3.74	3.65	3.60	3.62	3.62	3.67	3.76	3.65
Mean	3.57	3.64	3.66	3.66	3.68	3.64	3.59	3.65	3.67	3.66	3.68	3.65

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.005	0.013	0.007	0.019
M	0.003	0.007	0.008	0.017
N at M	0.008	0.019	0.018	0.039
M at N	0.008	0.016	0.019	0.039
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.008	0.021	0.002	0.006
M	0.010	0.021	0.003	0.006
N at M	0.022	0.047	0.006	0.013
M at N	0.023	0.048	0.006	0.013

4.1.9 Fresh weight of shoot

The fresh weight of the shoot per plant showed increase in weight with advancement of crop growth. The data are presented in Table 9.

Different levels of N and micronutrients were found to have significant effect at different phases of crop growth. Increased fresh weight of the shoot was noticed in treatment N_4 at 3rd month (32.80 g), 6th month (246.77 g), 9th month (259.73 g) and 12th month (304.21 g).

Micronutrient applications exerted great influence on fresh weight of the shoot. Foliar spray of $ZnSO_4$ (0.5%) + $FeSo_4$ (1.0%) recorded increased fresh weight of the shoot at 3rd month (24.30 g), 6th month (203.08 g), 9th month (230.69 g) and 12th month (273.25 g).

Among the interaction effects, the treatment N_4 showed increased fresh weight of shoot of 34.45, 265.21, 268.25 and 324.96 g with M_4 at 3rd, 6th, 9th and 12th month respectively.

4.1.10 Dry weight of the shoot

Data indicated that the dry weight of shoot per plant increased as the crop stage advanced from 3rd month to 12th month (Table 10).

Application of N and micronutrients were found to register significant results at stages of crop growth. Among different N levels, the treatment N_4 registered increased

Table 9. Effect of nitrogen and micronutrients on fresh weight of shoot per plant (g) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	10.19	14.69	14.84	14.81	15.17	13.94	75.90	81.01	82.48	81.92	120.76	88.42
N_1	12.90	17.06	17.96	18.02	19.49	17.09	87.17	163.50	164.11	164.70	166.33	149.16
N_2	14.72	21.44	21.69	22.14	23.17	20.63	105.35	170.15	196.20	206.30	212.42	178.09
N_3	16.46	25.26	26.22	28.48	29.23	25.13	157.19	216.78	223.73	239.96	250.68	217.67
N_4	31.10	32.55	32.69	33.21	34.45	32.80	203.90	242.89	259.17	262.67	265.21	246.77
Mean	17.07	22.20	22.68	23.33	24.30	21.92	125.91	174.87	185.14	191.11	203.08	176.02
	9th month						12th month					
N_0	119.96	130.59	142.95	143.21	151.05	137.56	205.76	213.65	215.78	219.17	220.20	214.91
N_1	152.31	200.21	218.31	220.63	225.66	203.43	216.21	220.71	226.69	228.75	232.22	224.88
N_2	155.70	174.26	239.70	241.13	248.26	211.81	228.22	242.16	282.17	286.24	287.70	265.30
N_3	177.66	248.21	251.78	252.19	260.21	238.01	245.70	290.65	295.18	297.62	301.17	286.06
N_4	239.19	260.70	264.05	266.46	268.25	259.73	254.23	305.70	315.51	320.65	324.96	304.21
Mean	168.97	202.80	223.36	224.73	230.69	210.11	230.04	254.57	267.07	270.49	273.25	259.08

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.133	0.368	1.756	4.876
M	0.120	0.251	1.286	2.683
N at M	0.275	0.617	3.115	7.181
M at N	0.269	0.561	2.876	5.999

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.233	0.648	0.73	2.03
M	0.391	0.816	0.71	1.47
N at M	0.817	1.749	1.59	3.55
M at N	0.875	1.825	1.58	3.30

Table 10. Effect of nitrogen and micronutrients on dry weight of shoot (g) per plant during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.57	3.69	3.75	3.76	3.95	3.54	19.65	20.25	24.39	24.79	26.08	23.03
N_1	3.70	4.48	4.82	4.80	4.87	4.54	28.54	36.23	37.86	40.27	40.54	36.69
N_2	4.07	5.29	5.38	5.41	5.68	5.17	27.04	42.88	43.33	46.72	51.00	42.20
N_3	4.43	6.44	7.15	7.27	7.31	6.52	35.82	53.73	54.74	59.78	61.92	53.20
N_4	5.43	8.20	8.62	9.09	9.15	8.10	41.03	62.96	65.29	65.08	66.88	66.25
Mean	4.04	5.62	5.95	6.07	6.20	5.58	30.42	43.21	45.12	47.33	49.29	43.07
	9th month						12th month					
N_0	30.11	32.64	35.27	37.32	37.40	34.55	41.61	53.40	53.78	55.37	55.10	51.86
N_1	33.18	50.10	54.31	54.98	56.26	49.77	54.13	55.71	57.48	57.09	58.22	56.53
N_2	36.72	58.51	59.19	58.06	63.02	55.10	56.20	57.16	59.63	60.11	62.25	59.07
N_3	44.92	63.48	63.37	64.46	65.11	60.27	61.06	62.70	63.22	63.04	65.11	63.03
N_4	60.56	65.67	65.71	66.79	67.81	65.31	63.63	76.42	79.09	80.21	81.25	76.12
Mean	41.10	54.08	55.57	56.32	57.92	53.00	55.33	61.08	62.64	63.17	64.39	61.32

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.036	0.099	0.235	0.653
M	0.038	0.080	0.221	0.460
N at M	0.085	0.187	0.500	1.120
M at N	0.086	0.179	0.493	1.029
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.073	0.203	0.221	0.613
M	0.237	0.494	0.206	0.430
N at M	0.479	1.007	0.468	1.047
M at N	0.529	1.104	0.461	0.962

dry weight of shoot at 3rd month (8.10 g), 6th month (66.25 g), 9th month (65.31 g) and 12th month (76.12 g) of planting respectively.

Treatment M_4 registered a higher value of 6.20, 49.29, 57.92 and 64.39 g at 3rd, 6th, 9th and 12th month of planting respectively.

Treatment N_4 registered increase in dry weight of the shoot in interaction with M_4 at 3rd month (9.15 g) 6th month (66.88 g), 9th month (67.81) and 12th month (81.25).

4.1.11 Fresh weight of the root

Data on fresh weight of the root at different stages of crop growth are presented in Table 11.

The fresh weight of the root showed progressive increase during the period of study. Increased fresh weight of the root was associated with increased N levels. Among different nitrogen levels, the treatment N_4 registered increase in fresh weight of the root at 3rd (2.98 g), 6th (46.33 g), 9th (62.85 g) and 12th month (81.18 g).

Application of micronutrients exerted great significant influence on fresh weight of the root, treatment M_4 recorded increase fresh weight of the root at 3rd (2.55 g), 6th (37.73 g), 9th (51.89 g) and 12th month (62.91 g).

The interaction effects showed significant results at all stages of crop growth. In 3rd month, N_4M_4 recorded the highest fresh weight of the root of 3.58 and 49.40 g at 3rd and 6th month. N_4M_4 recorded 66.55 g at 9th month which was on par with N_4M_2

Table 11. Effect of nitrogen and micronutrients on fresh weight of root (g) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.70	0.96	1.52	1.71	1.83	1.35	15.03	20.30	22.47	24.16	24.68	21.33
N_1	0.76	1.88	1.93	2.04	2.19	1.76	17.76	27.60	30.71	31.90	34.38	28.48
N_2	1.38	2.21	2.26	2.28	2.30	2.09	20.79	34.72	37.24	36.88	37.73	33.48
N_3	1.52	2.41	2.63	2.64	2.85	2.41	34.03	38.85	39.28	40.09	42.44	38.94
N_4	2.04	2.84	3.16	3.25	3.58	2.98	39.66	45.50	48.49	48.58	49.40	46.33
Mean	1.28	2.06	2.30	2.39	2.55	2.12	25.46	34.00	35.64	36.32	37.73	33.71
	9th month						12th month					
N_0	27.46	32.69	37.11	38.33	39.97	35.11	40.20	43.76	42.69	44.54	45.29	43.29
N_1	31.84	41.49	41.75	44.89	44.11	40.82	41.72	56.46	55.73	57.04	54.96	53.18
N_2	39.72	42.99	46.20	50.07	52.71	46.34	54.05	56.01	56.32	58.06	54.49	55.78
N_3	45.40	53.17	53.89	55.10	56.20	52.76	55.39	67.69	68.61	69.20	70.64	66.31
N_4	55.20	60.71	66.53	65.33	66.55	62.85	73.69	75.71	80.96	86.36	89.18	81.18
Mean	39.93	46.21	49.10	50.75	51.89	47.58	53.01	59.92	60.86	63.04	62.91	59.95

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.020	0.056	0.361	1.001
M	0.013	0.028	0.234	0.488
N at M	0.034	0.079	0.591	1.384
M at N	0.030	0.062	0.524	1.092

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.453	1.257	0.309	0.857
M	0.259	0.541	0.424	0.885
N at M	0.688	1.641	0.903	1.956
M at N	0.580	1.209	0.949	1.979

(66.50) and at 12th month, N_4M_4 recorded the highest value of 89.18 g followed by N_4M_3 with 86.36 g.

4.1.12 Dry weight of the root

The dry weight of the root per plant showed an increasing trend with crop growth (Table 12).

Application of different levels of N along with micronutrients showed significant results on dry weight of the root at different growth phases. Treatment N_4 registered increase in dry weight of the root at 3rd month (0.73), 6th month (11.06 g), 9th (15.55 g) and 12th month (20.05 g).

Treatment M_4 [foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] registered increased dry weight of the root at different stages of crop growth. It recorded a higher value of 0.62 g, 9.38 g, 13.00 g and 15.53 g at 3rd, 6th, 9th and 12th month respectively. N x M interaction also showed significant effects at all stages of crop growth. The treatment N_4M_4 recorded increased dry weight of the root at 3rd month (0.83g), 6th month (12.38g), 9th month (16.77g) and 12th month (22.05 g). At 9th month N_4M_4 was on par with N_4M_3 (16.60 g).

4.1.13 Shoot root ratio

The shoot-root ratio showed decreasing trend as the crop stage advanced (Table 13).

Table 12. Effect of nitrogen and micronutrients on dry weight of root per plant (g) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.197	0.272	0.368	0.430	0.451	0.340	3.65	5.22	5.83	5.80	5.92	5.29
N_1	0.400	0.471	0.487	0.512	0.540	0.482	5.50	6.47	7.11	8.05	8.61	7.15
N_2	0.390	0.553	0.540	0.573	0.581	0.527	5.81	8.65	9.03	9.38	9.54	8.48
N_3	0.420	0.611	0.669	0.680	0.704	0.616	8.84	9.71	10.04	10.17	10.45	9.84
N_4	0.505	0.715	0.803	0.791	0.833	0.730	7.45	11.23	12.05	12.17	12.38	11.06
Mean	0.382	0.520	0.570	0.600	0.620	0.530	6.25	8.26	8.81	9.12	9.38	8.36
	9th month						12th month					
N_0	6.66	8.36	9.38	9.69	9.79	8.78	9.80	10.05	10.65	10.94	11.28	10.55
N_1	7.97	10.58	10.65	10.53	11.10	10.17	10.30	12.13	12.41	13.23	13.15	12.25
N_2	10.12	10.80	11.32	12.87	13.28	11.68	13.01	14.00	14.10	14.15	14.01	13.86
N_3	11.64	13.48	13.59	13.79	14.05	13.31	13.94	15.18	16.23	16.85	17.12	15.87
N_4	12.88	15.28	16.21	16.60	16.77	15.55	18.28	19.03	19.76	21.12	22.05	20.05
Mean	9.86	11.70	12.23	12.70	13.00	11.90	13.07	14.08	14.63	15.26	15.53	14.51

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.002	0.005	0.059	0.165
M	0.004	0.009	0.061	0.128
N at M	0.009	0.018	0.137	0.303
M at N	0.009	0.020	0.137	0.287

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.088	0.245	0.017	0.047
M	0.080	0.167	0.005	0.009
N at M	0.183	0.411	0.019	0.050
M at N	0.179	0.374	0.010	0.021

Table 13. Effect of nitrogen and micronutrients on shoot-root ratio during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	12.82	13.63	10.13	8.74	8.78	10.83	5.38	4.87	4.17	4.26	4.40	4.62
N_1	9.25	9.52	9.85	9.40	9.01	9.41	5.18	5.59	5.31	5.00	4.70	5.16
N_2	10.44	9.62	9.94	9.32	9.80	9.82	4.65	4.96	4.80	4.97	5.34	4.95
N_3	10.50	10.57	10.86	10.70	10.44	10.61	4.04	5.52	5.45	5.87	5.91	5.36
N_4	10.85	11.41	10.78	11.50	11.02	11.11	5.05	5.60	5.19	5.35	5.40	5.32
Mean	10.77	10.95	10.32	10.36	9.81	10.44	4.86	5.31	4.99	5.09	5.15	5.08
	9th month						12th month					
N_0	4.50	3.90	3.75	3.84	3.81	3.96	4.23	5.28	5.05	5.07	4.88	4.90
N_1	4.16	4.73	5.10	5.22	5.07	4.86	5.27	4.59	4.63	4.30	4.43	4.65
N_2	3.64	5.42	5.22	4.52	4.74	4.71	4.33	4.07	4.24	4.25	4.45	4.27
N_3	3.89	4.71	4.66	4.68	4.63	4.52	4.39	4.13	4.07	3.76	3.90	4.05
N_4	4.70	4.31	4.05	4.02	4.04	4.23	3.49	4.06	4.00	3.85	3.70	3.82
Mean	4.18	4.62	4.56	4.46	4.46	4.46	4.34	4.43	4.40	4.25	4.27	4.34

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.013	0.036	0.123	0.341
M	0.007	0.015	NS	NS
N at M	0.019	0.046	0.284	0.628
M at N	0.016	0.033	0.286	0.596

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.007	0.020	0.027	0.075
M	0.002	0.005	0.015	0.031
N at M	0.008	0.022	0.040	0.097
M at N	0.005	0.011	0.033	0.070

Nitrogen application showed significance effects on shoot-root ratio at different stages of crop growth. Treatment N_4 registered increased shoot root ratio of 11.11 at 3rd month and treatment N_3 recorded increased shoot root ratio of 5.36 at 6th month. Treatment N_1 recorded the highest shoot root ratio (4.86) at 9th month and at 12th month, N_0 recorded the highest shoot root ratio of 4.90.

Micronutrient application showed significant effects at 3rd, 9th and 12th month of planting. Treatment M_1 recorded the highest shoot-root ratio of 10.95 and 4.62 at 3rd and 9th month respectively. The treatment M_1 recorded the highest shoot root ratio of 4.43 followed by M_2 (4.40) at 12th month.

The interaction effect of N x M exhibited significant effects at all stages of crop growth. At 3rd month, N_0M_1 recorded increased shoot root ratio of 13.63 followed by N_4M_3 (11.50). At 6th month, the treatment N_3M_4 registered increased shoot root ratio of 5.91 followed by N_3M_3 (5.87). At 9th month, treatment N_2M_1 recorded the highest shoot root ratio of 5.42 and at 12th month N_0M_1 recorded the highest shoot root ratio of 5.28.

4.1.14 Dry matter production (Table 14, Fig. 3)

The dry matter production also showed the same trend of increase in weight with advancement of crop growth.

Application of nitrogen showed significant values at different stages of crop growth. The treatment N_4 recorded the highest dry matter production of 13.30, 79.01 and

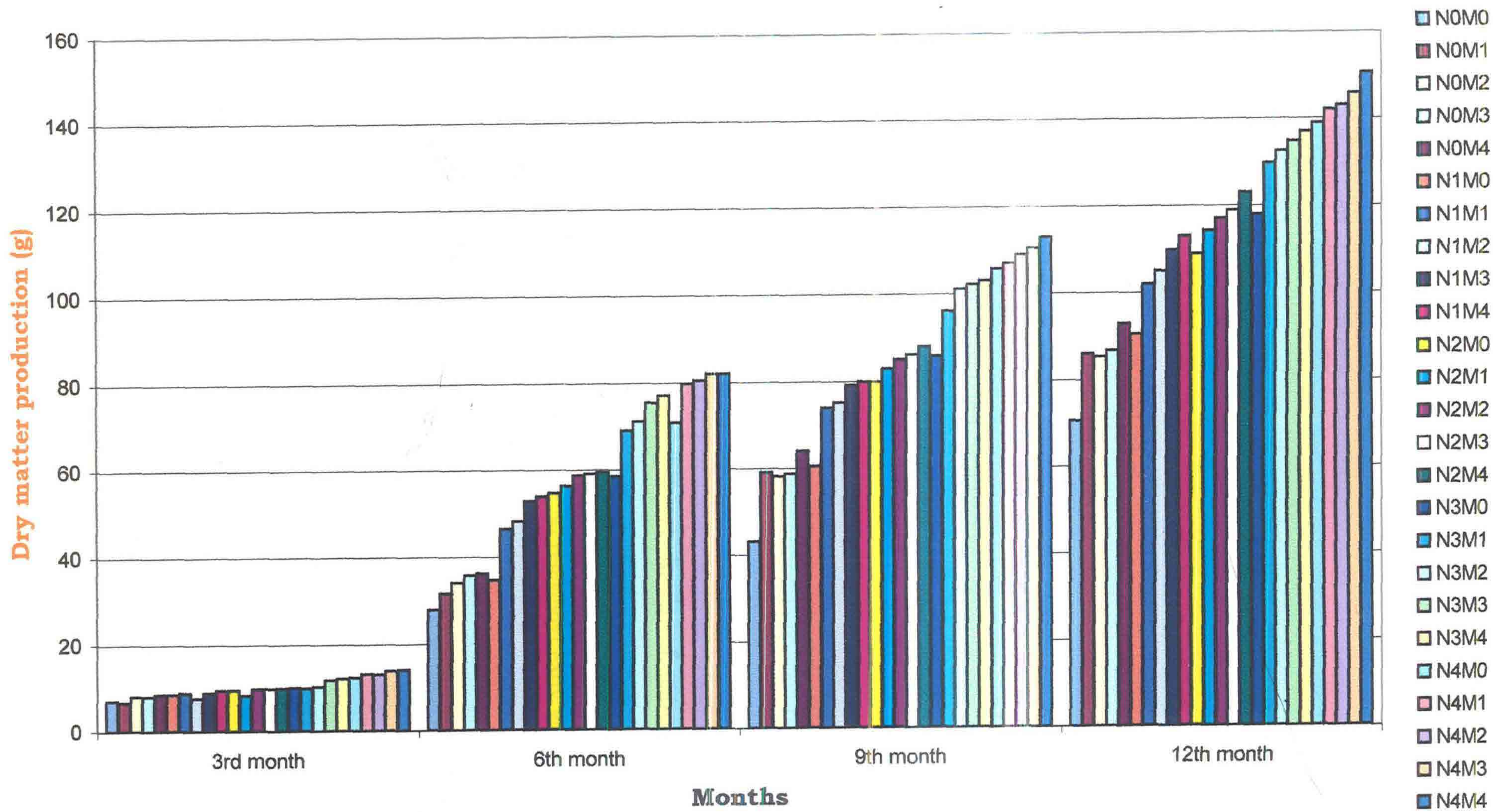
Table 14. Effect of nitrogen and micronutrients on dry matter production (g) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	7.08	6.79	8.17	8.12	8.59	7.75	27.90	31.60	34.10	35.84	36.21	33.13
N_1	8.63	8.94	7.64	8.99	9.55	8.76	34.76	46.50	48.17	52.93	53.91	47.26
N_2	9.59	8.40	9.88	9.89	9.93	9.54	54.73	56.32	58.69	59.06	59.39	57.64
N_3	10.13	10.00	10.30	11.86	12.12	10.88	58.45	69.10	71.10	75.48	77.08	70.25
N_4	12.33	13.14	13.08	13.87	14.07	13.30	70.77	79.71	80.57	81.95	82.02	79.01
Mean	9.55	9.46	9.82	10.55	10.85	10.05	49.32	56.65	58.53	61.05	61.72	57.46
	9th month						12th month					
N_0	43.16	59.10	58.12	58.70	64.00	56.62	70.55	86.05	85.35	86.72	92.90	84.32
N_1	60.50	74.00	75.10	79.15	79.90	73.73	90.50	101.95	104.95	109.80	112.95	104.03
N_2	80.00	82.95	84.95	86.10	87.95	84.39	108.85	114.25	116.95	118.85	122.90	116.36
N_3	85.75	96.15	101.15	102.25	103.00	97.66	117.95	129.75	132.50	134.75	136.95	130.38
N_4	105.75	107.00	108.95	110.50	112.95	87.34	138.95	141.95	143.00	145.75	150.50	144.03
Mean	75.03	83.84	85.65	87.34	89.56	84.29	105.36	114.79	116.55	119.18	123.24	115.82

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.896	2.487	0.197	0.549
M	NS	NS	0.155	0.324
N at M	NS	NS	0.369	0.842
M at N	NS	NS	0.348	0.726

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.122	0.339	0.121	0.335
M	0.110	0.230	0.153	0.318
N at M	0.253	0.568	0.328	0.715
M at N	0.247	0.515	0.341	0.712

Fig.3. Effect of nitrogen and micronutrients on dry matter production (g)



144.03 g at 3rd, 6th and 12th month respectively.N3 recorded the highest dry matter production (97.66 g) during 9th month.

Micronutrients application showed significant effects at 6th, 9th and 12th month of planting. The treatment M_4 registered increase in dry matter production during 6th month (61.72 g), 9th month (89.56 g) and 12th month (123.24 g).

The interaction effect of N x M was found to be non-significant during 3rd month but significant during 6th, 9th and 12th month. The treatment N_4M_4 recorded dry matter production of 82.02, 112.95, 150.50 at 6th, 9th and 12th month respectively.

4.2 Yield attributes

4.2.1. Time taken for spike emergence (Table 15, Fig. 4)

Significant results were obtained with different levels of nitrogen and micronutrients on time taken for spike emergence. The emergence of the spike was advanced with the application of nitrogen. The treatment N_4 registered early emergence of the spike (74.45 days).

Treatment M_4 [foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded early spike emergence (78.59 days).

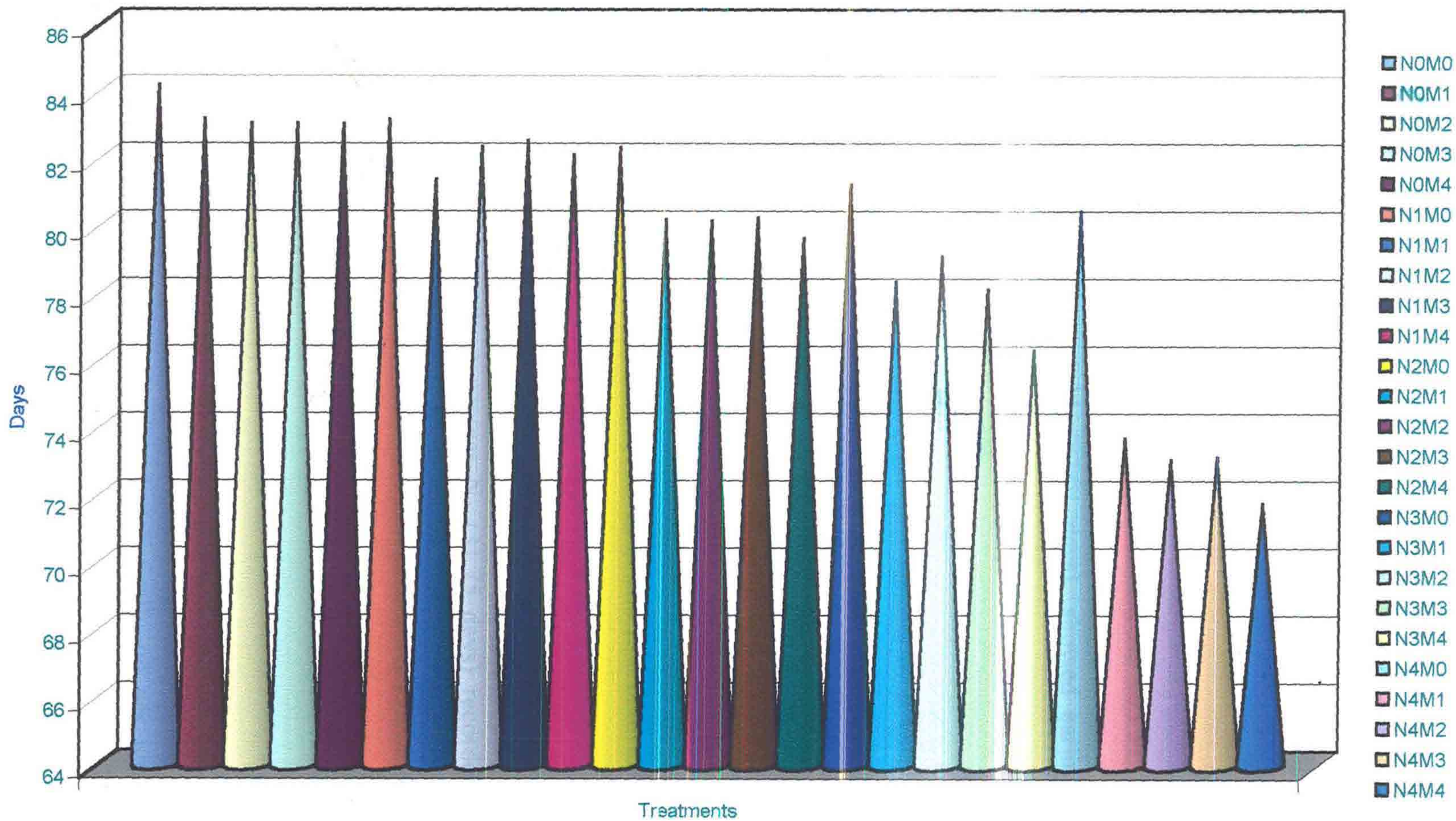
Treatment N_4M_4 registered earlier emergence of the spike (71.80 days) followed by N_4M_2 (73.09 days).

Table 15. *Effect of nitrogen levels and micronutrients on time taken for spike emergence (days), time taken for first harvest (days) and time taken for completion of harvest (days)*

N levels/ Micro-nutrients	Time taken for spike emergence (day)						Time taken for first harvest (days)						Time taken for completion of harvest (days)					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	84.20	83.20	83.06	83.05	83.04	83.31	91.82	90.93	89.07	89.16	89.09	80.02	49.45	49.31	47.22	47.31	45.25	40.84
N_1	83.18	81.39	82.37	82.54	82.11	82.32	88.24	89.93	89.36	88.95	88.90	89.08	46.13	43.26	42.25	39.12	38.24	41.80
N_2	82.35	80.21	80.17	80.25	79.66	80.53	88.23	88.89	87.73	88.25	87.30	88.08	36.17	39.12	34.18	35.82	35.28	36.12
N_3	81.24	78.37	79.12	78.14	76.34	78.65	87.53	89.77	86.23	86.57	86.13	87.25	35.62	36.23	34.26	35.25	34.15	35.11
N_4	80.46	73.72	73.09	73.17	71.80	74.45	86.10	88.24	84.26	84.31	83.63	85.31	34.09	33.29	30.89	30.31	30.18	31.75
Mean	82.29	79.38	79.56	79.43	78.59	79.85	78.37	89.56	87.33	87.45	87.01	85.95	43.32	40.24	37.76	37.56	36.62	37.12

	SEd	CD(P=0.05)	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.122	0.338	NS	NS	1.904	5.288
M	0.154	0.321	NS	NS	1.908	3.981
N at M	0.331	0.722	NS	NS	4.265	9.485
M at N	0.344	0.718	NS	NS	4.267	8.901

Fig.4. Effect of nitrogen and micronutrients on time taken for spike emergence (days)



4.2.2. Time taken for first harvest in a spike

The data on time taken for first harvesting of flowers are presented in Table 15.

N levels and micronutrients showed non significant effects on time taken for first harvest in a spike.

The time taken for first harvest was reduced in the treatment N_4 (85.31 days). Among different micronutrients, the treatment M_4 (87.01 days) showed earlines in flowering.

Among the interaction effect, the time taken for first harvest in a spike was reduced by the treatment N_4M_4 (83.63 days) as compared to 91.82 days in the control.

4.2.3 Time taken for completion of flowering in a spike

Significant results were obtained at different levels of N and micronutrients on time taken for completion of flowering in a spike (Table 15).

Among different nitrogen levels, the treatment N_4 (31.75 days) recorded the earliest of completion of flowering in a spike followed by treatment N_3 (35.11 days). N_4 was on par with N_3, while No recorded 40.84 days.

Micronutrient application also showed significant effects. Treatment M_4 took 36.62 days followed by treatment M_3 (37.56 days) and statistically on par with M_2 (37.76 days), while Mo took 43.42 days for completion of flowering in a spike.

Treatment N_4M_4 [application of 180 kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] took 30.18 days, while the treatment without the application of fertilizers took 49.45 days to complete flowering in a spike. N_4M_4 was found statically on par with N_4M_3 (30.31 days) and N_4M_2 (30.89 days).

4.2.4 Number of flowers per spike (Table 16, Fig. 5)

Number of flowers per spike showed a steady increase with crop growth. There was significant effect with increasing levels of N at all stages of crop growth. Treatment N_4 registered increased number of flowers per spike at 3rd month (25.23), 6th month (61.13), 9th month (60.68) and 12th month (62.05).

Application of micronutrients recorded increased number of flowers per spike. Treatment M_4 registered increased number of flowers per spike at all stages of crop growth. Treatment M_4 registered 23.18,51.92,53.74 and 54.88 flowers per spike during 3rd, 6th, 9th and 12th month respectively.

N x M interaction also showed significant effects at all stages of crop growth. The highest number of flowers was registered in the treatment N_4M_4 at 3rd month (25.85), 6th month (64.52), 9th month (62.79) and at 12th month (64.05) respectively.

4.2.5 Number of spikes per plant (Table 17, Fig. 6)

Number of spikes per plant due to the application of nitrogen and micronutrients varied significantly. Treatment N_4 registered more number of spikes per plant for 3rd month (6.25), 6th month (43.33), 9th month (50.21) and 12th month (59.31).

Table 16. Effect of nitrogen and micronutrients on number of flowers/spike during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	18.32	19.38	18.70	19.41	19.44	19.05	30.22	31.02	30.76	33.69	34.25	31.99
N_1	19.18	20.66	21.27	22.56	22.73	21.28	36.14	39.22	43.72	45.79	46.26	42.23
N_2	21.21	23.19	23.36	23.52	22.97	22.85	36.19	46.01	49.70	52.72	55.59	48.05
N_3	21.34	23.52	24.22	24.60	24.60	23.66	39.70	56.55	58.60	58.88	58.95	54.55
N_4	24.63	24.89	25.01	25.75	25.85	25.23	54.02	59.80	63.09	64.19	64.52	61.13
Mean	20.94	22.33	22.51	23.17	23.18	22.41	39.26	46.52	49.18	51.06	51.92	47.59
	9th month						12th month					
N_0	34.70	38.34	39.76	42.53	42.99	39.67	35.96	38.50	39.51	43.03	44.03	40.21
N_1	37.99	43.79	47.15	48.25	48.46	45.13	37.68	44.48	47.77	49.15	49.40	45.70
N_2	42.27	50.81	50.97	54.01	54.65	50.54	44.45	53.95	53.10	55.63	55.91	52.61
N_3	50.58	57.55	58.83	58.99	59.80	57.15	52.56	58.95	59.94	59.99	60.97	58.49
N_4	56.40	60.78	61.11	62.27	62.79	60.68	58.39	62.16	62.16	63.48	64.05	62.05
Mean	44.39	50.26	51.57	53.21	53.74	50.63	45.81	51.61	52.50	54.26	54.88	51.81

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.212	0.589	0.233	0.648
M	0.185	0.386	0.209	0.436
N at M	0.426	0.963	0.479	1.077
M at N	0.414	0.863	0.468	0.975
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.349	0.970	0.137	0.381
M	0.196	0.408	0.192	0.399
N at M	0.525	1.255	0.407	0.881
M at N	0.438	0.913	0.428	0.893

Fig.5.Effect of nitrogen and micronutrients on number of flowers per spike

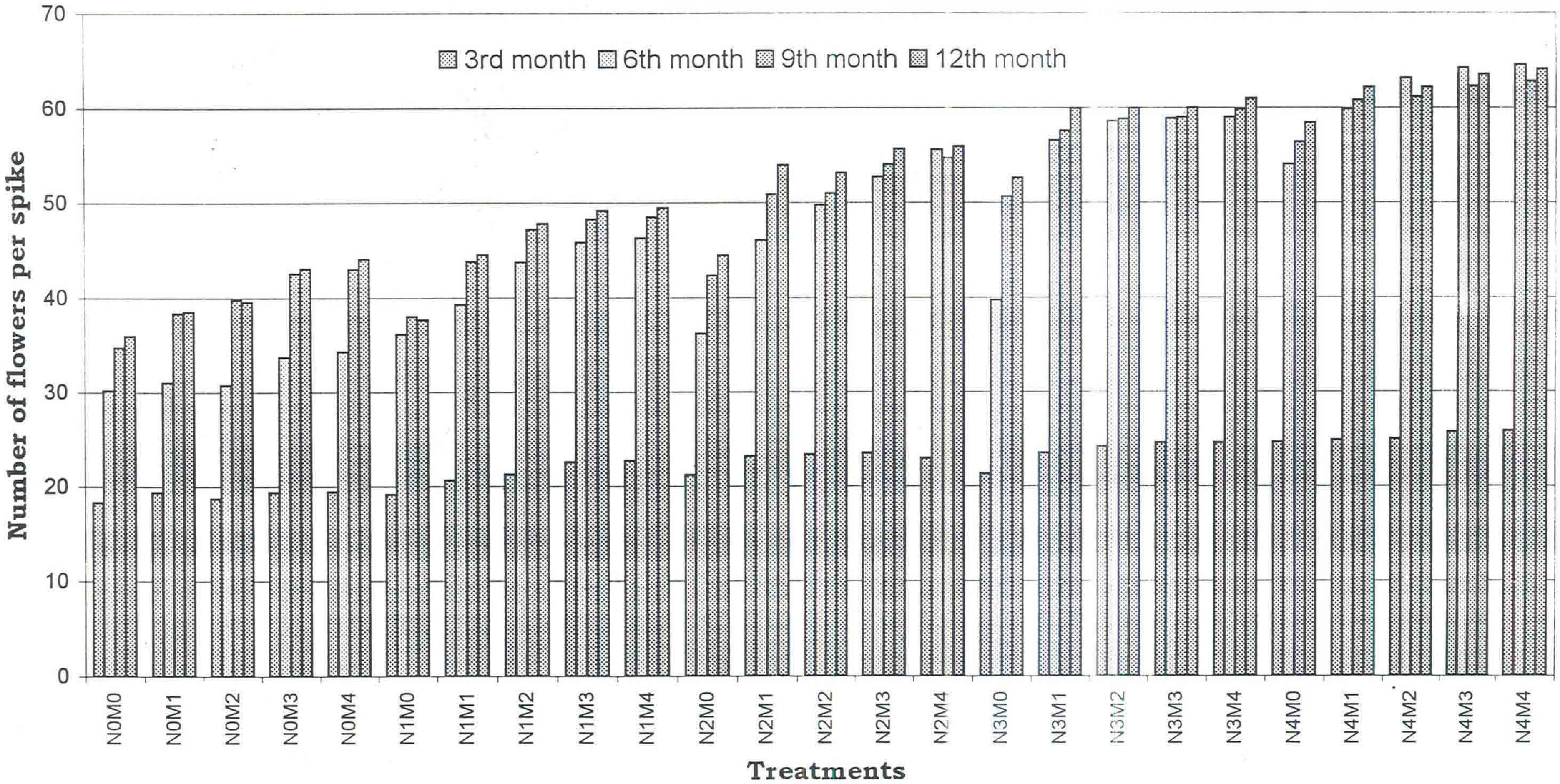


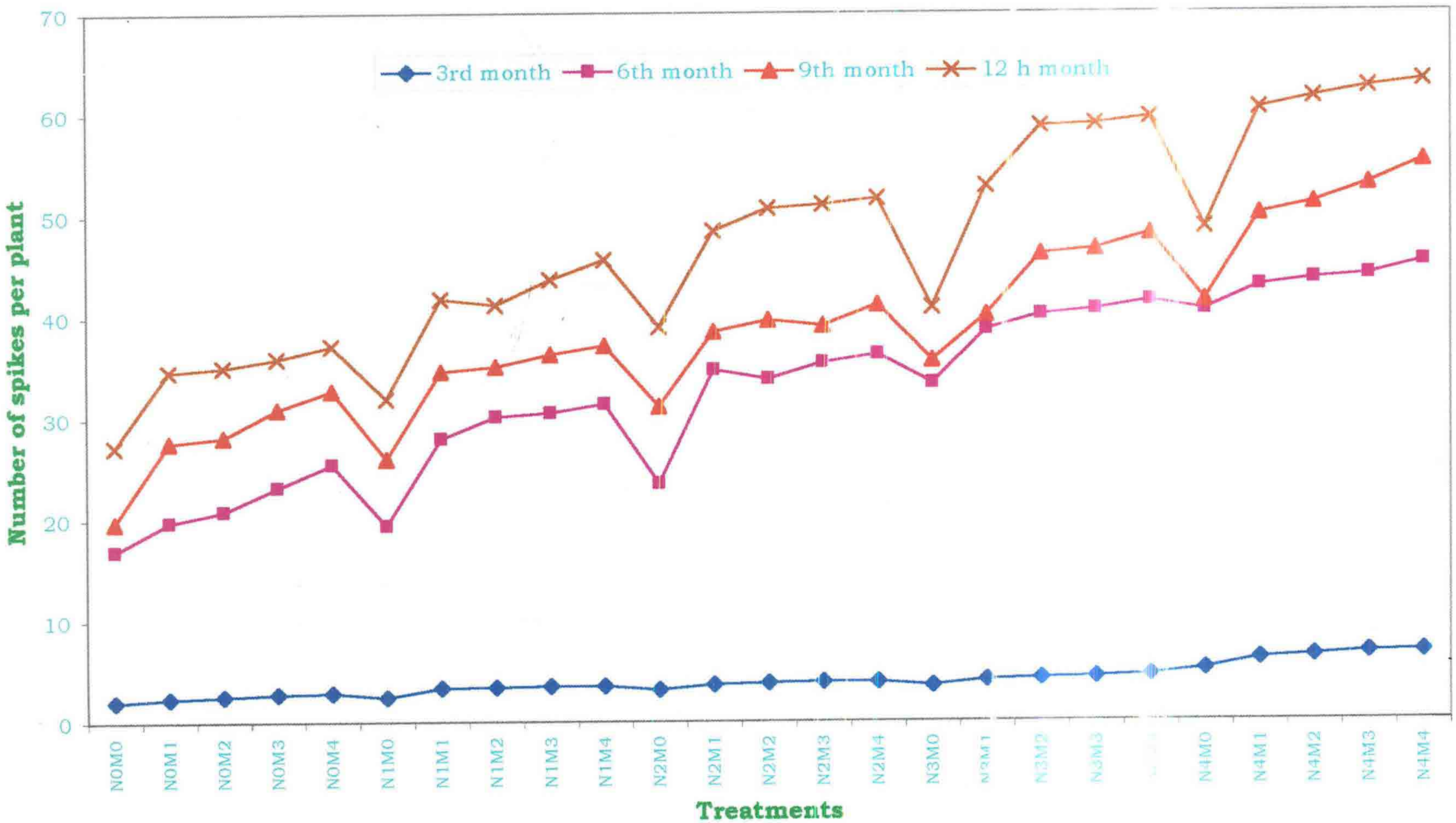
Table 17. Effect of nitrogen and micronutrients on number of spikes/plant during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.03	2.39	2.61	2.79	2.91	2.55	16.88	19.79	20.87	23.22	25.47	21.25
N_1	2.47	3.42	3.46	3.54	3.59	3.30	19.44	28.05	30.20	30.57	31.44	27.94
N_2	3.16	3.69	3.85	3.92	3.92	3.71	23.57	34.76	33.86	35.48	36.28	32.79
N_3	3.58	4.09	4.24	4.40	4.57	4.18	33.45	38.71	40.17	40.67	41.55	38.91
N_4	5.11	6.15	6.41	6.74	6.81	6.25	40.64	43.01	43.65	44.01	45.30	43.33
Mean	3.27	3.95	4.12	4.28	4.36	4.00	26.80	32.87	33.75	34.79	36.01	
	9th month						12th month					
N_0	19.73	27.67	28.19	30.93	32.78	27.86	27.22	34.69	35.13	35.95	37.21	34.04
N_1	26.06	34.67	35.17	36.36	37.23	33.90	32.00	41.85	41.24	43.74	45.69	40.91
N_2	31.15	38.56	39.72	39.18	41.20	37.97	39.04	48.52	50.74	51.10	51.71	48.23
N_3	35.70	40.18	46.18	46.69	48.18	43.39	40.96	52.90	58.74	58.96	59.64	54.24
N_4	41.59	50.05	51.16	52.96	55.27	50.21	48.75	60.50	61.56	62.53	63.19	59.31
Mean	30.85	38.23	40.09	41.23	42.93	38.67	37.60	47.69	49.49	50.46	51.49	47.35

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.044	0.121	0.793	2.201
M	0.035	0.073	0.745	1.555
N at M	0.083	0.189	1.689	3.779
M at N	0.079	0.164	1.667	3.477

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.572	1.587	0.375	1.042
M	0.372	0.777	0.299	0.625
N at M	0.939	2.199	0.707	1.613
M at N	0.833	1.737	0.670	1.399

Fig.6.Effect of nitrogen and micronutrients on number of spikes per plant



Micronutrient application also showed significant effect for this parameter at all stages of crop growth. Treatment M_4 registered increased number of spikes at 3^{rd} month (4.36), 6^{th} month (36.01), 9^{th} month (42.93) and 12^{th} month (51.49).

The interaction effect between N and M were significant at 3^{rd}, 9^{th} and 12^{th} month. The treatment N_4M_4 recorded the highest number of spikes of 6.81, 55.27 and 63.19 at 3^{rd}, 9^{th} and 12^{th} month respectively.

4.2.6 Stalk length (Table 18, Fig. 7)

There was an increase in the length of the stalk with the application of nitrogen and micronutrients. Treatment N_4 recorded increased flower stalk length of 2.90 cm at 3^{rd} month, 2.94 cm at 6th month, 2.97 cm at 9^{th} month and 3.19 cm at 12^{th} months.

Micronutrient application exerted significant influence at all stages of crop growth. Treatment M_4 recorded increased flower stalk length at 3^{rd} (2.57 cm), 6^{th} (2.59 cm) 9^{th}, (2.68 cm) and 12^{th} month (2.75 cm) respectively.

N x M interaction also exhibited significant effects at all stages of crop growth. The treatment N_4M_4 recorded increased stalk length of 3.11, 3.17 3.22 and 3.28 cm at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively.

4.2.7 Diameter of flower

The diameter of flower expressed a steady increase with crop growth. Application of nitrogen and micronutrients had significant effect at all stages of crop growth (Table 19).

Table 18. *Effect of nitrogen and micronutrients on stalk length (cm) during 3rd, 6th, 9th and 12th month of planting*

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.03	2.22	2.23	2.27	2.28	2.21	2.07	2.20	2.23	2.26	2.27	2.21
N_1	2.10	2.30	2.34	2.35	2.35	2.29	2.14	2.33	2.33	2.36	2.37	2.31
N_2	2.19	2.35	2.38	2.38	2.41	2.35	2.22	2.38	2.39	2.42	2.46	2.38
N_3	2.21	2.39	2.42	2.64	2.69	2.47	2.24	2.45	2.46	2.66	2.69	2.50
N_4	2.35	2.95	2.97	3.08	3.11	2.90	2.39	2.97	3.04	3.09	3.17	2.94
Mean	2.18	2.45	2.47	2.54	2.57	2.44	2.21	2.47	2.49	2.56	2.59	2.47
	9th month						12th month					
N_0	2.08	2.24	2.30	2.40	2.45	2.30	2.10	2.30	2.36	2.44	2.46	2.33
N_1	2.17	2.47	2.48	2.50	2.50	2.43	2.17	2.47	2.48	2.50	2.52	2.43
N_2	2.26	2.40	2.39	2.44	2.48	2.40	2.30	2.44	2.46	2.52	2.56	2.46
N_3	2.30	2.43	2.46	2.65	2.71	2.51	2.34	2.58	2.69	2.76	2.90	2.66
N_4	2.39	3.02	3.04	3.15	3.22	2.97	3.00	3.18	3.21	3.27	3.28	3.19
Mean	2.24	2.51	2.54	2.63	2.68	2.52	2.39	2.60	2.64	2.70	2.75	2.61

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.005	0.014	0.007	0.020
M	0.005	0.010	0.006	0.013
N at M	0.011	0.025	0.014	0.032
M at N	0.011	0.023	0.014	0.029

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.009	0.024	0.006	0.016
M	0.008	0.018	0.005	0.010
N at M	0.019	0.042	0.011	0.026
M at N	0.019	0.040	0.011	0.023

Fig.7.Effect of nitrogen and micronutrients on stalk length (cm)

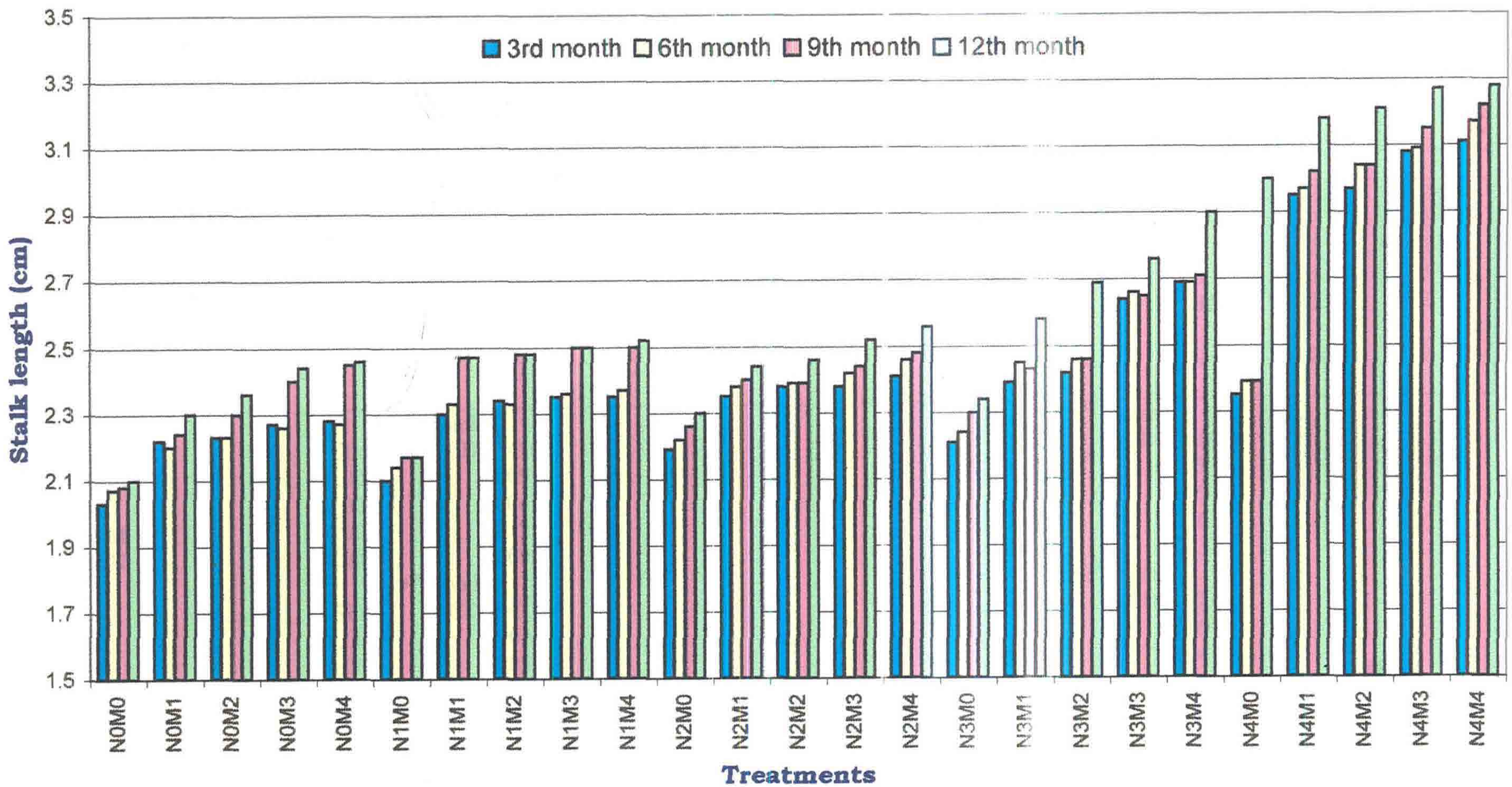


Table 19. Effect of nitrogen and micronutrients on diameter of flower during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.44	2.50	2.50	2.51	2.53	2.50	2.50	2.53	2.53	2.56	2.55	2.54
N_1	2.54	2.60	2.62	2.64	2.63	2.61	2.56	2.63	2.63	2.64	2.65	2.62
N_2	2.71	2.75	2.79	2.81	2.83	2.78	2.72	2.79	2.81	2.82	2.85	2.80
N_3	2.80	2.84	2.86	3.01	3.10	2.92	2.86	2.89	2.89	3.05	3.00	2.94
N_4	3.00	3.13	3.17	3.20	3.23	3.15	3.15	3.17	3.21	3.23	3.24	3.20
Mean	2.70	2.77	2.79	2.84	2.87	2.79	2.76	2.80	2.82	2.86	2.86	2.82
	9th month						12th month					
N_0	2.50	2.60	2.61	2.61	2.62	2.59	2.50	2.62	2.65	2.65	2.63	2.61
N_1	2.60	2.64	2.65	2.64	2.66	2.64	2.65	2.63	2.65	2.66	2.74	2.67
N_2	2.73	2.79	2.80	2.82	2.84	2.80	2.80	2.81	2.83	2.83	2.90	2.84
N_3	2.89	2.94	2.93	3.03	3.02	2.96	2.90	2.96	2.97	3.01	3.05	2.98
N_4	3.14	3.15	3.23	3.24	3.26	3.21	3.16	3.15	3.17	3.22	3.25	3.16
Mean	2.77	2.83	2.84	2.87	2.88	2.84	2.77	2.84	2.86	2.88	2.92	2.85

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.003	0.009	0.007	0.019
M	0.002	0.004	0.004	0.009
N at M	0.005	0.012	0.011	0.026
M at N	0.005	0.009	0.010	0.021

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.001	0.004	0.003	0.009
M	0.002	0.005	0.002	0.004
N at M	0.005	0.009	0.005	0.012
M at N	0.005	0.010	0.004	0.009

Treatment N_4 recorded the highest diameter of flower of 3.15, 3.20, 3.21, 3.16 cm at 3rd, 6th, 9th and 12th month respectively.

Treatment M_4 [foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] registered the highest diameter of flowers at 3rd (2.87 cm), 6th (2.86 cm), 9th (2.88 cm) and 12th month (2.92 cm).

The interaction between nitrogen and micronutrients was significant at all stages of crop growth. Treatment N_4M_4 [application of 180 kg N ha^{-1} + foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded increase in diameter of flower at 3rd month (3.23 cm), 6th (3.24 cm), 9th month (3.26 cm) and 12th month (3.25 cm). At 6th month N_4M_4 was found to be on par with N_4M_3 (3.23 cm).

4.2.8 Spike length (Table 20, Fig. 8)

The spike length increased with advancement of crop growth. Significant results were observed with the application of nitrogen and micronutrients on spike length.

N_4 recorded increase in spike length at 3rd month (8.58 cm), 6th month (9.56 cm), 9th month (11.24 cm) and 12th month (12.44 cm) respectively.

Treatment M_4 registered increased spike length at 3rd (7.28 cm), 6th (8.96 cm), 9th (9.80 cm) and 12th month (10.51 cm).

Application of 180 kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) resulted in increased spike length of 9.99, 11.07, 12.35 and 14.07 cm respectively at 3rd, 6th, 9th and 12th month respectively.

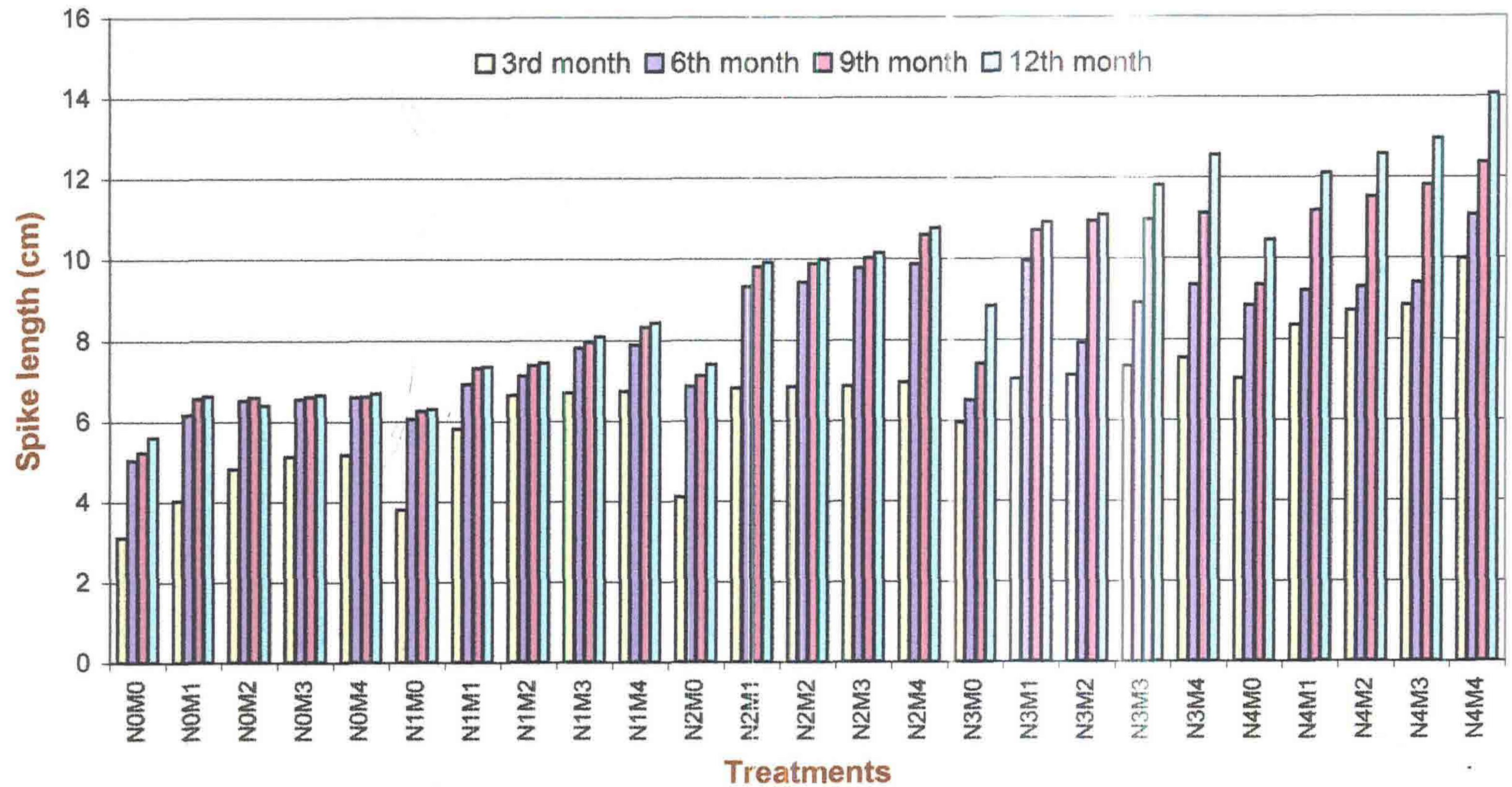
Table 20. Effect of nitrogen and micronutrients on spike length (cm) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	3.10	4.02	4.81	5.12	5.16	4.44	5.03	6.16	6.51	6.54	6.60	6.17
N_1	3.80	5.81	6.64	6.70	6.73	5.94	6.06	6.91	7.11	7.81	7.89	7.16
N_2	4.11	6.81	6.84	6.86	6.95	6.32	6.86	9.32	9.42	9.77	9.87	9.05
N_3	5.95	7.03	7.12	7.35	7.53	7.00	6.50	9.94	7.91	8.91	9.35	8.52
N_4	7.03	8.34	8.70	8.83	9.99	8.58	8.84	9.21	9.28	9.39	11.07	9.56
Mean	4.80	6.40	6.83	6.97	7.28	6.46	6.66	8.31	8.05	8.49	8.96	8.09
	9th month						12th month					
N_0	5.22	6.56	6.59	6.61	6.61	6.32	5.60	6.63	6.40	6.66	6.69	6.40
N_1	6.25	7.32	7.38	7.94	8.32	7.45	6.30	7.34	7.44	8.09	8.42	7.52
N_2	7.12	9.81	9.89	10.02	10.59	9.49	7.39	9.92	9.99	10.14	10.76	9.64
N_3	7.41	10.70	10.93	10.97	11.11	10.23	8.84	10.89	11.08	11.80	12.56	11.04
N_4	9.34	11.18	11.51	11.80	12.35	11.24	10.45	12.10	12.58	12.96	14.07	12.44
Mean	7.07	9.12	9.26	9.47	9.80	8.94	7.72	9.38	9.50	9.93	10.51	9.41

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.030	0.084	0.023	0.063
M	0.026	0.055	0.023	0.048
N at M	0.061	0.137	0.051	0.114
M at N	0.059	0.124	0.052	0.108

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.028	0.077	0.092	0.257
M	0.016	0.033	0.049	0.103
N at M	0.042	0.099	0.135	0.326
M at N	0.035	0.073	0.110	0.230

Fig.8.Effect of nitrogen and micronutrients on spike length (cm)



4.2.9 Weight of flowers

The weight of hundred flowers increased with the advancement of crop growth (Table 21, Fig. 9).

Application of nitrogen was found to have significant influence at all phases of crop growth. The treatment N_4 registered increased weight of flowers of 4.66, 5.01, 4.67 and 4.69 g at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively.

Micronutrient application exhibited significant results on weight of flowers. Treatment M_4 recorded increased weight of flowers 4.40, 4.41, 4.43 and 4.45 g at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively.

The interaction of N and M had significant effect at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month of planting. The treatment N_4M_4 recorded increased weight of flowers of 5.03 g at 3^{rd} and 9^{th} month and 5.26 g at 6^{th} month and 5.04 g at 12^{th} month.

4.2.10 Flower yield per plant (Table 22, Fig. 10)

Flower yield per plant showed an increasing trend with crop growth. Application of N and micronutrients showed significant effects at different stages of crop growth. Among different levels of N, treatment N_4 (180 kg N ha^{-1}) recorded the highest yield of 1.54 g, 60.43 g, 99.12 g and 159.31 g at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month after planting respectively.

Table 21. Effect of nitrogen and micronutrients on weight of flower (g) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	3.09	3.31	3.39	3.62	3.68	3.42	3.18	3.33	3.48	3.81	3.38	3.44
N_1	3.34	3.83	4.08	4.27	4.34	3.98	4.07	4.21	4.26	4.31	4.32	4.24
N_2	3.41	4.35	4.34	4.35	4.36	4.16	4.34	4.35	4.36	4.48	4.56	4.43
N_3	3.92	4.53	4.56	4.56	4.57	4.43	4.50	4.57	4.57	4.58	4.51	4.55
N_4	4.03	4.63	4.68	4.89	5.03	4.66	4.70	4.89	5.02	5.14	5.26	5.01
Mean	3.56	4.13	4.22	4.34	4.40	4.13	4.16	4.27	4.34	4.37	4.41	4.33
	9th month						12th month					
N_0	3.28	3.38	3.56	3.79	3.90	3.58	3.30	3.43	3.54	3.79	3.83	3.58
N_1	3.38	4.08	4.22	4.26	4.30	4.05	3.53	4.07	4.23	4.26	4.30	4.08
N_2	3.41	4.35	4.34	4.35	4.36	4.17	3.61	4.15	4.44	4.49	4.50	4.24
N_3	4.04	4.57	4.56	4.57	4.57	4.47	4.04	4.61	4.57	4.57	4.58	4.50
N_4	4.05	4.63	4.71	4.90	5.03	4.67	4.14	4.65	4.80	4.90	5.04	4.69
Mean	3.63	4.21	4.28	4.38	4.43	4.19	3.73	4.19	4.32	4.41	4.45	4.22

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.009	0.026	0.003	0.008
M	0.007	0.014	0.003	0.007
N at M	0.017	0.038	0.007	0.015
M at N	0.015	0.032	0.007	0.015

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.006	0.017	0.013	0.036
M	0.007	0.015	0.010	0.021
N at M	0.016	0.034	0.024	0.055
M at N	0.016	0.034	0.022	0.047

Fig 9. Effect of nitrogen and micronutrients on weight of flowers (g)

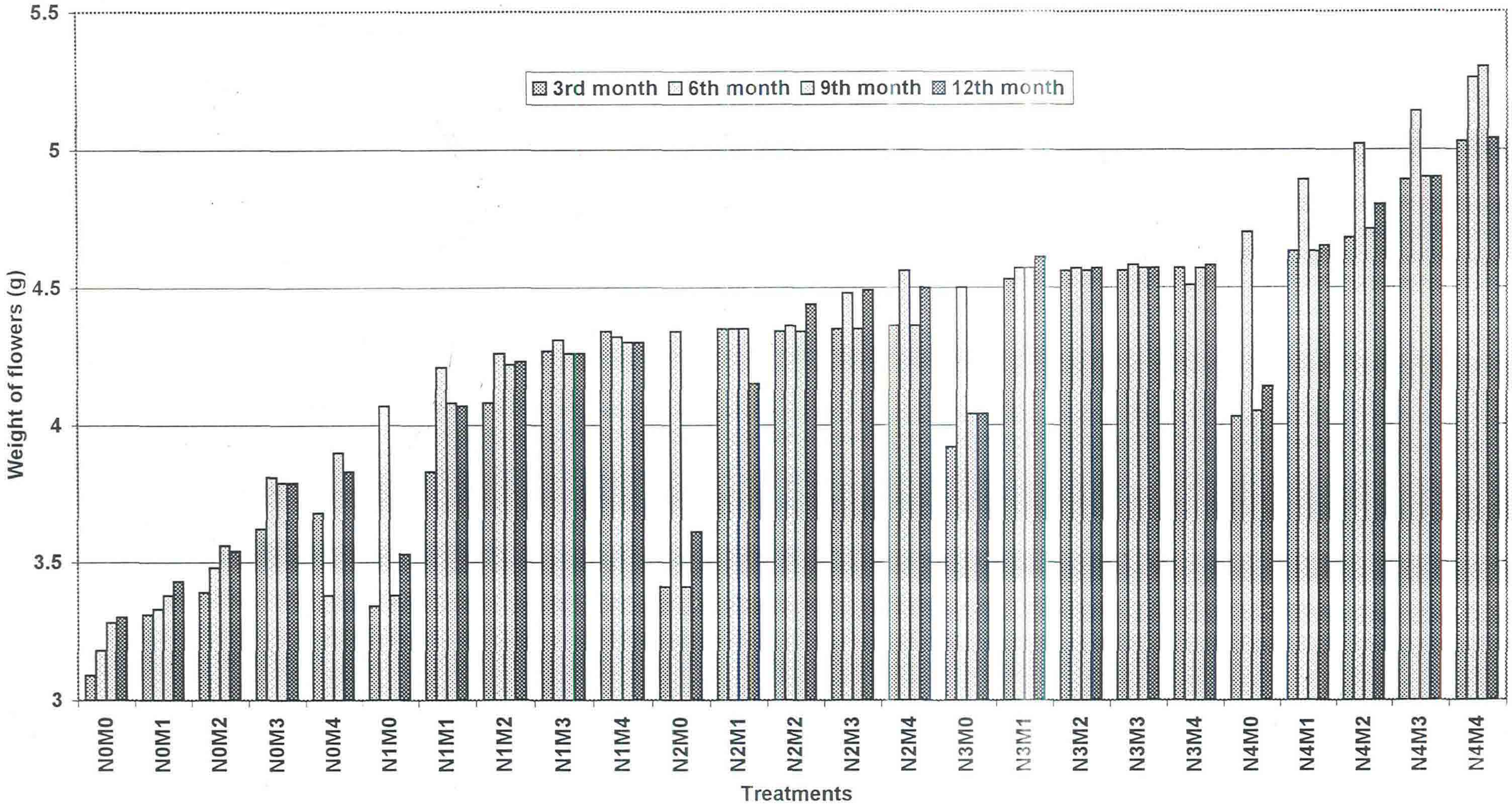


Table 22. Effect of nitrogen and micronutrients on flower yield (gm/plant) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.88	0.91	0.95	0.96	0.96	0.94	31.21	35.37	36.59	40.28	40.34	36.76
N_1	0.91	1.23	1.26	1.26	1.27	1.19	38.36	44.29	46.80	47.42	49.37	45.25
N_2	1.20	1.27	1.28	1.28	1.29	1.27	43.36	50.19	51.19	53.18	53.22	50.23
N_3	1.17	1.30	1.32	1.34	1.36	1.30	50.19	53.89	54.95	55.21	56.22	54.09
N_4	1.34	1.39	1.40	1.67	1.89	1.54	53.19	58.21	62.22	63.28	65.24	60.43
Mean	1.10	1.23	1.25	1.31	1.36	1.25	43.26	48.39	50.35	51.88	52.88	49.35
	9th month						12th month					
N_0	70.42	72.27	73.19	73.23	75.25	72.87	110.10	114.20	116.31	118.26	120.02	115.78
N_1	72.91	78.34	81.25	84.20	87.10	80.76	123.15	129.26	134.09	134.86	136.21	131.52
N_2	79.29	88.33	89.28	90.13	93.83	88.17	131.11	139.20	140.21	143.22	145.20	139.79
N_3	84.23	94.25	95.37	95.45	96.66	93.19	135.82	146.20	149.13	151.16	160.86	148.64
N_4	90.30	98.79	100.24	101.25	105.04	99.12	150.15	165.21	178.18	179.19	185.20	171.59
Mean	79.43	86.39	87.86	88.85	91.58	86.82	130.07	138.81	143.59	145.35	149.50	141.46

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.0004	0.0012	0.005	0.015
M	0.0005	0.0010	0.019	0.039
N at M	0.0011	0.0023	0.038	0.080
M at N	0.0011	0.0022	0.042	0.088

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.023	0.063	0.244	0.679
M	0.032	0.066	0.248	0.518
N at M	0.067	0.150	0.554	1.230
M at N	0.070	0.150	0.555	1.159

Fig 10. Effect of nitrogen and micronutrients on flower yield (g / plant)

Micronutrient application showed significant effect at all phases of crop growth. Among different micronutrients, M_4 recorded the highest yield of 1.36 g and 52.88 g at 3rd and 6th month and 91.58 g and 145.74 g at 9th and 12th month respectively.

Among the interaction effects, the treatment N_4M_4 registered the highest yield of 1.89 g and 65.24 g at 3rd and 6th month respectively. The treatment N_4M_4 recorded the highest yield of 105.04 g at 9th month followed by N_4M_3 (101.25 g). The highest yield of 167.17 g was recorded in the treatment N_4M_4 at 12th month followed by treatment N_4M_3 (179.19 g).

4.2.11 Flower yield per hectare

The flower yield per hectare also followed the same trend as that of flower yield per plant (Table 23).

The flower yield increased with the advancement of crop growth. With increasing levels of nitrogen, there was increase in flower yield per hectare. At 3rd and 6th month, N_4 recorded the highest yield of 42.83 and 1678.13 kg ha^{-1} followed by N_3 with 36.18 and 1502.44 kg ha^{-1} respectively. The treatment N_4 recorded the highest yield of 2752.43 kg ha^{-1} and 4426.55 kg ha^{-1} at 9th and 12th month respectively.

M_4 recorded the highest flower yield of 37.68 kg ha^{-1}, 1468.44 kg ha^{-1}, 2542.99 kg ha^{-1} and 4052.67 kg ha^{-1} at 3rd, 6th, 9th and 12th month of planting.

Table 23. Effect of nitrogen and micronutrients on flower yield (kg/ha) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	24.57	25.47	26.60	26.67	26.86	26.04	866.70	982.22	1016.07	1118.57	1120.23	1020.76
N_1	25.49	34.39	35.09	35.25	35.39	33.12	1065.39	1229.93	1299.77	1316.99	1371.00	1256.62
N_2	33.47	35.46	35.14	35.75	35.83	35.13	1204.35	1393.77	1421.53	1476.94	1478.03	1394.93
N_3	32.50	36.26	36.80	37.47	37.83	36.18	1393.77	1496.52	1526.09	1534.57	1561.23	1502.44
N_4	37.40	38.63	38.98	46.64	52.48	42.83	1477.10	1616.47	1727.95	1757.42	1811.71	1678.13
Mean	30.69	34.04	34.52	36.36	37.68		1201.47	1343.79	1398.28	1440.90	1468.44	1370.58
	9th month						12th month					
N_0	1955.42	2006.89	2032.48	2034.84	2089.69	2023.87	3056.21	3171.31	3230.02	3282.69	3332.95	3214.64
N_1	2024.59	2175.38	2256.17	2338.23	2418.63	2242.60	3419.87	3589.97	3723.81	3745.06	3782.69	3652.28
N_2	2203.09	2452.78	2479.22	2502.78	2605.52	2248.68	3641.04	3865.97	3893.77	3937.09	4032.32	3873.97
N_3	2339.07	2617.18	2648.28	2650.64	2684.20	2587.88	3771.86	4059.97	4141.48	4197.84	4467.20	4127.67
N_4	2506.36	2743.40	2783.66	2811.78	2916.94	2752.43	4169.80	4587.86	4948.19	4976.10	5087.60	4753.91
Mean	2205.71	2399.13	2439.97	2467.66	2542.99	2391.10	3611.76	3854.95	3987.46	4027.76	4140.56	3924.50

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.065	0.180	0.188	0.522
M	0.066	0.138	0.523	1.091
N at M	0.147	0.326	1.062	2.239
M at N	0.147	0.308	1.169	2.439

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.593	1.648	4.840	13.439
M	0.754	1.572	5.362	11.187
N at M	1.620	3.529	11.767	25.921
M at N	1.685	3.515	11.992	25.014

The N and M interaction showed significant results at 3rd, 6th, 9th and 12th month respectively. N_4M_4 registered the highest yield of 52.48 kg ha^{-1} followed by N_4M_3 (46.64 kg ha^{-1}) at 3rd month and was on par with N_4M_2. Treatment N_4M_4 recorded the highest yield of 1811.71, 2916.94 and 4648.15 kg ha^{-1} at 6th, 9th and 12th month respectively. The treatment N_4M_4 recorded the highest yield at all phases of crop growth.

4.3. Physiological and biochemical constituents

4.3.1 Chlorophyll 'a'

The chlorophyll 'a' content increased with crop growth. Nitrogen and micronutrients application had significant effect on chlorophyll 'a' content at all stages of crop growth.

Among different levels of nitrogen, treatment N_4 (180 kg N ha^{-1}) registered the highest chlorophyll 'a' content of 0.215, 1.218, 1.215 and 1.216 mg g^{-1} at 3rd, 6th, 9th and 12th month respectively.

Treatment M_4 registered increased chlorophyll 'a' content of 0.182 and 0.918, 0.915 and 0.924 mg g^{-1} at 3rd, 6th, 9th and 12th month respectively.

The interaction effect between N and M was significant at 3rd, 6th, 9th and 12th month of planting. N_4 recorded the highest value for chlorophyll 'a' content of

Table 24. Effect of nitrogen and micronutrients on chlorophyll a (mg g^{-1}) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.062	0.109	0.102	0.104	0.123	0.100	0.585	0.629	0.651	0.665	0.666	0.639
N_1	0.106	0.135	0.151	0.155	0.162	0.142	0.623	0.683	0.749	0.755	0.800	0.722
N_2	0.125	0.164	0.169	0.171	0.176	0.161	0.631	0.803	0.806	0.805	0.812	0.771
N_3	0.136	0.180	0.185	0.214	0.218	0.186	0.683	0.921	0.951	0.982	1.025	0.912
N_4	0.150	0.251	0.221	0.223	0.283	0.215	1.002	1.249	1.270	1.281	1.290	1.218
Mean	0.116	0.168	0.165	0.173	0.182	0.161	0.705	0.857	0.885	0.898	0.918	0.853
	9th month						12th month					
N_0	0.400	0.614	0.634	0.638	0.658	0.589	0.600	0.626	0.651	0.670	0.670	0.643
N_1	0.425	0.680	0.745	0.754	0.794	0.679	0.626	0.688	0.752	0.762	0.811	0.728
N_2	0.533	0.795	0.802	0.804	0.811	0.749	0.643	0.811	0.810	0.811	0.820	0.779
N_3	0.643	0.880	0.923	0.976	1.021	0.889	0.707	0.929	0.990	0.993	1.029	0.930
N_4	0.979	1.239	1.274	1.290	1.294	1.215	0.979	1.239	1.280	1.290	1.294	1.216
Mean	0.596	0.842	0.875	0.892	0.915	0.824	0.711	0.859	0.897	0.905	0.924	0.859

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.002	0.004	0.002	0.006
M	0.001	0.002	0.003	0.006
N at M	0.002	0.005	0.006	0.013
M at N	0.002	0.004	0.006	0.012

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.003	0.007	0.005	0.014
M	0.002	0.003	0.002	0.005
N at M	0.004	0.010	0.007	0.016
M at N	0.004	0.007	0.005	0.011

0.283 and 1.290 mg g^{-1} with M4 at 3rd and 6th month. N_4M_4 recorded the highest value of 1.294 mg g^{-1} each at 9th and 12th month.

4.3.2 Chlorophyll 'b'

The data on chlorophyll 'b' content are presented in Table 25.

Chlorophyll 'b' content increased with advancement of crop growth. The highest chlorophyll 'b' content was obtained with the application of 180 kg N ha^{-1}. N_4 recorded the highest chlorophyll 'b' content of 0.070, 0.388, 0.429 and 0.565 mg g^{-1} at 3rd, 6th, 9th and 12th month and 9th month respectively.

Micronutrient application had significant effect at 3rd, 6th, 9th and 12th month respectively. Treatment M_4 [Foliar application of $FeSO_4$ (1.0%) + $ZnSO_4$ (0.5%)] recorded the highest value of 0.061, 0.321, 0.380 and 0.443 mg g^{-1} at 3rd, 6th, 9th and 12th month respectively.

N x M interaction showed significance at different stages of crop growth. N_4M_4 registered increase in chlorophyll 'b' content of 0.081, 0.462, 0.488 and 0.698 mg g^{-1} at 3rd, 6th, 9th and 12th month respectively.

4.3.3 Total chlorophyll

The total chlorophyll content exhibited progressive increase from 3rd month to 12th month (Table 26).

Table 25. Effect of nitrogen and micronutrients on chlorophyll 'b' (mg g^{-1}) during 3^{rd}, 6^{th}, 9^{th} and 12^{th} month of planting

N levels/ Micro-nutrient	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.030	0.035	0.037	0.039	0.042	0.036	0.198	0.210	0.215	0.224	0.226	0.214
N_1	0.034	0.047	0.050	0.052	0.054	0.047	0.209	0.229	0.220	0.233	0.265	0.231
N_2	0.045	0.055	0.056	0.056	0.057	0.054	0.222	0.235	0.238	0.274	0.311	0.256
N_3	0.050	0.057	0.061	0.068	0.070	0.061	0.254	0.302	0.321	0.334	0.342	0.310
N_4	0.054	0.070	0.072	0.074	0.081	0.070	0.270	0.357	0.424	0.429	0.462	0.388
Mean	0.043	0.053	0.055	0.058	0.061	0.054	0.230	0.266	0.283	0.298	0.321	0.280
	9th month						12th month					
N_0	0.229	0.294	0.302	0.318	0.324	0.293	0.307	0.325	0.333	0.347	0.362	0.334
N_1	0.241	0.327	0.329	0.332	0.335	0.313	0.316	0.375	0.384	0.386	0.390	0.370
N_2	0.317	0.338	0.335	0.342	0.345	0.335	0.323	0.399	0.336	0.357	0.346	0.352
N_3	0.320	0.345	0.377	0.407	0.411	0.372	0.370	0.384	0.392	0.408	0.419	0.395
N_4	0.329	0.421	0.445	0.465	0.488	0.429	0.315	0.540	0.610	0.665	0.698	0.565
Mean	0.287	0.345	0.357	0.372	0.380	0.348	0.326	0.404	0.411	0.432	0.443	0.403

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.001	0.002	0.001	0.004
M	0.001	0.001	0.001	0.003
N at M	0.001	0.003	0.003	0.007
M at N	0.001	0.002	0.003	0.007

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.004	0.012	0.002	0.006
M	0.003	0.006	0.005	0.011
N at M	0.007	0.017	0.011	0.023
M at N	0.007	0.014	0.012	0.025

Table 26. Effect of nitrogen and micronutrients on total chlorophyll (mg g^{-1}) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.091	0.137	0.142	0.142	0.159	0.134	0.786	0.812	0.851	0.874	0.885	0.841
N_1	0.141	0.180	0.193	0.205	0.213	0.186	0.817	0.913	0.986	1.019	1.067	0.960
N_2	0.172	0.213	0.216	0.222	0.233	0.211	0.876	0.922	0.936	0.944	0.962	0.928
N_3	0.187	0.231	0.237	0.279	0.264	0.239	0.937	1.215	1.132	1.306	1.233	1.164
N_4	0.287	0.282	0.285	0.292	0.302	0.287	1.260	1.379	1.631	1.684	1.839	1.558
Mean	0.173	0.208	0.214	0.228	0.234	0.212	0.935	1.048	1.107	1.165	1.197	1.090
	9th month						12th month					
N_0	0.519	0.739	0.815	0.846	0.876	0.759	0.890	1.011	1.045	1.057	1.060	1.012
N_1	0.559	0.905	0.831	0.986	1.030	0.862	0.943	1.016	1.083	1.142	1.184	1.073
N_2	0.750	0.950	0.968	1.077	1.208	0.990	0.972	1.139	1.154	1.067	1.132	1.093
N_3	0.935	1.125	1.232	1.182	1.351	1.165	0.968	1.230	1.318	1.338	1.441	1.259
N_4	1.134	1.250	1.415	1.432	1.450	1.336	1.296	1.701	1.902	1.961	1.965	1.763
Mean	0.779	0.994	1.052	1.104	1.183	1.022	1.011	1.219	1.300	1.313	1.356	1.240

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.001	0.003	0.003	0.008
M	0.001	0.003	0.002	0.004
N at M	0.003	0.006	0.005	0.011
M at N	0.003	0.006	0.004	0.009
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.019	0.054	0.013	0.036
M	0.019	0.040	0.012	0.024
N at M	0.043	0.095	0.027	0.060
M at N	0.043	0.089	0.026	0.054

Application of Nitrogen was significantly effective at all stages of crop growth. N_4 registered the highest total chlorophyll content of 0.287, 1.558, 1.336 and 1.763 mg g^{-1} at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively .

Application of micronutrients had significant effect throughout the stages of crop growth. Treatment M_4 [foliar spray of $FeSO_4$ (1.0%) + $ZnSO_4$ (0.5%)] recorded the highest total chlorophyll content of 0.234, 1.197, 1.183 and 1.356 mg g^{-1} at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively.

The N and M interaction was significant at different stages of crop growth. The interaction effect revealed that the treatment N_4M_4 registered the highest total chlorophyll content of 0.302,1.839,1.450 and 1.965 mg g^{-1} at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively.

4.3.4 Crop Growth Rate

The data on crop growth rate are presented in Table 27.

Nitrogen application exerted significant effects in the first phase. The treatment N_4 recorded the highest crop growth rate of 2.118, 0.092 and 0.107 g m^{-2} day^{-1} at first, second and last phase respectively.

Micronutrient application also showed significant effects. The treatment M_4 registered the highest crop growth rate of 1.625 g m^{-2} day^{-1} in the first phase, 0.089 and 0.104 m^{-2} day^{-1} at second and last phase respectively.

Table 27. Effect of nitrogen and micronutrients on crop growth rate (gm^{-2} day^{-1}) during different phases of crop growth

N levels/ Micro-nutrients	3-6 month						6-9 month						9-12 month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.655	0.730	0.795	0.841	0.850	0.774	0.047	0.066	0.074	0.070	0.086	0.069	0.083	0.083	0.084	0.087	0.090	0.085
N_1	0.801	1.201	1.211	1.341	1.372	1.185	0.083	0.085	0.087	0.084	0.084	0.085	0.090	0.086	0.094	0.096	0.103	0.094
N_2	1.431	1.430	1.511	1.672	1.702	1.559	0.084	0.085	0.085	0.086	0.085	0.085	0.090	0.096	0.099	0.102	0.108	0.099
N_3	1.561	1.822	1.831	1.941	2.005	1.832	0.081	0.089	0.084	0.086	0.087	0.085	0.099	0.104	0.105	0.103	0.105	0.103
N_4	2.060	2.035	2.130	2.170	2.195	2.118	0.085	0.087	0.089	0.095	0.106	0.092	0.102	0.107	0.105	0.109	0.114	0.107
Mean	1.302	1.443	1.496	1.593	1.625	1.492	0.076	0.082	0.084	0.084	0.089	0.083	0.093	0.095	0.097	0.099	0.104	0.098

	SEd	CD(P=0.05)	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.005	0.015	0.0001	0.0003	0.0002	0.0007
M	0.005	0.011	0.0003	0.0007	0.0002	0.0004
N at M	0.011	0.025	0.0007	0.0014	0.0005	0.0012
M at N	0.011	0.024	0.0007	0.0016	0.0005	0.0010

Among the interaction effect, the treatment N_4 showed the highest CGR of 2.195 g m^{-2} day^{-1} with M_4 and was on par with N_4M_3 (2.170 g m^{-2} day^{-1}) in the first phase. The treatment N_4M_4 recorded the highest crop growth rate of 0.106 g m^{-2} day^{-1} in the second phase and 0.114 g m^{-2} day^{-1} at the last phase respectively.

4.3.5 Relative growth rate

The relative growth rate showed an increase in the first phase and then decreased in the final phase (Table 28).

Application of nitrogen exhibited significant effects at different phases of crop growth. Among different levels of nitrogen, treatment N_3 recorded the highest value of 0.021 g m^{-2} day^{-1} at the first phase. M_0 recorded the highest RGR (0.020 g m^{-2} day^{-1}) at the first phase. Among the interaction effect, the treatment N_3M_1 recorded the highest RGR in the first phase (0.021 g m^{-2} day^{-1}).

In the second phase, the treatment N_0 recorded the highest RGR of 0.005 g m^{-2} day^{-1}. Treatment M_1,M_2 and M_4 recorded the highest RGR (0.004 g m^{-2} day^{-1}) at second phase. Among the interaction effect, the treatment N_1M_0 (0.006 g m^{-2} day^{-1}) recorded the highest RGR. N_0 (0.005 g m^{-2} day^{-1}) recorded the highest RGR in the final phase. Treatment M_4 (0.003) recorded the highest RGR and are statiscally on par with M_3, M_2 and M_1 respectively.

In the final phase, N_0M_2 recorded the highest RGR of 0.006 g m^{-2} day^{-1} and was on par with N_0M_1, N_0M_3 and N_0M_4(0.005 g m^{-2} day^{-1}).

Table 28. Effect of nitrogen and micronutrients on relative growth rate (g m^{-2} day^{-1}) during different phases of crop growth

N levels/ Micro-nutrients	3-6 month						6-9 month						9-12 month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.02	0.016	0.016	0.017	0.016	0.017	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
N_1	0.015	0.020	0.019	0.019	0.018	0.018	0.006	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.003	0.003	0.003
N_2	0.020	0.019	0.020	0.020	0.020	0.020	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.002	0.003	0.003
N_3	0.024	0.021	0.020	0.020	0.020	0.021	0.003	0.002	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.003	0.002
N_4	0.020	0.019	0.020	0.020	0.019	0.020	0.003	0.003	0.003	0.004	0.004	0.003	0.002	0.002	0.002	0.002	0.002	0.002
Mean	0.020	0.019	0.019	0.019	0.019	0.019	0.004	0.004	0.004	0.003	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003

	3-6 month SEd	3-6 month CD(P=0.05)	6-9 month SEd	6-9 month CD(P=0.05)	9-12 month SEd	9-12 month CD(P=0.05)
N	0.00017	0.0005	0.0001	0.0002	0.0001	0.0004
M	0.00016	0.0003	0.0001	0.0001	0.0001	0.0003
N at M	0.0004	0.0008	0.0001	0.0003	0.0003	0.0007
M at N	0.0004	0.0007	0.0001	0.0002	0.0003	0.0007

4.3.6 Net Assimilation Rate

N levels and micronutrients exhibited significant effects on net assimilation rate at different phases of crop growth (Table 29).

Among N levels, the treatment N_3 registered higher value for net assimilation rate (0.515 mg cm^{-2} day^{-1}) during the first phase. Micronutrients application did not have significant effects in the first phase. The interaction effect between N and M also showed significant effects on net assimilation rate. Treatment N_4M_0 registered increased net assimilation rate in the first phase (0.607 mg cm^{-2} day^{-1}).

At second phase, the treatment N_1 recorded the highest net assimilation rate of 0.112 mg cm^{-2} day^{-1}. Application of micronutrients did not have effect on net assimilation rate during the second phase. M_0 recorded the highest net assimilation rate (0.104 mg cm^{-2} day^{-1}) during the second phase. Treatment N_1M_0 recorded higher net assimilation rate of 0.136 mg cm^{-2} day^{-1} at second phase. At the last phase, application of fertilizers did not have any effect on net assimilation rate.

4.3.7 Soluble protein content

Nitrogen and micronutrient application showed significant effect for all the treatments (Table 30).

N_4 recorded the highest soluble protein content of 2.53, 5.18, 5.25 and 5.41 mg cm^{-2} at 3rd, 6th, 9th and 12th month respectively.

Table 29. Effect of nitrogen and micronutrients on net assimilation rate (mg cm^{-2} day^{-1}) during different phases of crop growth

N levels/ Micro-nutrients	3-6 month						6-9 month						9-12 month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.250	0.277	0.316	0.318	0.308	0.294	0.085	0.090	0.059	0.098	0.012	0.068	0.125	0.083	0.084	0.083	0.081	0.091
N_1	0.259	0.415	0.403	0.445	0.446	0.394	0.136	0.111	0.107	0.105	0.104	0.112	0.103	0.078	0.069	0.085	0.074	0.082
N_2	0.487	0.488	0.476	0.527	0.539	0.503	0.117	0.105	0.103	0.105	0.099	0.106	0.087	0.104	0.083	0.081	0.085	0.088
N_3	0.504	0.513	0.500	0.533	0.525	0.515	0.092	0.097	0.085	0.088	0.084	0.089	0.074	0.077	0.074	0.073	0.075	0.075
N_4	0.607	0.519	0.524	0.531	0.253	0.487	0.088	0.084	0.080	0.083	0.098	0.087	0.072	0.072	0.070	0.077	0.078	0.074
Mean	0.421	0.442	0.444	0.471	0.414	0.439	0.104	0.097	0.087	0.096	0.079	0.093	0.092	0.083	0.076	0.080	0.079	0.082

	3-6 month SEd	3-6 month CD(P=0.05)	6-9 month SEd	6-9 month CD(P=0.05)	9-12 month SEd	9-12 month CD(P=0.05)
N	0.032	0.089	0.005	0.014	0.002	0.005
M	NS	NS	0.006	0.013	0.002	0.004
N at M	0.073	0.162	0.014	0.030	0.004	0.010
M at N	0.073	0.153	0.014	0.029	0.004	0.009

Table 30. Effect of nitrogen and micronutrients on soluble protein content (mg cm^{-2}) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.85	1.49	1.68	1.54	1.61	1.43	1.25	2.25	2.80	2.78	2.85	2.38
N_1	1.02	1.58	1.75	1.69	1.78	1.56	1.44	2.40	3.39	3.09	3.23	2.71
N_2	1.29	1.83	1.77	1.80	1.76	1.69	2.46	3.52	3.55	3.55	3.66	3.35
N_3	1.31	1.92	2.16	2.50	2.20	2.02	2.76	3.89	3.91	3.95	4.35	3.77
N_4	2.28	2.35	2.55	2.66	2.80	2.53	4.19	4.90	5.54	5.56	5.71	5.18
Mean	1.35	1.83	1.98	2.03	2.04	1.85	2.42	3.39	3.84	3.78	3.96	3.48
	9th month						12th month					
N_0	2.10	2.26	2.80	2.83	2.87	2.57	1.27	2.36	2.88	2.87	2.95	2.46
N_1	1.46	2.93	2.97	2.97	3.04	2.67	1.75	3.11	3.19	3.24	3.27	2.91
N_2	3.06	3.57	3.60	3.62	3.65	3.50	3.24	3.57	3.65	3.77	3.90	3.62
N_3	2.80	3.91	3.96	3.86	4.39	3.78	3.72	3.88	4.09	4.39	4.65	4.15
N_4	4.60	4.89	5.57	5.51	5.70	5.25	4.40	5.60	5.62	5.66	5.79	5.41
Mean	2.80	3.51	3.78	3.76	3.93	3.55	2.87	3.70	3.88	3.98	4.11	3.71

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.008	0.021	0.021	0.057
M	0.014	0.030	0.013	0.028
N at M	0.030	0.064	0.034	0.079
M at N	0.032	0.067	0.030	0.062

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.115	0.318	0.009	0.024
M	0.113	0.237	0.009	0.018
N at M	NS	NS	0.020	0.043
M at N	NS	NS	0.020	0.041

With regard to micronutrients, treatment M_4 [Foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest soluble protein content of 2.04 mg cm^{-2} which was on par with treatment M_3 (2.03 mg cm^{-2}). Treatment M_4 registered 2.04, 3.96, 3.93 and 4.11 mg cm^{-2} at 3rd, 6th, 9th and 12th month respectively.

N x M interaction effect showed significant results at all stages of crop growth. N_4M_4 showed increased soluble protein content of 2.80, 5.71 and 5.79 mg cm^{-2} at 3rd, 6th and 12th month respectively.

4.3.8 Nitrate reductase activity

The data on nitrate reductase activity during different stages of crop growth revealed that it increased as the stages of the crop advanced. Nitrogen and micronutrients application showed significant effects for all treatments (Table 31).

N_4 registered higher nitrate reductase activity of 1.84, 1.91, 2.09 and 1.99 μg g^{-1} hr^{-1} at 3rd, 6th, 9th and 12th month respectively. At 3rd and 12th month, treatment M_4 recorded higher reductase activity of 0.87 and 1.49 μg g^{-1} hr^{-1} .

Treatment N_4M_4 showed higher nitrate reductase activity of 1.85, 1.92, 2.54, 2.10 μg g^{-1} hr^{-1} at 3rd, 6th, 9th and 12th month respectively.

4.3.9 Catalase activity

Effect of nitrogen and micronutrients on catalase activity at different stages of growth are presented in Table 32.

Table 31. Effect of nitrogen and micronutrients on nitrate reductase activity (µg g^{-1} hr^{-1}) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.30	0.31	0.31	0.31	0.31	0.31	0.35	0.36	0.37	0.37	0.38	0.36
N_1	0.58	0.58	0.58	0.59	0.59	0.58	0.62	0.62	0.49	0.61	0.63	0.60
N_2	0.64	0.64	0.65	0.65	0.65	0.65	1.26	1.28	1.28	1.28	1.28	1.28
N_3	0.92	0.92	0.93	0.94	0.94	0.93	1.80	1.80	1.81	1.82	1.82	1.75
N_4	1.84	1.84	1.84	1.84	1.85	1.84	1.92	1.90	1.91	1.92	1.92	1.91
Mean	0.85	0.86	0.86	0.86	0.87	0.86	1.19	1.13	1.17	1.20	1.20	1.18
	9th month						12th month					
N_0	0.39	0.41	0.43	0.42	0.43	0.41	0.41	0.42	0.43	0.42	0.41	0.42
N_1	0.63	0.66	0.68	0.65	0.69	0.66	0.77	0.74	0.77	0.79	1.25	0.86
N_2	1.31	1.31	1.33	1.32	1.34	1.32	1.28	1.67	1.58	1.74	1.77	1.61
N_3	1.85	1.89	1.87	1.90	1.93	1.89	1.95	1.92	1.92	1.91	1.91	1.92
N_4	1.95	1.96	1.98	2.03	2.54	2.09	1.92	1.96	1.98	1.99	2.10	1.99
Mean	1.23	1.24	1.26	1.26	1.39	1.27	1.26	1.34	1.33	1.37	1.49	1.36

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.006	0.016	0.041	0.113
M	0.001	0.002	NS	NS
N at M	0.006	0.017	NS	NS
M at N	0.002	0.004	NS	NS

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.067	0.185	0.006	0.017
M	NS	NS	0.007	0.014
N at M	NS	NS	0.015	0.032
M at N	NS	NS	0.015	0.031

Table 32. Effect of nitrogen and micronutrients on catalase activity (μ moles H_2O_2 utilized 100 g^{-1} min^{-2}) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	1.02	1.16	3.24	3.30	3.34	2.41	1.82	1.94	4.85	4.85	4.88	3.67
N_1	1.16	1.35	3.89	3.98	4.28	2.93	2.01	2.08	5.17	5.22	5.36	3.97
N_2	1.64	1.87	4.61	4.64	4.77	3.50	2.04	2.22	5.74	5.79	5.84	4.33
N_3	2.02	2.15	4.86	5.07	5.18	3.85	2.12	2.32	5.88	5.91	5.94	4.44
N_4	2.22	2.78	5.31	5.80	5.90	4.40	2.37	2.43	5.92	5.98	6.12	4.57
Mean	1.61	1.86	4.38	4.56	4.70	3.42	2.07	2.20	5.51	5.55	5.63	4.20
	9th month						12th month					
N_0	2.92	3.17	5.06	5.18	5.29	4.33	1.84	4.86	5.32	5.51	5.31	4.57
N_1	3.07	5.27	6.95	7.13	7.38	5.96	3.06	6.75	6.96	7.12	7.28	6.23
N_2	4.59	6.67	7.59	8.25	8.66	7.15	4.14	7.96	8.44	8.67	8.62	7.56
N_3	4.75	7.05	8.25	8.54	8.95	7.51	4.60	8.05	8.85	9.03	9.96	8.10
N_4	5.12	6.79	9.20	9.57	9.78	8.10	5.00	9.03	10.09	10.41	10.55	9.01
Mean	4.09	5.79	7.41	7.73	8.01	6.61	3.73	7.33	7.94	8.15	8.35	7.09

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.031	0.086	0.017	0.048
M	0.036	0.075	0.020	0.042
N at M	0.078	0.171	0.043	0.095
M at N	0.080	0.167	0.045	0.093

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.184	0.511	0.061	0.168
M	0.074	0.154	0.096	0.200
N at M	0.236	0.592	0.201	0.432
M at N	0.165	0.345	0.215	0.447

Considering the catalase activity there were marked differences among the stages. Treatment N_4 showed higher catalase activity at 3rd (4.40 μ moles H_2O_2), 6th (4.57 μ moles H_2O_2), 9th (8.10 μ moles H_2O_2) and 12th month (9.01 μ moles H_2O_2) of planting.

Treatment M_4 recorded higher catalase activity at 3rd (4.70μ moles H_2O_2), 6th (5.63 μ moles H_2O_2), 9th (8.01 μ moles H_2O_2) and 12th month (8.35 μ moles H_2O_2) respectively.

Regarding the interaction effect, the treatment N_4M_4 recorded higher catalase activity of 5.90, 6.12, 9,78 and 10.55 μ moles H_2O_2 utilized 100 g^{-1} fresh weight min^{-1} at 3rd, 6th, 9th and 12th month respectively.

4.3.10 IAA oxidase activity

IAA oxidase activity differed significantly among the stages (Table 33).

Nitrogen and micronutrient application showed significant results at different stages of crop growth. Treatment N_4 registered an increase in IAA oxidase activity of 2065.34, 2211.19, 2334.11 and 3957.44 μ g of unoxidised auxin g^{-1} hr^{-1} at 3rd, 6th, 9th and 12th month respectively.

Micronutrient application showed significant effects at all stages of crop growth. Treatment M_4 registered increase in IAA oxidase activity of 2179.23, 2194.10, 2189.90 and 4136.56 μ g of unoxidised auxin gm^{-1} hr^{-1} at 3rd, 6th, 9th and 12th month respectively.

Table 33. Effect of nitrogen and micronutrients on IAA oxidase (µ gm of unoxidised auxin/gm/hr) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	1414.00	1652.65	1415.56	1945.00	1952.25	1678.89	1732.75	1940.50	1756.50	1948.50	1961.50	1867.95
N_1	1422.15	1700.00	1429.05	1983.00	1986.50	1704.14	1752.05	1984.75	1759.65	1983.25	1988.00	1893.54
N_2	1427.08	2119.75	1433.75	2242.50	2245.00	1893.62	1754.15	2227.15	1758.05	2228.25	2228.75	2039.27
N_3	1435.07	2250.00	1443.90	2261.75	2254.00	1928.95	1755.90	2267.50	1756.55	2266.75	2271.75	2063.69
N_4	1460.15	2483.50	1474.40	2450.25	2458.40	2065.34	1761.05	2498.25	1760.90	2515.25	2520.50	2211.19
Mean	1431.69	2041.18	1439.33	2176.50	2179.23	1853.59	1751.18	2183.63	1758.33	2188.40	2194.10	2015.13
	9th month						12th month					
N_0	1946.90	1975.00	1948.60	1955.00	1962.25	1957.55	1981.25	2498.25	1984.50	2597.00	2613.00	2334.80
N_1	1950.55	1983.75	1954.30	1985.75	1997.25	1974.32	1985.15	2419.25	1989.55	3027.06	3056.52	2495.51
N_2	1954.40	2127.00	1952.95	2247.75	2249.25	2106.27	1991.15	4215.00	1995.80	4512.00	4492.25	3441.24
N_3	1962.01	2255.60	1966.86	2277.50	2154.50	2123.30	2005.55	4790.00	2010.65	5018.25	5107.00	3786.29
N_4	1967.05	2564.50	1972.50	2580.25	2586.25	2334.11	2014.05	5012.25	2024.90	5322.00	5414.00	3957.44
Mean	1956.18	2181.17	1959.04	2209.25	2189.90	2099.11	1995.43	3786.95	2001.08	4095.26	4136.56	3203.06

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	34.413	95.548	0.913	2.535
M	34.040	71.007	0.542	1.130
N at M	76.284	169.85	1.417	3.361
M at N	76.116	158.777	1.211	2.526

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.326	0.906	63.171	175.393
M	0.487	1.016	63.187	131.807
N at M	1.027	2.214	141.284	314.218
M at N	1.089	2.271	141.291	294.730

N x M interaction registered significant results for IAA oxidase activity. Treatment N_4M_4 recorded higher value of 2458.40, 2520.50, 2586.25 and 5414.00 μ g of unoxidised auxin g^{-1} hr^{-1} at 3rd, 6th, 9th and 12th month respectively.

4.3.11 Peroxidase activity

The peroxidase activity increased as the crop stage progressed from 3rd month to 12th month of planting. Nitrogen and micronutrient application showed significant results at all stages of crop growth (Table 34).

Nitrogen application showed significant results on peroxidase activity. N_4 registered higher peroxidase activity of 0.31, 0.32, 0.33 and 0.34 μg g^{-1} hr^{-1} at 3rd, 6th, 9th and 12th month respectively.

Among different micronutrients, the treatment M_4 registered higher peroxidase activity of 0.25, 0.26, 0.28 and 0.29 μg g^{-1} hr^{-1} at 3rd, 6th, 9th and 12th month respectively.

N x M interaction showed significant effects at 6th, 9th and 12th month of planting. Treatment N_4 recorded higher peroxidase activity of 0.35 μg g^{-1} hr^{-1} with M_4 at 6th month and was on par with N_4M_2 (0.34 μg g^{-1} hr^{-1}) and N_4M_3 (0.33 μg g^{-1} hr^{-1}). At 9th month, treatment N_4M_4 recorded peroxidase activity of 0.36 μg g^{-1} hr^{-1} and it was on par with N_4M_2 (0.35 μg g^{-1} hr^{-1}). At 12th month, treatment N_4M_4 registered higher peroxidase activity of 0.37 μg g^{-1} hr^{-1} and it was on par with N_4M_2 (0.36 μg g^{-1} hr^{-1}) and N_4M_3 (0.35 μg g^{-1} hr^{-1}).

Table 34. Effect of nitrogen and micronutrients on peroxidase activity (µg g^{-1} hr^{-1}) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.10	0.12	0.14	0.14	0.14	0.12	0.11	0.12	0.12	0.13	0.16	0.13
N_1	0.14	0.15	0.17	0.20	0.22	0.17	0.15	0.18	0.21	0.21	0.24	0.20
N_2	0.20	0.25	0.25	0.26	0.27	0.24	0.18	0.26	0.24	0.23	0.27	0.24
N_3	0.23	0.28	0.27	0.31	0.31	0.28	0.24	0.30	0.30	0.32	0.31	0.29
N_4	0.26	0.28	0.33	0.34	0.34	0.31	0.27	0.32	0.34	0.33	0.35	0.32
Mean	0.18	0.21	0.23	0.25	0.25	0.23	0.19	0.23	0.24	0.24	0.26	0.23
	9th month						12th month					
N_0	0.10	0.11	0.13	0.14	0.20	0.13	0.11	0.20	0.21	0.18	0.21	0.18
N_1	0.16	0.19	0.20	0.22	0.24	0.20	0.17	0.21	0.22	0.24	0.25	0.22
N_2	0.21	0.28	0.27	0.27	0.28	0.26	0.22	0.28	0.27	0.28	0.29	0.27
N_3	0.24	0.32	0.30	0.29	0.33	0.29	0.24	0.33	0.31	0.33	0.33	0.31
N_4	0.27	0.33	0.35	0.33	0.36	0.33	0.28	0.34	0.36	0.35	0.37	0.34
Mean	0.19	0.24	0.25	0.25	0.28	0.24	0.20	0.27	0.27	0.27	0.29	0.26

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.006	0.016	0.005	0.014
M	0.006	0.013	0.004	0.008
N at M	NS	NS	0.009	0.021
M at N	NS	NS	0.009	0.018

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.004	0.011	0.005	0.015
M	0.005	0.009	0.004	0.009
N at M	0.010	0.022	0.010	0.023
M at N	0.010	0.021	0.010	0.020

4.3.12 Tryptophan

The data on tryptophan content are presented in Table 35.

All the combinations of treatments had improved the tryptophan content over control. Treatment N_4 showed significant increase in tryptophan content at 3rd month (8.04 μg g^{-1}), 6th month (12.00 μg g^{-1}) 9th month (11.32 μg g^{-1}) and 12th month (10.36 μg g^{-1}).

Among the micronutrient treatments, treatment M_4 [foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest tryptophan content of 7.85, 9.55, 9.68 and 9.89 μg g^{-1} at 3rd, 6th 9th and 12th month respectively.

The variations due to interaction between treatments and stages were found to be statistically significant. Treatment N_4M_4 registered the highest tryptophan content of 9.41 μg g^{-1} at 3rd month and was found to be on par with N_4M_3 (9.35 μg g^{-1}). Treatment N_4M_4 recorded the highest tryptophan content at 9th month (13.29 μ g g^{-1}) and 12th month (12.13 μ g g^{-1}).

4.4.Nutrient contents

4.4.1 N content in leaf

Different levels of N and micronutrients exhibited significant effects on N content in leaf (Table 36).

Among different levels of N, treatment N_4 recorded higher value for N content in leaf (1.28, 1.27, 1.33, 1.20 per cent) at 3rd, 6th, 9th and 12th month respectively.

Table 35. Effect of nitrogen and micronutrients on tryptophan content (μ g g^{-1} fresh weight) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	3.68	4.37	3.84	4.46	4.58	4.18	5.91	6.41	6.05	6.47	7.44	6.46
N_1	5.11	7.87	5.88	7.96	7.99	6.96	6.01	8.35	6.09	8.73	8.97	7.63
N_2	5.39	7.93	5.96	8.18	8.21	7.13	7.62	9.49	9.11	9.36	9.74	9.07
N_3	5.77	8.49	5.96	8.89	9.05	7.63	8.29	10.08	12.20	13.10	7.36	10.21
N_4	6.02	9.30	6.11	9.35	9.41	8.04	9.02	13.49	9.10	14.09	14.28	12.00
Mean	5.19	7.59	5.55	7.77	7.85	6.79	7.37	9.56	8.51	9.55	9.56	9.07
	9th month						12th month					
N_0	5.93	7.56	6.45	7.44	7.60	7.00	6.00	8.21	7.20	8.25	8.31	7.59
N_1	6.04	8.48	8.09	8.58	8.79	8.01	7.21	8.56	7.80	8.84	8.96	8.27
N_2	7.11	8.96	8.31	9.09	9.21	8.54	7.87	8.70	8.07	9.36	9.52	8.70
N_3	7.81	9.41	8.21	9.53	9.50	8.90	8.07	10.17	8.58	10.53	10.56	9.58
N_4	8.33	12.46	10.37	12.15	13.29	11.32	8.23	10.71	9.58	11.16	12.13	10.36
Mean	7.05	9.38	8.29	9.36	9.68	8.75	7.47	9.27	8.24	9.62	9.89	8.91

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.081	0.226	0.780	2.165
M	0.073	0.152	0.751	1.567
N at M	0.167	0.375	NS	NS
M at N	0.163	0.340	NS	NS
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.050	0.140	0.112	0.311
M	0.039	0.082	0.094	0.196
N at M	0.094	0.214	0.219	0.496
M at N	0.088	0.184	0.211	0.439

Table 36. *Effect of nitrogen and micronutrients on nitrogen content in leaf (%) during 3rd, 6th, 9th and 12th month of planting*

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.74	0.81	1.05	1.00	1.09	0.94	0.76	0.81	1.05	1.00	1.09	0.94
N_1	0.95	1.11	1.14	1.11	1.12	1.09	0.95	1.12	1.15	1.11	1.14	1.10
N_2	1.09	1.16	1.18	1.20	1.21	1.17	1.09	1.19	1.20	1.20	1.21	1.18
N_3	1.12	1.22	1.23	1.25	1.25	1.22	1.12	1.20	1.23	1.24	1.23	1.21
N_4	1.20	1.21	1.26	1.28	1.41	1.28	1.20	1.21	1.25	1.28	1.40	1.27
Mean	1.02	1.11	1.18	1.17	1.22	1.14	1.03	1.11	1.18	1.17	1.22	1.14
	9th month						12th month					
N_0	0.74	0.82	1.03	1.01	1.09	0.94	0.75	0.81	1.01	1.00	1.09	0.93
N_1	0.95	1.12	1.15	1.15	1.09	1.08	0.95	1.12	1.15	1.11	1.14	1.09
N_2	1.09	1.18	1.19	1.22	1.21	1.18	1.09	1.16	1.17	1.20	1.20	1.16
N_3	1.13	1.20	1.22	1.23	1.32	1.20	1.12	1.20	1.20	1.21	1.20	1.18
N_4	1.20	1.31	1.36	1.39	1.41	1.33	1.20	1.21	1.26	1.30	1.40	1.20
Mean	1.02	1.13	1.19	1.20	1.22	1.15	1.02	1.10	1.16	1.16	1.20	1.13

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.004	0.011	0.003	0.007
M	0.005	0.011	0.002	0.005
N at M	0.011	0.024	0.005	0.012
M at N	0.012	0.024	0.005	0.011
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	0.003	0.008	0.003	0.009
M	0.002	0.004	0.002	0.004
N at M	0.005	0.011	0.005	0.012
M at N	0.004	0.001	0.005	0.010

Micronutrient application exerted significant influence at all stages of crop growth. Treatment M_4 recorded the highest value of 1.22 at 3rd, 6th and 9th month and 1.20 per cent at 12th month.

The interaction effect showed significant results. The highest N content in leaf (1.41 per cent) was observed in the treatment N_4M_4 at 3rd and 9th month, 1.40 per cent during 6th and 12th month respectively.

4.4.2 P content in leaf

The phosphorus content in leaf showed a declining trend (Table 37)..

Nitrogen application had significant effect at all stages of crop growth. N_4 recorded the highest phosphorus content of 0.130 per cent at 3rd month and 0.131 per cent at 6th, 9th and 12th month respectively.

Micronutrient application also exhibited significant effects at all stages of crop growth. Treatment M_4 [foliar application of $FeSO_4$ (1.0%) + $ZnSO_4$ (0.5%)] recorded the highest value for phosphorus content. It recorded the highest phosphorus content of 0.121 per cent and 0.122 per cent at 3rd and 6th month and 0.120 at 9th and 0.119 per cent at 12th month respectively.

The interaction effect of nitrogen and micronutrients of leaf phosphorus was significant. The treatment N_4M_4 recorded the highest phosphorus content in leaf with

Table 37. Effect of nitrogen and micronutrients on phosphorus content in leaf (%) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.101	0.102	0.102	0.103	0.104	0.102	0.101	0.103	0.103	0.103	0.104	0.103
N_1	0.102	0.105	0.102	0.106	0.107	0.104	0.102	0.105	0.103	0.106	0.108	0.105
N_2	0.105	0.120	0.110	0.123	0.125	0.116	0.105	0.121	0.111	0.124	0.125	0.117
N_3	0.107	0.129	0.127	0.131	0.132	0.125	0.108	0.130	0.128	0.131	0.132	0.126
N_4	0.112	0.134	0.132	0.135	0.139	0.130	0.113	0.135	0.133	0.136	0.140	0.131
Mean	0.105	0.118	0.115	0.119	0.121	0.116	0.106	0.119	0.116	0.120	0.122	0.116
	9th month						12th month					
N_0	0.100	0.101	0.102	0.103	0.102	0.101	0.100	0.101	0.101	0.102	0.102	0.101
N_1	0.102	0.103	0.102	0.105	0.107	0.104	0.101	0.103	0.102	0.104	0.106	0.103
N_2	0.104	0.119	0.107	0.123	0.124	0.115	0.103	0.119	0.107	0.122	0.123	0.114
N_3	0.108	0.129	0.126	0.130	0.130	0.124	0.106	0.128	0.126	0.129	0.130	0.124
N_4	0.113	0.131	0.134	0.138	0.139	0.131	0.115	0.133	0.134	0.136	0.138	0.131
Mean	0.105	0.116	0.114	0.119	0.120	0.115	0.105	0.116	0.114	0.118	0.119	0.115

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.0002	0.0007	0.0002	0.0002
M	0.0002	0.0005	0.0002	0.0001
N at M	0.0005	0.0012	0.0005	0.0004
M at N	0.0005	0.0011	0.0005	0.0004

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.0002	0.0007	0.001	0.002
M	0.0002	0.0004	0.001	0.001
N at M	0.0005	0.0012	0.001	0.003
M at N	0.0005	0.0010	0.001	0.003

0.140 per cent at 6th month, 0.139 per cent at 3rd and 9th month and 0.138 per cent at 12th month.

4.4.3 K content in leaf

Nitrogen and micronutrient application resulted in considerable enhancement of foliar K content in crossandra (Table 38).

The treatment N_4 excelled others in increasing the K content in leaf which recorded the highest value of 3.47, 3.48, 3.45 and 3.46 per cent at 3rd, 6th, 9th and 12th month respectively.

Micronutrient application showed significant effect for all treatments. Treatment M_4 recorded increased K content in leaf with 3.35 per cent at 3rd and 3.34 per cent at 6th month. Increased K content in leaf with 3.32 per cent at 9th and 12th month was observed in the treatment M_4.

N_4M_4 [combined application of nitrogen 180 kg N ha^{-1} + foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded higher K content in leaf at 3rd month (3.54 per cent) and 6th month (3.48 per cent), 9th month (3.50 per cent) and 12th month (3.57 per cent).

4.4.4 N content in flower

The data on N content in flower under different treatments and stages of crop are presented in Table 39.

Table 38. Effect of nitrogen and micronutrients on potassium content in leaf (%) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.23	2.83	2.71	2.94	3.00	2.74	2.27	2.87	2.70	2.95	3.00	2.76
N_1	2.90	3.19	3.20	3.32	3.35	3.19	2.90	3.18	3.20	3.30	3.33	3.18
N_2	3.02	3.38	3.39	3.40	3.43	3.32	3.00	3.38	3.37	3.33	3.41	3.36
N_3	3.26	3.44	3.47	3.48	3.46	3.42	3.28	3.42	3.46	3.47	3.44	3.41
N_4	3.30	3.49	3.52	3.49	3.54	3.47	3.31	3.50	3.51	3.52	3.54	3.48
Mean	2.94	3.27	3.26	3.32	3.35	3.23	2.95	3.27	3.25	3.33	3.34	3.23
	9th month						12th month					
N_0	2.29	2.85	2.69	2.95	2.98	2.75	2.28	2.84	2.67	2.92	2.95	2.73
N_1	2.86	3.16	3.19	3.28	3.30	3.15	2.84	3.12	3.17	3.26	3.27	3.13
N_2	2.97	3.35	3.39	3.40	3.40	3.30	2.96	3.33	3.36	3.39	3.43	3.29
N_3	3.26	3.45	3.44	3.45	3.43	3.40	3.23	3.44	3.42	3.43	3.40	3.38
N_4	3.28	3.49	3.50	3.48	3.50	3.45	3.25	3.46	3.50	3.51	3.57	3.46
Mean	2.93	3.26	3.24	3.31	3.32	3.21	2.91	3.24	3.22	3.30	3.32	3.20

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.004	0.011	0.004	0.011
M	0.004	0.008	0.004	0.008
N at M	0.008	0.019	0.008	0.019
M at N	0.008	0.017	0.008	0.017

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.001	0.002	0.008	0.023
M	0.002	0.004	0.005	0.010
N at M	0.004	0.008	0.013	0.030
M at N	0.004	0.009	0.011	0.022

Table 39. Effect of nitrogen and micronutrients on nitrogen content in flower (%) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.56	0.81	1.01	1.00	1.07	0.89	0.55	0.80	0.98	1.00	1.07	0.88
N_1	0.99	1.12	1.15	1.11	1.13	1.10	0.91	0.97	1.11	1.08	1.11	1.03
N_2	1.17	1.17	1.17	1.18	1.20	1.18	1.04	1.11	1.15	1.16	1.19	1.13
N_3	1.20	1.22	1.24	1.25	1.25	1.23	1.09	1.18	1.19	1.15	1.23	1.17
N_4	1.26	1.24	1.27	1.29	1.32	1.27	1.14	1.20	1.25	1.27	1.29	1.23
Mean	1.03	1.11	1.17	1.16	1.19	1.13	0.94	1.05	1.14	1.13	1.18	1.09
	9th month						12th month					
N_0	0.66	0.87	1.00	1.01	0.96	0.90	0.62	0.88	1.01	0.97	0.85	0.86
N_1	0.86	0.95	1.07	1.00	1.08	0.99	0.78	0.88	0.96	1.01	1.01	0.93
N_2	0.97	0.96	0.49	0.96	1.09	0.89	0.86	0.96	0.88	0.88	1.16	0.94
N_3	1.09	0.87	0.94	1.11	1.16	1.03	0.89	0.94	1.07	1.10	1.18	1.03
N_4	1.15	1.16	1.20	1.22	1.27	1.20	0.91	1.16	1.13	1.20	1.23	1.12
Mean	0.94	0.96	0.94	1.06	1.11	1.00	0.81	0.96	1.01	1.03	1.08	0.98

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.008	0.022	0.005	0.013
M	0.003	0.007	0.006	0.013
N at M	0.010	0.025	0.013	0.029
M at N	0.007	0.015	0.014	0.029

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.053	0.148	0.004	0.010
M	NS	NS	0.004	0.008
N at M	NS	NS	0.009	0.020
M at N	NS	NS	0.009	0.019

N content in flower increased significantly at 3rd and 6th month and then decreased at 9th and 12th month. Among different N levels, nitrogen application exhibited significant effects at all stages of crop growth. Treatment N_4 had greater effect in increasing the N content significantly in flower at 3rd (1.27 per cent), 6th month (1.23 per cent), 9th month (1.20 per cent) and 1.12 per cent at 12th month.

Among the micronutrients, foliar application of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) registered an increase in N content of flower at 3rd month (1.19 per cent) 6th month (1.18 per cent) and 12th month (1.08 per cent). At 9th month it showed non significant effects. N_4M_4 recorded increase in N content in flower of 1.32, 1.29 and 1.23 per cent at 3rd, 6th and 12th Month respectively.

4.4.5 P content in flower

Data on P content in flower are presented in Table 40. Application of nitrogen and micronutrients exhibited significant effects for all the treatments.

Among N levels, N_4 recorded the highest P content in flower of 0.127 per cent at 3rd month and 0.129 per cent at 9th and 12th month.

In case of micronutrients, the treatment M_4 recorded the highest phosphorus content in flower of 0.125 per cent at 3rd month. At 6th month, treatment M_3 [soil application of $ZnSO_4$ (50 kg ha^{-1}) + $FeSO_4$ (25 kg ha^{-1})] recorded higher value (0.127 per cent) followed by M_4 (0.123 per cent). Treatment M_4 recorded higher value of

Table 40. Effect of nitrogen and micronutrients on phosphorus content in flower (%) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.100	0.115	0.117	0.120	0.140	0.118	0.104	0.115	0.114	0.140	0.130	0.119
N_1	0.135	0.120	0.115	0.125	0.120	0.123	0.120	0.120	0.115	0.122	0.114	0.117
N_2	0.111	0.111	0.112	0.113	0.112	0.112	0.110	0.112	0.110	0.125	0.116	0.114
N_3	0.114	0.122	0.121	0.125	0.126	0.121	0.110	0.120	0.121	0.122	0.127	0.120
N_4	0.118	0.129	0.129	0.128	0.130	0.127	0.114	0.126	0.127	0.128	0.132	0.125
Mean	0.115	0.119	0.118	0.122	0.125	0.120	0.110	0.119	0.117	0.127	0.123	0.120
	9th month						12th month					
N_0	0.093	0.122	0.115	0.120	0.140	0.118	0.103	0.114	0.125	0.125	0.115	0.116
N_1	0.110	0.115	0.126	0.126	0.128	0.121	0.110	0.112	0.127	0.124	0.112	0.117
N_2	0.114	0.114	0.123	0.120	0.125	0.119	0.113	0.113	0.115	0.115	0.115	0.114
N_3	0.121	0.123	0.124	0.126	0.127	0.124	0.135	0.122	0.121	0.121	0.124	0.124
N_4	0.123	0.129	0.129	0.130	0.133	0.129	0.139	0.125	0.124	0.127	0.131	0.129
Mean	0.112	0.120	0.123	0.124	0.130	0.122	0.120	0.117	0.122	0.122	0.119	

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.002	0.007	NS	NS
M	0.002	0.004	0.002	0.004
N at M	0.005	0.011	0.004	0.010
M at N	0.005	0.009	0.004	0.008

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.002	0.007	0.002	0.007
M	0.002	0.005	0.002	0.003
N at M	0.005	0.011	0.004	0.009
M at N	0.005	0.010	0.003	0.007

0.130 per cent at 9th month and treatment M_2 and M_3 recorded higher phosphorus content in flower (0.122 per cent) at 12th month respectively.

The interaction effect also showed significant results. Treatment N_4M_4 [application of nitrogen 180 kg per hectare + foliar application of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] registered increased 'P' content in flower at 3rd month (0.130 per cent), 6th month (0.132 per cent), 9th month (0.133 per cent) and 12th month (0.131 per cent).

4.4.6 K content in flower

K content in flower as influenced by nitrogen and micronutrient applications and on stages of crop are presented in Table 41.

Treatment N_4 registered increase in K content in flower of 3.20, 3.18, 3.16 and 3.14 per cent at 3rd, 6th, 9th and 12th month respectively.

Micronutrient applications also showed significant effects over all the treatments. These was a rise in K content in flower with the treatment M_4 which registered 3.04 per cent at 3rd and 6th month, 3.01 per cent at 9th and 12th month respectively.

The interaction effect of N and micronutrients exerted significant results. Treatment N_4M_4 registered increase in K content in flower of 3.36 per cent at 3rd and 9th month and 3.34 per cent at 6th month and 3.26 per cent at 12th month.

Table 41. Effect of nitrogen and micronutrients on potassium content in flower (%) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.62	2.78	2.81	2.85	2.87	2.79	2.69	2.77	2.79	2.83	2.86	2.79
N_1	2.86	2.89	2.88	2.90	2.92	2.89	2.87	2.87	2.87	2.89	2.91	2.88
N_2	2.90	2.96	2.97	3.00	3.00	2.97	2.88	2.95	2.97	3.01	3.03	2.97
N_3	2.97	3.04	3.07	3.04	3.08	3.04	2.96	2.97	3.05	3.02	3.07	3.01
N_4	3.02	3.11	3.25	3.28	3.36	3.20	3.00	3.10	3.28	3.25	3.34	3.18
Mean	2.87	2.95	3.00	3.01	3.04	2.98	2.88	2.93	2.98	3.00	3.04	2.96
	9th month						12th month					
N_0	2.62	2.75	2.78	2.86	2.86	2.77	2.62	2.74	2.82	2.86	2.87	2.78
N_1	2.86	2.87	2.87	2.89	2.92	2.88	2.86	2.87	2.87	2.87	2.90	2.87
N_2	2.88	2.96	2.97	3.03	3.00	2.96	2.87	2.95	2.95	3.00	2.99	2.95
N_3	2.96	2.97	3.00	3.00	3.06	3.00	2.94	2.95	3.02	3.01	3.02	2.99
N_4	2.99	3.10	3.12	3.25	3.36	3.16	3.00	3.11	3.11	3.21	3.26	3.14
Mean	2.86	2.93	2.94	3.00	3.04	2.95	2.86	2.92	2.95	2.99	3.01	2.94

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.006	0.016	0.008	0.023
M	0.007	0.015	0.006	0.012
N at M	0.016	0.034	0.015	0.033
M at N	0.016	0.034	0.013	0.028

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.009	0.025	0.004	0.011
M	0.005	0.011	0.006	0.013
N at M	0.014	0.032	0.013	0.029
M at N	0.011	0.024	0.014	0.030

4.4.7 Fe content in leaf

The data on Fe content in leaf are presented in Table 42.

Application of nitrogen and micronutrients had significant influence at different stages of crop growth. Treatment N_4 recorded higher values at 6th (519.24 ppm), 9th (519.23) and 12th month (553.78 ppm).

Micronutrient application had significant influence at different stages of crop growth. M_4 recorded higher value of 522.98, 522.95, 530.81 and 511.15 ppm at 3rd, 6th, 9th and 12th months respectively.

The interaction effect between N and M showed significance at different stages of crop growth. The treatment N_4M_4 registered increased Fe content in leaf of 573.50, 575.64, 576.56 and 579.50 ppm at 3rd, 6th, 9th and 12th month respectively.

4.4.8 Zn content in leaf

The Zn content in leaf showed an increasing trend with crop growth Table 43.

There was a steady increase in Zn content in leaf during different stages of crop growth. Treatment N_4 recorded higher value of 18.78, 18.87, 19.30 and 19.54 ppm at 3rd, 6th, 9th and 12th month respectively.

Micronutrient application registered significant effects for all the treatments. Treatment M_4 recorded increase in Zn content in leaf (18.14 ppm) at 3rd month and

Table 42. Effect of nitrogen and micronutrients on iron content in leaf (ppm) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	301.75	449.25	323.03	451.85	455.65	396.30	311.68	452.98	329.16	454.28	457.38	401.09
N_1	311.50	482.75	476.30	481.80	489.86	448.44	325.75	469.70	487.50	489.05	450.50	444.50
N_2	333.25	506.85	500.05	530.55	534.35	481.01	334.70	507.77	480.50	535.15	557.11	483.04
N_3	342.19	537.42	540.61	545.05	561.55	505.36	420.31	528.54	460.63	567.67	574.13	510.25
N_4	352.90	311.10	568.75	570.55	573.50	475.36	427.16	550.60	474.72	568.10	575.64	519.24
Mean	328.31	457.47	481.74	515.96	522.98	461.29	363.92	501.92	446.50	522.85	522.95	471.63
	9th month						12th month					
N_0	305.16	450.22	372.21	454.71	459.70	408.40	354.97	371.43	455.21	462.97	464.35	421.79
N_1	382.43	459.04	479.68	481.64	493.05	459.16	382.18	481.72	484.10	495.40	469.75	450.63
N_2	410.90	504.75	444.70	535.14	554.16	489.93	422.00	446.19	537.17	551.16	552.06	501.72
N_3	421.27	527.13	467.22	565.08	570.60	510.26	421.79	469.67	570.16	425.42	550.09	487.43
N_4	426.38	552.50	477.105	563.60	576.56	519.23	477.24	562.12	573.04	577.00	579.50	553.78
Mean	389.22	498.73	448.18	520.03	530.81	477.39	411.64	466.23	523.94	502.39	511.15	483.07

	3rd month		6th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	NS	NS	0.516	1.433
M	32.307	67.391	0.372	0.777
N at M	NS	NS	0.906	2.094
M at N	NS	NS	0.832	1.737
	9th month		12th month	
	SEd	CD(P=0.05)	SEd	CD(P=0.05)
N	6.524	18.114	0.381	1.057
M	6.337	13.219	0.294	0.610
N at M	14.255	31.798	0.695	1.390
M at N	14.171	29.560	0.650	1.360

Table 43. Effect of nitrogen and micronutrients on zinc content in leaf (ppm) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	2.20	9.65	13.12	13.26	14.11	10.47	2.59	10.22	13.13	13.33	14.14	10.68
N_1	9.21	11.16	15.21	15.81	16.04	13.49	9.35	12.50	15.47	15.89	16.02	13.84
N_2	10.16	13.21	16.31	17.11	17.44	14.84	10.93	13.38	16.37	17.27	17.56	14.98
N_3	10.70	14.20	17.69	19.13	20.02	16.35	10.80	15.45	18.30	18.69	20.19	16.69
N_4	11.10	16.25	21.12	22.35	23.09	18.78	11.20	16.24	21.28	22.41	23.21	18.87
Mean	8.67	12.89	16.69	17.53	18.14	14.78	8.85	13.56	16.91	17.52	18.22	15.01
	9th month						12th month					
N_0	2.63	10.33	13.19	13.41	14.28	10.77	2.67	10.25	13.22	13.48	14.32	10.78
N_1	9.45	12.58	15.59	15.99	16.11	13.94	9.56	12.60	15.70	16.01	16.12	14.00
N_2	10.50	13.42	16.33	17.34	17.65	15.05	11.05	13.46	16.41	17.41	17.76	15.22
N_3	11.07	16.07	18.42	19.25	20.48	17.05	11.21	16.48	18.55	19.32	20.88	17.28
N_4	12.04	16.38	21.39	22.52	24.19	19.30	12.16	16.46	21.47	22.86	24.76	19.54
Mean	9.14	13.75	16.98	17.70	18.54	15.22	9.33	13.85	17.07	17.81	18.76	15.36

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.068	0.188	0.043	0.119
M	0.086	0.179	0.072	0.151
N at M	0.184	0.402	0.151	0.324
M at N	0.192	0.400	0.162	0.338

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.025	0.068	0.060	0.167
M	0.014	0.028	0.046	0.096
N at M	0.037	0.088	0.110	0.251
M at N	0.030	0.063	0.103	0.214

18.22 ppm at 6^{th} month. It recorded a higher value of 18.54 ppm and 18.76 ppm at 9^{th} and 12^{th} month respectively.

The interaction effect between nitrogen and micronutrients showed significant results for Zn content in leaf. Treatment N_4M_4 recorded increase in Zinc content in leaf of 23.09, 23.21, 24.19 and 24.76 ppm at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively.

4.4.9 Available nitrogen in soil

The data on available nitrogen in the soil are presented in Table 44.

Nitrogen application showed significant effect on available N in the soil at 3^{rd}, 6^{th}, 9^{th} and 12^{th} months. N_4 registered the highest available nitrogen of 305.50, 305.21, 304.43, 303.83 at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively

Application of micronutrients also showed significant effect at all stages of crop growth. Treatment M_4 registered the highest available nitrogen in soil (261.18 kg ha^{-1}) followed by M_3 (254.04 kg ha^{-1}) at 3^{rd} month. M_4 registered the highest available nitrogen of 261.18, 260.89 and 260.48 kg ha^{-1} at 6^{th}, 9^{th} and 12^{th} month respectively.

The interaction effect of N and M showed significant values. The treatment N_4M_3 registered the highest available soil nitrogen of 325.05, 325.60, 324.18 and 323.66 kg ha^{-1} at 3^{rd}, 6^{th}, 9^{th} and 12^{th} month respectively

4.4.10 Available phosphorus in soil

The available phosphorus in soil decreased with the advancement of crop growth (Table 45). Significant results were observed at different stages of crop growth.

Table 44. Effect of nitrogen and micronutrients on available nitrogen in soil (kg/ha) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	202.13	214.35	213.55	216.32	215.12	212.29	201.75	214.70	214.08	216.21	215.27	212.40
N_1	214.65	216.24	214.99	225.27	216.19	217.47	214.21	216.00	215.07	225.23	216.22	217.34
N_2	220.67	228.76	232.27	246.21	240.15	233.61	220.20	229.75	232.02	244.71	241.21	233.58
N_3	233.10	256.70	261.11	293.05	280.65	264.92	232.58	259.66	261.06	294.18	281.35	265.76
N_4	271.25	300.17	312.96	325.05	318.10	305.50	270.41	300.10	311.61	325.60	318.32	305.21
Mean	228.36	243.24	246.97	261.18	254.04	246.76	227.83	244.04	246.77	261.18	254.47	246.86
	9th month						12th month					
N_0	200.72	214.45	214.70	216.24	215.18	212.25	200.73	215.05	215.25	217.29	214.19	212.50
N_1	214.18	216.11	233.02	226.25	216.19	221.15	214.21	216.09	215.10	225.52	216.20	217.42
N_2	222.11	230.53	232.17	243.69	239.18	233.53	222.41	231.11	232.15	242.19	240.21	233.61
N_3	230.03	258.85	262.13	294.12	283.15	265.65	229.18	258.64	262.38	293.75	283.70	265.53
N_4	269.93	300.08	310.04	324.18	317.95	304.43	268.67	300.10	309.14	323.66	317.58	303.83
Mean	227.39	244.00	250.41	260.89	254.33	247.40	227.04	244.20	246.80	260.48	254.37	246.58

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.179	0.497	0.233	0.648
M	0.143	0.299	0.170	0.354
N at M	0.338	0.771	0.412	0.951
M at N	0.321	0.669	0.380	0.792

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	2.302	6.392	0.307	0.852
M	2.274	4.743	0.183	0.382
N at M	5.098	11.352	0.478	1.133
M at N	5.085	10.607	0.409	0.854

Table 45. Effect of nitrogen and micronutrients on available phosphorus in soil (kg/ha) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	10.09	10.15	10.16	10.17	10.14	10.14	10.09	10.15	10.13	10.16	10.14	10.13
N_1	12.04	12.16	13.03	13.10	13.15	12.69	11.95	12.15	13.04	13.10	13.12	12.67
N_2	13.05	13.95	14.28	14.82	14.75	14.17	13.03	13.90	14.26	14.79	14.71	14.13
N_3	13.91	14.87	14.90	14.73	14.84	14.65	13.90	14.87	14.89	14.70	14.81	14.63
N_4	15.07	15.48	16.12	16.24	16.13	15.81	15.05	15.46	16.10	16.20	16.12	15.78
Mean	12.83	13.32	13.70	13.81	13.80	13.49	12.80	13.30	13.68	13.79	13.78	13.47
	9th month						12th month					
N_0	10.07	10.13	10.14	10.14	10.13	10.12	10.05	10.11	10.15	10.16	10.13	10.12
N_1	12.07	12.15	12.98	13.12	13.11	12.68	12.22	12.15	12.83	13.10	13.10	12.68
N_2	12.39	13.87	14.25	14.78	14.69	13.99	12.31	13.90	14.24	14.75	14.68	13.97
N_3	13.87	14.85	14.86	14.70	14.80	14.61	13.85	14.82	14.85	14.69	14.79	14.60
N_4	15.04	15.44	16.08	16.19	16.10	15.77	15.01	15.43	16.06	16.19	16.09	15.75
Mean	12.69	13.29	13.66	13.78	13.77	13.44	12.68	13.28	13.62	13.78	13.76	13.42

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.003	0.008	0.005	0.013
M	0.006	0.012	0.009	0.019
N at M	0.012	0.025	0.019	0.040
M at N	0.013	0.027	0.020	0.042

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.004	0.012	0.027	0.075
M	0.004	0.009	0.025	0.052
N at M	0.010	0.021	0.057	0.127
M at N	0.010	0.020	0.056	0.117

N_4 registered the highest value of 15.81, 15.78, 15.77 15.75 kg ha^{-1} at 3rd, 6th, 9th and 12th month respectively.

Micronutrient application showed significant effects. M_3 recorded the highest value of 13.81 kg ha^{-1} at 3rd month and 13.79 kg ha^{-1} at 6th month and 13.78 kg ha^{-1} at 9th and 12th month respectively.

The interaction effects of N and M exhibited significant effects for available phosphorus in soil. N_4M_3 registered increase in available phosphorus soil of 16.24 and 16.20 ppm at 3rd and 6th month and 16.19 kg ha^{-1} at 9th and 12th month respectively.

4.4.11 Available potassium in soil

Nitrogen and micronutrients exhibited significant effects on available potassium in soil (Table 46).

Among N levels, treatment N_4 increased the available K in soil at 3rd month (608.39 kg ha^{-1}) 6th month (610.47 kg ha^{-1}), 9th month (609.66 kg ha^{-1}) and 12th months (615.77 kg ha^{-1}).

Micronutrient application also showed significant effects. Among different micronutrients, M_3 recorded the highest available potassium in soil of 572.49, 574.46, 574.24 and 575.71 kg ha^{-1} during 3rd, 6th, 9th and 12th month of planting respectively.

N x M interaction also showed significant effects. Increased available potassium in the soil was registered by the treatment N_4M_3 at 3rd month (620.55 kg ha^{-1}), 6th month (625.00 kg ha^{-1}), 9th month (624.45 kg ha^{-1}) and 12th month (626.30 kg ha^{-1}).

Table 46. Effect of nitrogen and micronutrients on available potassium in soil (kg/ha) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	404.95	530.35	527.90	529.71	526.95	503.97	403.80	529.55	529.25	530.50	525.15	503.65
N_1	426.10	552.59	550.20	552.00	547.06	525.59	426.84	553.55	551.20	552.95	550.10	526.93
N_2	546.10	558.60	568.60	573.20	569.70	563.24	546.15	560.55	571.05	574.00	570.55	564.46
N_3	567.45	577.10	580.70	587.00	580.09	578.46	567.35	577.75	581.71	589.85	580.68	579.46
N_4	578.50	611.50	616.50	620.55	614.90	608.39	580.05	612.20	615.05	625.00	620.05	610.47
Mean	504.62	566.02	568.78	572.49	567.74	555.93	504.83	566.72	569.65	574.46	569.30	556.99
	9th month						12th month					
N_0	407.70	531.50	529.90	531.67	527.00	505.55	406.60	532.75	531.35	530.70	527.15	505.71
N_1	427.10	554.69	552.85	553.25	556.15	528.80	427.38	557.02	552.95	553.45	555.10	529.18
N_2	546.70	561.30	572.50	574.19	571.55	565.24	547.65	561.80	570.70	575.17	572.55	565.57
N_3	567.35	577.75	582.57	587.68	581.22	579.31	568.80	577.86	582.51	592.95	591.00	582.62
N_4	575.70	612.75	616.22	624.45	619.20	609.66	590.20	619.12	620.30	626.30	622.95	615.77
Mean	504.91	567.59	570.80	574.24	517.02	557.71	508.12	569.71	571.56	575.71	573.75	559.77

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.221	0.614	0.148	0.411
M	0.279	0.582	0.272	0.567
N at M	0.600	1.308	0.563	1.202
M at N	0.624	1.301	0.608	1.268

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.213	0.592	0.276	0.765
M	0.240	0.502	0.225	0.469
N at M	0.526	1.157	0.528	1.200
M at N	0.538	0.122	0.503	1.050

4.4.12 Iron content in soil

The data on Fe content in soil is presented in Table 47.

Application of nitrogen and micronutrients exhibited significant results at all stages of crop growth. Treatment N_4 registered increase in Fe content of soil of 12.36, 12.33, 12.40 and 12.41 at 3rd, 6th, 9th and 12th month respectively.

Treatment M_3 recorded increase in Fe content of soil of 12.82, 12.81, 12.88 and 12.89 ppm at 3rd, 6th, 9th and 12th month respectively.

Treatment N_4M_3 recorded increase in Fe content in soil of 14.15 ppm at 3rd month, 14.10 ppm at 6th month, 14.08 ppm at 9th month and 14.07 ppm at 12th month respectively.

4.4.13 Zinc content in soil

Zinc content as influenced by nitrogen and micronutrient application are presented in Table 48.

Treatment N_4 recorded increase in Zn content in soil with 1.56 ppm at 3rd and 6th month and 1.59 ppm at 9th month and 1.61 ppm at 12th month respectively.

Micronutrient application played a significant role in Zn content in soil. At 3rd month, treatment M_3 recorded higher value (1.46 ppm) for Zn content in soil followed by M_4 (1.43 ppm). Treatment M_3 recorded increased Zinc content in soil with 1.46 ppm at 3rd and 6th month and 1.49 and 1.51 ppm at 9th and 12th month respectively.

Table 47. Effect of nitrogen and micronutrients on iron content in soil (ppm) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	8.50	9.04	12.05	12.20	12.09	10.77	6.33	9.11	12.11	12.15	12.11	10.36
N_1	8.84	8.25	12.23	12.27	12.15	10.75	8.93	9.86	12.28	12.33	12.20	11.12
N_2	8.95	10.17	12.71	12.32	12.22	11.27	8.95	10.30	12.83	12.23	12.22	11.31
N_3	9.36	10.32	12.94	13.16	12.94	11.74	9.28	10.37	12.89	13.23	12.95	11.74
N_4	9.81	10.74	13.93	14.15	13.20	12.36	9.86	10.81	13.80	14.10	13.09	12.33
Mean	9.09	9.70	12.77	12.82	12.52	11.38	8.67	10.09	12.78	12.81	12.51	11.37
	9th month						12th month					
N_0	8.35	9.16	12.08	12.37	12.06	10.80	8.40	9.16	12.12	12.21	12.03	10.78
N_1	8.96	10.08	12.36	12.40	12.28	11.22	9.02	10.22	12.38	12.47	12.38	11.29
N_2	9.03	10.42	12.89	12.35	12.18	11.37	9.03	10.20	12.99	12.40	12.17	11.36
N_3	9.29	10.35	12.94	13.23	13.07	11.77	9.26	10.32	12.98	13.31	13.12	11.79
N_4	9.95	10.87	13.93	14.08	13.18	12.40	9.99	10.92	13.95	14.07	13.13	12.41
Mean	9.11	10.17	12.84	12.88	12.55	11.51	9.14	10.16	12.88	12.89	12.56	11.53

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.137	0.380	0.016	0.046
M	0.126	0.263	0.015	0.031
N at M	0.287	0.643	0.034	0.076
M at N	0.282	0.587	0.033	0.069

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.024	0.066	0.018	0.050
M	0.017	0.034	0.022	0.046
N at M	0.041	0.094	0.048	0.104
M at N	0.037	0.077	0.049	0.103

Table 48: Effect of nitrogen and micronutrients on zinc content in soil (ppm) during 3rd, 6th, 9th and 12th month of planting

N levels/ Micro-nutrients	3rd month						6th month					
	M_0	M_1	M_2	M_3	M_4	Mean	M_0	M_1	M_2	M_3	M_4	Mean
N_0	0.30	1.03	0.73	1.05	1.00	0.82	0.31	1.01	0.74	1.05	1.01	0.82
N_1	0.42	1.21	1.02	1.29	1.20	1.03	0.44	1.21	1.05	1.26	1.21	1.03
N_2	0.52	1.38	1.05	1.47	1.42	1.17	0.60	1.39	1.10	1.46	1.43	1.20
N_3	0.79	1.67	1.21	1.70	1.70	1.41	0.81	1.68	1.23	1.72	1.70	1.43
N_4	1.01	1.77	1.38	1.82	1.80	1.56	1.08	1.73	1.38	1.81	1.80	1.56
Mean	0.61	1.41	1.08	1.46	1.43	1.20	0.65	1.40	1.10	1.46	1.43	1.21
	9th month						12th month					
N_0	0.32	1.03	0.78	1.03	1.02	0.84	0.34	1.03	0.79	1.06	1.05	0.85
N_1	0.43	1.22	1.05	1.26	1.21	1.04	0.46	1.22	1.06	1.27	1.22	1.05
N_2	0.61	1.39	1.11	1.48	1.45	1.21	0.61	1.39	1.12	1.48	1.47	1.21
N_3	0.84	1.69	1.24	1.81	1.80	1.47	0.85	1.67	1.24	1.83	1.80	1.48
N_4	1.10	1.73	1.40	1.89	1.82	1.59	1.10	1.14	1.40	1.92	1.90	1.61
Mean	0.66	1.41	1.12	1.49	1.46	1.24	0.67	1.41	1.12	1.51	1.49	1.24

	3rd month SEd	3rd month CD(P=0.05)	6th month SEd	6th month CD(P=0.05)
N	0.006	0.017	0.001	0.003
M	0.008	0.016	0.002	0.005
N at M	0.017	0.036	0.005	0.010
M at N	0.017	0.036	0.005	0.011

	9th month SEd	9th month CD(P=0.05)	12th month SEd	12th month CD(P=0.05)
N	0.019	0.053	0.004	0.010
M	0.020	0.042	0.003	0.007
N at M	0.044	0.098	0.008	0.017
M at N	0.045	0.093	0.008	0.016

N x M interaction showed significant effects at all stages of crop growth. Treatment N_4M_3 recorded increased Zinc content in soil with 1.82, 1.81, 1.89 and 1.92 ppm at 3rd, 6th, 9th and 12th month respectively.

4.5. Association of characters

Simple correlation, Linear regression and multiple regressions were carried out to find out the association of yield with Growth characters, yield attributing characters, physiological and biochemical constituents and nutrient contents at third, sixth, ninth and 12th month of planting with yield.

4.5.1. Simple correlations

The data on correlation coefficient (r value) and linear regression equation ($y = a + bx$) are presented in tables 49, 50, 51 and 52.

Growth characters *viz.*, plant height, number of branches, number of leaves, fresh and dry weights of shoot and root, leaf area index and dry matter production exhibited significant and positive correlation with yield at third, sixth, ninth and twelfth month of planting respectively. However, specific leaf weight and shoot-root ratio exhibited non-significant correlation towards yield at all stages of crop growth.

Regarding yield attributes, the time taken for spike emergence, time taken for first harvest in a spike and time taken for completion of harvest in a spike exhibited negative and non-significant correlation towards yield at all stages of plant growth. The contributions were highly significant at third, sixth, ninth and twelfth month for number

Table 49. Simple correlation and linear regression between yield and growth characters.

Characters	3rd month		6th month		9th month		12th month	
	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation
Plant height	Y=0.497+0.054x	0.863**	Y=4.49+2.30x	0.970**	Y=16.58+3.26x	0.896**	Y=-4.67+5.18x	0.909**
Number of branches	Y=0.019+0.35x	0.889**	Y=2.57+4.66x	0.944**	Y=34.84+3.96x	0.918**	Y=39.68+7.30x	0.937**
Number of leaves	Y=-0.808+0.091x	0.854**	Y=12.66+0.36x	0.898**	Y=35.12+0.28x	0.862**	Y=45.50+0.45x	0.920**
Specific leaf weight	Y=-0.37+0.45x	0.300	Y=179.1-35.72x	-0.244	Y=44.32+11.51x	0.061	Y=344.18-55.46x	0.154
Fresh weight of shoot	Y=0.64+0.028x	0.864**	Y=25.45+0.146x	0.967**	Y=47.41+0.185x	0.894**	Y=19.48+0.47x	0.923**
Dry weight of shoot	Y=0.65+0.107x	0.834**	Y=25.07+0.56x	0.959**	Y=47.70+0.73x	0.907**	Y=13.01+2.09x	0.956**
Fresh weight of root	Y=0.64+0.28x	0.898**	Y=19.60+0.88x	0.982**	Y=44.06+0.89x	0.929**	Y=56.47+1.42x	0.970**
Dry weight of root	Y=0.64+1.52x	0.875**	Y=20.54+3.47x	0.970**	Y=43.50+3.60x	0.930**	Y=58.57+5.71x	0.978**
Shoot root ratio	Y=1.50 – 0.02x	-0.140	Y=33.67+3.043x	0.216	Y=68.39+4.01x	0.203	Y=282.05-32.42x	-0.764
Dry matter Production	Y=0.297+0.09x	0.849**	Y=20.68+0.499x	0.968**	Y=45.43+0.48x	0.915**	Y=39.53+0.88x	0.951**
Leaf area index	Y=0.148+8.1x	0.697**	Y=11.86+59.25x	0.900**	Y=33.35+46.25x	0.861**	Y=78.97+48.88x	0.619**

* significance at 5% level
** significance at 1% level

Table 50. Simple correlation and linear regression between yield and yield attributing characters

Characters	3rd month		6th month		9th month		12th month	
	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation
Time taken for spike emergence	Y=5.602 - .055x	-0.853**	Y=225.57 -2.21x	-0.898**	Y=286.55+2.50x	-0.855**	Y=571.99 - 392x	-0.961**
Time taken for first harvest	Y=9.215 - .019x	-0.785**	Y=374.39-3.70x	-0.833**	Y=425.67-3.86x	-0.755**	Y=917.47+-.82x	-0.871**
Time taken for completion of harvest	Y=2.30 - 0.028x	-0.823**	Y=94.92-1.20x	-0.930**	Y =137.51-1.35x	-0.907**	Y=243.65-2.69x	-0.913**
Number of flowers per spike	Y=-.766+0.090x	0.906**	Y=13.80+0.75x	0.963**	Y=29.38+1.12x	0.934**	Y=31.32+2.13x	0.927**
Number of spikes per plant	Y=0.616+0.157x	0.903*	Y=16.44+1.002x	0.978**	Y=45.35+1.06x	0.922**	Y=56.29+1.18x	0.939**
Spike length	Y=0.442+0.123x	0.911**	Y=8.79+5.01x	0.884**	Y=45.70+4.54x	0.934**	Y=67.27+7.89x	0.958**
Stalk length	Y=-.373+0.663x	0.846**	Y=14.30+25.83x	0.878**	Y=7.12+27.46x	0.790*	Y=3.39+53.33x	0.887**
Diameter of flower	Y=-1.08+0.831x	0.874**	Y=-5.35+33.59x	0.926**	Y=22.73+38.40x	0.871**	Y=-7.37+87.14x	0.941**
Weight of flowers	Y=-.353+0.387x	0.895**	Y=-8.50+15.68x	0.951**	Y =7.64+18.79x	0.897**	Y=-0.60+38.45x	0.907**

* significance at 5% level
** significance at 1% level

of flowers per spike, number of spikes per plant, spike length, stalk length, diameter of flower and weight of flowers.

Physiological and biochemical constituents *viz.*, chlorophyll 'a', chlorophyll 'b', total chlorophyll, soluble protein content, crop growth rate, IAA oxidase activity, nitrate reductase activity, catalase activity, peroxidase activity and tryptophan content at third, sixth, ninth and twelfth month of planting.

Relative Growth rate recorded highly significant positive correlation during third month, whereas highly significant negative correlation was recorded during sixth, ninth and twelfth month. Net assimilation rate recorded highly significant positive correlation during third month and non-significant effects during sixth, ninth and twelfth month.

In case of nutrient contents, NPK content in leaf, available NPK in soil, Fe and Zn content in leaf and soil exhibited a highly significant positive association with yield at third, sixth, ninth and twelfth month of planting.

N content in flower recorded highly significant positive correlation towards yield during third, ninth and twelfth month, while sixth month recorded negative and non-significant correlation.

Table 51. Simple correlation and linear regression between yield and physiological and biochemical constituents

Characters	3rd month		6th month		9th month		12th month	
	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation
Chlorophyll `a'	Y=0.578+4.08x	0.907**	Y=18.63+36.03x	0.906**	Y=56.39+36.23x	0.891**	Y=65.65+85.22x	0.967**
Chlorophyll `b'	Y=0.381+16.02x	0.931**	Y=19.51+106.5x	0.895**	Y=37.30+104.4x	0.843**	Y=75.69+163.0x	0.858**
Total Chlorophyll	Y=0.481+3.59x	0.894**	Y=17.92+29.38x	0.859**	Y=48.48+36.93x	0.919**	Y=67.23+59.88x	0.929**
CGR	Y==0.62+0.418x	0.892**	Y =7.12+678.38x	0.808**	Y =18-3+1069.9x	0.935**	Y =-7.97+2040.0	0.901**
RGR	Y=0.161+56.63x	0.467*	Y=69.08-5696.9x	-0.630**	Y=110.31-096.2x	-0.811	Y=188.99-5993.45x	-0.809**
NAR	Y=0.804+1.002x	0.466**	Y=47.84+16.00x	0.040	Y=118.91-398.8x	-0.483**	Y=209.95-836.4x	-0.512**
Protein content	Y=0.51+0.398x	0.844**	Y=24.29+7.20x	0.935**	Y=55.75+8.57x	0.904**	Y=79.02+16.82x	0.955
Nitrate reductase activity	Y=0.95+0.343x	0.793**	Y=34.36+12.65x	0.881**	Y=69.58+13.07x	0.860**	Y=104.67+27.0x	0.851**
Catalase activity	Y=0.911+0.094x	0.754**	Y=39.76+2.352x	0.456**	Y=58.62+4.18x	0.837**	Y=90.45+7.19x	0.839**
IAA oxidase	Y=0.65+0.0003x	0.550**	Y=44.74+0.002x	0.245	Y=17.48+0.033x	0.675**	Y=132.4+0.003x	0.208
Peroxidase	Y=0.61+2.77x	0.879**	Y=22.33+114.7x	0.973**	Y=54.94+127.90 x	0.949**	Y=66.89+243.3x	0.931**
Tryptophan	Y=0.57+0.099x	0.798**	Y=23.50+2.85x	0.822**	Y=44.00+4.83x	0.857**	Y=30.09+12.51x	0.854**

* significance at 5% level
** significance at 1% level

Table 52.. Simple correlation and linear regression between yield and nutrient contents

Characters	3rd month		6th month		9th month		12th month	
	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation	Regression coefficient	Correlation
N content-leaf	Y=0.373+1.42x	0.878**	Y=17.4+58.5x	0.976**	Y=20.67+56.98x	0.889**	Y=-2.00+126.6x	0.877**
P content-leaf	Y=-0.38+14.0x	0.805**	Y=-19.9+594.92x	0.896**	Y=8.90+670.74x	0.882**	Y=-6.4+1374.9x	0.917**
K content-leaf	Y=-0.67+0.593x	0.808**	Y=-37.31+26.85x	0.924**	Y=-6.66+28.89x	0.854**	Y=-35.45+55.2x	-0.843**
N content-flower	Y=0.017+1.11x	0.788**	Y=49.82-0.012x	-0.255	Y=56.01+30.07x	0.504*	Y=39.68+103.5x	0.743**
P content-flower	Y=0.123+0.099x	0.096	Y=-0.66+417.20x	0.386	Y=89.24-19.16x	-0.302	Y=-6.61+1230.4x	0.501**
K content-flower	Y=-2.68+1.322x	0.908**	Y=-117.13+56.1x	0.954**	Y=-93.24+60.69x	0.899**	Y=-7.1+141.9x	0.952**
Fe content-leaf	Y=0.56+0.002x	0.844**	Y=8.98+0.09x	0.580**	Y=34.70+0.108x	0.725**	Y=30.90+0.23x	0.777**
Zn content-leaf	Y=0.66+0.39x	0.793**	Y=24.46+1.66x	0.854**	Y=59.50+1.764x	0.800**	Y=85.65+3.63x	0.844**
Available N-soil	Y=-0.02+0.01x	0.833**	Y=-2.57+0.210	0.894**	Y=24.43+0.25x	0.830**	Y=13.60+0.52x	0.955**
Available P-soil	Y=-0.11+0.10x	0.550**	Y=1.32+3.52x	0.899**	Y=23.36+4.68x	0.927**	Y=17.40+9.24x	0.922*
Available K-soil	Y=-0.82+0.004x	0.879**	Y=-35.38+0.15x	0.876**	Y=-6.86+10.17x	0.817**	Y=-37.85+0.3x	0815**
Fe content-soil	Y=0.507+0.07x	0.501*	Y=18.17+2.74x	0.580**	Y=51.31+3.03x	0.502*	Y=71.60+6.04x	0508**
Zn content-soil	Y=0.738+0.42x	0.779**	Y=26.91+18.56x	0.867**	Y=82.69+2.56x	0.182	Y=92.97+39.1x	0.829**

* significance at 5% level
** significance at 1% level

In case of P content in flower significant positive association was recorded during twelfth month. However non-significant effects were recorded during third, sixth and ninth month.

4.6. Economics

Based on the annual production expenses, the economics was worked out in this experiment(Table 53). The hectare yield of flowers ranged between 3056.91 kg and 4648.00 kg and the highest yield was recorded in the treatment N_4M_4 [N at 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)]. The cost ranged between Rs. 162398.74 in N_0M_0 and Rs. 164214.86 in treatment N_4M_4. The revenue ranged from Rs. 183360 applied in N_0M_0 to Rs. 278880 in N_4M_4 which also recorded the highest cost benefit ratio of 1:1.70 and the lowest of 1:1.13.

Table 53. Economics

Treatment	Yield	Revenue	Cost	C / B ratio
N_0M_0	3056.91	183414.6	162398.74	1:1.13
N_0M_1	3171.31	190278.6	162898.74	1:1.16
N_0M_2	3230.02	193801.2	162798.74	1:1.19
N_0M_3	3282.69	196961.4	163298.74	1:1.21
N_0M_4	3332.95	199977.0	162798.34	1:1.23
N_1M_O	3419.87	205192.2	163106.99	1:1.25
N_1M_1	3589.97	215398.2	163606.99	1:1.32
N_1M_2	3723.81	223428.6	163506.99	1:1.36
N_1M_3	3745.06	224703.6	164006.99	1:1.37
N_1M_4	3782.69	226961.4	163506.59	1:1.38
N_2M_0	3641.04	218462.4	163343.09	1:1.33
N_2M_1	3865.97	231958.2	163843.09	1:1.42
N_2M_2	3893.77	233626.2	163743.09	1:1.43
N_2M_3	3937.09	236225.4	164243.09	1:1.44
N_2M_4	4032.32	241939.2	163742.69	1:1.48
N_3M_0	3771.86	226311.6	163579.19	1:1.38
N_3M_1	4059.97	243598.2	164079.19	1:1.48
N_3M_2	4141.48	248488.8	163979.19	1:1.52
N_3M_3	4197.84	251870.4	164479.19	1:1.53
N_3M_4	4467.20	268032.0	163978.79	1:1.53
N_4M_0	3891.00	233460.0	163815.26	1:1.43
N_4M_1	4476.13	268560.0	164315.26	1:1.63
N_4M_2	4533.20	271980.0	164215.26	1:1.66
N_4M_3	4584.00	275040.0	164715.26	1:1.67
N_4M_4	4648.00	278880.0	164214.86	1:1.70

Discussion

CHAPTER V

DISCUSSION

The results of the study on yield and physiological responses to nitrogen levels and micronutrients in Crossandra (***Crossandra infundibuliformis*** (L) Nees) are discussed in this chapter.

Crossandra infundibuliformis produces flowers throughout the year. The demand for the flower is high due to its majestic colour, light weight and good keeping quality. It has a great economic potential. Standardization of optimum nutrient management holds promise for improving the production and productivity and also will help in extending the economic life of the plant. Hence, studies were carried out in Delhi crossandra to find out the optimum nutritional requirement with varying levels of nitrogen and micronutrients.

The field experiment was carried out at Botanic gardens, Horticultural College and Research Institute, Coimbatore. Observations on growth and floral characters, physiological and biochemical constituents and estimation of NPK and micronutrients and yield were recorded.The experiment consisted of five levels of nitrogen (0, 90, 120, 150 and 180 kg ha^{-1}) and application of micronutrients in a split plot design with a total of 25 treatments. The results of the experiments are discussed below.

Growth characters

Different levels of nitrogen and micronutrients had significantly influenced the growth characters in crossandra. In the present study, the growth of crossandra as influenced by various treatments have been elucidated through plant height, number of branches, number of leaves, leaf area, leaf area index, specific leaf area, specific leaf weight, fresh and dry weight of the shoot and root, shoot-root ratio and dry matter production.

Application of nitrogen increased the plant height significantly. It increased as the age of the crop progressed from 3rd month to 12th month. The highest plant height was observed by the application of 180 kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%). The reason for better growth might be due to stimulation of root system with consequent help in greater absorption and translocation of nutrients and due to the favourable and additive effect of nitrogen and micronutrients on balanced nutritional requirements for plant height. Maheswar (1980) reported increased plant height with highest dose of nitrogen (100 kg N ha^{-1}) in china aster. Similar results were reported by Bhaskaraiah *et al.* (1991), Halepyati *et al.* (1995), Amarjeet Singh *et al.* (1996) in tuberose and Belgoankar *et al.* (1997) in Chrysanthemum. The number of branches per plant was significantly increased by the application of nitrogen and micronutrients. Number of branches produced per plant directly influenced the yield in crossandra because more number of branches contributed for more flower bearing spikes. In the present investigation, application of 180 kg N ha^{-1} along with the combination of foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) resulted in maximum number of branches. This might be due to the activation of lateral buds due to better N nutrition and micronutrients. Mohir (1985) reported maximum number of branches in marigold by the application of 100 kg N ha^{-1}. Similar results were reported by Avari and Patel (1991) that application of 200 kg N ha^{-1} recorded more number of lateral branches in african marigold. The present findings also corroborate with the earlier works of Kozik (1992) in aster.

Number of leaves is the single most important character, since it has an important role in carbohydrate metabolism and photosynthetic partitioning. The number of leaves per plant also significantly increased with increasing levels of nitrogen as that of plant height and number of branches. Application of nitrogen 180kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) registered the maximum number of leaves. The increase in leaf number may be due to continuous availability of nitrogen and also due to foliar spray of micronutrients. Similar results were reported by Mariappan (1992) in african marigold, John and Paul (1992) in ***Gomphrena globosa***, Parthiban *et al.* (1992) in tuberose and Kageyama and Konishi (1996) in chrysanthemum.

Number of leaves and leaf area have contributed greatly on the growth and development of crossandra plant. In the present study, application of nitrogen and micronutrients increased the leaf area. The leaf area per plant increased from 3rd month to 12th month. The leaf area index also followed the same pattern. The effect of nitrogen in enhancing the leaf area is well established and increasing levels usually have positive relationship with growth (Sarro *et al.* (1989)). Higher level of nitrogen (180 kg N ha^{-1}) recorded the maximum leaf area, leaf area index and dry matter production. The results indicated that highest level of nitrogen (180 kg N ha^{-1}) with the combination of foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) recorded the highest leaf area. The results indicated that there was a perceptible influence of nitrogen and micronutrients on the development of leaf area. These findings are also in agreement with Ravindran *et al.* (1986) in african marigold, Selvaraj (1988) in rose, Srinivasan and Balakrishnan (1988) in ***Jasminum sambac*** and Hugar and Nalawadi (1994) in ***Jasminum auriculatum***. Treatment N_4M_4 recorded maximum specific leaf area and specific leaf weight at 3rd, 6th, 9th and 12th month. This indicated the vigorous photosynthetic activities of the leaf which led to higher carbohydrate accumulation in leaves leading to highest specific leaf weight.

In this experiment, the fresh and dry weight of the shoot increased with increasing levels of nitrogen and also with the advancement of the crop growth from third month and twelfth month. Treatment N_4M_4 [(application of nitrogen 180kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest fresh and dry weight of the shoot. This level of higher fresh and dry weight production may be due to high level uptake of nutrients under integrated nutrient management. This was in agreement with the findings of Nanjan (1979), Dole *et al.* (1994) in poinsettia, Swaminathan (1995) in crossandra, Hummel *et al.* (1996), Ashok (1998) in rose and Parthiban (1998) in ***Gomphrena globosa***.

Proper plant growth and development can be achieved only by the supply of optimum nutrients to the root zone and their absorption by root system. In the present experiment with nitrogen and micronutrients, highest fresh and dry weights of the root was noted. Treatment N_4M_4 [application of nitrogen 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded increased fresh and dry weight of the root followed by treatment N_4M_3 [application of N at 180 kg ha^{-1} along with soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})]. It is clear that the micronutrients either as soil or foliar application had better effect than application of nitrogen alone. The perceptible increase in fresh and dry weight of root may be due to the active synthesis of tryptophan in the presence of Zn, the precursor of indole acetic acid which could have stimulated the growth of plant tissues. Fawzi and Bussler (1980) reported that spraying micronutrients led to increase in plant dry matter. Similar line of works of increased fresh and dry weight of the root by application of nitrogen and micronutrients were reported by Saad *et al* (1980), Mobarek (1985), Selvaraj (1988) in rose, Hussein *et al.* (1989) in ***Hibiscus subdariffa*** and Suhuch *et al.* (1996) in poinsettia.

Shoot root ratio showed a declining trend with the age of the crop. Shoot root ratio progressively reduced from third month to twelfth month. Treatment N_oM_1 [$ZnSo_4$ (25 Kg ha^{-1})] exhibited the highest shoot-root ratio at 3^{rd} month. At early stages of growth, the plants required nutrition to build up sufficient frame work. This might be the cause for increased shoot-root ratio at 3^{rd} month (Wild *et al.*, 1987). These results on shoot-root ratio were in corroboration with earlier findings of Wood House (1977). Swaminathan (1995) also reported similar results in crossandra.

Glass and Siddique (1984) reported that low external concentrations of nutrients restrict the dry matter production. The biological efficiency of any species could be reflected in the amount of dry matter it produces. Dry matter production increased with increasing levels of nitrogen. Treatment N_4 (180 Kg N ha^{-1}) increased the dry matter production. This might be due to increased photosynthetic ability which in turn have favoured an increased accumulation of dry matter and also efficient partitioning of photosynthates towards sink. In the present experiment, treatment N_4M_4 [(application of nitrogen 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] produced the highest dry matter production. This might be due to the fact that nitrogen and micronutrients might be responsible for enhancing the translocation of metabolites and thereby increasing the growth. This is in agreement with the earlier works of Anuradha *et al.* (1988) in marigold, Bankar and Mukhopodhyay (1990) in tuberose, Sable and Kale (1990) in rose, Venkatesh and Nalawadi (1991) and Ravichandran and Pappiah (1995) in crossandra. The results indicated that the growth characters were enhanced due to the application of higher doses of nitrogen and application of foliar spray of micronutrients. The favourable effect of N in promoting the growth of plant might be due to the fact that N application improved the transport of metabolites (Marschker, 1983).

Nitrogen is the chief constituent of protein which is essential for the formation of protoplasm which leads to cell division and cell enlargement. It is also an important constituent of aminoacids and coenzymes which are of considerable importance (Bakly, 1974). Similar effects of conjoint application of nutrients providing better growth were reported by Kageyama and Konishi (1996) and Belgaonkar *et al.* (1997) in Chrysanthemum.

Yield parameters

The aim of any applied research study is to get increased yield. In the present work, earliness in flowering through early emergence of the spike was observed. Number of spikes Per plant, number of flowers per spike, spike length, weight of 100 flowers, stalk length and flower diameter were recorded. Application of nitrogen and micronutrients has significantly advanced the time taken for emergence of flower spike and time taken for first flowering. Treatment N_4M_4 [N – 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] followed by N_4M_3 [application of N at 180 kg ha^{-1} along with soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})] which exhibited earliness in spike emergence and flowering. Mukhopadhayay (1981) in tuberose observed early emergence of the flower spike due to N application.

According to Marschker (1983), a balanced supply of nitrogen promotes the translocation of phytohormones to the shoot which probably induces flower initiation. Number of flowers per spike significantly increased with increase in nitrogen level. Micronutrient application also exerted significant influence. The highest number of flowers was obtained in the treatment N_4M_4-[application of Nitrogen –180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)]. Similar results were reported by Dod *et al.* (1991) in gladiolus, Bhujbal *et al.* (1992) in rose and Berlokar *et al.* (1992) in tuberose.

Number of spikes per plant, spike length and stalk length was significantly improved by the application of nitrogen and micronutrients as they boost the over all vegetative growth. Anuradha *et al.* (1998) also reported lengthier flower stalk by application of N at 90 kg ha^{-1} in marigold. Similarly Maya Gopalakrishna *et al.* (1995) observed that higher dose of nitrogen (120 kg N ha^{-1}) increased the length of the spike in tube rose.

Increased flower diameter was recorded in the treatment N_4M_4. Preethi (1990) reported that application of nitrogen increased flower diameter in Edward rose. Similar line of works were reported by John *et al.* (1981) in pansy, Jayanthi and Narayana Gowda (1990) in chrysanthemum and Berlorkar *et al.* (1992) in african marigold. Treatment N_4M_4 increased the weight of flowers. Mononmani (1992) reported that flower weight was increased with the application of nitrogen at 45 g per plant in ***Jasminum sambac***. This is in consonance with the findings of Natarajan and Madava Rao (1983) in ***Jasminum grandiflorum***, Chezhyian *et al.* (1986) in chrysanthemum, Bhaskariah *et al.* (1991) in tuberose, Jana and Pal (1991) in cosmos and Kageyama and Konishi (1996) in Chrysanthemum.

From the present study it was inferred that flower yield increased as the age of the crop increased. The increased flower yield was through the increase in number of spikes per plant, number of flowers per spike, spike length, stalk length, flower diameter and weight of hundred flowers which resulted due to increasing levels of nitrogen and application of micronutrients. These results are in confirmity with the findings of Farag *et al* (1983), Abdul Khader *et al.* (1985) in crossandra, Mobarek (1985), Srinivasan and Balakrishnan (1989) in ***Jasminum sambac***, Singh and Sujatha (1990) in gladiolus, Avari and Patel (1991) in african marigold, Fawzi *et al.* (1993) and Hugar and Nalawadi (1994).

High yield by the application of fertilizers was also reported by Swaminathan (1997) in crossandra, Parthiban (1998) in ***gomphrena globosa*** and Ashok (1998) in rose.

Physiological and biochemical constituents

The efficiency of utilization of nutrients within the plant system is measured through growth and development of the plants and the plants live in a ever fluctuating environment. To elucidate on the environmental manifestations of plants, a study on their physiology is essential (Clark, 1983). Hence, an attempt was made to study the physiology and biochemical constituents of crossandra through chlorophyll contents, net assimilation rate, crop growth rate (CGR), relative growth rate (RGR), soluble protein content, nitrate reductase, IAA oxidase activity, catalase activity and peroxidase activity.

In the present work, chlorophyll 'a' and 'b' contents were observed at 3rd, 6th, 9th and 12th month of planting. The chlorophylls are the essential components for photosynthesis and occur in chloroplasts as green pigments in all photosynthetic plant tissues. In general, chlorophyll 'a' and 'b' contents increased with crop growth. There was significant differences in chlorophyll content with every increase of nitrogen level in combination with micronutrients. Application of nitrogen with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) recorded increased chlorophyll content at all stages of crop growth followed by treatment N_4M_3 [(application of N at 180 kg ha^{-1} along with soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})]. Nitrogen being the constituent of protein and protoplasm might have increased the chlorophyll content and hence enhanced the photosynthetic activity of the plant. Application of Zn and Fe also increased the chlorophyll content of the leaves. It was evident from the present study that the chlorophyll, a vital basic pigment for augmenting the available light for photosynthetic function was conditioned by nitrogen and micronutrient application. Similar to chlorophyll 'a' and 'b', total chlorophyll content was also found to be high in the treatment N_4M_4. This might be due to higher synthesis of chlorophyll 'a' and 'b' in this treatment. This confirm the earlier findings of Sharma *et al.* (1974). Similar studies of increasing leaves of chlorophyll due to fertilizer application was reported by Damke (1995). He reported that application of nitrogen at 125g/1.44m^2/plant resulted in the highest leaf chlorophyll content in rose cv. Super Star. Similar results were reported by Linder (1980), Patel and Patel (1985) and parthiban (1997) in ***Gomphrena globosa***.

The net assimilation rate decreased as the crop stage progressed from 3rd month to 12th month. The treatment N_4M_0 (application of nitrogen –180 kg ha^{-1}) recorded the highest net assimilation rate at third month. Net assimilation rate gives an indirect measure of photosynthetic efficiency and is an important factor for increasing the biomass production. Similar results were reported by Watson (1947a).

The estimation of soluble protein content is considered as an indirect measure of RUBP carboxylase enzyme activity, a prime enzyme for carbon fixation in photosynthesis. RUBP carboxylase enzyme is found relatively at high concentration in soluble protein fractions of leaves. RUBP carboxylase enzyme as the abundant protein in the world was observed by Noggle and Fritz (1986). In the present study, treatment N_4M_4 [(N at 180 kg ha^{-1} + foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest soluble protein content at all stages of crop growth. The soluble protein content was conditioned by zinc and iron supply. In general, micronutrient deficiency resulted in reduced protein synthesis ultimately leading to low enzyme activity. It may be attributed that application of N –180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) induced the conversion of available soluble protein in to structural proteins resulting in the development of more lateral buds. This is in agreement with the findings of Naik and Asana (1970), Valler and Wacker (1970), Del Rio *et al.* (1978), Ramadevi (1986) and Durga Devi (1995).

Nitrate reductase enzyme activity occurs in cytoplasm and catalyses the conversion of nitrate into ammonia and further utilization of nitrogen for metabolism and physiology of plants. The nitrate reducing system consists of nitrate reductase and nitrite reductase which catalyse stepwise reduction of nitrate to nitrite and then to ammonia. Application of micronutrients controlled the activity of nitrate reductase enzyme. Treatment N_4M_4 [(N 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] have improved the enzyme activity at all stages of crop growth. The nitrate reductase activity was increased from 3rd month to 12th month. Thus application of micronutrients favourably regulated the nitrate reductase activity for better metabolism. The present study confirmed it. Mishra *et al.* (1978) reported increase in nitrate reductase activity by application of nitrate and ammonium. Similar line of works was observed by Ranjeet *et al.* (1976), Maskina *et al.* (1984) and Sachdev *et al.* (1987).

At all stages of plant growth, the enzyme catalase was hastened to a greater extent by the application of micronutrients. This enzyme activity was increased from 3rd month to 12th month. The significant enhancement in the enzyme activity was observed in the treatment N_4M_4 [(N 180 kg ha^{-1} + combination of foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)]. The results confirmed the involvement of iron in activating this enzyme. The decreased activity of the enzyme catalase in the control plants might be due to reduced iron translocation. This is in agreement with the findings of Agarwala *et al.* (1965), Gauch (1972) and Rahimi and Schropp (1985).

IAA oxidase activity was expressed in terms of µg of unoxidised auxin g^{-1} hr^{-1}. For maintaining the IAA levels at optimum concentration, the enzyme IAA oxidase is a must and this regulates apical dominance and initiation of lateral vegetative and floral buds. IAA, a premier bioregulator was influenced by the aminoacid tryptophan and zinc level in leaves. Zn involving treatments particularly lowered its activity indicating the hastening of growth. IAA oxidase was found maximum by the application of Nitrogen – 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%). IAA oxidase activity was found to be high in zinc as well as iron treated crossandra plants. Foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) increased the auxin synthesis of the leaves through tryptophan metabolism. Vlasyuk *et al.* (1964) reported that zinc was essential for auxin synthesis through tryptophan metabolism. Similar findings were reported by Gowthaman (1995).

In case of peroxidase activity, there was an increase in the activity as the crop stage progressed from third month to twelfth month. The peroxidase activity was found to be high in the treatment N_4M_4 [application of N –180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)]. Low levels of peroxidase activity was recorded in control. Increased peroxidase activity with increasing iron concentration was reported by Linn *et al.* (1994).

Tryptophan, which is the precursor of IAA is activated by zinc application. In the present investigation, the tryptophan content was significantly enhanced by foliar and soil application of $ZnSO_4$ and $FeSO_4$. Treatment N_4M_4 [application of N at 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest tryptophan content followed by treatment N_4M_3 [application of N 180 kg ha^{-1} along with soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})]. Thus micronutrient treatments significantly influenced the tryptophan content. Mehta (1995) reported that an increase in tryptophan content was due to Zinc application. Similar findings were reported by Durga Devi (1995).

Chemical analysis

Efficient use of fertilizers is necessary for optimum growth and yield. So a knowledge about availability of nutrients in the soil is very essential. To assess the availability of various nutrients in the soil and the effect of fertilizer addition, foliar and soil analysis of macro and micronutrients were made.

Leaf and flower analysis

Use of plant analysis in planning a fertilizer programme has been found useful to prevent the effects of deficiency or excess of a nutrient in many horticultural crops. The concentration of nutrients in plant varies with the age of the crop, plant parts, season and cultivars. Plant analysis serves as a diagnostic and elegant tool for understanding the physiology of the plant at various phases of its growth.

The present study was taken up to find out the optimum requirement of fertilizers for higher yield in crossandra. NPK contents in leaf and flower were estimated. The effect of application of nitrogen and micronutrients which produced significant results on nutrient contents of leaf and flower were observed in the treatment N_4M_4. Increased N level may be due to the non-dilution of N level in the way of accumulation of carbohydrate which may take place gradually with advancement in the growth of the plants.

Micronutrient application resulted in a considerable enhancement of leaf and flower N content. Fertilizing with micronutrients both through soil as well as foliage enabled to accumulate more of leaf and flower N content. The application of nitrogen and micronutrients had resulted in the enhanced absorption of nitrogen by the crop ultimately leading to higher yield. Treatment N_4M_4 [application of N at 180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest nitrogen content in leaf and flower followed by treatment N_4M_3 [application of N at 180 kg ha^{-1} along with soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})]. Similar findings were reported by Lunt and Kofranek (1958) in chrysanthemum, Joiner and Smith (1961) and Shanmugam and Muthuswamy (1983) in chrysanthemum.

The relatively highest P content in leaf and flower indicated the effectiveness of application of N –180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%). Similar findings were reported by Nanjan and Shanmugavelu (1979) in Edward rose and Selvaraj and Pappiah (1988) in rose.

The K content in leaf and flower decreased as the crop stage progressed from 3rd month to 12th month. The leaf K content exhibited a similar trend as that in the case of N and P. The combined application of zinc and iron through soil as well as foliar application enhanced K absorption at all stages of crop growth. Treatment N_4M_4 [N –180 kg ha^{-1} + foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest K content in leaf and flower. The transformation reactions that took place led to greater availability of K in soil and consequently better utilization by the plant. It is also possible that the micronutrients have activated the physiological processes for the rapid absorption and utilization of the nutrient for primary metabolic processes. Banker and Mukhopadhyay (1990) revealed that the content of NPK in leaf was significantly increased with application of NPK in tuberose. Hazan *et al.* (1994) also reported that foliar nutrient contents increased with increased fertilizer application rate in roses. These findings are in line with those reported by Anuradha *et al.* (1988) in african marigold and Swaminathan (1995) in crossandra.

The leaf Fe status revealed that most of the treatments including the application of ferrous sulphate registered significantly higher values for iron content at various stages. The Fe content in leaf increased with crop growth. It was higher due to application of nitrogen –180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) at different stages of crop growth. Treatment N_4M_3 was found next best to N_4M_4 [application of N-180 kg ha^{-1} along with soil application of $ZnSO_4$ (25kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})]. Sharma *et al.* (1974) also reported than an increase in iron content was due to iron application. Vadivel (1980) reported that application of micronutrients increased the iron content. The results are in agreement with the findings of Pandian (1980), Subramaniam (1982) and Swaminathan (1995) in crossandra. From the results of the study, it is evident that application of N-180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) (N_4M_4) increased the leaf zinc content. The next best treatment was N_4M_3 [application of N at 180 kg ha^{-1} along with soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})] which recorded highest zinc in leaf. From this, it could be concluded that application of zinc either as soil or foliar resulted in highest Zn content. Mann and Sidhu (1983) have made it clear that foliar spray of $ZnSO_4$ increased the leaf zinc status. Dixit and Yamdagni (1983) have also suggested that application of Fe and Zn increased the Fe and Zn status of the leaf.

Soil analysis

Plant nutrient availability in the soil is very important for higher production. In the current study, nutrient availability status due to addition of increased levels of N and micronutrients were noted.

Application of 180 kg N ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) recorded the highest available NPK in the soil, supporting the concept of increasing levels of nitrogen and micronutrients spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%) which induced promotion of growth in crossandra and hence increased yield.

Increased levels of nitrogen and micronutrients increased the available soil N, P and K and thus made the plants to absorb more nutrients (Sindhu and Yamadagni, 1992). In the present study, increased available N, P and K was observed in the soil when higher levels of N and micronutrients were applied. Similar results were obtained by Bhujbal *et al.* (1992), Carbera *et al.* (1996) and Damke and Bhattacharjee (1997) in rose.

In the current investigation, increased availability of N, P and K in soil totally improved the yield. This is in agreement with the results reported by Uma and Gowda (1987) in rose, Bhujbal *et al.* (1992), Parthiban and Abdulkhader (1992) in tuberose and Parthiban (1998) in ***Gomphrena globosa***.

Fe and Zn content in soil

The effect of application of various levels of nitrogen and micronutrients on iron and zinc content in soil were recorded.

Fe and Zn content in soil increased with increasing levels of N. The treatment with N at 180 kg ha^{-1} along with Soil application of $ZnSO_4$ (25 kg ha^{-1}) + $FeSO_4$ (–50 kg ha^{-1}) recorded the highest Fe and Zn content in soil. The results indicated that there was significant effect on application of NPK and micronutrients and this ultimately led to better growth and yield in crossandra. Abdul khader *et al.* (1985) reported improved growth and yield by application of NPK and micronutrients. Similär findings were reported by Subramanian (1982) in crossandra.

Use efficiency of nitrogen

Use efficiency in terms of yield was studied by calculating the response ratio (kg of economic produce per kg of nitrogen applied). Nitrogen use efficiency increased with increased nitrogen levels. The use efficiency was more when both Fe and Zn were added (Table 54, Fig. 11).

When nitrogen was applied alone at any level, the use efficiency in terms of response ratio was less. When both micronutrients was added, the N use efficiency was enhanced.

Increasing doses of nitrogen from N_2 to N_4 resulted in decreased N use efficiency namely 4.88 at N_2 and 4.63 at N_4. When accompanied by zinc and iron, the response ratio was increased from 8.13 to 8.84. The results indicated that integration of N and micronutrients such as Fe and Zn helped in enhancing the N use efficiency. The results generated from the present investigation clearly indicated the possibility of increasing N use efficiency and yield through the integration of N with Zn and Fe.

Response of crossandra to the conjoint use of nitrogen and micronutrients

There is a linear response by application of nitrogen. The response of crossandra to to the conjoint use of nitrogen and micronutrients are presented in Fig. 12. The graph

Table 54. Nitrogen use efficiency

S.No	Treatments	Yield (kg/ha)	Response (Kg/ha)	Response ratio (Kg/kg)
1	**N_1M_0**	3419	363	4.03
2	**N_1M_1**	3589	533	5.92
3	**N_1M_2**	3723	667	7.41
4	**N_1M_3**	3745	689	7.65
5	**N_1M_4**	3782	726	8.07
6	**N_2M_0**	3641	585	4.88
7	**N_2M_1**	3865	809	6.74
8	**N_2M_2**	3893	837	6.98
9	**N_2M_3**	3937	881	7.34
10	**N_2M_4**	4032	976	8.13
11	**N_3M_0**	3771	715	4.77
12	**N_3M_1**	4059	1003	6.69
13	**N_3M_2**	4141	1085	7.23
14	**N_3M_3**	4197	1141	7.61
15	**N_3M_4**	4467	1410	9.41
16	**N_4M_0**	3890	835	4.63
17	**N_4M_1**	4476	1420	7.88
18	**N_4M_2**	4533	1477	8.21
19	**N_4M_3**	4584	1528	8.49
20	**N_4M_4**	4648	1592	8.84

Fig.11. Nitrogen use effeciency

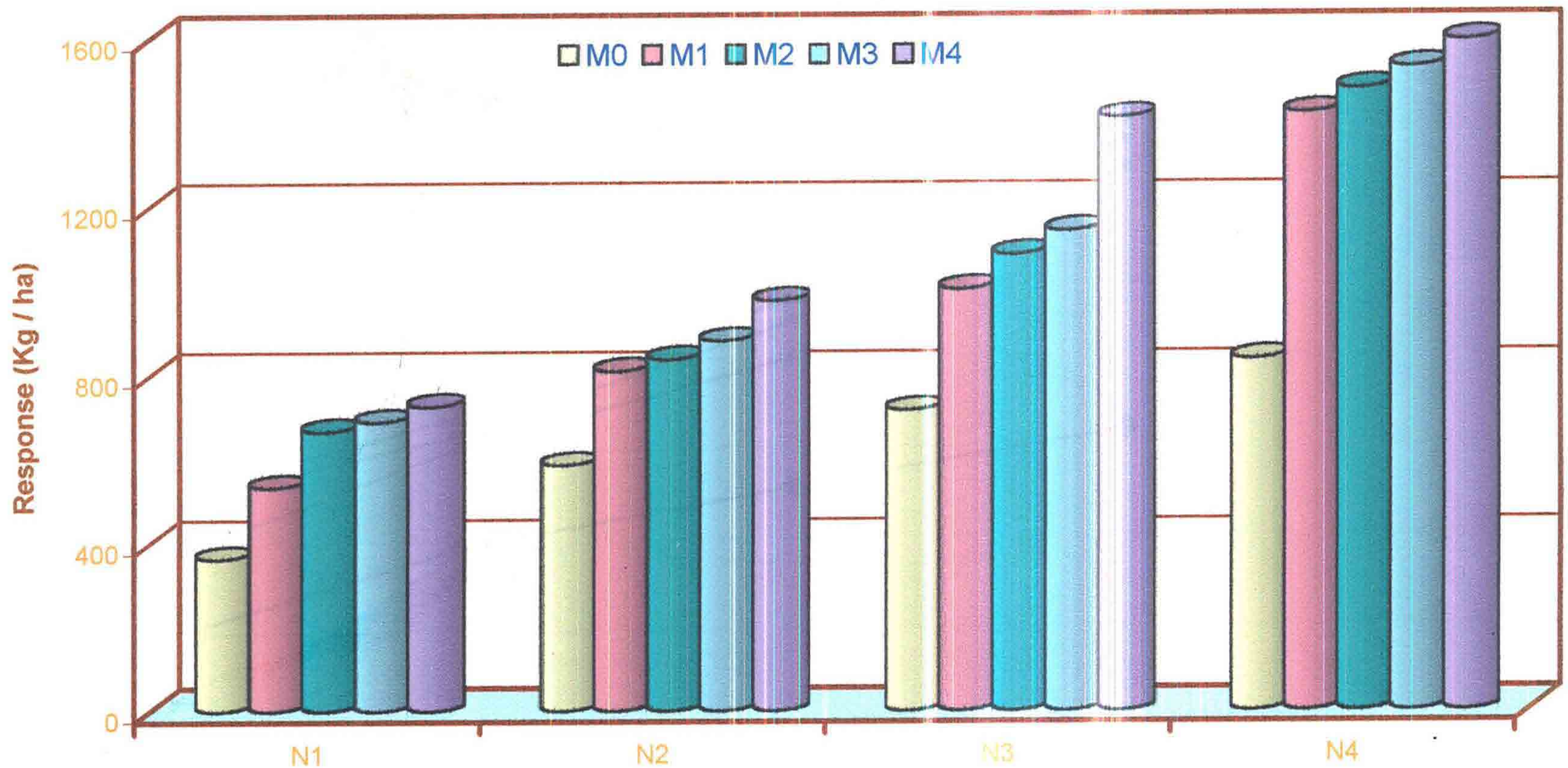
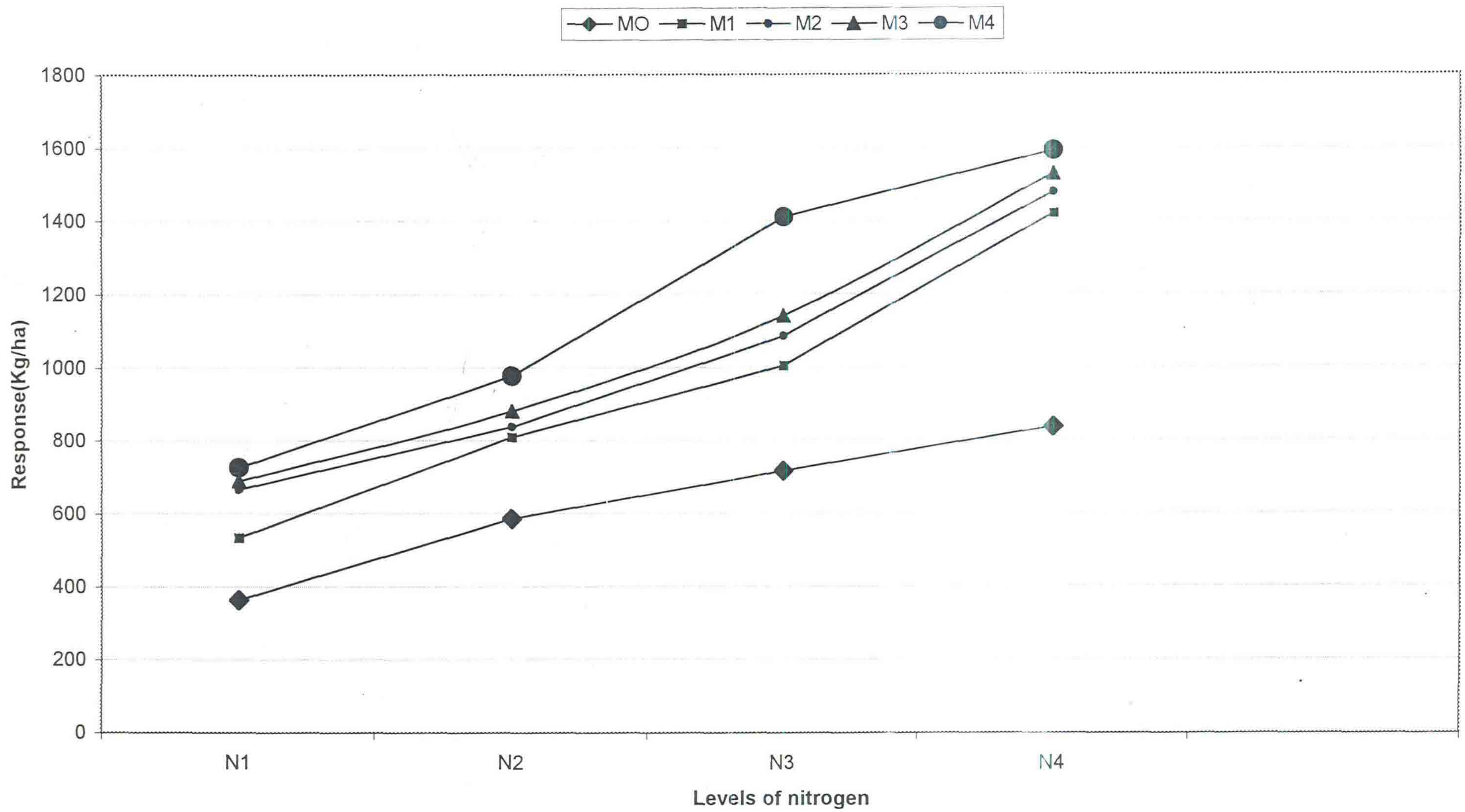


Fig. 12.Response of crossandra to the conjoint use of nitrogen and micronutrients



indicates that there is a scope for getting higher yield with increase in levels of nitrogen. Highest yield was noticed with higher levels of nitrogen in combination with micronutrients. Because of the linearity, the quadratic equation was not obtained and hence the optimisation is not possible. This warrants further studies.

Effect of micronutrients under high production system

The effect of micronutrients under high level of nitrogen (production system) is presented in Table 55, Fig. 13.

In the present study, increasing the rates of N up to 180 kg ha^{-1} with constant levels of P and K recorded linear response. In nature, on account of the existence of 'Law of diminishing returns', the increasing rates of N will result in 'decrimental response'. So any increase beyond 180 kg ha^{-1} may result in declining or plateauing of yield.

When N was applied alone, the yield increase was small as compared to that recorded when N was integrated with Fe or Zn or both. This influence of Zn and Fe when they accompanied N on increasing the yield potential of the test crop would suggest that under high level of nitrogen, that is, beyond 180 kg ha^{-1}, if there would be 'decrimental response' that could be reduced. Under such situations, the linear response could be expected to some more extent if there is the integrated supply of N and micronutrients.

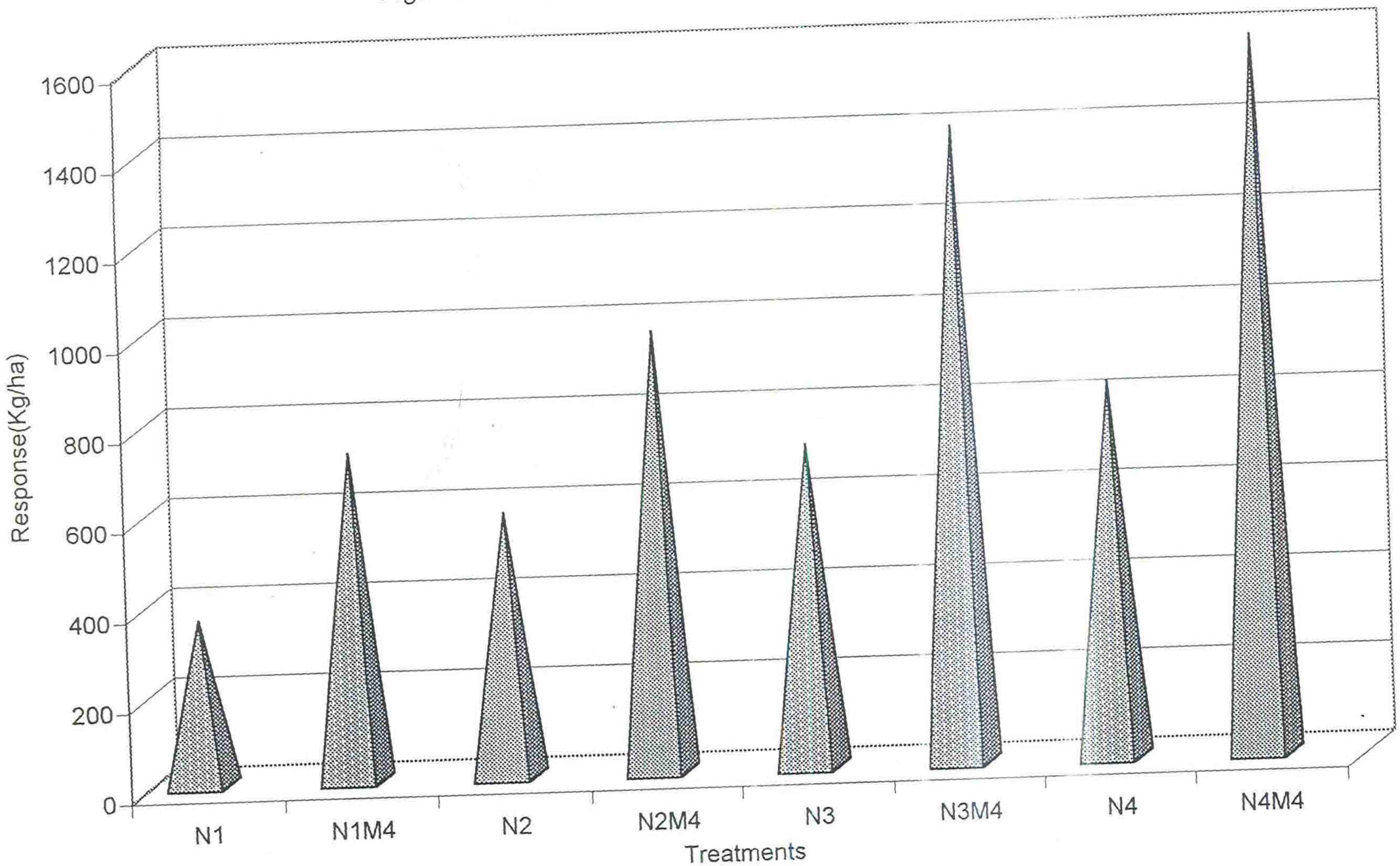
Correlation

A knowledge of the association between yield and other biometrical characters and the association among the component traits themselves will greatly help in predicting the yield.

Table 55. Effect of micronutrients under high production system

Sl. No.	Treatments	Response (kg/ha)	Yield increase
1	N_1	363	-
2	N_2	584	-
3	N_3	715	-
4	N_4	835	-
5	N_1M_4	726	363
6	$N_2 M_4$	976	392
7	$N_3 M_4$	1411	695
8	$N_4 M_4$	1592	757

Fig.13.Effect of micronutrients under high production system



Highly significant positive correlation was recorded for plant height, number of branches, number of leaves, fresh and dry weights of the shoot and root, leaf area index and dry matter production. This indicates that these growth characters positively influenced the yield to a large extent. Similar trend of results have been documented by Pandey and Gritton (1975), Mishra *et al.* (1989) and Sendur Kumar *et al.* (1995).

With respect to yield attributing characters, highly significant and positive correlation with yield was recorded for number of flowers per spike, number of spikes per plant, spike length, stalk length, diameter of flower and weight of flowers which can be utilized as selection criteria for yield improvement. This is in agreement with the findings of Nandpuri *et al.* (1973), Natarajan and Arumugam (1980), Vadivel (1988), Prasad *et al.* (1989) and Janwal *et al.* (1996).

Highly significant positive correlation was recorded for yield with physiological and biochemical constituents *viz.*, chlorophyll contents, soluble protein content, nitrate reductase activity, catalase activity, peroxidase and tryptophan content. This is in consonance with the findings of Mathew and Ramadasan (1975), Ramadasan and Satheesan (1980), Sivasankar and Ramadasan (1983) and Durga Devi (1995). It was found that these traits had certain inherent relationship with yield suggesting their importance in determining the yield of flowers.

Nutrient contents recorded highly significant and positive correlation with yield at different stages of crop growth. Ravindran et al. (1986) noticed a positive and significant correlation between flower yield and nitrogen content of african marigold at different stages of crop growth. Thus the NPK content in leaf, available NPK in soil, Fe and Zn content in leaf and soil contributed significantly towards yield.

Multiple regression

The multiple regression equations were worked out to relate the yield of flowers with growth characters, physiological and biochemical constituents and nutrient contents at third, sixth, ninth and twelfth month of planting.

Predicting the yield of flowers from the associated parameters will be very useful for making recommendations for the whole sequence at the beginning itself. For predicting the yield of flowers, the linear additive model is generally used. The linear additive equations were fitted relating the growth characters, yield attributing characters, physiological and biochemical constituents and nutrient contents in crossandra. Fitted equation during third, sixth, ninth and twelfth and are presented in tables 53, 54, 55 and 56.

Significant coefficients were observed for number of leaves, fresh and dry weight of the root and shoot root ratio during third month. Dry matter production recorded significant values during sixth month and fresh weight of shoot exhibited significant effects during twelfth month on yield.

Table 56. Multiple regression equation of growth characters with yield

Growth characters	Fitted equation
3rd month	Y = 0.164 - 0.011 plant height - 0.172 number of branche).05* number of leaves + 0.36 LAI - 0.18 SLW - 0.001 fresh wt of shoot + 0.023 dry wt of sh(1.24** fresh wt root - 3.66* dry wt root +0.06* shoot root ratio + -0.002 dry matter production.(0.96**)
6th month	Y = 14.72 + 0.047 plant height + 0.963 number of branches)5 number of leaves -13.69 LAI-2.63 SLW - 0.002 fresh wt of shoot - 0.027 dry wt of shoot + 0.4resh wt root + 1.73 dry wt root+1.94 shoot root ratio + 0.204* dry matter production. (R^2 = 0.99**
9th month	Y = 49.86 - 0.83 plant height +0.39 number of branches -0.ımber of leaves + 73.79 LAI + 1.05 SLW - 0.023 fresh wt of shoot - 0.09 dry wt of shoot + 0.86h wt root + 2.57 dry wt root + 2.033 shoot root ratio + 0.14 dry matter production. (R^2 = 0.95**)
12th month	Y = 108.14 - 0.68 plant height +1.34 number of branches - (number of leaves - 0.85 LAI - 19.09 SLW+0.113* fresh wt of shoot + 1.03 dry wt of shoot + 0.esh wt root + 0.84 dry wt root - 2.09 shoot root ratio + 0.228 dry matter production. (R^2 = 0.99**)

* significance at 5% level
** significance at 1% level

Table 57. Multiple regression equation of yield attributing characters with yield

Yield attributing characters	Fitted equation
3rd month	Y= 0.08 + 0.005 time taken for spike emergence -0.01 time taken for first harvest + 0.010 time taken for completion of harvest + 0.034 number of flowers/spike + 0.19 number of spikes/plant -0.04 spike length - 0.19 stalk length - 0.17 diameter of flowers +0.221 weight of flowers. (R^2 = 0.97**).
6th month	Y= 84.43 - 0.122 time taken for spike emergence -0.53 time taken for first harvest - 0.118 time taken for completion of harvest - 0.042 number of flowers/spike + 0.62** number of spikes/plant + 0.52* spike length + 3.89** stalk length - 9.43** diameter of flowers + 4.71** weight of flowers. (R^2 = 0.99**)
9th month	Y= 248.46-1.094 time taken for spike emergence - 0.683* time taken for first harvest - 0.537 time taken for completion of harvest + 0.479 number of flowers/spike - 0.62 number of spikes/plant + 1.32 spike length - 1.64 stalk length - 9.75 diameter of flowers + 6.09* weight of flowers. (R^2 = 0.96**)
12th month	Y= 357.61 - 1.75 time taken for spike emergence -1.50 time taken for first harvest - 0.39 time taken for completion of harvest - 0.203 number of flowers/spike - 0.322 number of spikes/plant + 2.57 spike length + 7.70 stalk length + 0.993 diameter of flowers + 11.73 weight of flowers. (R^2 = 0.99**)

* significance at 5% level
** significance at I% level

Table 58. Multiple regression equation of Physiological and biochemical constituents with yield

Physiological and biochemical constituents	Fitted equation
3rd month	Y= 0.63 -1.03 Chlorophyll 'a'+ 2.02 Chlorophyll 'b' - 1.53 total Chlorophyll + 0.30 CGR + 8.36* RGR + 0.48* NAR + 0.114* soluble protein content + 0.111 nitrate reductase activity + 0.04 catalase activity - 0.0002 IAA oxidase activity - 0.48 peroxidase activity + 0.082* tryptophan content. (R^2 = 0.95**)
6th month	Y= 23.78 -10.61 Chlorophyll 'a'+ 27.26 Chlorophyll 'b' - 1.29 total Chlorophyll - 42.09 CGR - 859.05* RGR + 47.60** NAR + 4.66** soluble protein content + 1.83 nitrate reductase activity + 0.28catalase activity + 0.0001 IAA oxidase activity + 24.26 peroxidase activity + 0.30 tryptophan content. (R^2 = 0.99**)
9th month	Y= 61.03 - 6.34 Chlorophyll 'a'+102.43 Chlorophyll 'b' + 13.06 total Chlorophyll + 40.59 CGR + 661.18 RGR + 26.63 NAR + 3.23 soluble protein content + 0.76 nitrate reductase activity + 0.63 catalase activity - 0.08 IAA oxidase activity + 75.85 peroxidase activity + 3.08 tryptophan content. (R^2 = 0.97**)
12th month	Y= 103.46 - 28.87 Chlorophyll 'a'- 20.91 Chlorophyll 'b' + 64.68* total Chlorophyll - 5.03 CGR - 4818.89* RGR - 40.47 NAR - 0.17 soluble protein content + 12.68* nitrate reductase activity + 1.44 catalase activity - 0.0001 IAA oxidase activity + 73.97 peroxidase activity + 0.77 tryptophan content. (R^2 = 0.99**)

* Significance at 5% level
** Significance at 1% level

Table 59. Multiple regression equation of nutrient contents with yield

Nutrient contents	Fitted equation
3rd month	Y= 1.27 + 1.85** N content in leaf + 12.95 P content in leaf + -0.424 K content in leaf -1.250 N content in flower + 0.027 P content in flower + 0.567 K content in flower + 0.002 Fe content in leaf + 0.010 Zn content in leaf + 0.0002 available nitrogen in soil + 0.122** available phosphorous in soil + 0.001 available potassium in soil + 0.042* Fe content in soil + 0.164 Zn content in soil . (R^2 = 0.95**)
6th month	Y= 59.5 + 6.73 N content in leaf + 2.19 P content in leaf + 17.30* K content in leaf -0.01 N content in flower-13.88 P content in flower + 19.93* K content in flower + 0.001 Fe content in leaf + 0.123 Zn content in leaf + 0.07* available nitrogen in soil + 0.123* available phosphorous in soil + 0.046 available potassium in soil + 0.402 Fe content in soil + 1.993 Zn content in soil. (R^2 = 0.99**)
9th month	Y= 36.23-3.21 N content in leaf + 125.89 P content in leaf + 3.43 K content in leaf-0.896 N content in flower + 5.816 P content in flower + 24.29 K content in flower + -0.035 Fe content in leaf + 0.397 Zn content in leaf + -0.03* available nitrogen in soil +2.57* available phosphorous in soil + 0.015 available potassium in soil + 0.439 Fe content in soil + -1.44 Zn content in soil. (R^2 = 0.97**)
12th month	Y= 31.09 + 7.50 N content in leaf - 345.6 P content in leaf - 24.09 K content in leaf - 2.58 N content in flower - 88.47 P content in flower + 1.601K content in flower + 0.025 Fe content in leaf + 1.701 Zn content in leaf + 0.31* available nitrogen in soil + 6.84* available phosphorous in soil + 0.04 available potassium in soil + 1.24 Fe content in soil - 12.63 Zn content in soil. (R^2 = 0.99**)

* Significance at 5% level
** Significance at 1% level

Yield attributing characters *viz.*, number of spikes per plant, spike length, stalk length and weight of flowers exhibited significant effects towards yield at 6th month and 9th month.

Among physiological and biochemical constituents, RGR and NAR recorded significant effects during 3rd and 6th month, while soluble protein content and tryphtophan content also exhibited significant effects during 3rd month. At 12th month, total chlorophyll, RGR and nitrate reductase activity exhibited significant effects.

Among different nutrient contents, highly significant effects for yield was observed for N content in leaf, available phosphorus in soil and Fe content in soil at 3rd month. At 6th month, K content in leaf, K content in flower, available phosphorus in soil exhibited significant 'b' values. Available nitrogen in soil and available phosphorus in soil exhibited significant effects towards yield during 9th and 12th month.

Considering the significant values in all the cases, it clearly elucidates that growth characters, yield attributing characters, physiological and biochemical constituents and nutrient contents with yield were adequate to describe the changes for yield of flowers.

The results are in agreement with the findings of Muthukrishnan and Arumugam (1980), Maragatham (1995), Durga Devi (1995) and Chezhiyan and Anandhan (1998).

Economics

The ultimate aim of fertilizer application is to get maximum returns with minimum addition of external inputs. Hence in the present study, economics were worked out in the experiment with the application of increased levels of nitrogen and micronutrients application. The treatment N_4M_4 [180 kg ha^{-1} along with foliar spray of $ZnSO_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded the highest flower yield of 4648.60 kg per hectare with the highest returns of Rs 278880. The highest cost benefit ratio of 1:1.70 was also recorded in this treatment.

Summary

CHAPTER VI

SUMMARY

Investigation carried out to study on the yield and physiological responses to nitrogen levels and micronutrients in Crossandra (***Corssandra infundibuliformis*** (L.) Nees), were conducted at Botanic gardens, Horticultural College and Research Institute, Coimbatore. Salient findings are presented here.

1. Application of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%) significantly increased the plant height at different stages of crop growth.
2. The number of branches was highest in the treatment N_4M_4 [180 kg N ha^{-1} in combination with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].
3. The highest number of leaves was observed with the highest levels of nitrogen [180 kg N ha^{-1} in combination with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].
4. Application of stem girth increased with the application of nitrogen and micronutrients. Treatment N_4 (180 kg N ha^{-1}) in combination with M_4 [(foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)] was more effective in increasing the stem girth.
5. The highest leaf area was recorded with N at 180 kg ha^{-1} along with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%) at different stages of plant growth.
6. The treatment N_4 (180 kg N ha^{-1}) in combination with M_4 [foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded highest leaf area index at 6^{th} and 9^{th} month. N_4M_4 did not have significant effects during 3^{rd} and 12^{th} month.

7. With reference to specific leaf area, treatment N_4M_4 increased SLA at 3rd, 9th and 12th month. Application of nitrogen and micronutrients and the interaction effect between nitrogen and micronutrients showed non significant effects during 6th month.

8. Specific leaf weight was high in the treatment combination N_4M_4 [N at 180 kg ha^{-1} along with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

9. The highest fresh and dry weight of the shoot and root was recorded by application of N at 180 kg ha^{-1} in combination with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%).

10. The shoot-root ratio increased at early stages and started declining at later stages of crop growth. Treatment N_0M_1 [$ZnSo_4$ (25 kg ha^{-1})] recorded highest shoot-root ratio during third month.

11. The highest dry matter production was highest in the treatment N_4 (180 kg N ha^{-1}) in combination with M_4 [foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

12. Earliness in spike emergence, early flowering and earliness in completion of flowering in the spike was recorded in the treatment N_4M_4 [N at 180 kg ha^{-1} along with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

13. The highest number of flowers per spike was recorded in treatment N_4 (180 kg N ha^{-1}) in combination with M_4 [(foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)], while different levels of nitrogen and micronutrients individually had no corresponding increase in number of flowers per spike.

14. Treatment N_4 (180 kg N ha^{-1}) increased the number of spikes per plant in combination with M_4 [foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)]. Decreased number of spikes per plant were noted in the control.

15. The stalk length increased as the crop stage progressed from 3rd month to 12th month. Increased stalk length was observed in the treatment N_4M_4 [N at 180 kg ha^{-1} + foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

16. Increased levels of nitrogen in combination with micronutrients increased the diameter of flower at 3rd, 6th, 9th and 12th month. Treatment N_4 (180 kg ha^{-1}) with M_4 [foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded increased diameter of flower at different stages of crop growth.

17. Different levels of N and micronutrients individually recorded decreased spike length. The treatment N_4 (180 kg N ha^{-1}) enhanced the spike length in combination with M_4 [foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)], while the control had no corresponding increase in spike length.

18. The stalk length increased significantly with the fertilizer treatments at different stages of crop growth. The stalk length was maximum in the treatment with 180 kg N ha^{-1} in combination with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%).

19. The weight of flowers which is an important yield attributing character increased as the crop stage progressed form 3rd month to 12th month, the weight of flowers increased significantly with 180 kg N ha^{-1} in combination with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%).

20. The highest flower yield was recorded by the application of increasing levels of nitrogen and micronutrients. Treatment N_4 (180 kg N ha^{-1}) along with M_4

[foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded highest flower yield. The flower yield increased significantly with the advancement of crop growth.

21. Chlorophyll 'a', chlorophyll 'b' and total chlorophyll contents was significantly improved due to nitrogen and micronutrients application. The highest chlorophyll 'a', chlorophyll 'b' and total chlorophyll contents was recorded in treatment N_4M_4 [(N 180 kg ha^{-1}) in combination with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

22. The soluble protein content was maximum in the treatment N_4M_4 with 180 kg N ha^{-1} along with combination of foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%). Application of the above dose of N and micronutrients recorded highest soluble protein content.

23. The crop growth rate was significant at all stages of crop growth. Application of 180 kg N ha^{-1} along with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%) recorded highest crop growth rate at all stages of plant growth.

24. The relative growth rate increased in the first phase of crop growth. The treatment N_3M_1 [N – 150 kg ha^{-1} along with soil application of $ZnSo_4$ (25 kg ha^{-1})] recorded highest relative growth rate during 3rd month.

25. The catalase activity was significantly improved by the application of nitrogen and micronutrients. Highest level of nitrogen [180 kg N ha^{-1} in combination with foliar spray $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)] recorded increased catalase activity.

26. Similar trend was observed in case of IAA oxidase activity which recorded higher value by the treatment N_4M_4 [180 kg N ha^{-1} along with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

27. Application of fertilizers recorded highest peroxidase activity. Increased enzyme activity was recorded in the treatment N_4 (180 kg N ha^{-1}) in combination with M_4 [foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

28. Tryptophan synthesis was triggered by the application of increased levels of nitrogen and micronutrients. The maximum tryptophan content was recorded in the treatment combination N_4M_4 [(N at 180 kg ha^{-1} + foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

29. The foliar and flower N, P and K content was highest in the treatment N_4M_4 [180 kg N ha^{-1} along with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)]. Nitrogen and micornutrients application showed significance at all stages of crop growth.

30. Iron and Zinc content of leaf was highest in the treatment N_4M_4 [N at 180 kg ha^{-1} along with foliar spray to $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)] followed by N_4M_3 [N at 180 kg ha^{-1} + soil application of $ZnSo_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})].

31. All treatments had influenced the soil available nitrogen, phosphorus and potassium. The available nitrogen, phosphorus and potassium was highest in the treatment N_4M_3 [application of nitrogen 180 kg ha^{-1} + soil application of $ZnSo_4$ (25 kg ha^{-1}) + $FeSO_4$ 50 kg ha^{-1})].

32. Fe and Zn content in soil was highest in the treatment N_4M_3 [application of N 180 kg ha^{-1} along with soil application of $ZnSo_4$ (25 kg ha^{-1}) + $FeSO_4$ (50 kg ha^{-1})].

33. Integration of N and micronutrients such as Fe and Zn enhanced the N use efficiency. When both micronutrients were added, the N use efficiency was enhanced.

34. The correlation analysis studies revealed the existence of a highly significant and positive association for most of biometric characters with yield.

35. Highly significant positive correlation with yield was recorded for plant height, number of branches, number of leaves, fresh and dry weight of the shoot and root, leaf area, leaf area index and dry matter production.

36. Number of flowers per spike, number of spikes per plant, spike length, stalk length, diameter of flower and weight of flowers exhibited highly significant and positive correlation with yield. Most of the physiological attributes and nutrient contents recorded positive association with yield at different stages of crop growth.

37. In case of multiple regression, the linear additive equations were fitted for third, sixth, ninth and twelfth month relating to growth characters, yield attributing characters, physiological and biochemical constituents and nutrient contents in crossandra.

38. The highest cost benefit ratio (1:1.70) for the yield of flowers was obtained in the treatment N_4M_4 [application of nitrogen 180 kg ha^{-1} along with foliar spray of $ZnSo_4$ (0.5%) + $FeSO_4$ (1.0%)].

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* Originals not seen.

Appendices

Appendix-1
Cost of cultivation per hectare

S no	Particulars	A	B	Cost
I	Cost of the planting material-Rs 3/plant, 27700 Plants			83100
II	Main field			
	Preparatory cultivitation			
	(i) Ploughing tractor drawn – 5 hrs @ Rs 125 /hr			625
	(ii)Formation of ridges and furrows	25		990
	(iii)Cost of Farm yard manure-30t/ha@Rs 250/t			7500
	(I) Cost of Fertilizers (Super phosphate 50 kg/ha @ 3.72 Rs/ kg + Murate of potash 125 kg/ha @ 3.72 Rs/kg)			1668.74
	Application cost	1	1	180.40
III	Transplanting the plants in the main field	2	20	783.2
IV	Irrigation-36 irrigations, 2A type / irrigation	72		2851.2
V	Plant protection			
	Furadon 3 G . 2 kg. 4.16 Rs/kg			8.32
	Monocrotophos @ 284.26 / lit –1.25 liltre			355.33
	Application cost	2	8	360.6
VI	Earthing up(2times) 30A type/earthing up	60		2376
VII	Picking cost : 35 pickings-25 B type/picking 2 pickings per week		1750	61600
	Total			162398.74

A type – Rs 39.60/day , B type – Rs 35.20/ day.

Cost for the treatments

N1-Rs. 708.25, N2 – Rs. 944.35, N3 – Rs.1180.45, N4 – Rs. 1416.52 , M1-Rs. 500, M2 – Rs. 400, M3 – Rs. 900, M4 – Rs. 250, Urea – Rs. 3.62/kg , Super phosphate – Rs 2.86 / kg , Muriate of potash – Rs 3.72 Rs / Kg . one kg of flowers sold at Rs 60/-

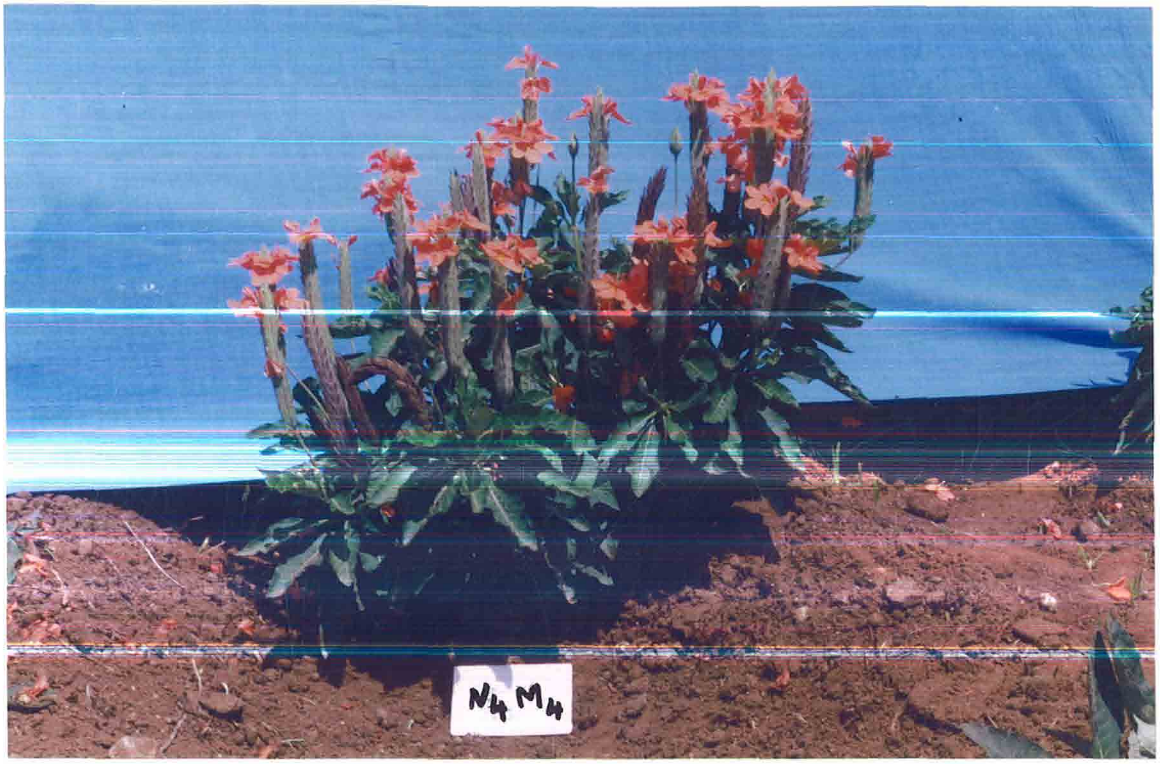
APPENDIX-II

WEATHER DATA (97 December –98 December)

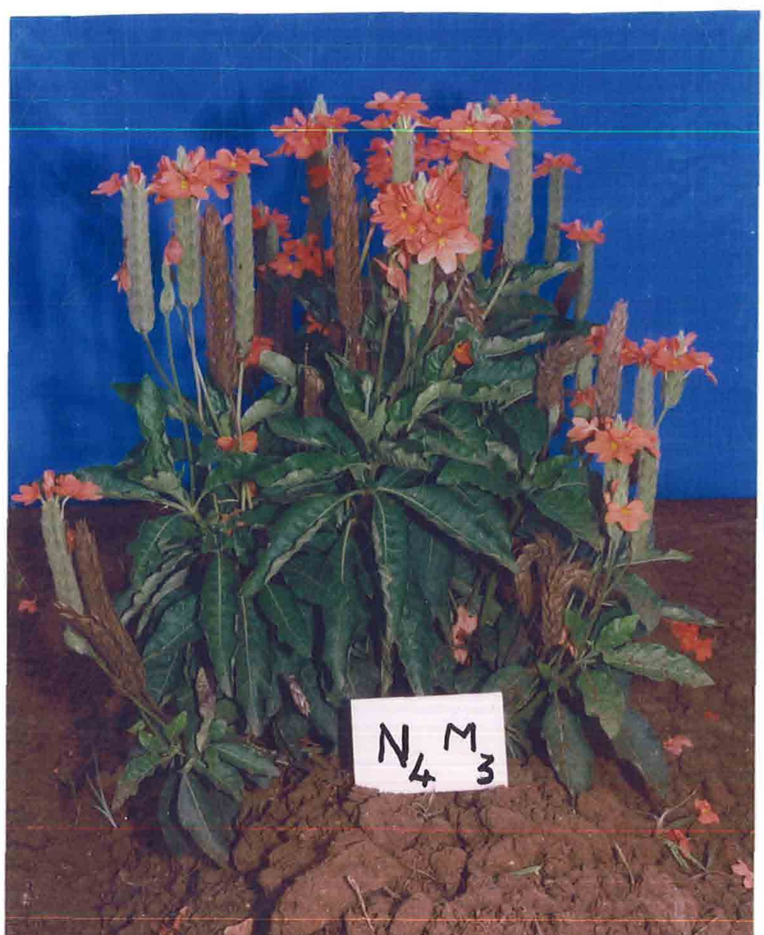
Months	Average maximum temperature	Average minimum temperature	Average RH Maximum	Average RH Miniimum	Total Rainfall	No of rainy days
December	28.9	21.8	90.0	62	37.3	8
January	30.1	20.2	87.0	47	-	-
February	32.8	20.5	85.0	40	-	-
March	35.5	22.0	82.0	80	-	-
April	36.6	24.8	80.0	31	96.0	4
May	35.5	24.8	81.0	46	52.5	3
June	32.7	24.2	71.0	56	57.8	6
July	30.8	23.3	80.0	56	51.5	6
August	31.4	22.9	85.0	60	25.4	5
Ssptember	30.8	22.6	83.0	58	170.5	4
October	31.2	22.3	84.0	56	30.0	3
November	29.9	20.9	89.0	51	303.7	4
December	27.9	20.0	90.0	61	161.6	6

Plates

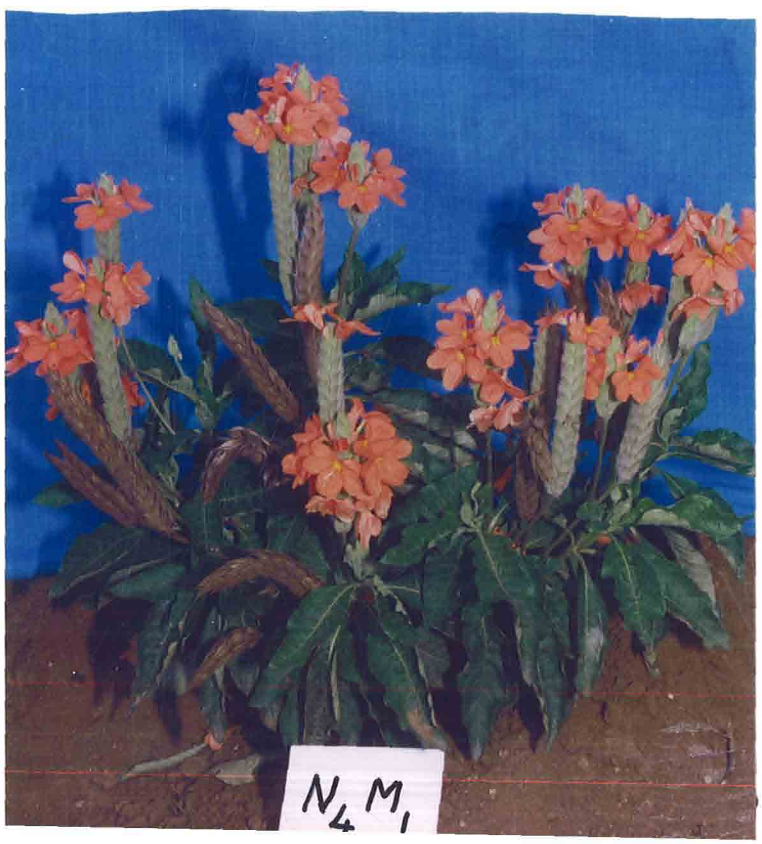
View of the experimental field



Plants at sixth month of planting under different treatments



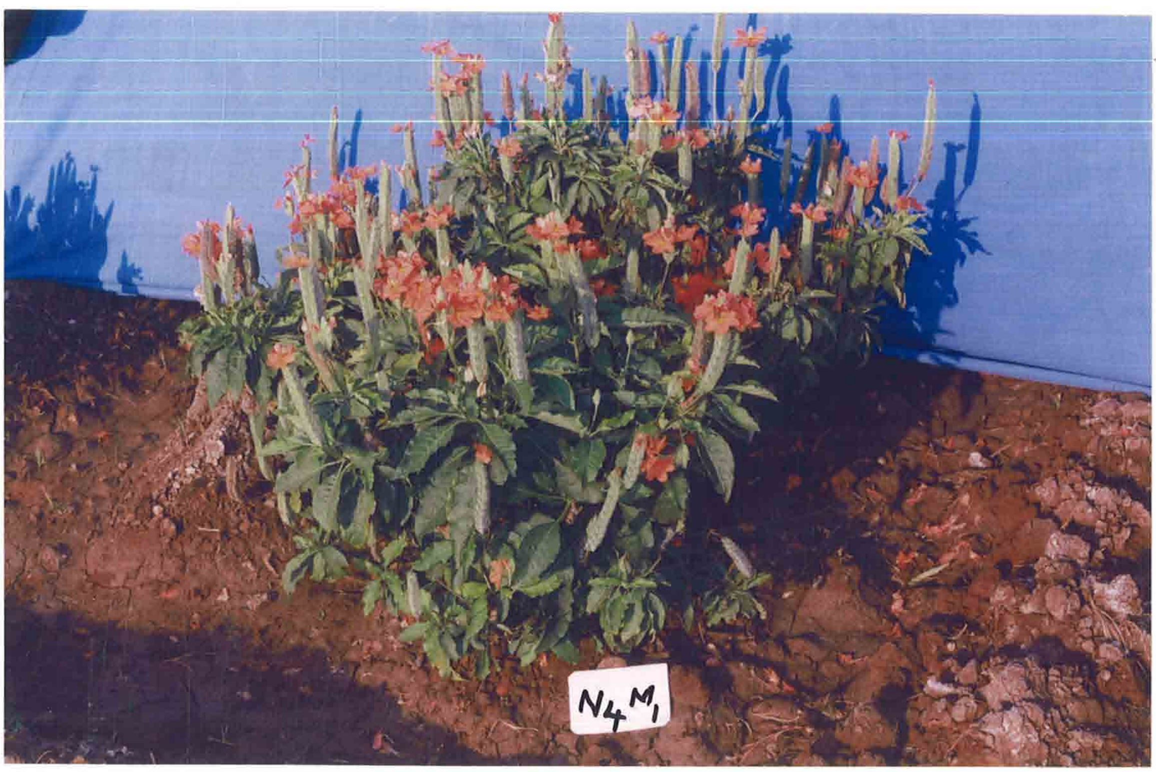
Plants at sixth month of planting under different treatments



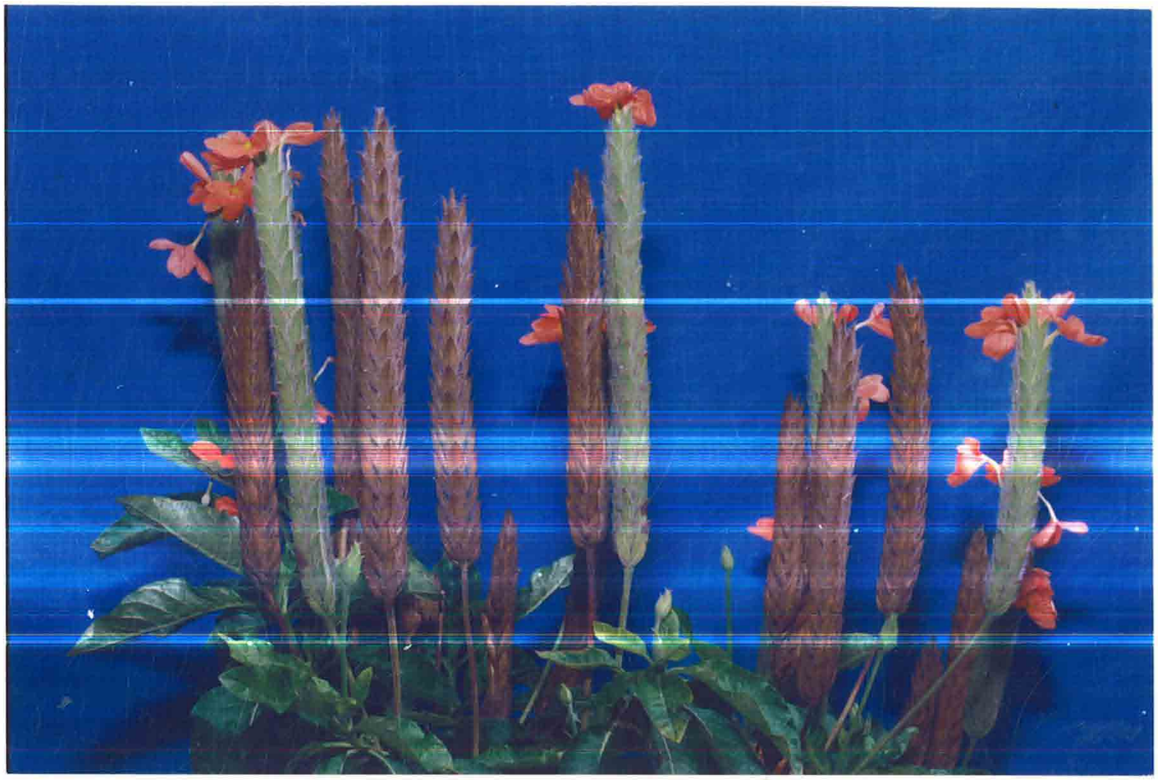
Plants at sixth month of planting under different treatments

Plants at twelfth month of planting under different treatments

Plants at twelfth month of planting under different treatments



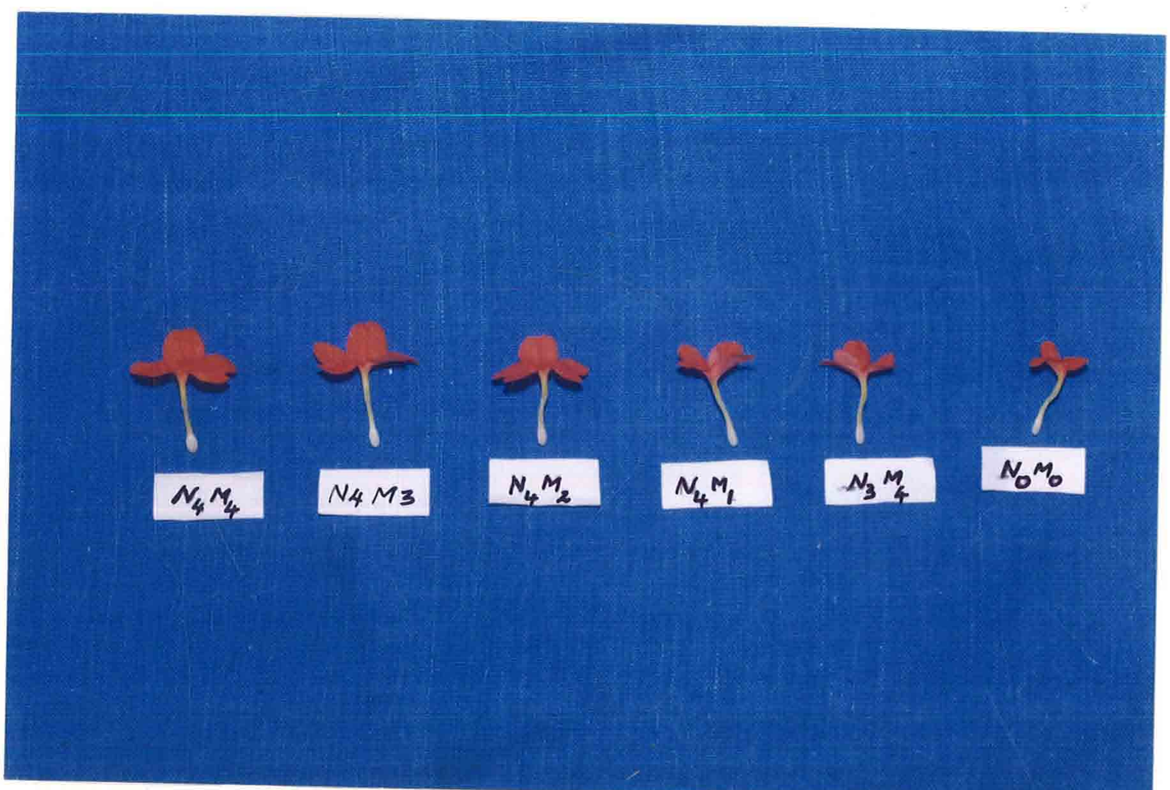
Plants at twelfth month of planting under different treatments



Increased spike length – N_4M_4

Comparison of spike length under N_4M_4 with other treatments

Increased flower diameter – N_4M_4



Comparison of flower diameter under N_4M_4 and other treatments